Social and Non-social Reasoning

in Relation to Autism and Autistic Traits

by

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Abstract

Four experiments examined reasoning and decision-making tendencies across social and non-social domains in relation to autism and autistic traits in adults. Experiments were created to measure forced-choice judgments and written justifications in a comparison paradigm of social and non-social scenario-based domains. Three experiments used a scenario-based task to measure moral reasoning, while one experiment focused specifically on causal reasoning with a task following a common cause network structure.

Dual Process Theories propose a distinction between two types of information processing: intuition and deliberation. Intuition represents a quicker and more automatic process, while deliberation represents a slower and more effortful process. Following this notion, the Dual Process Theory of Autism suggests a tendency of greater deliberation and less intuition in decision-making and reasoning among autistic people and those with high autistic traits. To test this hypothesis across domains to see whether these tendencies are domain-specific or domain-general, three experiments (Experiment 1, 2, and 4) recruited participants from the general population and measured their levels of autistic traits. One experiment (Experiment 3) recruited autistic and well-matched non-autistic participants for a between group comparison.

Experiment 1 found a relationship between higher autistic traits and a greater reliance on deliberation for forced-choice moral judgments within the social domain, and not the non-social domain. However, Experiment 2, using a modified version of the same task, did not reveal such a relationship, which was supported with participants' written justifications. Experiment 3 used the first version of the same task and found no meaningful differences between autistic and matched non-autistic people in their moral judgments. Experiment 3 revealed subjective yet not objective differences between groups in their reasoning and

decision-making, suggesting a subjective preference for and performance in reduced intuition among autistic people. Finally, Experiment 4 revealed no substantial differences in levels of autistic traits between participants, clustered as decisive and indecisive reasoners, based on their reasoning tendencies. Consistently, across all experiments, a distinction between social and non-social domains in terms of reasoning and decision-making was found.

Taken together, this thesis suggests that there is strong evidence for a distinction between social and non-social domains in reasoning and decision-making. However, this thesis does not provide strong evidence for a greater deliberation and less intuition associated with a diagnosis of autism or high autistic traits. Nevertheless, mismatch between subjective and objective reasoning and decision-making among autistic people might suggest meta-cognitive differences to non-autistic people, rather than a difference in reasoning and decision-making.

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Chapter I

General Introduction

1.1. Introduction

A growing area of research involves translating tools, techniques, and insights from reasoning and decision-making studies into the investigation of reasoning and decision-making of neurodivergent populations. One of the endeavours in this field over the past decade has been the focus on autistic people[1] and those with high autistic traits (Morsanyi & Byrne, 2020; Rozenkrantz et al., 2021). New discoveries about how autistic people and those with high autistic traits reason and make decisions have had significant impacts on shifting the traditional views on Autism Spectrum Disorder, hereinafter 'autism'[2], which were primarily focused on impairments and delays, towards recognising intact and enhanced features in autism. These discoveries not only compel us to reconsider our perception of autism but also help us realise

[1] The terminology used in autism research is evolving, and the language preferences of the autistic community (autistic people, their caregivers, autism researchers, and professionals) might differ nationally and internationally. While there is a relative consensus among various groups upon the use of identity-first language (e.g., "autistic person") rather than person-first language (e.g., "person with autism"; Bury et al., 2023; Keating et al., 2023; Kenny et al., 2016; Lei et al., 2021), there is no internationally accepted manner to discuss autism (Keating et al., 2023). Additionally, using person-first terminology in academic writing might accentuate stigma (Gernsbacher, 2017; Lei et al., 2021). To largely respect the preferences of the autistic community and consistency-sake throughout the thesis, in this thesis the identity-first language is preferred, instead of the person-first language or a mix of identity-first and person-first language.

[2] Many autistic people reject the word 'disorder' by highlighting that autism is a natural variation (Fletcher-Watson & Happé, 2019). Therefore, in this thesis, "Autism Spectrum Disorder" is referred as "autism".

that the cognitive profile of autism is more subtle and complex than previously believed. Furthermore, these discoveries, focusing on differences within and between clinical and non-clinical samples, raise several questions. These questions include (1) whether reasoning and decision-making differences stem from variations in thinking abilities or thinking styles, (2) whether these differences can be advantageous or disadvantageous, and (3) whether these differences are domain-specific or domain-general.

This thesis aims to explore reasoning and decision-making tendencies across social and non-social domains in relation to autism and autistic traits. In this chapter, I will first provide an overview of reasoning and decision-making. Next, I will explain why research on reasoning and decision-making in relation to autism and autistic traits is important and necessary. I will then briefly introduce autism as a clinical diagnosis and autistic traits, as self-reported characteristics associated with autism. Following that, I will introduce some of the major cognitive theories of autism that I consider relevant to the rationale and aims of this thesis, along with their limitations. Finally, I will focus on the Dual Process Theory of autism, which forms the theoretical background of this thesis.

1.2. Reasoning and Decision-making

Reasoning is a higher-order cognitive process that involves moving from multiple *inputs* through a single *output* to achieve a final outcome, which can be a conclusion or an action (Krawczyk, 2018). Decision-making is an intentional cognitive process in which one option is selected among two or more options to achieve a desired goal or choice (Huitt, 1992). Reasoning and decision-making are highly interrelated and important for various aspects of life. These aspects range from decisions that might involve smaller consequences, such as what to wear or which coffee to order, to decisions that might involve more remarkable consequences, such as relationships, healthcare, finance, and justice. Theories of reasoning and decision-making have been employed in several fields, such as economics, psychology, and sociology, to explore reasoning and decision-making behaviour. These theories help us to explore individual differences in reasoning and decision-making (Khemka, 2021). These attempts involve both (1) normative reasoning rules to maximise rationality, and (2) non-normative explanations of human capacity for rationality with interdependent roles of cognition, motivation, and emotion. Dual Process Theories are an example of these theories which have been highly influential on reasoning and decision-making research. These theories can be employed to investigate reasoning and decision-making preferences and performances of neurodiverse populations to better understand and maximise their decision-making processes.

1.3. Why study reasoning and decision-making in relation to autism and autistic traits?

Levin et al. (2015, 2021) reported that autistic adults face more challenges in everyday decision-making compared to non-autistic adults, but they do not show such differences in major life decisions. For autistic people, difficulties in everyday decision-making sometimes lead them to losses in everyday consumer behaviour (Levin et al., 2015, 2021). For instance, autistic people show higher tendency to purchase products which become unused and contribute to higher consumer debt for them (Levin et al., 2015, 2021). Additionally, autistic people report that they over-think decisions by deliberating on details and as a result tend to avoid decision-making (Komeda, 2021; Levin et al., 2021; Luke et al., 2011; Vella et al., 2018).

Based on a decision-making inventory (S. Scott & Bruce, 1995), Luke et al. (2011) highlighted three areas of difficulties, which were self-reported by autistic people and autistic people's caregivers. For autistic people, decision-making was reported to be particularly difficult when decision-making process (1) involved interacting with others, (2) involved a change in routine, and (3) had to be made quickly (Luke et al., 2011). While difficulties of interacting with others and changes in routine reflect core diagnostic features of autism (American Psychiatric Association, 2013), difficulty with quick decision-making, which might be indicative of a less preference for and engagement in intuition, is not yet well-covered.

The difficulty with quick decision-making might indicate a general tendency towards slower processing in autism, which leads to an inability or a dislike of engaging in quick decision-making. For instance, regarding sensory processing, Tardif et al. (2007) and Laine et al. (2011) found that slowing down stimuli, such as facial movements, body movements, and vocal sounds, improves recognition of facial expressions and imitation performance among autistic children. Moreover, Bertrams and Schlegel (2020) reported that speeded reasoning plays a moderating role in the inverse relationship between emotion recognition and levels of self-reported autistic traits. As a practical implication, Morsanyi and Byrne (2020) suggested that giving more times to autistic people to make decisions, such as providing more time during exams, may be useful due to their greater engagement in slower decision-making.

1.4. Moral Reasoning in Autism

Moral reasoning is a specific area of social cognition in which autistic people or those with higher autistic traits may differ from non-autistic people or those with lower autistic traits (for a review, Dempsey, Moore, Johnson, et al., 2020; Dempsey, Moore, Richard, et al., 2020; Komeda, 2021). Moral reasoning can be defined as the process of understanding what is good and bad, or what is right or wrong. Moral decision-making refers to the process of making decisions within the moral domain, which might involve justice, harm, care, and fairness (Garrigan et al., 2018). Research suggested that moral judgment is more of a matter of intuition, predominantly driven by emotions and affect, rather than a heavy reliance on deliberation (Greene & Haidt, 2002). Haidt (2001) proposed *the intuitionist model of moral judgment* by stating that moral development is not solely based on discursive moral reasoning. Dempsey et al. (2020) suggested that this model can be used to explore reduced moral reasoning among autistic people, who generally show intact moral judgment abilities.

In their study, Komeda et al. (2016) investigated specific information used by autistic and non-autistic adolescents, when making judgments on social scenarios' main characters as being better or worse. In their Experiment 1, using a sentence-by-sentence paradigm, they found that autistic adolescents relied on main characters' behaviours and outcomes, whereas their non-autistic counterparts relied on main characters' characteristics, behaviours, and outcomes. In their Experiment 2, using a comparison-paradigm, non-autistic adolescents made moral judgments using characteristics information of main characters. Overall, in both conditions, autistic participants did not typically rely on character-based information, which include mental states of social agents, suggesting that they might be ignoring this type of information, when making moral judgments. Moreover, the tendency of an over-reliance on a specific kind of information, in this case behaviour-based information, is consistent with a more deliberative reasoning approach, because it suggests that autistic participants might be more consistent, yet less flexible, in their moral reasoning. These findings align with previous research (Gleichgerrcht et al., 2013) suggesting autistic participants demonstrate greater utilitarianism compared to non-autistic people, but exhibit lower skills to infer mental states, involving intentions of others, when responding to moral scenarios, such as Trolley and Footbridge Dilemmas. Additionally, autistic adolescents are reported to provide blame judgments based on physical outcomes of a behaviour or action, rather than the intentions of the perpetrator (Salvano-Pardieu et al., 2016).

It is essential to note that other potential traits and co-existing conditions, such as alexithymia, may play crucial roles in reasoning and decision-making (Komeda, 2021). Alexithymia refers to difficulty in identifying and describing one's own emotions (Nemiah et al., 1976). Alexithymia is highly common among autistic people, with 40-65% of autistic adults reportedly experiencing co-existing alexithymia (Bird & Cook, 2013). Furthermore, in a study, co-existence of alexithymia in autistic people was reported to be responsible for lowering their helping motivation (Komeda et al., 2019). In another study, using emotionally demanding and harmful moral scenarios, autistic participants demonstrated normative moral judgments, despite facing difficulties in social cognition and emotional information processing (Patil et al., 2016). Additionally, this study revealed that higher levels of autistic traits were associated with lower utilitarian bias due to increased distress which was caused by emotionally demanding scenarios (Patil et al., 2016). On the other hand, higher levels of alexithymia traits were linked to greater utilitarian bias because of reduced concern for scenarios' victims (Patil et al., 2016).

The differences between autistic and non-autistic people or those with higher and lower levels of autistic traits in reasoning and decision-making are more pronounced when value-based decision making (for a review, van der Plas et al., 2023) or morality (for a review, Dempsey, Moore, Johnson, et al., 2020) is involved. Many studies exploring moral reasoning and decision-making in relation to autism and autistic traits have used tasks which involved (1) solely a social component, (2) solely a non-social component, (3) harmful or intense scenarios, or (4) rare or extreme scenarios. To overcome the unrepresentativeness of these tasks in real-life and an absence of a systematic comparison between social and non-social domains, I adapted Komeda et al.'s (2016) task into English and created a structurally equivalent non-social component. Chapter II and III present three experiments, using this scenario-based comparison task to measure forced-choice moral judgments and written justification for these judgments.

1.5. Autism – Definition, Prevalence, Cognitive Abilities, and Cognitive Profile

1.5.1. Definition

Autism is referred as a collective term in the latest version of the Diagnostic and Statistical Manual of Mental Disorders—Fifth Edition (DSM-5; American Psychiatric Association, 2013). According to DSM-5, autism is characterised based on a presentation of difficulties in social communication and social interaction, along with repetitive, restricted, and stereotyped behaviours, activities, and interests, which are present from early childhood. Autism impacts various aspects of everyday life, including social, academic, and occupational, while also affecting how one relates to oneself and others. In contemporary understanding, autism is considered as a *constellation*, encompassing a diverse and non-linear spectrum of strengths and weaknesses among autistic people, alongside similarities and differences to non-autistic people in cognition, perception, and behaviour (Fletcher-Watson & Happé, 2019; Happé & Frith, 2020). Besides being recognised as a clinical diagnosis, certain autistic traits are present in the general population, with autism being positioned at the end of the continuum (Baron-Cohen et al., 2001; Kanne et al., 2012; Ruzich et al., 2015). Autistic traits refer to behavioural characteristics that are associated with autism, such as directness in conversation, literal interpretation, affinity for solitude, and social imperviousness (Gernsbacher et al., 2017). For research purposes, autistic traits are measured with self-report questionnaires, with the Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001) being a widely used example.

1.5.2. Prevalence

The prevalence of autism has been increasing, with a rate of 1 in 36 eight-year-old children in the United States, recently reported by the Centres for Disease Control and Prevention (CDC; Maenner et al., 2023). The rise in autism diagnosis can be attributed to various reasons, including increased awareness and changes in diagnostic criteria (Baird et al., 2006). The CDC also reports a 4:1 male to female gender ratio, which seemingly has remained unchanged for a long time (Maenner et al., 2023). However, Loomes et al. (2017) suggested that girls and women are misdiagnosed or diagnosed later in life due to *the female autism phenotype*, wherein girls and women are being less likely to present their condition with clear symptoms, compared to boys and men and may mask their social challenges through *camouflaging*.

1.5.3. Cognitive Abilities

Cognitive abilities within autistic people vary. Traditionally, around 70% of autistic people have been estimated to have co-existing Intellectual Disability (Intelligence Quotient or IQ score ≤ 70, Fombonne, 2006). Currently, this rate is reported to be around 37.9% of autistic children having co-existing Intellectual Disability, with 23.5% of autistic children being at borderline range for Intellectual Disability (71 ≤ IQ score ≤ 85) in the United States (Maenner et al., 2023). Decision-making and reasoning abilities are higher-order cognitive abilities, in which autistic people exhibit similarities yet notable differences to non-autistic people (Luke et al., 2011; Morsanyi & Byrne, 2020; for a review, van der Plas et al., 2023).

Contrary to traditional belief stating that higher intelligence is associated with quick information processing, which results in faster reaction times (for a review on intelligence and speed of information processing, Sheppard & Vernon, 2008), Schirner et al. (2023) suggested that quick information processing is not always better. Their study showed that higher intelligence is linked to taking longer time to solve complex problems, since participants who took longer did not typically prefer *jumping to conclusions* and consider every possible details before concluding with a response to a Penn Matrix Reasoning test, where participants were asked to match a set of patterns (Schirner et al., 2023). While a rapid approach might be better for resolving relatively easy problems, a slower approach might be better for more difficult problems, since slower approach allows us to carefully consider information in depth.

1.5.4. Cognitive Profile of Autism

The aetiology of autism remains unclear, with no certain biomarker identified as a single, direct, and explanatory cause. Nevertheless, researchers widely agree that genetic factors play a crucial role, resulting in a *constellation* of behavioural manifestations (Fletcher-Watson & Happé, 2019). Several attempts have been made to understand autism from various perspectives, including at biological (encompassing genetics and neurological factors), behavioural, psychological, and sociological levels. Psychological or cognitive theories of autism aim to connect biological and behavioural variability among autistic people through investigating cognition, including perception, memory, and language, to provide explanatory and exploratory accounts for the cognitive profile of autism. Some of these theories have been investigated extensively and have dominated the autism literature (Rajendran & Mitchell, 2007). Some of the major cognitive theories of autism have taken either a deficit-based approach, focusing on one particular concept, such as the Theory of Mind Hypothesis (ToM; Baron-Cohen et al., 1985) and Theory of Executive (Dys)function (ED; Ozonoff et al., 1991) or a dimensional approach, contrasting two concepts, such as the Weak Central Coherence Theory (WCC; Frith & Happé, 1994), Empathising-Systemising Theory (ES; Baron-Cohen, 2009), and more recently, the Dual Process Theory of autism (Ashwin & Brosnan, 2019). Given the focus of this thesis being on higher cognition, specifically on reasoning and decision-making, this chapter will provide a brief review of these cognitive theories of autism. These theories have been chosen, because they are highly influential in the autism literature, and they relate to cognition, specifically to thinking processes. These theories will be presented with their strengths and limitations.

1.6. Cognitive Theories of Autism

1.6.1. The Theory of Mind Hypothesis

The Theory of Mind (ToM) hypothesis was proposed as a key factor in explaining autistic difficulties within social domain (Baron-Cohen, 1995; Baron-Cohen et al., 1985). ToM refers to the ability for understanding and attributing mental states, such as beliefs, desires, and intentions, to others and oneself, which enables people to interpret, predict, and explain behaviour (Premack & Woodruff, 1978). ToM involves dealing with mental states that require meta-representation—representation of representations (Perner, 1991). For instance, recognising that someone is happy does not require ToM, but understanding *why* they might be happy requires using judgments to infer beliefs, desires, and intentions.

1.6.1.1. Overview

Many studies have demonstrated that autistic children face challenges to pass formalised ToM tests (Mazza et al., 2017). However, the effect sizes of these studies are reported to be getting smaller (Rødgaard et al., 2019). The first-ever study examining ToM using a *false belief* task compared autistic children, children with Down Syndrome, and neurotypical children, who were not matched based on age or cognitive ability (Baron-Cohen et al., 1985). For this task, most autistic children failed to provide the correct answer, while most neurotypical children and children with Down Syndrome passed. Based on these findings, researchers suggested that autistic children, independent of their cognitive ability, may have difficulty representing the mental states of others (Baron-Cohen et al., 1985).

Research suggested that ToM is involved in moral judgments (Greene & Haidt, 2002). In everyday decision-making within rapidly changing social settings, quickly and fluently understanding, and attributing subtle cues of social communications and interactions is expected. An inability or difficulty in understanding and attributing mental states might affect the quality of everyday decision-making, especially within social domain. Some studies evaluated the relationship between ToM and moral reasoning, decision-making and judgments in relation to autism. For instance, studies reported that autistic adults with ToM difficulties demonstrated (1) greater challenges in distinguishing accidental harm from intentional harm (Moran et al., 2011), (2) reduced ability in rating injury severity following blame judgments in unfamiliar social scenarios (Salvano-Pardieu et al., 2016), and (3) poorer evaluations on seriousness of some moral transgressions (Zalla et al., 2011). ToM difficulties in autistic adults have also been linked to a greater tendency of providing utilitarian judgments for personal dilemmas with diminished distress in perception of these dilemmas (Gleichgerrcht et al., 2013). Given that, a mismatch between reasoning styles of an autistic person and a non-autistic person might create challenges in social reciprocity which involve quick decision-making as often adopted and expected by non-autistic people.

1.6.1.2. Limitations

While the ToM hypothesis of autism has been highly influential, it has also been significantly challenged (e.g., Gernsbacher & Yergeau, 2019). For instance, some autistic children pass the ToM tasks, suggesting a lack of universality (Happé, Ronald, et al., 2006; Happé, 2015). Moreover, Chevallier et al. (2014) emphasised the importance of the audience effect on ToM tasks, suggesting that performance differences between autistic and non-autistic children can be eliminated when there is no observer. Therefore, caution should be exercised when interpreting studies that report performance differences, as many of them might arise from feelings of separateness or difference to the experimenter, who is often not an autistic person (Fletcher-Watson & Happé, 2019).

There are also inconsistencies in the literature regarding the relationship between ToM in autism and moral reasoning, decision-making, and judgments. There are results contradictory to the assumption for an essential link between ToM and morality in autism (e.g., Leslie et al., 2006; Li et al., 2019; Patil et al., 2016). For instance, a recent study exploring third-party judgments, by measuring verbal evaluations (explicit ToM) with eye fixations and pupil dilations (implicit ToM), revealed that autistic adolescents can in fact understand the intentions of perpetrators (Li et al., 2019).

1.6.1.3. Summary

The ToM hypothesis of autism focuses solely on weaknesses within social domain. While many autistic people may struggle with classic ToM tasks, this does not reflect their entire cognitive profile. Furthermore, ToM fails to explain *why* autistic people face challenges with subtle aspects of everyday life, particularly in social situations.

1.6.2. The Theory of Executive (Dys)function

The theory of Executive (Dys)function (ED) is a primary-deficit, domain-general account of autism, drawing parallels with people who have had damage to their prefrontal cortex, initially suggested by Ozonoff et al. (1991). Executive functioning involves executive actions, such as problem solving, planning, inhibition of irrelevant responses, and flexibility in thought and actions (Ozonoff et al., 1991).

1.6.2.1. Overview

Ozonoff et al. (1991) reported that 96% of their autistic sample performed worse than the comparison group on executive functioning tests. Executive functioning plays an important role in thinking, reasoning, and decision-making. For instance, making a decision between two or more options requires attention, inhibitory control, and working memory capacity. Executive functioning has an important influence on higher-order thoughts, actions, and emotions, and consequently, on decision-making (Khemka, 2021). Emotions are important components that play a role in how people use their executive functioning skills in rapidly changing, highly stressed situations.

1.6.2.2. Limitations

Like the ToM hypothesis of autism, the theory of ED of autism lacks universality since some autistic people do not exhibit such problems. For instance, a study with a large group of autistic adolescents found connections between ToM and autism diagnostic profile, as well as ToM and ED, but not between ED and autism (Jones et al., 2018). Additionally, Pellicano et al. (2007) found only half of their autistic sample demonstrated a poorer performance compared to the non-autistic group. Moreover, these difficulties are not specific to autism, lacking discriminant validity. For instance, people with attention deficit hyperactivity disorder perform similar to or worse than autistic people in some executive functioning tasks (Happé, Booth, et al., 2006; Rajendran & Mitchell, 2007). Studies that are trying to differentiate executive functioning difficulties have provided mixed and inconsistent results (Rajendran & Mitchell, 2007). More generally, a recent meta-analysis revealed that there was only a small number of executive functioning measures that reached clinical sensitivity (Demetriou et al., 2018). Hill (2004) cautioned against the interpretation of ED literature in autism due to various task differences, diverse comparison groups, potential task presentation impact on the performance, and failure in replication. Additionally, when cognitive ability was controlled between groups, differences in executive functioning were no longer significant (see also, White, Burgess, et al., 2009).

1.6.2.3. Summary

In summary, the theory of ED of autism can be useful for explaining some autistic characteristics. However, as the ToM hypothesis of autism, the theory of ED of autism focuses on weaknesses and delays in autism, while ignoring intact and enhanced abilities within the autistic community.

1.6.3. The Weak Central Coherence Theory

The Weak Central Coherence (WCC; Frith & Happé, 1994) Theory of autism is a domain-general and multi-dimensional account, with an attempt to explain both social and non-social characteristics of autism.

1.6.3.1. Overview

According to the WCC theory of autism, autistic people tend to engage in a more detailed and local processing, while non-autistic people generally engage in a more global processing (Frith & Happé, 1994). This leads to enhanced attention to detail in autism, which has been observed through various tasks, such as block designs and embedded figures tests. These tasks present a global pattern that includes smaller components. Autistic people often excel in these tasks, because they focus on processing smaller components without being influenced by the global pattern (A. Shah & Frith, 1993). In other words, they do not attend *the big picture*, unlike non-autistic people who prioritise the global figure over small components (A. Shah & Frith, 1993). Evidence for the WCC theory of autism has also been found in studies on visual illusions, showing that autistic people are less susceptible to certain illusions relative to comparison groups (Happé, 1996). Some studies reported relevant strengths in autism in enhanced local processing. For instance, Mottron et al. (2006) suggested that enhanced local processing in autism may contribute to autistic participants outperforming non-autistic participants in certain tasks. This theory suggests both an enhanced perceptual ability and a difficulty of attending to global meaning or context (Mottron et al., 2006).

1.6.3.2. Limitations

Despite its merits, the WCC theory of autism has also faced challenges. Research has shown contradictory results, some suggesting that autistic people can be susceptible to illusions, depending on the specific context of the question (Brosnan et al., 2004). Some measures used to assess central coherence in the general population were found not to correlate well, raising validity concerns (Pellicano et al., 2005). Moreover, autistic people have been shown to engage in global processing when explicitly instructed to do so, but tend to default to local processing automatically (Mottron et al., 1999). Similarly, Happé and Frith (2006) proposed that local bias in autism could be overcome when autistic people made conscious effort to do so, indicating a particular cognitive style in relation to autism, rather than a cognitive deficit (also see, Happé, 1999). Additionally, some autistic people have been shown to engage in intact or enhanced analogical processing, which requires engagement in both local and global processing (Morsanyi & Holyoak, 2010). Therefore, atypical network connectivity in autism might not be universal (White, O'Reilly, et al., 2009), suggesting that WCC may have different underlying causes in different autistic people.

1.6.3.3. Summary

In summary, Booth and Happé (2018) have suggested that increased local processing and reduced global processing might be distinct and independent features in autism. This theory is related to this thesis because it offers enhanced abilities in autism and focuses on strengths alongside weaknesses. However, as the ToM and ED accounts of autism, it lacks universality and explanatory power.

1.6.4. The Empathising-Systemising Theory

The Empathising-Systemising Theory of autism (ES; Baron-Cohen, 2009; Baron-Cohen et al., 2003) is closely linked to the Extreme Male Brain theory of autism (EMB; Baron-Cohen, 2002).

1.6.4.1. Overview

Systemising refers to preference for and engagement in systematic and rule-based activities and thinking styles. However, people are not always rule-based, and therefore, empathising, suggesting a reliance on intuition, might be more effective for predicting human behaviour. This requires understanding that people's mental states might not relate to their behaviours (Ringshaw et al., 2022). Studies have shown that empathising and systemising are related concepts but in different directions, as they display a strong negative correlation (Brosnan et al., 2010). It has been suggested that some people show enhanced emphasising abilities, some show enhanced systemising skills, while some show more balanced skills (Baron-Cohen et al., 2003).

According to the EMB theory of autism, autism can be understood as results of greater systemising and reduced empathising abilities (Baron-Cohen, 2002). Similarly, the ES theory of autism suggests that autistic people possess strong systemising skills but struggle with empathising (Baron-Cohen, 2009). As compensation, it was suggested that autistic people might be predicting the behaviours of systems and objects rather than people in social settings (Baron-Cohen et al., 2005). Consistent with this, although it might be considered as an out-dated perspective, Kennett (2002) proposed that autistic people might be more likely to adopt a Kantian moral approach, implying rules without regarding to social agent's emotions or the ultimate outcomes of the actions. The ES theory of autism, highlighting contrasting features, is important, because enhanced systemising skills can be attributed to a tendency of enhanced attention to detail and greater deliberation, which both have been proposed in relation to autism and high levels of autistic traits.

1.6.4.2. Limitations

The assumption that autism is linked to an extreme male brain may stem from the higher diagnosis rates among boys and males, compared to girls and women. However, it is now debated that this gender disparity might not be reflecting the actual prevalence rates, rather might be indicating a gender bias towards boys and men, resulting in girls and women to be misdiagnosed or diagnosed later in life (Hull et al., 2020; Loomes et al., 2017). However, the true prevalence rate might likely be still higher for boys and males. Nevertheless, such gender-based theories may perpetuate harmful stereotypes about autism. Additionally, a study attempting to capture whether autistic children perform highly systematically compared to non-autistic children yielded no significant difference between autistic and non-autistic children (Pellicano et al., 2011). Moreover, Morsanyi et al. (2012) found spatial thinking styles to be more correlated with systemising skills than self-scored systemising scores or gender differences, raising validity concerns for this theory.

1.6.4.3. Summary

In summary, the ES is a promising theory, highlighting strengths within the autistic community, such as an eye for detail, enhanced local processing, and greater systemising, which might relate to slower yet more careful information processing, in other words, a deliberative approach. However, the ES theory lacks explanatory power, while reflecting what autistic people sometimes do and do not do as much. Given that autism remains heterogenous with an unknown aetiology, attempts to explain autism with a single theory have been limited or incomplete. Furthermore, some theories, such as the EMB theory of autism, have been harmful for the autistic community (Fletcher-Watson & Happé, 2019).

1.7. The Dual Process Theory of Autism

Cognitive theories of autism that have been reviewed above are still valuable as they might bring insights into difficulties experienced by a wide group of autistic people to some extent. For instance, they can allow for some sorts of adaptations to be made. However, existing theories we have are incomplete, inconsistent, out-dated, and have not necessarily brought meaningful changes to the lives of autistic people. Furthermore, what these cognitive theories have told us is that a theory with a single and narrow focus cannot explain autism, and we need a multi-dimensional approach with a broader focus. This is because that autism is highly heterogenous with unknown aetiology, and therefore, single, or even single-dimensional cognitive theories of autism are always going to fall flat. What we need is to understand the range of cognitive differences commonly experienced by autistic people, and how this plays out in the real world.

From a strength-based and multi-dimensional approach, the Dual Process Theory of autism (Ashwin & Brosnan, 2019) can be a possible modern theory. The Dual Process Theory of autism claims to explore both social and non-social differences between autistic and non-autistic people, alongside between those with higher and lower levels of autistic traits, but implicitly assumes social and non-social domains coalesce. Before moving to the evidence and limitations from the literature for this theory, this chapter will define Dual Process Theories from a general perspective and provide evidence for two types of information processing: deliberation and intuition.

1.7.1. An Overview on Dual Process Theories

People often rely on immediate or relevant knowledge rather than adhering to logical and normative rules of reasoning when making decisions, even in situations where they possess expertise or when they are provided with the structure of normative rules of reasoning (Evans, 2003; Evans & Frankish, 2009). This leads to a discrepancy between normative rules of reasoning and non-normative decisions of people. Although it is subject to ongoing debate (for recent developments see, De Neys, 2018; but see, Kruglanski & Gigerenzer, 2011; Melnikoff & Bargh, 2018; Osman, 2004), Dual Process Theories propose that people employ two *distinct* types of information processing (for a historical overview, Frankish & Evans, 2009). These two types are fast "intuition" and slow "deliberation"[3] (Epstein, 1994; Evans & Stanovich, 2013; Kahneman, 2011; Sloman, 1996). See Table 1.1 for some properties of these two types of information processing.

[3] The terms of "intuition" and "deliberation" became popularly referred to as "System I" for the former and "System II" for the latter (Stanovich, 1999). However, the terms "Type I" and "Type II" have commonly been preferred instead in later discussions (Evans, 2018).

Table 1.1

The properties of Dual Process Theories (Kahneman, 2011)

Type I	Type II
intuitive	deliberative
rapid	slow
effortless	effortful
parallel	sequential
implicit	explicit
automatic	controlled
experiential	rational
independent of cognitive ability	dependent on cognitive ability

Broadly, intuition represents a fast, effortless, and autonomous process that is independent of cognitive abilities, such as working memory capacity, yet dependent on the context (Evans & Stanovich, 2013). We engage in this type of processing when we make a lucky guess or associations from relevant experiential learning (Evans, 2018). On the other hand, deliberation represents a slow, effortful, and rule-based process that is linked to cognitive abilities, yet independent of the context (Evans & Stanovich, 2013). We engage in this type of processing when we try to solve complex problems (Evans, 2018). Dual Process Theories have been popular accounts in various fields, including psychology and philosophy, to explore many areas of interest (for a review, Evans, 2008), such as reasoning (e.g., Sloman, 1996), decision-making (e.g., Frederick, 2005; Kahneman, 2011), social cognition (e.g., Epstein et al., 1996), and theory of mind (Apperly & Butterfill, 2009).

Evidence from several studies supported the notion that people engage in two *distinct* types of information processing. For instance, speeded tasks, in which participants are required to respond in a short period of time, use time pressure as a modification. The time pressure modification increases engagement in fast intuition which often leads to common reasoning biases (e.g., the belief bias in, Evans & Curtis-Holmes, 2005; e.g., the matching bias in, Roberts & Newton, 2001). Additionally, telling participants to respond quickly can have similar effects on participants' conditional reasoning (e.g., Schroyens et al., 2003). As an opposite approach, telling participants to bring their focus to the task, taking as much time as needed, or forcing them to engage in analytical thought can increase the likelihood of them to rationalise their decisions (Denes-Raj & Epstein, 1994; Evans et al., 2010).

There have also been various theoretical attempts to explore whether these two types of processing are always distinct. An important notion comes from *default-interventionist models* (Evans, 2007), which propose an interplay between belief and logic, stating that a reasoner overrides the content through deliberation, which was delivered by intuition as a default output. In other words, sometimes reasoners notice a conflict between their belief and logic. Consequently, reasoners override their initial decision with careful deliberation. Broadly, this model links deliberation to logic-based and intuition to belief-based thinking. For this model, the reasoner needs to have enough cognitive abilities to be able to recognise the conflict in the first place (Stanovich & West, 2008). An example of this distinction is represented in the well-known bat-and-ball problem, presented below (Frederick, 2005):

> A bat and a ball cost £1.10 in total. The bat costs £1.00 more than the ball. How much does the ball cost?

The bat-and-ball problem is one of three problems in the Cognitive Reflection Test (CRT; Frederick, 2005), which measures the propensity to engage in deliberative reasoning by overriding intuitive responses (Toplak et al., 2014). For this problem, most participants (64.9% of undergraduate students, in Pennycook et al., 2016) respond as £0.10, which typically comes to mind first. However, £0.10 cannot be the correct answer, because then, the bat would cost £1.10, and the total cost would be £1.20. Some people (30.3%, in Pennycook et al., 2016) can solve this problem and respond with the correct answer which is £0.05. Additionally, few people give a response other than £0.10 or £0.05. Broadly, the CRT can be used to distinguish people who are willing to think harder and people who are happy to go with their gut feelings. While the latter are so-called intuitive, or associative, thinkers, the former are so-called analytical, in other words, deliberative thinkers. In experimental studies, Pennycook et al. (2015) found that high analytical thinking performance on the CRT negatively correlated with several beliefs, such as religious and paranormal beliefs. In contrast, Howarth et al. (2016) found that highly analytical reasoners in their sample were more influenced by belief-based judgments, when they were faced belief-based conflicts.

Another notion comes from *parallel-competitive models* (Evans, 2007). These models propose that intuition and deliberation work in a parallel manner and deliver putative responses, which might sometimes result in a conflict, that needs to be resolved by the reasoner. Epstein's (1994) *the rational-experiential theory* is an important example of these models. For these models, when the responses are in conflict, the reasoner simultaneously believes both contradictory responses. On the other hand, *default-interventionist models* propose that intuition always comes first as a default response for a decision, and then, the decision is overridden by deliberation, when necessary. This process sometimes happens without the awareness of reasoner. Moreover, while *default-interventionist models* assume a direct mapping between intuition with belief-based judgments and deliberation with logic-based judgments, *parallel-competitive models* do not assume such a direct mapping and propose that both deliberation and intuition rely on cognitive capacities to some extent. The idea of intuition being belief-based, and deliberation logic-based, is challenged by "the belief fallacy" (Evans, 2018). Additionally, while *default-interventionist models* propose that intuition always takes us to default responses, which are typically incorrect, and deliberation, with effortful process, to normative responses, which are typically correct, *parallel-competitive models* propose that correct responses do not always require an effortful process, suggesting intuition also sometimes leads to correct responses. Broadly, intuitions occur from a combination of innate cognitive processes, learned associations, and personal experiences. Some factors that contribute to the formation of intuitions are pattern recognition and expertise, cognitive heuristics (Tversky & Kahneman, 1974), and evolutionary factors (Cosmides & Tooby, 1994). Even though intuition has traditionally been linked to biased and inaccurate responses, it is crucial to note that, intuition can be valuable at certain contexts and guide decision-making.

The idea of intuition always delivering incorrect, and deliberation correct, responses is challenged by "the normative fallacy" (Evans, 2018). A correct response might sometimes reflect a lucky guess or a helpful heuristic which were typically attributed to Type I processing. On the other hand, a wrong response might sometimes reflect fast and shallow Type II processing. Additionally, sometimes, fast, and intuitive processing might be more effective for expert judgment (Evans, 2018). Evans (2006) and Stanovich and West (2008) stated that engaging in cognitive effort does not always deliver a normative response. For instance, *the heuristic-analytic theory* (Evans, 2006) proposes that deliberation overrides intuition, however, often deliberation is used to justify the biased intuitive response (also referred as "rationalisation phenomenon"). Later, Evans and Stanovich (2013) updated their theories, following criticisms and unsupportive experiment results, emphasising that intuition cannot always be linked to incorrect, biased, and belief-based judgments, and vice versa (Evans, 2018).

While the arguments *for* and *against* Dual Process Theories bring helpful insights into cognitive processing field in a bigger scale, De Neys (2021) argues that there is no good enough evidence or scientific argument to decide the debate of single- versus dual-processing. Furthermore, De Neys (2021) claims that this debate is irrelevant to empirical scientists. Additionally, most studies following the notion of the Dual Process Theory of Autism relied on a distinction between intuition and deliberation while often emphasising a direct link between deliberation and correct responding, and intuition and incorrect responding (for a review, see, Rozenkrantz et al., 2021) which aligns with *default-interventionist models*. To continue this trend, in this thesis, Dual Process Theories in a general perspective, and *default-interventionist models* in a more specific perspective, were broadly followed.

1.7.2. Evidence for the Dual Process Theory of Autism

This section will be presenting reasoning and decision-making research in relation to autism and autistic traits with a focus on Dual Process Theories over the last decade. The results from this limited but interesting collection of studies can help us understand social and non-social profiles of autism, as well as decision-making difficulties self-reported by autistic people themselves and caregivers of them (Luke et al., 2011).

The Dual Process Theory of autism (Ashwin & Brosnan, 2019; Brosnan et al., 2016; Brosnan & Ashwin, 2021) proposes that autistic people and those who self-report higher levels of autistic traits tend to prefer for and engage in enhanced deliberation and reduced intuition, as opposed to non-autistic people and those who self-report lower levels of autistic traits. The

Dual Process Theory of autism (Ashwin & Brosnan, 2019; Brosnan et al., 2016; Brosnan & Ashwin, 2021) aligns well with other cognitive theories of autism, which emphasise superior attention to detail and enhanced pattern recognition (Baron-Cohen, 2009, 2020), alongside greater systemising skills (Baron-Cohen et al., 2009). The WCC account of autism (Happé, 1999) also emphasises greater attention to detail in autism, accompanied by enhanced local processing skills. Brosnan et al. (2014) reported a positive correlation between these skills and deliberative information processing. Hyper-focus on details in autism has been associated with systematic processing and literal interpretation, possibly suggesting a reduced ability to capture the gist of experiences and materials (McCrory et al., 2007). Furthermore, superior attention to detail in autism has been suggested as being predisposing to enhanced skills and savant talents in autism (Baron-Cohen, 2020; Baron-Cohen et al., 2009; Happé & Vital, 2009).

Autistic people, as well as those with higher autistic traits, tend to exhibit a preference for and performance in more rational and logical reasoning, compared to non-autistic people or those with lower autistic traits (e.g., Brosnan, Chapman, et al., 2014; Brosnan et al., 2016, 2017; Brosnan & Ashwin, 2022b, 2022a; De Martino et al., 2008; Levin et al., 2015; Lewton et al., 2019; Morsanyi & Byrne, 2020; Rozenkrantz et al., 2021; P. Shah et al., 2016). Termed as *enhanced rationality* in autism (for a review, see, Rozenkrantz et al., 2021), these tendencies have been observed in various contexts. For instance, Brosnan et al. (2014) used the computerised version of the Beads Task (Huq et al., 1988), which is a probabilistic sampling distribution paradigm, with autistic adolescents and a matched comparison group to compare the number of beads asked prior to making a decision in. Their findings indicated that the autism group requested a greater number of beads compared to the non-autism group, suggesting that autistic participants do not typically *jump to conclusions*, a bias that arises when making decisions with insufficient information. Similar results were reported by Brosnan et al.

(2013) for people who self-report higher levels of autistic traits in the general population, gathering more data before making a decision. Researchers of these studies also proposed that reasoning in autism can be characterised with higher systemising relative to empathising skills.

Studies exploring reasoning in autism have used various subjective and objective measures. For instance, using the classical version of the Cognitive Reflection Test (CRT; Frederick, 2005) as an objective measure, some studies showed that autistic participants outperform their non-autistic counterparts (Brosnan et al., 2016, 2017). One particular study (Brosnan et al., 2016, Study 2) recruited autistic and non-autistic late adolescents and matched the groups based on age. Additionally, all participants in this study identified as male. Additionally, Brosnan et al. (2017), recruited autistic and non-autistic late adolescents and young adults and matched the groups based on gender and non-verbal intelligence. In this study, the autism group was slightly older. Both studies reported fewer intuitive responses provided by the autism group compared to non-autism group, while deliberative responses did not differ between groups. These studies also stated that greater deliberation in autism was not linked to their intelligence levels, indicating that these findings cannot be explained by cognitive ability differences between groups. Additionally, they reported that levels of self-reported autistic traits, which were measured with the AQ, were significantly positively correlated with deliberative responses on the CRT after pooling the groups and controlling for the effects of age, gender, and diagnostic group membership.

More recently, another study (Brosnan & Ashwin, 2022b) used the CRT to explore reasoning performance among late adolescents by matching autistic and non-autistic groups based on age, but not on cognitive abilities. This time, they used time modifications, employing untimed and under time pressure conditions, and found that in both conditions the autism group provided more deliberative and fewer intuitive responses compared to the non-autism group. They also reported a small sized positive correlation between levels of self-reported autistic traits, which was measured with the Subthreshold Autism Trait Questionnaire (SATQ; Kanne et al., 2012), and deliberative performance on the CRT, after pooling groups and controlling for condition, gender, age, and diagnostic group membership.

Research also suggests that autism and high levels of autistic traits are associated with being less susceptible to common reasoning biases (e.g., Farmer et al., 2017; Fujino et al., 2019). For instance, autistic people were found to be less influenced by *the framing effect*, a bias that arises when people change their decisions based on how options are presented, even if the options are mathematically equivalent (De Martino et al., 2008; Shah et al., 2016; but see, Levin et al., 2015). Additionally, autistic people were found to be less susceptible to the conjunction fallacy (Morsanyi et al., 2010). A negative correlation between levels of autistic traits and an engagement in belief bias in the general population was also found (Lewton et al., 2019).

Autism is characterised with relative strengths within the non-social domain and relative weaknesses within the social domain (Baron-Cohen et al., 2011). The Dual Process Theory of autism offers insights into these strengths and weaknesses. On one hand, autistic people can avoid certain reasoning biases and refrain from over-relying on emotional and contextual information. This can be seen as a strength, as it leads to a normatively and economically better decision-making behaviour. These abilities can also be useful in fields like mathematics and statistics, which typically require a highly logical reasoning style (Rozenkrantz et al., 2021). On the other hand, in the context of social communication and interaction, relying on automatic, quick, and effortless information processing is crucial (Rand et al., 2012). The social domain is characterised by unpredictability, which is shown as a difficulty for cue processing in unstable contexts among autistic people (Robic et al., 2015). This finding is in line with Allman et al. (2005), who suggested a challenge of fast intuitive processing for autistic people. Therefore, alongside a strength-based approach stating enhanced rationality in autism, it is essential to acknowledge the significance of necessity of intuition in various contexts, especially in social contexts, that often demand quick decision-making (Evans & Stanovich, 2013; Kahneman, 2011; Rand et al., 2012).

Extracting emotional information in a rapid and automatic manner from social environments is argued to be an intuitive processing (Kahneman, 2011). Difficulties in intuition and quick decision-making may result in difficulties associated with autism within the social domain. For example, during a conversation, it might be difficult for an autistic person to quickly and automatically decide to end the conversation or change the topic, even if autistic person notices that their counterpart is bored or not interested in the topic—an aspect that has been reported as being challenging for autistic people (Brosnan & Ashwin, 2021). In line with this example, Mendelson et al. (2016) suggested that slow information processing in social situations, such as forming and sustaining friendships, may particularly be an underlying reason for social difficulties experienced by autistic people. Therefore, understanding and addressing these challenges in reasoning and decision-making across social and non-social domains can be crucial in supporting autistic people in their social communication and interaction.

1.7.3. Limitations of the Literature on the Dual Process Theory of Autism

Findings of a tendency of enhanced rationality in relation to autism and high levels of autistic traits have been inconsistent. For instance, Brosnan et al. (2017) did not identify significant group differences between autistic and non-autistic participants for correct responses, indicative of deliberation, on the CRT. The Rational-Experiential Inventory (REI; Epstein et al., 1996) is a commonly used self-report measure for rationality and experientiality. Self-reported group differences found on the rationality sub-scale of the REI (Epstein et al., 1996), indicative of deliberation, were only marginally significant (Brosnan et al., 2016). These results in line with Morsanyi et al. (2010), who reported a lack of evidence for group differences between autistic and non-autistic adolescents in deliberative responses for heuristics reasoning. Heuristics refer to cognitive short-cuts, often associated with cognitive errors or biases. Furthermore, recent studies (e.g., Morsanyi & Hamilton, 2023; Taylor et al., 2022) using updated versions of CRT were unable to replicate the previous findings. For instance, after carefully matching comparison groups on age, gender, and cognitive ability, Taylor et al. (2022, in Study 4) did not find significant differences between comparison groups in intuitive and deliberative responses. Taylor et al. (2022, in Studies 1-3) used a recently updated version of the CRT (CRT-7; Sirota & Juanchich, 2018) and recruited a large sample from the general population, measuring autistic traits using the AQ. They found no significant relationship between autistic traits and CRT responses (Taylor et al., 2022, in Study 3). They observed a single significant positive relationship between autistic traits and deliberative responses and a single significant negative relationship between autistic traits and intuitive responses (Taylor et al., 2022, in Study 3). However, these relationships were statistically weak. Furthermore, these relationships became non-significant, after controlling for age, gender, and cognitive ability (Taylor et al., 2022, in Study 3). Overall, these findings suggest that neither levels of autistic traits nor an autism diagnosis might be related to performance on the CRT when groups are carefully matched, and potential variables are controlled between groups.

Similarly, Morsanyi and Hamilton (2023) used a longer version of the CRT and showed no significant group differences between autistic and non-autistic early adolescents and young adults, after carefully matching the comparison groups based on age, gender, cognitive ability, and educational background. However, they found a significant effect of age on CRT responses for both adolescent and adult groups, reporting more deliberative and less intuitive responses by adults compared to adolescents, regardless of the diagnosis (Morsanyi & Hamilton, 2023). This conflicts with findings of Lewton et al. (2019), who found an opposite pattern regarding the effect of age, suggesting a decrease in deliberative responses on the CRT with age. Additionally, Morsanyi and Hamilton (2023) did not find meaningful correlations between autistic traits, measured by the AQ, and responses on the CRT. However, they found a significant strong correlation between attention to detail, a sub-scale of the AQ, and deliberative responses on the CRT for the adult autism group, with a weaker but still significant for the adult non-autism group (Morsanyi & Hamilton, 2023). It is important to note that their sample consisted of university students, limiting the representativeness of their findings to a broader autistic adult population.

Deliberative thinking has been found to be closely linked to cognitive abilities (Toplak et al., 2014). Thus, when the same authors of the previously mentioned studies matched their groups based on some kind of cognitive ability, they could not find a strong direct link between autism and deliberative reasoning (Brosnan et al., 2017). Moreover, the classical CRT has faced remarkable challenges from researchers like Pennycook et al. (2016) who stated that the CRT should be viewed as an indicator of susceptibility to common biases rather than a measure of intuitive ability. They added that this test might be measuring the *propensity* to engage in deliberative reasoning, rather than an *ability* (Pennycook et al., 2016). Additionally, the widespread use of the CRT online and on newspapers has increased the likelihood of participants being familiar with its items. To address this concern, the CRT has recently been updated by Sirota and Juanchich (2018) with an addition of four-items.

Another methodological issue with these studies is the relatively small sample sizes, resulting in limited statistical power and raising questions about the generalizability of the results (e.g., De Martino et al., 2008). Additionally, these studies employed homogeneous samples, mainly consisting of university students. However, the lack of diversity makes these samples unrepresentative for the broader autistic community (Hanel & Vione, 2016). Considering the replication crisis in Psychology (Tackett et al., 2019), there is a need for rigorous studies with larger and more diverse samples, including both clinical and non-clinical participants, to validate and replicate the results reported in the literature.

Despite inconsistencies and limitations with studies using the CRT, a consistent finding across most of these studies shows that autistic people self-report lower levels of intuition (Morsanyi & Hamilton, 2023; Taylor et al., 2022). Several studies demonstrated that autistic people self-report significantly lower experientiality, determining intuition, compared to non-autistic groups (Brosnan et al., 2016; Levin et al., 2015; Morsanyi & Hamilton, 2023; Taylor et al., 2022). However, they found no group differences in self-reported rationality, determining deliberation. Overall, it appears reasonable to speculate that intuition, which is typically a fast and automatic reasoning style for non-autistic people, seems to be reduced, disliked, or neglected among autistic people. Regarding this, Brosnan and Ashwin (2021) proposed two potential explanations: (1) autistic people may have difficulties engaging in intuition, or (2) intuition is intact in autism yet deliberation is triggered more often, resulting deliberation dominating over intuition for them. This could be particularly relevant for social situations and can be considered as an explanation for *why* autistic people take longer to make decisions (Luke et al., 2011). Nevertheless, there is potential for autistic people to still engage in fast and automatic reasoning within the non-social domain.

Regarding measures like the CRT, finding no statistically significant group differences does not necessarily mean that autistic and non-autistic people do not differ in their reasoning in real life. However, the CRT is widely used, through online platforms and even on newspapers. Therefore, in Chapter III, I used a recently updated version of the CRT to minimise the risk of familiarisation with its items. I also carefully matched the autism and non-autism groups based on age, gender, and non-verbal cognitive ability. Additionally, most of the studies presented above were conducted with late adolescents and young adults. Given that adults and elderly people have often been overlooked within autism research (Fletcher-Watson & Happé, 2019), in Chapter III, I recruited adult participants with a broad range of ages, ranging between 18 to 72 years.

1.8. Social versus Non-social Reasoning in Relation to Autism

The social domain involves animate objects, such as people and animals, while non-social domain involves inanimate objects, such as cars and toys. Traditionally, cognition was thought to be a unified process across social and non-social domains (Piaget, 1963), but later researchers proposed a distinction between these domains (Glick, 1978; Shultz, 1982). For instance, Glick (1978) suggested that social objects not only react but also act, leading to less predictability in their behaviour. Additionally, Shultz (1982) noted that social causal reasoning involves perceiving causes of social events as intentions and actions of social agents. On the other hand, non-social causal reasoning involves perceiving causes of non-social events as physical forces or interactions between objects. Moreover, people consistently exhibit a tendency to perceive psychological and physical events as having distinct causal structures, even when the events were simply framed using psychological or physical terms (Strickland et al., 2017). Strickland et al. (Strickland et al., 2017, in Experiment 5) showed that this distinction was highly strong, since even only framing ambiguous events with psychological or physical terms was sufficient for participants to provide different causal structures for given events. In their study, they used several texts on mental states, such as anxiety, self-esteem, or political conservatism, which were presented as being either a “physical (e.g., brain-based)” or “psychological (e.g., mind based)” phenomena. Their participants provided significantly lower number of causes for states that were framed as physical, indicative of non-social domain, compared to states that were framed as psychological, indicative of social domain.

Participants exhibited *superior* reasoning about the causes of social events compared to non-social (Galotti et al., 1990), providing more detailed, yet slower, and less stereotypical causes for social events, relative to non-social events. Neuro-imaging studies (Mason et al., 2010), where participants made faster yet more accurate judgments within social domain, relative to non-social domain, revealed that people tend to treat these domains differently. Additional to evidence of discrepancy in speed and accuracy across domains, Mason et al. (2010) also suggested that, although both social and non-social relational judgments were based on brain regions that have a general role in reasoning, social judgments are specifically and uniquely associated with brain regions involved in mental state representations (e.g., temporoparietal junction or posterior superior temporal sulcus, and medial prefrontal cortex). Additionally, Cosmides (1989) reported that people perform better when the well-known Wason Task is presented in a social context. In the Wason Selection Task (Wason, 1968) participants are presented with four cards, with *p* or *p’* on one side, and *q* and *q’* on the other side. Participants are then given four cards: *p*, *p’*, *q*, and *q’*, and asked which cards they need to turn over to identify violations of the rule “If *p*, then *q*”. In this scenario, participants often perform poorly and turn over the wrong cards. However, when the scenario is presented in a social context, their performance improves. For instance, when asked to check violations of the rule “If a person buys alcohol, then they must be over 18 years of age”, they are more likely to turn over the right cards, which are “a person aged less than 18” and “a glass of alcohol”. Though differences between social and non-social domains are sometimes hard to interpret due to lack of explicit control, these findings suggest that these domains are distinct, potentially leading to different reasoning strategies.

A meta-analysis on social and non-social cognitive functioning in autism found that processing speed is significantly reduced in autistic people (Velikonja et al., 2019). In the social domain, quicker decision-making may be more advantageous due to limited time for cognitive assessment and reflection (Hoffman, 1981). Given the evidence of the Dual Process Theory of autism suggesting that autistic people follow a more logical and bias-free approach, it is reasonable to predict that autistic people would perform more logically across domains, whereas their non-autistic counterparts would change their reasoning strategy as being higher in intuition for social domain and higher in deliberation for non-social domain. The same pattern is expected to be seen for people with higher autistic traits relative to lower autistic traits. Furthermore, Li et al. (2019) compared autistic and non-autistic children, using dynamic visual stimuli to explore understanding intentional and accidental harm to persons and damage to objects. Results revealed preserved abilities to understand intentions of perpetrators among autistic children. Additionally, they found a particular sensitivity and emotional arousal among autistic children when they were viewing damage to objects.

It is important to control a task with a structurally equivalent components while only changing the target variable (Jarrold & Brock, 2004). Additionally, while exploring social phenomenon, there is always a need to implement a non-social component to be able to systematically compare the components and be sure that the target variable is specific to social component (Lockwood et al., 2020). However, most of the previous studies lack this systematic comparison. Furthermore, some differences might reflect differences in preferences (e.g., a preference for careful deliberation over quick intuition) rather than differences in abilities and skills. On the other hand, identifying no differences between autism and non-autism groups does not necessarily reflect that these groups reached their decisions and made judgments relying on same or similar cognitive mechanisms. Therefore, there is a need to systematically compare these tendencies between autistic and non-autistic groups or in relation to levels of autistic traits across social and non-social domains alongside both subjective and objective measures of reasoning. Moreover, there is always need for replication and extension of previous findings to see whether the results were specific to a particular group of participants that have been recruited and reported.

1.9. The Aims of the Current Thesis

The primary aim of this thesis is to explore reasoning preferences and tendencies in relation to autism and autistic traits, by conducting systematic comparisons between social and non-social domains, using scenario-based tasks with experimental methods. The existing literature in this field is limited and inconsistent, often using complex (e.g., syllogisms), tricky (e.g., the CRT), or rare and harmful (e.g., Trolley Problem) tasks. As discussed above, exploring reasoning and decision-making behaviour requires ecologically valid and meaningful tasks. Additionally, exploring a social phenomenon requires a systematic comparison to a structurally equivalent non-social component. Therefore, all tasks used in this thesis covered both social and non-social components, presented to participants in a blocked paradigm.

The Dual Process Theory of autism (Ashwin & Brosnan, 2019; Brosnan et al., 2016; Brosnan & Ashwin, 2021), compared to existing theoretical approaches, is a relatively modern, multi-dimensional, strength-based approach which gained increased popularity over the last decade.

This theory offers valuable insights into both strengths and weaknesses across social and non-social domains in relation to autism. This was apparent during the consultation meeting with autistic people themselves who explicitly highlighted that the theory and research projects planned to test it further sounded appealing and promising. This theory provided important yet limited and inconsistent collection of studies (see, Taylor et al., 2022). If correct, this theory can help us to understand autistic reasoning and decision-making behaviour better and provide support, regulations, and interventions needed for autistic people. If incorrect, this theory might increase inaccurate societal- and self-perception in relation to autism. Additionally, the Dual Process Theory of autism has never been tested across domains. For these reasons, the experiments in the following chapters aim to overcome the limitations in this field and expand the literature on the Dual Process Theory of autism.

The first three experiments (in Chapters II and III) used tasks involving social and non-social interactions that are common and natural in real life. These experiments covered moral reasoning as a specific area of reasoning. The fourth and last experiment (Chapter IV) utilised social scenarios expected to occur in real life, along with non-social scenarios involving domain-specific knowledge, aimed at minimising the influence of prior knowledge. This experiment covered causal reasoning as a specific area of reasoning. Causal reasoning may be the most convenient way to explore whether autism and higher autistic traits are more in line with normative models of reasoning, as suggested by the idea on enhanced rationality in autism.

In Chapter II, the first study was conducted via video-calls with a relatively large sample of university students to (1) examine reasoning tendencies across social and non-social domains by requesting forced-choice responses, (2) investigate the relationship between self-reported autistic traits and reasoning tendencies, and (3) pilot and validate the scenario-based comparison task adapted by Komeda et al. (2016). The second study in Chapter II was conducted online with a larger sample of university students to (1) examine reasoning tendencies across social and non-social domains by collecting written justifications for forced-choice responses, (2) investigate the relationship between self-reported autistic traits and reasoning tendencies, and (3) pilot and validate an updated version of the scenario-based comparison task. These steps were essential before using the task with a clinical sample of autistic participants.

Chapter III involved video-calls aimed at comparing autistic and a well-matched group of non-autistic participants for their reasoning tendencies. For this experiment, adults (≥ 18 years old) with no history of Intellectual Disability were recruited. In addition to the performance tasks, an objective (CRT) and a subjective (REI) measure of deliberation and intuition were used. I chose an updated version of the CRT to (1) minimise the risk of participants being familiar with its items, and (2) contribute to the literature on individual differences in responses to updated CRT. Furthermore, in Chapter III, I sought consultation from a group of autistic people to ensure participatory research.

The last study in this thesis presented in Chapter IV was conducted in-person with a relatively broad sample of university students using a different task. Participants were presented with social and non-social scenarios, each forming a specific type of causal mechanism, a common cause network. The aims of this study were to (1) examine the levels of violation for normative rules of reasoning across domains, (2) investigate reasoning tendencies between different types of reasoners as divided into clusters, and (3) explore the differences in the levels of violation and self-reported autistic traits across domains and clusters. The REI was also used for this study to be able to assess whether actual performance aligns with self-reported reasoning preference and abilities.

Collectively, all studies presented in this thesis provide insights into whether (1) people treat social and non-social domains differently based on moral and causal reasoning, and (2) reasoning tendencies are related to autistic traits and a diagnosis of autism. The overarching goal is to contribute to the literature on the Dual Process Theory of autism by examining social and non-social reasoning tendencies of clinical and non-clinical populations.

Chapter II

Reasoning in Social and Non-social Domains in Relation to Autistic Traits

2.1. Abstract

Enhanced rationality has been linked to higher levels of autistic traits, characterised by increased deliberation and decreased intuition, alongside reduced susceptibility to common reasoning biases. However, it is unclear whether this is domain-specific or domain general. We aimed to explore whether reasoning tendencies differ across social and non-social domains in relation to autistic traits. We conducted two experiments (N_1 = 72, N_2 = 217) using a reasoning task with social and non-social scenario comparisons to evaluate the specific information participants used when making judgments about children, in the social domain, and objects, in the non-social domain. We consistently found a greater reliance on behaviour-based information in the non-social domain, compared to the social domain, indicating a more deliberative approach. In Experiment 1, we found a correlation between autistic traits and the proportion of behaviour-based information, suggesting a more deliberative approach, when making judgments about children, and not about objects. In Experiment 2, with a larger sample, shortened version of the reasoning task, and requests for written justification, we did not identify a significant correlation between these variables. With this study, we introduce a novel scenario-based reasoning task that systematically compares social and non-social domains. Our findings highlight the complex nature of the relationship between reasoning style and autistic traits.

2.2. Introduction

Reasoning is crucial to everyday life. Reasoning can be defined as the capacity of moving from multiple inputs to a single output with a goal of achieving a conclusion or an action (Krawczyk, 2017, p. 10). Reasoning allows us to make decisions and draw judgments. Dual Process Theories, which are among the most popular accounts of cognition and behaviour, propose that reasoning is achieved by two types of processing: slow 'deliberation' and fast 'intuition' (De Neys, 2018; Evans, 2008, 2011; Evans & Frankish, 2009; Kahneman, 2011; but see, Grayot, 2020; Osman, 2004). Deliberation, also called reflectiveness (Kahneman & Frederick, 2002), is a slow, conscious, and effortful process, one that is demanding on cognitive ability and working memory and associated with fewer cognitive biases. This is the type of processing which underlies logical thinking, such as solving a complex problem. Intuition is a quicker and effortless process which shows more features of automaticity. Intuition enjoys a sort of default status in reasoning process and often leads the reasoner to cognitive biases or errors (Kahneman & Frederick, 2002). This is the type of processing which underlies rapid and instinctive decision-making, such as trait inferences. Broadly, quick decision-making, often influenced by emotional context, is associated with intuition, leading the reasoner to default outputs, unless the decision is re-evaluated through deliberation (Kahneman, 2011).

Autism, is characterised by persistent differences in social communication and interaction, alongside restricted, repetitive, and stereotyped behaviours, activities, and interests (American Psychiatric Association, 2013). Though autism is diagnosed as a clinical condition, autistic traits, as measured by self-report questionnaires, are believed to be present in the general population (Ruzich et al., 2015). The landscape of autism research is shifting away from focusing on deficits and delays to highlighting differences between autistic and non-autistic people, together with preserved and enhanced features of autism (Fletcher-Watson & Happé, 2019; Happé & Frith, 2020). An emphasis in recent research on *enhanced rationality* in autism is an example of this shift, providing evidence that autistic people show above-average reasoning abilities in some domains (Morsanyi & Byrne, 2020; for a review, see, Rozenkrantz et al., 2021; but see, Morsanyi & Hamilton, 2023; Taylor et al., 2022). The core hypothesis of this approach is that autistic people's reasoning is underpinned by a more consistent and logical reasoning style and is less susceptible to common reasoning biases (for instance, Brosnan et al., 2016; De Martino et al., 2008; Farmer et al., 2017; Lewton et al., 2019; P. Shah et al., 2016). Recent studies in autism have employed popular accounts of reasoning, like Dual Process Theories, to explore reasoning and decision-making in relation to autism and autistic traits (for instance, Ashwin & Brosnan, 2019; Brosnan, Chapman, et al., 2014; Brosnan et al., 2016, 2017; Brosnan & Ashwin, 2021, 2022b; Lewton et al., 2019; Morsanyi & Hamilton, 2023; Taylor et al., 2022). Most of these studies suggested that autism is characterized by a tendency for a more rational reasoning process, due to an increased preference for and engagement in deliberative reasoning, compared to intuitive reasoning (Morsanyi & Byrne, 2020; for a review, see, Rozenkrantz et al., 2021).

Kahneman (2011) reported that people are more likely to seek risk when a negative frame is presented, whereas risk is avoided when a positive frame is presented even though the options presented are mathematically equivalent. However, there is growing evidence suggesting that autistic people are less likely to engage in common reasoning biases, such as the framing effect (Brosnan, Chapman, et al., 2014; De Martino et al., 2008; Lewton et al., 2019; P. Shah et al., 2016). The framing effect occurs when people choose an option or change their decision based on whether the option is presented as a loss or as a gain, with the former negatively valenced and the latter positively valenced. The patterns of decision-making and risk-taking behaviour exhibited by autistic people are presented as showing enhanced *logical consistency* (De

Martino et al., 2008). Similarly, people who self-report higher levels of autistic traits state preferences for and engagement in a higher level of deliberation and a lower level of intuition, alongside less reliance on heuristics, cognitive short-cuts, compared to those who self-report lower levels of autistic traits (Brosnan et al., 2016, 2017). These results support previous reports by both autistic people and caregivers of autistic people, who report difficulties in rapid decision-making and a preference for deliberation (Luke et al., 2011). Over-reliance on logical and analytical reasoning might require longer and more in-depth consideration, likely resulting in subtle but important cues of rapidly changing social life being missed. Therefore, more exploration of enhanced rationality in autism would be beneficial to understand social difficulties faced by autistic people and people with high levels of autistic traits.

While showing relatively good performance in rational reasoning, autistic people and caregivers of autistic people report decision-making difficulties that might affect their everyday life, employment, and independence (Komeda, 2021; Levin et al., 2021; Luke et al., 2011; van der Plas et al., 2023). Reportedly, these difficulties can interfere with everyday decisions, such as deciding when to go to bed or what to wear, and can also interfere with more important decisions, such as those involved in successfully navigating a job interview or pursuing a goal of marriage (Gaeth et al., 2016; Robic et al., 2015; Vella et al., 2018). Autistic people specifically report difficulties when the decision-making process (1) involves interactions with others, (2) involves a change in routine, and (3) must be done quickly (Luke et al., 2011). The first two of these difficulties are related to the core diagnostic criteria of autism regarding, respectively, difficulties in the social domain and difficulties in the non-social domain (American Psychiatric Association, 2013), whereas the last difficulty is not yet well-covered. Given that quick information processing is associated with intuition and is likely to be required in social life (Robic et al., 2015), the difficulties autistic people report with respect to quick decision-making might create problems for them in daily life, especially when social interactions involve non-autistic persons or when moral reasoning is involved.

Autistic people also show differences from non-autistic people in moral reasoning (van der Plas et al., 2023). Moral reasoning, as a form of social reasoning, is reasoning about what is right or wrong, or good or bad. Moral reasoning is central to the evaluation of moral issues and choosing one's actions considering these evaluations. Moral reasoning is characterized as involving two competing perspectives: *rationalist* and *intuitionist*. The rationalist perspective proposes that moral judgments are results of deliberative reasoning and reflection, whereas the intuitionist perspective proposes that moral intuitions happen immediately and cause moral judgments (Haidt, 2001). Autistic people are reported to be more likely to provide moral justifications that are more concrete, and less abstract, flexible, and detailed (Dempsey, Moore, Johnson, et al., 2020; Shulman et al., 2012), compared to non-autistic comparison groups. For instance, autistic young people, compared to their non-autistic counterparts, are more likely to depend on rules and authority and be more focused on behaviours and outcomes rather than underlying characteristics or intentions of social agents (Fadda et al., 2016; Komeda et al., 2016). Komeda et al. (2016) asked autistic and non-autistic adolescents to judge main characters in scenarios as good or bad. Each scenario in their task presented a social interaction between a child and the child's parent with three lines of information: a line describing the character of the child, a line describing the behaviour of the child, and a line describing the outcome of the scenario. Komeda et al. (2016) found that autistic adolescents ignored the character-based information of the protagonists, but considered the behaviour-based information and outcome of the scenarios; whereas their non-autistic counterparts considered character-based information too, in forming their moral judgments. In other words, autistic participants were more likely to judge a scenario protagonist as being better when protagonist was presented with a positive behaviour, whether or not protagonist was also presented with a positive or negative characteristics (Komeda et al., 2016). The tendency of ignoring character-based information among autistic participants was not explained by working memory and language comprehension differences (Komeda et al., 2016). Furthermore, non-autistic participants showed sensitivity to the outcome type of the scenario (either good or bad) presented, by providing significantly higher proportion of behaviour-based responses for scenarios ending with a good outcome (90.4% of the time) compared to bad outcome (79.6% of the time). However, autistic participants did not differ their reasoning strategy based on the outcome type of the scenario (Komeda et al., 2016).

Reasoning in the social domain is considered here to be reasoning about the character, behaviours, and intentions of others to adjust one's own behaviour (Levesque, 2011). For instance, as a simplistic evaluation, social reasoning occurs when thinking about a generally well-behaved child who has broken her mother's favourite vase, trying to determine whether the child is good or bad (Komeda et al., 2016). Reasoning in the non-social domain is reasoning about inanimate objects, such as shoes and toys, about their features, properties, and actions. For instance, determining whether a pair of otherwise good-quality running shoes that have given you blisters after a quick run are good or bad. Since properties of social life and social behaviour are different than the properties of objects, social reasoning and non-social reasoning can be considered to be different than each other (Shultz, 1982). Studying differences between social and non-social domains in relation to autism by either recruiting people with a clinical diagnosis or recruiting non-autistic people and measuring autistic traits is common, but there is no study to date that examines how autistic traits relate to reasoning across social and non-social domains by comparing these two systematically.

Studies exploring reasoning in autism have predominantly focused either on the social or on the non-social domain but have rarely systematically compared the two domains. However, there is always a need for the implementation of a non-social condition to be able to warrant a conclusion related to social behaviour (Lockwood et al., 2020). Enhanced rationality in autism is proposed to contribute to core differences in relation to autism, because intuition is suggested to play a particularly strong role in the social domain (Robic et al., 2015). Therefore, it is important to investigate whether this claim is consistent across domains by comparing the social domain to the non-social domain. Moreover, researchers studying moral reasoning in autism have heavily relied on tasks involving negative scenarios like intense harm, such as the trolley problem in moral dilemmas (for a review, see, Dempsey, Moore, Johnson, et al., 2020) or scenarios involving risk-taking behaviour, such as the Ultimatum Game (for a review, see, Hinterbuchinger et al., 2018), that are rare in life and not representative of real-life interactions.

The aim of this study was to examine whether autistic traits relate to reasoning styles when making judgments about people, in the social domain, and making judgments about objects, in the non-social domain. We asked whether there is a relationship between autistic traits and reasoning styles in social versus non-social domains, and, if so, whether higher levels of autistic traits correlate with higher reliance on behaviour-based information when making judgments about people yet not about objects. For this, we adapted Komeda et al. (2016)'s scenario-based comparison task and created structurally equivalent non-social scenario comparisons. With this task, we aimed to measure the proportion of reliance on behaviour-based information in social versus non-social domains. We predicted that (1) all participants would reason more rationally in the non-social domain by providing higher percentages of behaviour-based responses for this domain, compared to the social domain. With the literature on the reasoning differences between autistic and non-autistic people in mind, we also predicted that (2) higher levels of autistic traits would be significantly correlated with a higher reliance on behaviour-based information in the social domain, and (3) no significant relationship with levels of autistic traits and a reliance on behaviour-based information in the non-social domain.

2.3. Experiment 1

2.3.1. Method

This project was pre-registered at https://osf.io/r8waf and conducted with the British Psychological Society ethical guidelines, with approval by the Science, Technology, Engineering, and Mathematics Ethical Review Committee at the University of Birmingham (ERN_09-719AP19).

2.3.1.1. Sample Size and Effect Size Calculations

An *a priori* power analysis, using G*Power (Faul et al., 2007), with 80% probability of detecting a medium-sized correlation ($r = 0.3$) at $\alpha < 0.05$ suggested at least 67 participants to detect a one-tailed correlation. Seventy-two participants met this target and allowed for some attrition. The key comparison of interest in the ANOVA was the 2W x 2W interaction between the factors of *consistency* and *domain type – a post-hoc* power analysis, using G*Power (Faul et al., 2007), suggested 72 participants in total with a medium effect size of 0.25 at $\alpha < 0.05$ would provide more than 95% power for this interaction. The exploratory 4-way interaction (inclusive of *domain order (2B)* and *outcome type (2W)*) was structurally equivalent to Komeda et al. (2016)'s analysis, in which 40 participants were recruited to run a 4-way mixed ANOVA (2B x 2W x 2W x 2W) to detect an estimated effect size of 0.45, which reportedly required approximately 40 participants in total to have 80% power.

2.3.1.2. Sample

Seventy-two university students (female = 60, male = 12, M_{age} = 19.36, SD_{age} = 1.2 in years) were recruited through a web-based research participation scheme (RPS) at the University of Birmingham. There were not specific inclusion or exclusion criteria. The mean score of participants' self-reported autistic traits was 18.13 (SD = 6.36), with a wide range of total scores reported ([5 – 31]). The data on ethnicity was not recorded for this study. All participants signed a consent form.

2.3.1.3. Materials

The Adult Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001). The AQ is a 50-item self-report measure of the levels of autistic traits for adults (≥ 16 years of age) with average or higher intelligence levels. The AQ is recorded on a four-point Likert scale presenting "definitely agree", "slightly agree", "slightly disagree", and "definitely disagree" as options. A response in the direction of autistic traits is scored as 1, and a response in the opposite direction is scored as 0. There is no difference between the responses of "definitely agree" and "slightly agree" or "definitely disagree" and "slightly disagree" in terms of scoring values. The AQ has five sub-scales, each presenting 10-items, including social skills, attention switching, attention to detail, communication, and imagination. The scores for sub-scales were also calculated for each participant. The highest score that can be obtained is 50, while the lowest is 0. Higher scores indicate higher levels of autistic traits, and lower scores indicate lower levels of autistic traits. A score of 32 has been considered as a cut-off for this measure (Baron-Cohen et al., 2001). The AQ shows good test-retest reliability ($r \geq 0.8$) and high level of internal consistency ($\alpha \geq 0.7$; Stevenson & Hart, 2017). See Appendix 1 for AQ items.

The Scenario-based Comparison Task (adapted from Komeda et al., 2016). This task involves pairs of scenarios in a forced-choice paradigm representing social and non-social interactions. This task is used to measure whether participants rely on a specific kind of information when judging a scenario's subject, which is either a person or an object, as being better or worse. In this task, each scenario provides three lines of information (first line, characteristics; second, behaviours; and third, outcomes). Each line valenced as binary, being either positive or negative. In social scenarios, behaviour-based information (second line) tends to report or prime an inference of intention. As in Figure 2.1a, social scenarios presented an interaction between a child and the child's parent. The scenarios in the social domain were translated directly from Komeda et al. (2016). The Japanese names of the children in the original scenarios were changed to common British English names. Participants were asked to judge which child was better or worse, after reading each pair of scenarios. This domain measures if people draw on the child's behaviour (second line) or underlying characteristics (first line) in making judgments. In addition to social scenarios, we created structurally equivalent non-social scenarios. As in Figure 2.1b, non-social scenarios presented an interaction between a person and an inanimate object. This domain measures if people draw on the performance of an object (second line) or its underlying qualities (first line) in making judgments. See Appendix 2 for the details of all social and non-social scenarios. See Appendix 3 for the script of all social and non-social scenarios.

Figure 2.1

Example scenario comparisons in the (a) Social Domain with a bad outcome and (b) Non-social Domain with a good outcome

Note. For comparisons with good outcomes, the question asked which child is better. For comparisons with bad outcomes, participants were asked whose [object(s)] is/are worse (in this case, whose running shoes). Consistent scenario comparison examples were presented on the left side, and inconsistent scenario comparison examples were presented on the right side of the figure.

The scenario comparisons varied in the consistency of behaviour- and character-based information. For the consistent scenario comparisons, the comparison was "good characteristics/good behaviour versus bad characteristics/bad behaviour". See examples on the left side of Figure 2.1. For the inconsistent scenario comparisons, the comparison was "bad characteristics/good behaviour versus good characteristics/bad behaviour". See examples on the right side of Figure 2.1. The inconsistent scenarios allowed for testing which kind of information (behaviour- or character-based) the participants drew on when making judgments. The inconsistent scenario comparisons did not necessarily have a right or wrong answer. Participants could make their decisions based on character or behaviour. The consistent scenarios allowed for estimating a proportion of reading errors, motor responses, and spurious responding. For instance, participants should always choose the good characteristic/good behaviour as being better. The outcome line was the same for each scenario in a comparison. The number of letters of each outcome line across each comparison was the same.

In summary, the Scenario-based Comparison Task included two key variables of interest: domain type—whether scenarios were social or non-social; and consistency—whether behaviour- and character-based information were presented in consistent or inconsistent ways. It is worth noting here, for consistent trials, behaviour-based responses were also characteristics-based responses, so not necessarily evidenced that the participant used behaviour as the determining factor in making their judgment.

The gender of the subjects (girl/female or boy/male), the subjects' positions (presented on the left or right of the screen), and the positive behaviour's position (presented on the left or right) were counterbalanced. Domain order (the presentation of the Social or the Non-social Domain First) was controlled across participants. For each domain, participants responded to 24 unique comparisons, 3 of them represented 2 characteristics (good x bad), 2 behaviours (good x bad), and 2 outcomes (good x bad). After counterbalancing, in total, participants completed 96-trials for this task.

2.3.1.4. Procedure

Data collection began on 28 November 2020 and ended on 4 March 2021. Participants completed the AQ (Baron-Cohen et al., 2001) via an online survey platform, Qualtrics (https://www.qualtrics.com/uk/). Then, they received a link for a video call over Zoom (https://zoom.us/) to complete the Scenario-based Comparison Task with the lead researcher. The Scenario-based Comparison Task was built on Microsoft PowerPoint and presented to each participant by using the screen-sharing option on Zoom. Participants completed two practice questions before the main task for familiarisation. Participants were not instructed which information to choose. The scenario comparisons were presented one at a time. The pairs of scenarios, questions, and options appeared at the same time. Participants responded verbally with their choice. The researcher stayed muted and turned their video off during the main task to eliminate distraction. The participant was free to keep their video on or off, depending on their preference. The researcher moved to the next comparison once the participant provided an answer verbally. Participants could not return to the instructions or previous comparisons. The responses were manually recorded by the researcher and transferred to Excel sheets after each session. The sessions were not video- or audio-recorded. There was no time limit when responding, and the sessions were not timed because response time was not a targeted variable. They were rewarded with course credits through RPS.

2.3.1.5. Data Analysis

SPSS Statistics 29.0 was used to analyse the data. Significance level was set at $\alpha = 0.05$. The key Dependent Variable (DV) was the percentage of participants' behaviour-based responses from the Scenario-based Comparison Task. If the participant's response was behaviour-consistent, this was coded as 1, and if behaviour-inconsistent, this was coded as 0. This coding did not intend to calculate accuracy, rather to calculate the tendency of a specific and consistent reliance on behaviour-based information. We ran a mixed 2 x 2 x 2 x 2 ANOVA with within-subjects factors domain type (Social, Non-social), consistency (Consistent, Inconsistent), and outcome type (Good Outcome, Bad Outcome), and between-subjects factor domain order (Social Domain First, Non-social Domain First) to explore the main and interaction effects of the manipulated variables on our DV. Follow-up tests were conducted on significant interactions. A two-tailed Pearson Correlation Test was conducted to investigate the relationship between the total scores on the AQ and the proportion of behaviour-based responses for the Social Domain. A two-tailed Spearman's Rank Order Correlation Test was conducted, because the proportions of behaviour-based responses for the Non-social Domain were not normally distributed, to investigate the relationship between the total scores on the AQ and the proportion of behaviour-based responses for the Non-social Domain. As exploratory analysis, correlation tests were conducted to examine the relationship between the proportions of behaviour-based responses for the Social and Non-social Domains and sub-scale scores on the AQ. Normality checks were done with Shapiro Wilk normality test. For the details of normality checks for each experiment presented in this thesis, see Appendix 23.

2.3.2. Results

2.3.2.1. Omnibus ANOVA

Results from the 2 x 2 x 2 x 2 ANOVA indicated a significant effect of domain type, with participants providing more behaviour-based responses for Non-social Domain (M = 86.63%, SD = 6.58%) than Social Domain (M = 83.02%, SD = 9.38%; $F(1, 70) = 10.11$, $p = 0.002$, $\eta_p^2 = 0.13$). We also found a significant effect of outcome type, with participants providing more behaviour-based responses for scenario comparisons ending with Good Outcomes (M = 86.86%, SD = 6.83%) than Bad Outcomes (M = 82.61%, SD = 7.50%; $F(1, 70) = 26.33$, p <

0.001, $\eta_p^2 = 0.27$). Additionally, we found a significant effect of consistency[4], with participants providing more behaviour-based responses for Consistent scenario comparisons (*M* = 96.73%, *SD* = 3.40%) than Inconsistent scenario comparisons (*M* = 72.74%, *SD* = 12.61%; $F(1, 70) = 246.68$, $p < 0.001$, $\eta_p^2 = 0.78$). Finally, we noted a significant main effect of domain order, with participants who completed the Social Domain First providing more behaviour-based responses (*M* = 86.37%, *SD* = 5.70%) than who completed the Non-social Domain First (*M* = 83.28%, *SD* = 6.78%; $F(1, 70) = 4.06$, $p = 0.048$, $\eta_p^2 = 0.05$). See Table 2.1 for the summary of the main effects and Appendix 4 for descriptive statistics.

Table 2.1

Summary of the main effects, Experiment 1

	M_{diff}	F	p	η_p^2
Domain Type	3.62%	10.11	0.002	0.13
Outcome Type	4.25%	26.33	< 0.001	0.27
Consistency	23.99%	246.68	< 0.001	0.78
Domain Order	3.10%	4.06	0.048	0.05

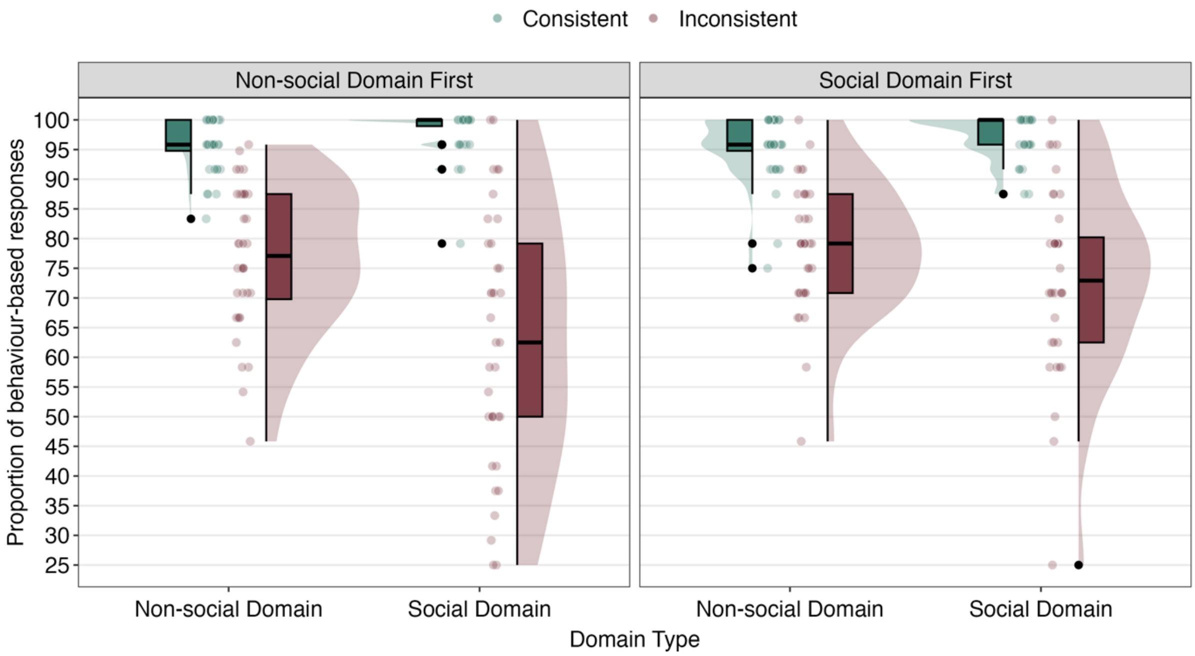
[4] We expected participants to perform close to ceiling on consistent scenario comparisons – since it was not possible to score higher than 100.00% on these trials. However, this was highly unlikely to meaningfully effect any comparisons – given the natüre of the task. Conssitent scenario comparisons effectively test whether participants paid attention to trials and/or presented unusual responding patterns (so, performance would be expected to be close to ceiling in all cases).

There was a significant domain type x consistency x domain order interaction ($F(1, 70) = 6.86$, $p = 0.011$, $\eta_p^2 = 0.09$). To unpack this interaction, we split the dataset with the between-subjects factor domain order. Then, we conducted two 2 x 2 ANOVAs with within-subjects factors domain type (Social, Non-social) and consistency (Consistent, Inconsistent). For the group who completed the Social Domain First, we identified a single significant main effect of consistency, ($F(1, 35) = 99.20$, $p < 0.001$, $\eta_p^2 = 0.74$; Consistent > Inconsistent), but there was no significant effect of domain type, nor was the domain type x consistency interaction significant. For the group who completed the Non-social Domain First, we identified a significant domain type x consistency interaction ($F(1, 35) = 29.00$, $p < 0.001$, $\eta_p^2 = 0.45$). Paired-samples *t*-tests showed a larger effect of consistency in the Social Domain ($t(35) = 10.74$, $p < 0.001$, $d = 1.8$, two-tailed), but the effect remained significant in the Non-social Domain ($t(35) = 9.17$, $p < 0.001$, $d = 1.5$; Social > Non-social, two-tailed), see Figure 2.2. For this group, we also found significant effects of domain type ($F(1, 35) = 12.88$, $p = 0.001$, $\eta_p^2 = 0.27$; Non-social > Social), and consistency ($F(1, 35) = 147.58$, $p < 0.001$, $\eta_p^2 = 0.81$; Consistent > Inconsistent). See Appendix 5 for the full table of interaction effects.

We identified other significant interactions between domain type x consistency ($F(1, 70) = 26.48$, $p < 0.001$, $\eta_p^2 = 0.2$), consistency x domain order ($F(1, 70) = 7.73$, $p = 0.007$, $\eta_p^2 = 0.10$), and domain type x domain order ($F(1, 70) = 4.95$, $p = 0.029$, $\eta_p^2 = 0.07$). However, these interactions have already been unpacked by the three-way interaction identified above. From the full model, we also noted a significant outcome type x consistency interaction ($F(1, 70) = 6.42$, $p = 0.014$, $\eta_p^2 = 0.08$). Paired-samples *t*-tests revealed a significant effect of consistency for both Good ($t(71) = 13.51$, $p < 0.001$, $d = 1.60$, two-tailed), and Bad Outcomes ($t(71) = 13.80$, $p < 0.001$, $d = 1.63$, two-tailed), with the larger effect being for Bad Outcomes.

Figure 2.2

Medians and quartiles of the proportion of behaviour-based responses



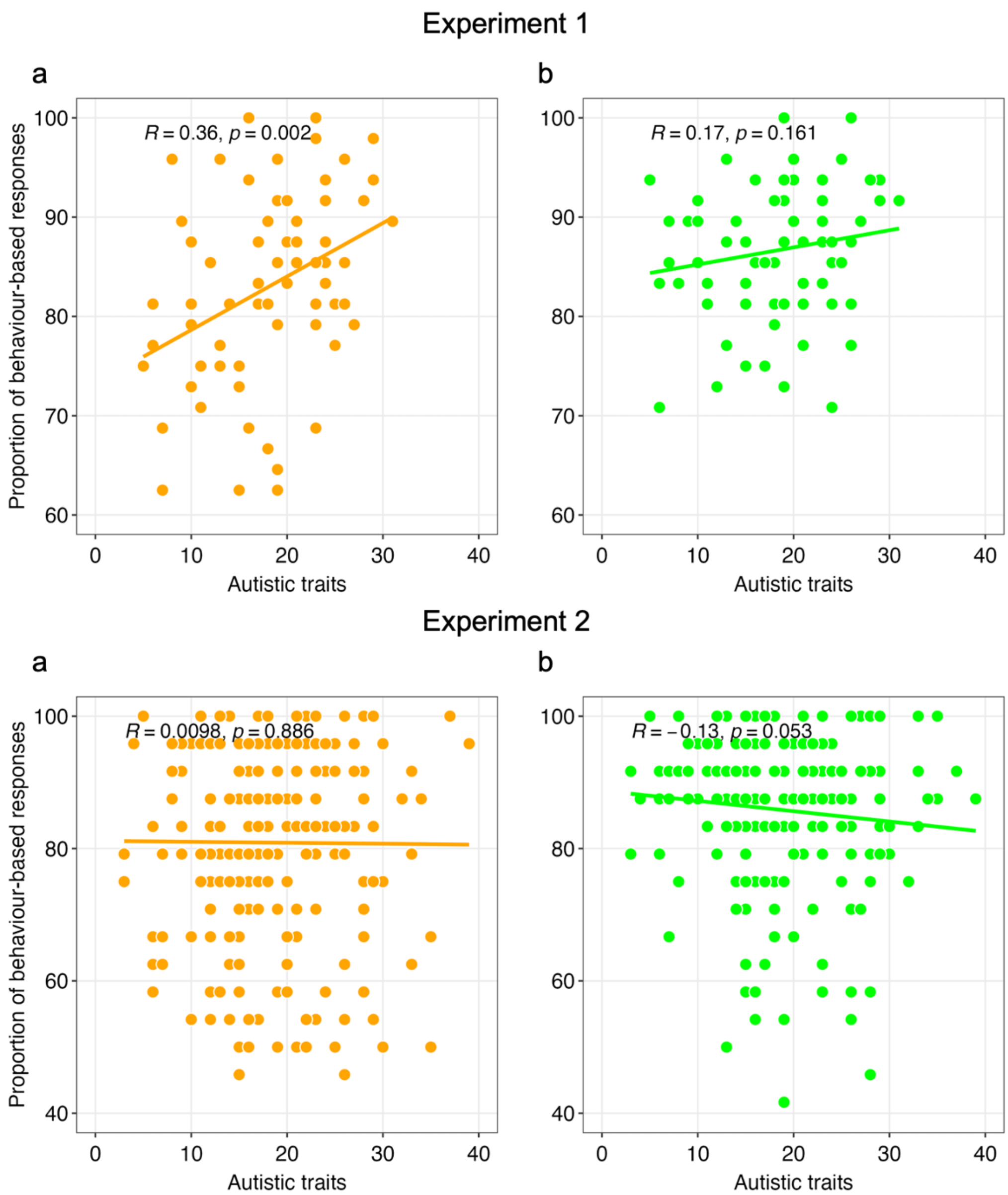
2.3.2.2. Correlations between the total scores on the AQ and the proportions of behaviour-based responses

The Pearson Correlation Test revealed a significant positive correlation between the total scores on the AQ and the proportion of behaviour-based responses in the Social Domain ($r(70) = 0.36$, $p = 0.002$, two-tailed). The Spearman's Rank Order Correlation Test revealed no significant correlation between the total scores on the AQ and the proportion of behaviour-based responses in the Non-social Domain ($r_s(70) = 0.17$, $p = 0.161$, two-tailed), see Figure 2.3. This test was run because data did not meet the normality assumption (see Appendix 23 for normality checks). The difference between the dependent correlations of the total scores on the AQ with the proportions of behaviour-based responses in the Social and Non-social domains was not statistically significant ($r_{diff} = 0.2$, lower = -0.081, upper = 0.081, $p_1 = 0.078$, $p_2 = 0.156$). Exploratory analysis revealed a significant correlation between the sub-scale scores of social skills ($r_s(70) = 0.31$, $p = 0.008$, two-tailed), attention switching

($r_s(70) = 0.25$, $p = 0.031$, two-tailed), and imagination ($r_s(70) = 0.33$, $p = 0.004$, two-tailed) of the AQ and the proportion of behaviour-based responses in the Social Domain. There was no significant correlation between any sub-scale of the AQ and the proportion of behaviour-based responses in the Non-social Domain. See Appendix 6 for the full table.

Figure 2.3

Simple Scatter Plots of the relationships between autistic traits and proportions of behaviour-based responses in the (a) Social and (b) Non-social Domains



2.3.3. Discussion

We investigated whether the information relied on by participants while making judgments of people (in the social domain) and objects (in the non-social domain) is affected by domain type, outcome type, consistency, and domain order. In line with our hypothesis, we found a significant effect of domain type, showing that participants relied on behaviour-based information more for non-social scenario comparisons, suggesting a more consistent and rational reasoning approach for the non-social domain compared to social. What we had not predicted was the impact of domain order on response patterns. Participants who completed the non-social scenarios first showed the expected pattern – of being influenced more by characteristics for social scenarios. Those who did the social domain first, however, showed similar patterns across domains. The outcome type also influenced participants' judgments. When the scenario comparison ended with a good outcome, they relied more on the behaviour-based information. This is in line with Komeda et al.'s (2016) finding for the control group, but not for the autism group.

There was no significant relationship between levels of autistic traits and proportion of behaviour-based responses in non-social domain. We also investigated whether there was a positive significant relationship between levels of autistic traits and proportion of behaviour-based responses in social domain. We found that the correlation between levels of autistic traits and proportion of behaviour-based responses in the social domain was significant, suggesting that the higher a person scores on the autistic traits, the more likely they were to rely on the behaviour-based information provided about the child while making judgments about them. This result was in line with the results from Komeda et al.'s (2016) study which found the autism group relied on behaviour-based responses more than the control group.

After confirming our hypotheses, we conducted a follow-up study to (1) test our task with a bigger sample, and (2) explore the forced-choice judgments in greater depth with justifications. Given the variability in forced-choice responses across trials (e.g., the effect of consistency), written justifications were recorded to explore the reasoning tendencies being consistent with either an intuitive responding pattern (just selecting which option feels right on each trial) or a deliberative pattern (carefully weighing up information from both and selecting based on local features. Our main hypotheses for forced-choice judgment responses were same as Experiment 1. For justifications, we predicted that (1) participants would provide more exclusively character-based justifications for the social domain, and (2) more exclusively behaviour-based justifications for the non-social domain. We also predicted that (3) levels of autistic traits would be significantly positively correlated with providing more exclusively behaviour-based justifications in the social domain, and levels of autistic traits would be significantly negatively correlated with providing more exclusively character-based justifications in the social domain. We predicted that (4) there would be significant correlation between neither behaviour- nor character-based justifications and levels of autistic traits in the non-social domain.

2.4. Experiment 2

2.4.1. Method

This project was pre-registered at https://osf.io/2rtp8 and approved by the Science, Technology, Engineering, and Mathematics Ethical Review Committee at the University of Birmingham (ERN_09-719AP26). Alongside the addition of a need for justifications, the key change from Experiment 1 was that participants made all responses on an online form, rather than reporting their responses to an experimenter over a video call.

2.4.1.1. Sample Size and Effect Size Calculations

To find a small effect size (0.01) with a 95% power at the alpha level of 0.05 in a 3-way mixed model ANOVA (2 groups, 4 conditions, non-sphericity correction = 1), a G*Power *a priori* power analysis (Faul et al., 2007) suggested at least 214 participants. We considered the ANOVA results from Experiment 1 for this power analysis. A total of 214 participants would yield 99% probability of detecting a medium-sized correlation of 0.3 (r) at $\alpha < 0.05$ for two-tailed correlation.

2.4.1.2. Sample

A total of 219 participants (female = 191, male = 23, other/non-binary = 3, M_{age} = 18.97, SD_{age} = 1.01 in years) were recruited. Two participants' data were excluded, as one participant reported that they did not answer the last two comparisons and the other participant reported that they "already answered" some comparisons because they did not realise that the comparisons were different. As a result, the final dataset was 217 participants. All participants were undergraduate and postgraduate students at the same university. They were recruited through the RPS and were awarded course credits for their participation. The participants who completed Experiment 1 were not able to participate in Experiment 2. There were no other specific inclusion or exclusion criteria. The mean score of participants' self-reported autistic traits on the AQ was 18.41 (SD = 6.9), with a wide range of total scores ([3 – 39]). All participants signed a consent form.

2.4.1.3. Materials and Procedure

Data collection began on 12 October 2021 and ended on 5 November 2021. The same materials (the AQ and Scenario-based Comparison Task) as Experiment 1 were used on Qualtrics with the following exceptions: we shortened the Scenario-based Comparison Task by selecting the scenario comparisons that were most representative of their domain. We used half of the comparisons from the first experiment after running an item validity check on the forced-choice data from Experiment 1. To do this, we calculated the proportion of behaviour-based responses for each scenario comparison across participants and selected the closest ones to the median score for that condition. In this way, we had 12 unique scenario comparisons for each domain. Participants completed 48 trials in total for this task.

Additionally, we asked participants to give written justifications for their forced-choice responses. They were presented with a blank section asking “Why?” after each comparison for providing justification to their forced-choice response. Participants were not instructed with any length or duration for providing justifications because neither time pressure nor response time was targeted. The comparisons were presented in a randomised order and the same counterbalancing technique was followed as in Experiment 1. Participants self-enrolled to the study through RPS and followed the study link to Qualtrics to complete the study on their own time.

2.4.1.4. Data Analysis

Data were recorded online and analysed as in Experiment 1 for forced-choice responses. For the written justifications, a blinded Research Assistant (RM; female) coded the responses into categories. Responses were coded to indicate which kind of information the participants mentioned (character, behaviour, both, neither). The lead researcher (EB; female) coded 10% of the responses to check inter-rater reliability. Inter-rater reliability was 87% (Cohen’s kappa = 0.71), suggesting a good level of agreement between coders. Written justifications were coded into 4 categories: (1) exclusively character-based, (2) exclusively behaviour-based, (3) both character- and behaviour-based, and (4) neither character- nor behaviour-based. For data analysis on the written justifications, we split the data by consistency. Then, we ran six 2 x 2 x 2 mixed ANOVAs with within-subjects factors domain type (Social, Non-social) and outcome type (Good Outcome, Bad Outcome), and between-subjects factor domain order (Social Domain First, Non-social Domain First) to explore the main and interaction effects of the manipulated variables on our DV for the categories of (1) exclusively character-based, (2) exclusively behaviour-based, and (3) both character- and behaviour-based separately. These analyses were run separately for consistent and inconsistent scenario comparisons. Here, unlike Experiment 1, both consistent and inconsistent trials provide meaningful data – for instance, even when characteristic- and behaviour-based information agree, one or the other or both can be used for justification. Follow-up tests were run on significant interactions. Lastly, we ran two-tailed Spearman's Rank Order Correlation Tests between the total scores on the AQ and the responses in these three categories. As exploratory analysis, Spearman's Rank Order Correlation Tests were conducted to examine the relationship between the proportion of behaviour-based forced-choice and written responses for the Social and Non-social Domains and sub-scale scores on the AQ. The Spearman's Rank Order Correlation Tests were conducted because data did not meet normality assumptions (see Appendix 23 for normality checks).

2.4.2. Results

2.4.2.1. Omnibus ANOVA

We found the same main effects with same directions as in Experiment 1. The results of 2 x 2 x 2 x 2 ANOVA indicated significant effects of domain type ($F(1, 215) = 23.01$, $p < 0.001$, $\eta_p^2 = 0.10$; Non-social > Social), outcome type ($F(1, 215) = 13.12$, $p < 0.001$, $\eta_p^2 = 0.06$); Good Outcome > Bad Outcome, consistency ($F(1, 215) = 225.58$, $p < 0.001$, $\eta_p^2 = 0.51$); Consistent > Inconsistent, and domain order ($F(1, 215) = 3.52$, $p = 0.062$, $\eta_p^2 = 0.02$; Social Domain First >

Non-social Domain First). See Table 2.2 for the summary of the main effects and Appendix 7 for descriptive statistics.

Table 2.2

Summary of the main effects, Experiment 2

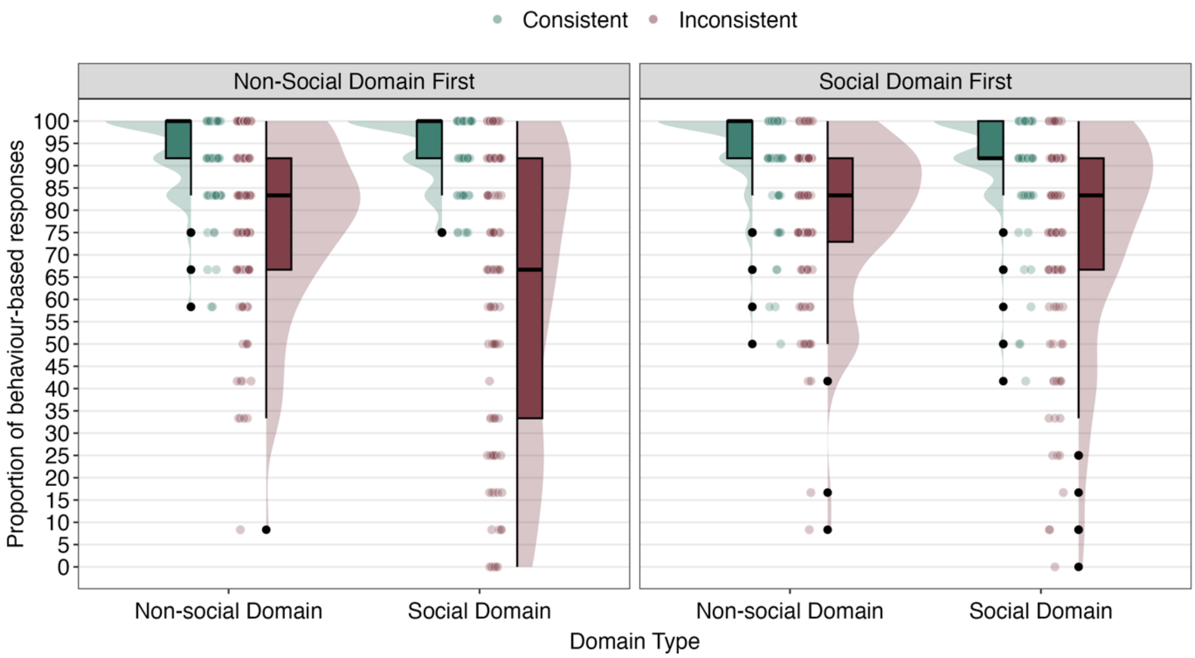
	M_{diff}	F	p	η_p^2
Domain Type	5%	23.01	< 0.001	0.1
Outcome Type	3.54%	13.12	< 0.001	0.06
Consistency	20.54%	225.58	< 0.001	0.51
Domain Order	2.73%	3.52	0.062	0.02

There was a significant domain type x consistency x domain order interaction ($F(1, 215) = 15.48$, $p < 0.001$, $\eta_p^2 = 0.07$). To unpack this interaction, we split the dataset with the between-subjects factor domain order. Then, we conducted two 2 x 2 ANOVAs with within-subjects factors domain type (Social, Non-social) and consistency (Consistent, Inconsistent). For the group who completed the Social Domain First, we identified significant main effects of domain type ($F(1, 107) = 5.17$, $p = 0.025$, $\eta_p^2 = 0.05$; Non-social > Social), and consistency ($F(1, 107) = 89.26$, $p < 0.001$, $\eta_p^2 = 0.46$; Consistent > Inconsistent). For this group, there was no significant domain type x consistency interaction. For the group who completed the Non-social Domain First, we identified significant main effects of domain type ($F(1, 108) = 18.93$, $p < 0.001$, $\eta_p^2 = 0.15$; Non-social > Social), and consistency ($F(1, 108) = 136.85$, $p < 0.001$, $\eta_p^2 = 0.56$; Consistent > Inconsistent). For this group, there was also a significant domain type x consistency interaction ($F(1, 108) = 29.63$, $p < 0.001$, $\eta_p^2 = 0.22$). Paired-samples t-tests showed a larger effect of consistency in the Social Domain ($t(108) = 8.24$, $p < 0.001$, $d = 1.0$, two-tailed), and the effect remained significant in the Non-social Domain ($t(108) = 10.42$, $p <$

0.001, *d* = 0.79, two-tailed); see Figure 2.4. See Appendix 8 for the full table of the interaction effects.

Figure 2.4

Medians and quartiles of the proportion of behaviour-based responses



We identified other significant interactions which were between domain type x consistency (F(1, 215) = 23.90, $p < 0.001$, $\eta_p^2 = 0.10$), and consistency x domain order (F(1, 215) = 7.36, $p = 0.007$, $\eta_p^2 = 0.03$). However, these interactions have already been unpacked by the three-way interaction identified above. From the full model, we also noted a significant domain type x outcome type interaction (F(1, 215) = 5.68, $p = 0.018$, $\eta_p^2 = 0.03$). Paired-samples *t*-tests revealed a significant effect of outcome type in the Non-social Domain (t(216) = 4.317, $p <$ 0.001, *d* = 0.29, two-tailed; Good Outcome > Bad Outcome).

2.4.2.2. Correlations between the total scores on the AQ and the proportions of behaviour-based forced-choice responses

Spearman's Rank Order Correlation Tests were run to investigate the relationship between the total scores on the AQ and the proportions of behaviour-based responses in the Social and Non-social Domains, because normality was not met. Contrary to our hypothesis and unlike the results from Experiment 1, no significant correlation was found between the total scores on the AQ and the proportion of behaviour-based responses in the Social Domain ($r_s(215) = 0.010$, $p = 0.886$, two-tailed). There was a trend in the negative direction for the Non-social Domain ($r_s(215) = -0.131$, $p = 0.053$, two-tailed); see Figure 2.3 above.

Exploratory analysis revealed only a significant correlation between and social skills sub-scale scores on the AQ and the behaviour-based judgments for the Non-social Domain ($r_s(215) = -0.15$, $p = 0.032$, two-tailed). However, given multiple comparisons, this result was quite marginal. See Appendix 9 for the full table.

2.4.2.3. Omnibus ANOVA on written justifications

The significant results from the 2 x 2 x 2 ANOVAs are described below for inconsistent and consistent scenario comparisons. These analyses were run to validate the forced-choice responses to scenario comparisons and get a more in-depth evaluation of participants' moral judgments. See Appendix 10 for descriptive details and paired-samples *t*-test statistics.

Inconsistent scenario comparisons. See Figure 2.5 for categories of written justifications for inconsistent scenario comparisons. For exclusively character-based justifications, we found a significant effect of domain type ($F(1, 215) = 24.69$, $p < 0.001$, $\eta_p^2 = 0.10$; Social > Non-social). Additionally, we found a significant domain type x domain order interaction ($F(1, 215) = 15.48$,

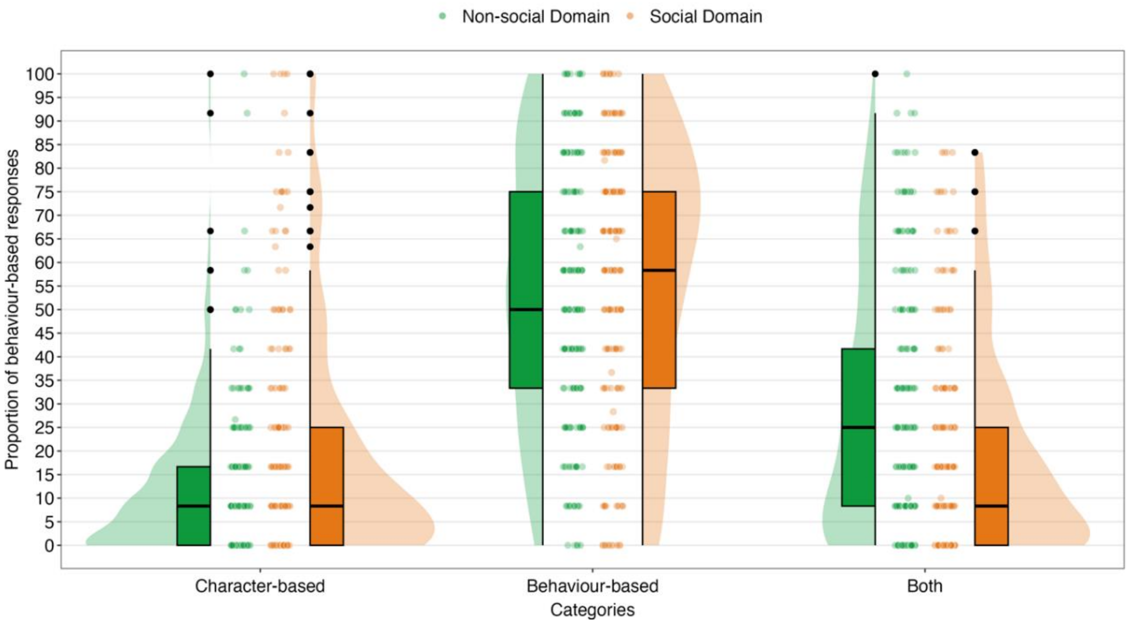
$p < 0.001$, $\eta_p^2 = 0.07$). Paired-samples *t*-tests revealed a significant effect of domain type for the group who completed the Non-social Domain First, ($t(1, 108) = 5.71$, $p < 0.001$, $d = 0.55$, two-tailed; Social > Non-social), and no significant effect for the group who completed the Social Domain First ($t(1, 107) = 0.83$, $p = 0.410$, $d = 0.08$).

For exclusively behaviour-based justifications, we found a significant effect of outcome type ($F(1, 215) = 10.62$, $p = 0.001$, $\eta_p^2 = 0.05$; Bad Outcome > Good Outcome). We found a significant outcome type x domain order interaction ($F(1, 215) = 8.08$, $p = 0.005$, $\eta_p^2 = 0.04$). Paired samples *t*-tests revealed a significant effect of outcome type for the group who completed the Social Domain First ($t(1, 107) = 3.81$, $p < 0.001$, $d = 0.37$, two-tailed; Bad Outcome > Good Outcome), and no significant effect for the group who completed the Non-social Domain First ($t(1, 108) = 0.35$, $p = 0.730$, $d = 0.03$). We also found a significant domain type x outcome type interaction ($F(1, 215) = 11.60$, $p = 0.001$, $\eta_p^2 = 0.05$). Paired-samples *t*-tests revealed a significant effect of outcome type for the Social Domain ($t(216) = 4.82$, $p < 0.001$, $d = 0.33$, two-tailed; Bad Outcome > Good Outcome), and no significant effect for the Non-social Domain ($t(216) = -0.15$, $p = 0.884$, $d = -0.01$) .

For both character- and behaviour-based justifications, we found a significant effect of domain type ($F(1, 215) = 36.51$, $p < 0.001$, $\eta_p^2 = 0.15$; Non-social > Social). We also found a significant domain type and outcome type interaction ($F(1, 215) = 13.76$, $p < 0.001$, $\eta_p^2 = 0.06$). Paired-samples *t*-tests revealed a significant effect of outcome type for the Social Domain ($t(216) = -3.90$, $p < 0.001$, $d = -0.26$, two-tailed; Good Outcome > Bad Outcome), and no significant effect for the Non-social Domain ($t(216) = 1.45$, $p = 0.149$, $d = 0.10$).

Figure 2.5

Medians and quartiles of categories of written justifications for inconsistent scenario comparisons



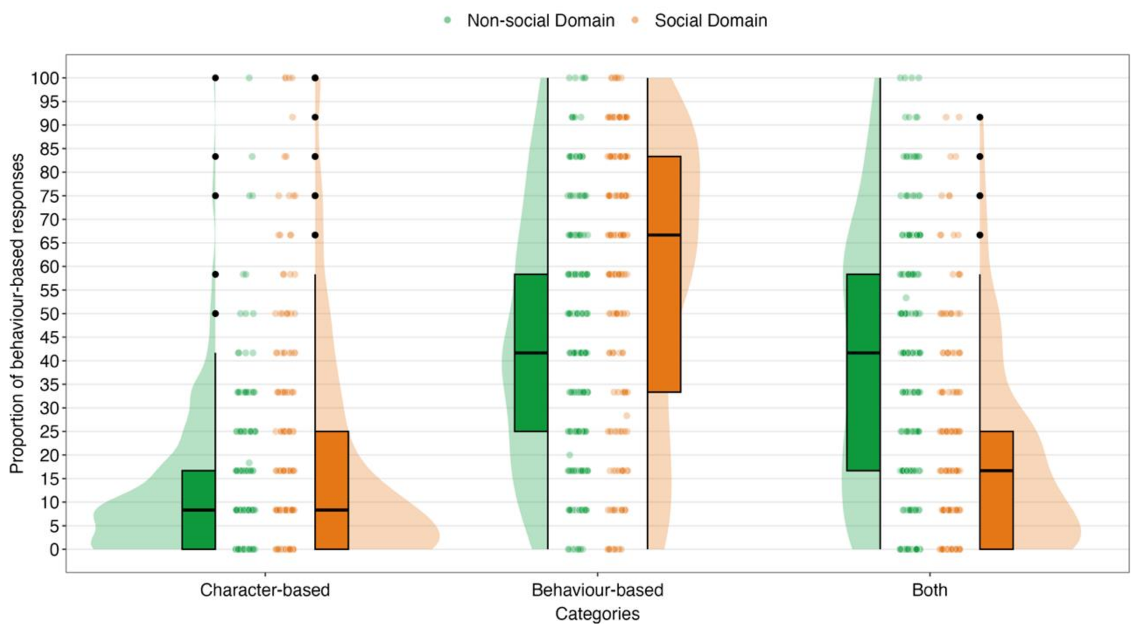
Consistent scenario comparisons. See Figure 2.6 for categories of written justifications for consistent scenario comparisons. For exclusively character-based justifications, we found significant effects of domain type ($F(1, 215) = 12.70$, $p < 0.001$, $\eta_p^2 = 0.06$; Social > Non-social), and outcome type ($F(1, 215) = 18.01$, $p < 0.001$, $\eta_p^2 = 0.08$; Good Outcome > Bad Outcome). We also found a significant domain type x domain order interaction ($F(1, 215) = 14.74$, $p < 0.001$, $\eta_p^2 = 0.06$). Paired-samples *t*-tests revealed a significant effect of domain type for the group who completed the Non-social Domain First ($t(1, 108) = 4.95$, $p < 0.001$, $d = 0.47$, two-tailed; Social > Non-social), and no significant effect for the group who completed the Social Domain First ($t(1, 107) = -0.208$, $p = 0.836$, $d = -0.02$).

For exclusively behaviour-based justifications, we found a significant effect of domain type ($F(1, 215) = 36.52$, $p < 0.001$, $\eta_p^2 = 0.15$; Social > Non-social). We also found a significant domain type x outcome type interaction ($F(1, 215) = 56.14$, $p < 0.001$, $\eta_p^2 = 0.21$). Paired-samples *t*-test revealed a significant effect of outcome type for the Social ($t(216) = 4.40$, $p < 0.001$, $d = 0.30$, two-tailed; Bad Outcome > Good Outcome) and Non-social Domains ($t(216) = 5.05$, $p < 0.001$, $d = 0.34$, two-tailed; Good Outcome > Bad Outcome).

For both character- and behaviour-based justifications, we found significant effects of domain type ($F(1, 215) = 131.32$, $p < 0.001$, $\eta_p^2 = 0.38$; Social > Non-social), and outcome type ($F(1, 215) = 32.47$, $p < 0.001$, $\eta_p^2 = 0.13$; Bad Outcome > Good Outcome). We also found significant domain type x outcome type interaction ($F(1, 215) = 56.98$, $p < 0.001$, $\eta_p^2 = 0.21$). Paired-samples *t*-test revealed a significant effect of outcome type for the Non-social Domain ($t(216) = 8.45$, $p < 0.001$, $d = 0.57$, two-tailed; Bad Outcome > Good Outcome), and no significant effect for the Social Domain ($t(216) = -0.90$, $p = 0.369$, $d = -0.06$).

Figure 2.6

Medians and quartiles of categories of written justifications for consistent scenario comparisons



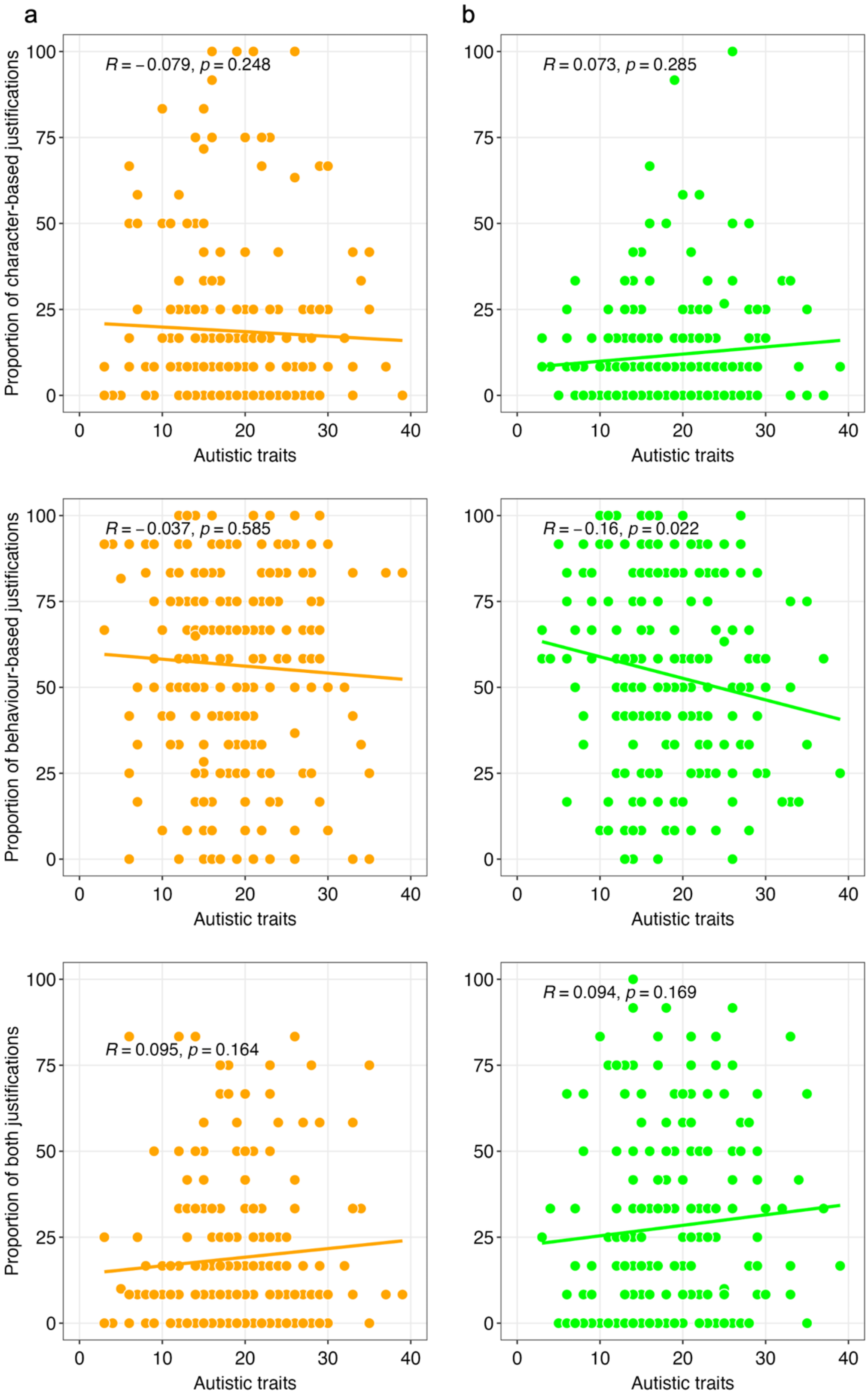
2.4.2.4. Correlations between the total scores on the AQ and the proportions of written justifications for inconsistent scenario comparisons

Spearman's Rank Order Correlation Tests were run to investigate the relationship between the total scores on the AQ and the proportions of written justifications in the Social and Non-social Domains, because normality was not met. For the Social Domain, we did not find significant correlations between the total scores on the AQ and the proportion of exclusively behaviour-based justifications ($r_s(215) = -0.037$, $p = 0.585$, two-tailed), and character-based justifications ($r_s(215) = -0.079$, $p = 0.248$, two-tailed). For the Non-social Domain, we found a significant negative correlation between the total scores on the AQ and the proportion of exclusively behaviour-based justifications; however, this correlation was not significant after Bonferroni correction ($r_s(215) = -0.16$, $p = 0.022$, two-tailed). There was no significant correlation between the total scores on the AQ and the proportion of exclusively character-based justifications in the Non-social Domain ($r_s(215) = 0.07$, $p = 0.285$, two-tailed). Finally, we found no significant correlation between the total scores on the AQ and the proportion of both character- and behaviour-based justifications in either Social ($r_s(215) = 0.09$, $p = 0.164$, two-tailed) or Non-social Domain ($r_s(215) = 0.09$, $p = 0.169$, two-tailed). See Figure 2.7.

Exploratory analysis revealed significant correlations only between sub-scale scores of social skill ($r_s(215) = -0.18$, $p = 0.008$, two-tailed) and attention to detail ($r_s(215) = -0.18$, $p = 0.007$, two-tailed) for the exclusively behaviour-based justifications in the Non-social Domain. For further details on the relationship between the sub-scales of the AQ and written justifications, see Appendix 11a for the Social Domain and Appendix 11b for the Non-social Domain.

Figure 2.7

Simple Scatter Plots of the relationships between autistic traits and proportions of justifications in the (a) Social and (b) Non-social Domains



2.5. General Discussion

We examined the tendency of young adults to rely just on behaviour-based information or on a combination of behaviour- and character-based information to make judgments across social and non-social domains. We ran correlations between participants' responses and their self-reported levels of autistic traits. We interpreted a greater consistency in reliance on behaviour-based responses across domains to be more indicative of deliberative reasoning and switching between behaviour- and character-based information across scenarios to be more indicative of intuitive reasoning. In other words, consistency effect across trials was considered to be evidence of more intuitive and less deliberative due to being more flexible and integrating more information. We predicted that the social domain would elicit more intuitive reasoning, particularly for those who self-report lower levels of autistic traits. Both experiments showed that participants reasoned more deliberatively in the non-social domain, consistently relying on the behaviour-based information of objects to determine their judgments regarding how good or bad the objects were. In the social domain, participants were more likely to alternate from relying on children's behaviour-based information to relying on their underlying character-based information to make judgments. Written justifications that were provided to explain their forced choice judgments, in Experiment 2, were broadly consistent with forced choice responses, though an interesting pattern emerged: even though participants were much more likely to rely on character-based information in justifying their responses in the social domain, in the non-social domain, they were more likely to use both behaviour- and character-based information for their justifications. Additionally, a mixed pattern emerged on the relation between reasoning biases and the levels of autistic traits. Experiment 1 found a significant association between autistic traits and a more deliberative reasoning pattern for the social domain. Experiment 2 found no meaningful association between autistic traits and the reasoning style for either domain.

2.5.1. Participants Reasoned More Intuitively in the Social Domain

We consistently found results showing that participants treated the social domain differently from the non-social domain by giving more behaviour-based forced choice judgments for the non-social domain compared to the social domain. We continued to find this pattern in Experiment 2 with participants' written justifications for their judgments showing that participants mentioned character-based information more for the social domain but both character- and behaviour-based information for the non-social domain. Glick (1978; reported in, Shultz, 1982) suggested that non-social knowledge requires logical strategies, whereas social knowledge requires intuitive strategies, and for the following reasons. First, behaviour of objects is more stable than behaviour of people because people do not only react but also act. Second, object behaviour is strictly deterministic whereas the behaviour of people is probabilistic. Finally, social knowledge (given, probably, the indeterministic nature of human behaviour) falls necessarily short of certainty and sensitive to context, in contrast with knowledge of objects, which sometimes allows for certainty. Shultz (1982) also suggested that people attribute moral responsibility to people and not to objects. People are therefore expected to reason in a more intuitive way in the social domain than in the non-social domain. Therefore, mentioning both character- and behaviour-based information when providing justifications regarding judgments of objects is as a more logical way of reasoning which is in line with the properties of the non-social domain.

2.5.2. Understanding the Relation Between Autistic Traits and Social Reasoning

Findings from Experiment 1 were in line with Komeda et al. (2016), who showed that autistic young people relied more on behaviour-based information and less on character-based information, compared to the non-autistic young people who relied on both character- and behaviour-based information, when making judgments about the social scenarios' main characters. However, Experiment 2 found no meaningful association between levels of autistic traits and reliance on the behaviour-based information for either domain. This might be due to minor methodological changes since the second experiment differed from the first in the following ways: the experiment (1) was run with a bigger sample, (2) was run online and without the presence of a researcher, (3) was updated with a shorter version of the Scenario-based Comparison Task, and (4) asked participants to provide justifications for their forced choice judgments.

A reasonable hypothesis is that autistic people and people who report higher levels of autistic traits would both reason more deliberatively across domains than non-autistic people and people who report lower levels of autistic traits, for the following reasons: given autistic people and people who report higher levels of autistic traits prefer and engage in a more deliberative thinking style, rather than an intuitive one (Brosnan et al., 2016, 2017), they engage in common reasoning biases less (Lewton et al., 2019), and they do not typically adapt their cognitive style according to their environment, but rather follow a highly logically consistent reasoning style (De Martino et al., 2008). These characteristics were previously conceptualised as enhanced rationality in autism. Our results from the first experiment are consistent with this concept (but see, Morsanyi & Hamilton, 2023; Taylor et al., 2022). The results showed that people who self-report higher levels of autistic traits might tend to reason more deliberatively across domains, by responding in a more consistent and yet inflexible way rather than adapting their reasoning strategy to the domain, in the way people who self-report lower levels of autistic traits do. Autistic people report experiencing difficulties in decision-making (Luke et al., 2011). These difficulties have not been considered across domains. But there remains a question of whether autistic people might find reasoning in the non-social domain easier than the social domain. Therefore, there is a need to consider such decision-making difficulties across domains.

There were minor methodological differences between the two experiments. There may therefore be several reasons why Experiment 2 produced a different pattern of results. The researcher being present through a video call during the first experiment might have created social anxiety or social acceptance bias among participants, or increased motivation. Moreover, the interaction between the participant and the researcher during the first experiment which made it so that the task was more socially interactive, which might have differentially influenced participants' responses. For future studies, checking the levels of social anxiety before and after the experiment could be useful, since social anxiety is highly common among autistic people and people who self-report higher levels of autistic traits (Freeth et al., 2013; Simonoff et al., 2008). It would be particularly interesting and have practical implications if social anxiety influenced autistic people's social reasoning.

2.5.3. Other Factors Influenced Reasoning Style

The broad pattern of results from the social domains of both experiments fit well with Komeda et al.'s (2016) results, which employed a social task only. Both experiments found that participants' forced choice judgments were influenced by the outcome type of the scenarios. Participants provided more behaviour-based judgments for the scenarios which ended with a good, rather than bad, outcome. Komeda et al. (2016) found a similar result with their non-autistic group who provided more behaviour-based judgments for the scenarios with a good outcome, compared to those with a bad outcome, while their autism group did not vary their strategy based on the outcome type.

We also unexpectedly identified that forced choice responses were affected by the domain order. Participants who completed the social domain first and participants who completed the non-social domain first followed a different pattern of reasoning across domains. Participants who completed the non-social domain first relied more on character-based information for the social domain. However, participants who completed the social domain first did not change their strategy across domains. This could be explained by a carry-over effect that occurred when a participant is introduced with the social task first. Previous studies suggested a carry-over effect when the social and non-social tasks were introduced to the participants as separate blocks (for instance, Surtees et al., 2012).

2.5.4. Limitations and Future Research

This study has limitations which could be addressed by future studies. Komeda et al. (2016) found no significant interaction effects of working memory and language comprehension on participants' forced-choice judgments; however, Taylor et al. (2022) showed that general cognitive ability predicted reasoning performance and reasoning style, rather than autism or presence of autistic traits. That we did not measure any sort of cognitive ability, then, is one of the limitations of our study. Future studies should employ measures of cognitive abilities to control for this variable. Even though there was a wide range of self-reported levels of autistic traits among our participants for both studies, samples that are dominated by specific groups (such as gender or age) are not adequate for generalisation. Although studies that employ measures of autistic traits in the general population have potential to inform our understanding of populations who have received a clinical diagnosis (Happé & Frith, 2020), the findings from our experiments need to be replicated and extended with autistic samples before they can be extrapolated to autistic people (Sasson & Bottema-Beutel, 2021). There might be interference from co-existing diagnoses and/or difficulties which were found to be associated with atypicality in reasoning and cognitive biases (for ADHD, Persson et al., 2020; for anxiety, Remmers & Zander, 2018; for alexithymia, Rinaldi et al., 2017). Therefore, future studies should check their sample on co-existing conditions. Finally, though we consistently found significant effects of domain type, it might be useful to label the stimuli as "social" and "non-social" or check participants' perception of the socialness of the stimuli (Lockwood et al., 2020; Varrier & Finn, 2022).

2.5.5. Implications

The question of whether autistic people or people who self-report high levels of autistic traits exhibit a higher level of deliberation that leads to a more deliberative and less intuitive reasoning is still open. Given the inconsistencies in the literature, potential publication bias might be damaging for the autistic community, which is highly heterogeneous in terms of strengths and weaknesses. If not well supported, the growing literature in this area might create pressure on the autistic community regarding a more logical thinking style. Given the inconsistent results from our studies, there is a need to be cautious before emphasising the enhanced deliberation and lack of intuition associated with autism. Moreover, we should focus more on the ability of automatically alternating the reasoning strategy from intuitive to deliberative or vice versa based on the context. A flexibility in reasoning strategies is crucial for everyday life. For instance, when the context is non-social, as in economics or meteorology, a deliberative reasoning style might be more helpful and a better strategy for non-social contexts and for areas that require an enhanced logical thinking style. However, when the context is social, we might want to switch to a more intuitive approach for a better fit in the social community or to better make sense of autistic people's social behaviour, especially if it does not match with non-autistic expectations.

2.5.6. Conclusion

Both experiments consistently showed that people treat social and non-social contexts differently, relying more on behaviour-based forced-choice responses in the non-social domain than in the social domain. We also found this by showing that people also justify their reasoning by mentioning both character- and behaviour-based information in the non-social domain. The first experiment shows that the levels of autistic traits correlate with a more deliberative and logical reasoning style in the social, but not in the non-social domain. This is in line with the research on enhanced rationality in autism. However, it might be due to minor methodological changes, our second experiment did not find a meaningful association. Here, we introduce a novel scenario-based comparison task that systematically compares the social and non-social domains. Future studies should further explore the reasoning tendencies in relation to autism across domains by addressing the limitations mentioned above.

2.6. Summary and link to Chapter III

In Chapter II, a mixed pattern was shown for the relationship between a reliance on deliberation and levels of self-reported autistic traits. While Experiment 1 showed a clear correlation between these two variables, Experiment 2 did not show such relationship. Furthermore, written justifications collected for Experiment 2 did not support the main hypothesis regarding this relationship. However, these two experiments did support a distinction between social and non-social domains.

Chapter III further develops this by comparing autistic participants to a group of matched non-autistic participants. Experiment 3 in this chapter uses the same task used in Experiment 1, instead of the updated version in Experiment 2. This is because this experiment was planned not to ask for written justifications, and therefore, did not need to be shortened. The methodology for data collection for the scenario-based task was kept as similar as possible to Experiment 1.

Chapter III

Autistic People Differ from Non-autistic People Subjectively, but not Objectively in Reasoning

3.1. Abstract

Autism has been associated with difficulties within the social domain and with quick decision-making. The Dual Process Theory of autism proposes that autistic people tend to prefer and perform in a more deliberative and less intuitive reasoning style, compared to non-autistic people, suggesting enhanced rationality in autism. However, this theory has not been systematically explored across social and non-social domains. Twenty-three autistic adults and 23 age, gender, and cognitive ability-matched non-autistic counterparts completed subjective and objective measures of reasoning. A scenario-based comparison task was employed, covering both social and non-social domains, to assess whether participants consistently used the same strategy across domains or switched between the strategies for their judgments. Autistic participants self-reported lower intuition, however, no significant group differences observed on either self-reported deliberation or judgments on scenario comparisons.

3.2. Introduction

Autism is characterised by differences from non-autistic people in social communication and interaction, alongside repetitive, stereotyped, and restricted behaviours and interests (American Psychiatric Association, 2013). One specific area of social cognition in which autistic people differ from non-autistic people is their *preference* for and *performance* in reasoning (Morsanyi & Byrne, 2020; Rozenkrantz et al., 2021; van der Plas et al., 2023). Reasoning is crucial for decision-making, affecting various aspects of life, including independence and employment.

3.2.1. Dual Process Theory of Autism

Dual process theories have recently been employed to explore how autistic people reason. Dual process theories, widely used in cognitive and behavioural studies to investigate reasoning, propose two processing types: intuition and deliberation. While there is an ongoing debate about this distinction (De Neys, 2018), intuition refers to a fast, effortless, and automatic process, mainly used for spontaneous judgements. On the other hand, deliberation refers to a slower, more effortful, and less automatic process, mainly used for significant decisions (Evans, 2008, 2011; Kahneman, 2011). According to *the default-interventionist model*, intuition serves as default mode for everyday reasoning, unless the decision is re-evaluated through deliberation (Evans & Stanovich, 2013).

The Dual Process Theory of autism proposes that autistic people demonstrate a *preference* for and *performance* in greater deliberation and less intuition compared to non-autistic people, suggesting enhanced rationality in autism (e.g., Ashwin & Brosnan, 2019; Brosnan et al., 2016, 2017; Brosnan & Ashwin, 2022a, 2022b; De Martino et al., 2008; Levin et al., 2021; Lewton et al., 2019; Rozenkrantz et al., 2021). This theory aligns with other characteristics linked to autism, such as *attention-to-detail* and *bottom-up thinking*, where autistic people tend to focus on details before considering bigger picture, leading to longer processing times (Baron-Cohen et al., 2009). These *hyper-attention* and *hyper-systemising* skills, which involve the capacity to identify and manipulate causal patterns, have been suggested to stimulate autistic strengths (Baron-Cohen, 2020). In contrast, non-autistic people tend to favour *top-down thinking*, where they consider concepts before delving into details. Seemingly, autistic people's approach demands more time and effort, yet it reduces the risk of overlooking important information. However, enhanced deliberation in autism might have potential downsides. Because autistic people tend to rely less on fast intuition compared to non-autistic people (Rand, 2016), they may face challenges in rapidly changing social situations that often necessitate quick decision-making based on subtle cues. For instance, in scenarios like job interviews, taking longer to respond might negatively influence interviewer's perception of the candidate (Brosnan et al., 2016).

3.2.2. Evidence for Greater Deliberation in Autistic People

A *preference* for deliberation and a tendency to *perform* in a more deliberative way among autistic people has been highlighted in several studies (e.g., Ashwin & Brosnan, 2019; Brosnan et al., 2016, 2017; Brosnan & Ashwin, 2022b; De Martino et al., 2008; Levin et al., 2021; Lewton et al., 2019; Rozenkrantz et al., 2021). Studies using subjective self-report measures, such as the Rational Experiential Inventory (REI; Epstein et al., 1996) and objective performance-based measures, such as, the Cognitive Reflection Test (CRT; Frederick, 2005), have reported that autistic people tend to score higher in deliberation and lower in intuition. Brosnan et al. (2016) employed the classical CRT, in which correct responses indicate deliberation and incorrect responses indicate intuition, to compare reasoning performance between autistic and non-autistic people. They reported that autistic people provided more correct and fewer incorrect responses compared to non-autistic people. Brosnan et al. (2016)

concluded that autistic people are not *"lazy thinkers"*, as they adopt a reasoning strategy that requires more time and effort yet leads to greater accuracy. Additionally, autistic people's self-reports highlighted greater rationality, indicative of deliberation, and lower experientiality, indicative of intuition (Brosnan et al., 2016).

Autistic people also show evidence of reduced engagement in common biases, resulting in more consistency (De Martino et al., 2008; Farmer et al., 2017; Fujino et al., 2019; P. Shah et al., 2016; Vella et al., 2018). For instance, autistic people typically do not *jump to conclusions* (Brosnan et al., 2014). Brosnan et al. (2014) used the Beads Task (Huq et al., 1988) to compare autistic adolescents to an age-matched non-autistic group. This task involves two jars filled with different coloured beads. Participants draw beads from each jar. Participants must determine which of two jars (with different distributions of beads) beads are being drawn from. The study found that autistic participants requested more beads before reaching a decision compared to non-autistic group who made decisions with fewer beads. This suggests that autistic people adopt a slower yet more careful reasoning approach. Similar results were observed with the general population, where participants with higher autistic traits requested more information prior to decision-making compared to those with lower autistic traits (Brosnan et al., 2013). These findings are consistent with self-reports from autistic people and caregivers of them indicating quick decision-making challenges (Luke et al., 2011).

3.2.3. Limitations of the Literature

There are discrepancies in the literature. Jänsch and Hare (2014) also employed the Beads Task after carefully matching autistic adults to a comparison group based on age, gender, and cognitive ability. Contrary to Brosnan et al. (2014)'s findings, they found that autistic adults required fewer beads to reach a decision in opposed to the comparison group. Autistic adults made quick decisions based on only one bead in half of the trials, while no non-autistic adult displayed this pattern. These studies, published around the same time, present conflicting results.

Reasoning performance is closely linked to cognitive abilities; therefore, adjusting for cognitive ability impacts the results. For instance, the link between autism and greater deliberation was not found when comparison groups are matched on cognitive ability or when cognitive ability is adjusted (e.g., Brosnan et al., 2017; Jänsch & Hare, 2014; Morsanyi & Hamilton, 2023; Taylor et al., 2022). After conducting four large-scale studies, Taylor et al. (2022) did not find associations between autism and objectively measured intuitive and deliberative reasoning. Even when they identified significant associations, adjusting for cognitive ability between groups rendered these associations non-significant. The single link they found was between autism and self-reported intuition. Moreover, many studies relied on the classical CRT, which has been widely spread through newspapers and online platforms, neglecting to measure the familiarity with its items (e.g., Brosnan et al., 2016, 2017; Brosnan & Ashwin, 2022b). Additionally, several studies recruited non-clinical samples by measuring autistic traits (e.g., Lewton et al., 2019). While this strategy allows recruitment of larger samples, results cannot be generalised to the autistic community (Sasson & Bottema-Beutel, 2021).

3.2.4. Moral Reasoning in Autism

An example in this field demonstrates decision-making differences related to moral reasoning between autistic and non-autistic young people when evaluating scenarios' main characters as being better or worse (Komeda et al., 2016). Moral reasoning is an important aspect of reasoning entailing the evaluation of what is good or bad, right or wrong. Komeda et al. (2016)

used social scenarios involving interactions between a child and the child's parent. Each scenario presented three lines of information: the first line described the child's character, the second line depicted the child's behaviour, and the third line provided the outcome of the scenario. Each line had either a positive or negative valence, and the scenario structures varied in consistency. Participants were asked to judge which child was better or worse (see Figure 2.1a and 2.1b). Komeda et al. (2016) found that autistic young people more consistently relied on behaviour-based information, whereas their non-autistic counterparts tended to use both character- and behaviour-based information. This suggests a more rational pattern for autistic young people, whereby they consistently relied on the same kind of information for each scenario while ignoring the characteristics. Experiment 1, presented in the previous chapter, developed this finding further by testing it across domains. This finding was supported with showing a positive correlation between self-reported autistic traits and a reliance on behaviour-based information for social scenario comparisons, and not for non-social scenario comparisons.

3.2.5. Social versus Non-social Reasoning

In order to draw conclusions regarding social cognition, it is important to examine the social phenomena in comparison to a non-social context (Lockwood et al., 2020). Performance in social and non-social domains may well differ, because deploying cognition is likely to be influenced by context. Autistic people might exhibit enhanced reasoning abilities related to non-social stimuli. For instance, Scott and Baron-Cohen (1996) suggested that autistic people face challenges in social-psychological reasoning, while they show enhanced abilities in non-social logical reasoning. While social and non-social reasoning have been studied in relation to autism, a systematic comparison across these domains has been overlooked.

3.2.6. This Study

In this study, we adapted Komeda et al. (2016)'s social scenarios and created a structurally equivalent non-social domain (see also Chapter 1). This allowed us to examine reasoning differences between autistic and non-autistic people across social and non-social domains. We also used the REI, as a subjective measure of reasoning, and an updated version of the CRT, as an objective measure of reasoning. Following the prevailing literature on the dual process theory of autism, we hypothesed that the autism group would (1) self-report higher levels of rationality and lower levels of experientiality, compared to the non-autistic group on the REI, (2) outperform the comparison group by providing more correct and less incorrect responses on the CRT, and (3) demonstrate more consistent reasoning by providing a greater proportion of behaviour-based responses for social scenario comparisons, compared to the non-autism group, while no significant group differences were expected for non-social scenario comparisons.

3.3. Method

See https://osf.io/9zxwd for pre-registration, data, and material. This project was conducted following the British Psychological Society ethical guidelines and approved by the Science, Technology, Engineering, and Mathematics Ethical Review Committee (ERN_16-0281AP11A).

3.3.1. Sample Size and Effect Size Calculations

A priori power analysis using G*Power (Faul et al., 2007) indicated that a sample size of 24 participants in each group would be required to detect a large effect size (Cohen's $d = 0.73$) with 80% power for one-tailed between-group comparison ($\alpha = 0.05$). As reference to a prior study on reasoning in autism (Brosnan et al., 2017) which recruited 26 participants for the autism and 22 for the comparison group, we decided to recruit 48 participants in total, with 24 participants in each group.

3.3.2. Sample

We recruited 48 participants, with 24 participants in the autism group (9 Female, 14 Male, 1 Other; M_{age} = 37.21, SD_{age} = 15.29) and 24 participants in the non-autism group (9 Female, 14 Male, 1 Other; M_{age} = 38.26, SD_{age} = 17.75). See Table 3.1 for the demographics of the final groups. All participants were aged 18 years or older, located in the United Kingdom, and fluent in English. The autism group was recruited through various channels, including Birmingham Psychology Autism Research Team's research participant database, student and staff mailing lists, social media platforms, and flyers around the University of Birmingham. The inclusion criteria for the autism group stated a clinical autism diagnosis, which was confirmed prior to recruitment and at the start of video call. Participants provided details about their diagnoses, including diagnosis date and the profession of the professional who made the diagnosis. For the comparison group, participants were recruited through mailing lists and flyers at the same university, social media platforms, and Prolific (https://www.prolific.co). Each participant in this group confirmed that they had never received a clinical autism diagnosis.

The levels of autistic traits for all participants were assessed to ensure the groups were distinct. See Table 3.1. The autism group reported significantly higher levels of autistic traits compared to the non-autism group ($t(45) = 9.61$, $p < 0.001$, $d = 2.80$). One participant from the autism group and one participant from the non-autism group were excluded from data analysis due to data inconsistencies. After removing these participants, groups remained matched on gender, age, and non-verbal reasoning ability. The levels of autistic traits ranged between 8 and 48 for the autism group and between 3 and 26 for the non-autism group. All participants provided demographics information on age, gender, ethnicity, education level, and first language and completed the Matrix Reasoning Item Bank (MaRs-IB; Chierchia et al., 2019), a non-verbal cognitive assessment, to achieve matched groups based on age, gender, and cognitive ability. Most participants identified as White (78.26%; see Appendix 12a) and had completed or attended higher education (69.57%; see Appendix 12b).

Table 3.1

Demographics of autism and comparison groups

	Autism (*N* = 23)	Comparison (*N* = 23)	Statistical test
Gender	9 female, 14 male	9 female, 14 male	$\chi^2(1) < 0.001$, $p = 1.000$
Age (*M/SD*)	37.74 (15.40)	38.26 (17.75)	$t(44) = 0.11$, $p = 0.916$
NVR (*M/SD*)	62.24 (19.54)	64.65 (15.73)	$t(44) = 0.46$, $p = 0.647$
AQ (*M/SD*)	36.74 (9.13, [8 – 48])	15.09 (6.32, [3 – 26])	$t(44) = 9.36$, $p < 0.001$

Note. NVR: Non-verbal reasoning, AQ: Autism Quotient, *M*: Mean, *SD*: Standard Deviation. Age in years. NVR shows the percentage of correct responses. Independent samples *t*-tests were conducted for age, NVR, and AQ scores. A chi-square test was conducted for gender.

3.3.3. Materials

Subjective Thinking Style. The subjective inclination towards deliberation and intuition was measured with the Rational-Experiential Inventory (REI; Epstein et al., 1996), which is a 40-item self-report questionnaire measuring the perception of engagement and ability in rationality and experientiality. The REI features four sub-scales, each compromising 10-item: rational engagement, rational ability, experiential engagement, and experiential ability. We combined the scores for rational engagement and rational ability to assess (1) rationality, and experiential engagement and experiential ability to assess (2) experientiality. The rationality sub-scale measures ‘deliberation’ (“need for cognition”, Cacioppo & Petty, 1982) with an example statement of “I have a logical mind”. The experientiality sub-scale measures ‘intuition’ (“faith in intuition”, Epstein et al., 1996) with an example statement of “I believe in trusting my hunches”. This questionnaire is scored on a five-point scale ranging from “1 = definitely not true of myself” to “5 = definitely true of myself”. Sub-scale scores ranged from a minimum of 20 to a maximum of 100. The REI has strong internal consistency (rationality, α = 0.90; experientiality, α = 0.87) and reliability (rationality, r = ranging between 0.86 and 0.91; experientiality, r = ranging between 0.87 and 0.90; Pacini & Epstein, 1999). See Appendix 13 for the items of REI.

Objective Reasoning Performance. The objective performance of cognitive reflection and intuition inhibition was measured using the recently updated Cognitive Reflection Test (Sirota & Juanchich, 2018). This test is an expanded version of CRT (Frederick, 2005), which originally consists of three problems with open-ended options. The CRT has been expanded with additional four problems (Toplak et al., 2014), presented with four-options. Each problem presents one correct option that can be reached through deliberation and one incorrect option that can be reached through intuition, along with two more incorrect options that are neither deliberative nor intuitive. The updated version was used because the classical CRT has extensively published, increasing the familiarity risk. An example from the classical CRT is as follows: “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.” The most common answer, and the one that comes to mind first, is 10 cents (Frederick, 2005). In the updated CRT, the following options are provided for this question: “10 pence”, “5 pence”, “9 pence”, and “1 penny”. Among these, “10 pence” is the incorrect and intuitive answer, while “5 pence” is the correct and deliberative answer. “9 pence” and “1 penny” are both incorrect, but neither deliberative nor intuitive. The problems and options were presented randomly. Participants received two scores: (1) ‘reflectiveness’ score for each correct answer, and (2) ‘intuitiveness’ score for each incorrect and intuitive answer. Therefore, a participant could get a score between 0 and 7 for each category. The multiple choice format with four-options was chosen following Sirota and Juanchich (2018)’s suggestion for practical and methodological reasons. The updated CRT has strong internal consistency (α = .71; Sirota & Juanchich, 2018). See Appendix 14 for the items of CRT.

The Scenario-based Comparison Task. This task was conducted in an identical way to Experiment 1 in Chapter II. This task (96-trials, adapted from Komeda et al., 2016) consisted of pairs of scenarios representing social and non-social domains. This task was designed to measure whether participants would rely on a specific information when making judgments on scenarios’ main characters. Each domain included 24 comparisons. In the social domain, scenarios featured an interaction between a child and the child’s parent. In the non-social domain, scenarios featured an interaction between a person and an object. Participants were asked to judge which child, in the social domain, or object, in the non-social domain, was better or worse.

Each scenario presented three lines of information: the first line presented character-based information, the second behaviour-based information, and the third the outcome. Each line had either positive or negative valence with either a consistent or inconsistent structure, depending on whether the values of character- and behaviour-based information were in line (both positive or both negative) or not (one positive and one negative). See Figure 2.1a and 2.1b.

The proportions of behaviour-based responses were calculated for social and non-social domains. If participant's response was behaviour consistent, it was coded as 1. For instance, when asked which child was better, if a participant chose the child that was described as showing positive behaviour, regardless of characteristics and outcome. If the response was behaviour inconsistent, it was coded as 0. For instance, when asked which child was better, if a participant chose the child that was described as showing negative behaviour, regardless of characteristics and outcome. Scenario main characters' genders and positive behaviour position (left or right) were counterbalanced. Domain order (social or non-social domain first) was controlled across participants. Outcome lines' length and word count were same across all scenarios.

Autistic Traits. This measure was given to participants in the same way as Experiment 1 and 2 in Chapter II. The levels of autistic traits were measured with the Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001), which is a 50-item self-report questionnaire for adults aged 16 years and above with average or higher intelligence. Each item is presented with four-options: "definitely agree", "slightly agree", "slightly disagree", and "definitely disagree". The AQ has five sub-scales, each presenting 10-items, including social skills, attention switching, attention to detail, communication, and imagination. The total scores were calculated by summing participants' responses. The total scores range from 0 to 50, with higher indicating higher levels of autistic traits. The AQ, widely used in clinical and non-clinical samples (Ruzich et al., 2015), demonstrates strong test-retest reliability ($r \geq 0.8$) and internal consistency ($\alpha \geq 0.7$; Stevenson & Hart, 2017).

Non-verbal Cognitive Ability. Non-verbal cognitive ability was measured with the Matrix Reasoning Item Bank (MaRs-IB; Chierchia et al., 2019), using the colour-blind palette 1. The colour-blind version was selected to increase accessibility. The MaRs-IB consisted of 80 puzzles, each puzzle presented as a 3 x 3 grid of patterns with the pattern in bottom-right missing. Patterns within the grid varied in shape, size, colour, and position. Participants were required to select the missing pattern from four-options displayed below the grid, considering the relational information. Participants had 30 seconds to provide a response for each puzzle. If a response was not provided, the test automatically moved to next item. The MaRs-IB has a time limit of eight minutes. However, participants are not required to solve all the puzzles within that time limit. Participants were instructed to be as fast and accurate as possible, with no penalty for incorrect answers was given. Puzzles were presented randomly and in a shuffle of difficulty. If a participant solved all the puzzles, a reiteration of the same puzzles was presented randomly. Following Chierchia et al. (2019)'s procedure, responses to repeated puzzles were not analysed. Scores were calculated as the proportion of correct responses achieved within eight-minute time limit. The MaRs-IB has strong test-retest reliability ($r \geq 0.7$) and internal consistency (Kuder-Richardson 20 ≥ 0.7; Chierchia et al., 2019).

3.3.4. Procedure

Participants received an information sheet and provided consent prior to testing via Zoom (https://zoom.us/). A video call was conducted to complete the Scenario-based Comparison Task with either EB or HF (both females). Participants were free to choose to keep their video on or off, aiming to mitigate anxiety. The researcher shared screen via Zoom to the task which was built on Qualtrics (https://www.qualtrics.com/uk/). Each scenario comparison with question and options was presented on the same screen and remained on the screen until the participant verbally responded. There was no time limit during this task because time pressure was not a target. Upon completing this task, participants were provided with three links to complete (1) the REI and CRT, (2) the MaRs-IB, and (3) a demographics form. These tests and tasks were conducted online using Qualtrics and Gorilla (https://gorilla.sc) and completed on participants' own time. Participants were compensated with £10 Amazon voucher.

3.3.5. Data Analysis

SPSS 29 was used for statistical analyses and significance level (α) was set to 0.05. To compare whether there was a difference between groups based on subjective thinking style, a 2 x 2 analysis of variance (ANOVA) was conducted with within-subjects factor thinking style (Rationality, Experientiality) and between-subjects factor group (Autism, Comparison). The sub-scale scores of 'rationality' and 'experientiality' on the REI were used as dependent variables (DVs). To compare whether there was a difference between groups in objective reasoning performance, a Mann-Whitney U test was conducted, because the scores of reflectiveness and intuitiveness were not normally distributed. The 'reflectiveness' and 'intuitiveness' scores on the CRT were used as DVs. For the Scenario-based Compairons Task, a 2 x 2 x 2 ANOVA was conducted with within-subjects factors domain type (Social Domain, Non-social Domain) and consistency (Consistent, Inconsistent), and between-subjects factor group (Autism, Comparison). As an exploratory analysis, a mixed 2 x 2 x 2 x 2 x 2 ANOVA was conducted with the within-subjects factors domain type (Social Domain, Non-social Domain), consistency (Consistent, Inconsistent), outcome type (Good Outcome, Bad Outcome), and the between-subjects factors group (Autism, Comparison) and domain order (Social Domain First, Non-social Domain First). This was an exploratory analysis, since the domain order or outcome type were not interests of the main hypothesis. The proportion of behaviour-based responses for scenario comparisons was used as the DV for both ANOVAs.

As another exploratory analysis, the correlation between the proportion of behaviour-based responses for scenario comparisons and total scores and sub-scale scores from the AQ for each group were also analysed, using Pearson Correlation Test for ‘attention to detail’ and ‘imagination’ sub-scales for Autism group, and AQ total score, ‘attention switching’, and ‘attention to detail’ for Comparison Group. For the rest, Spearman’s Rank Order Correlation Test was used, because these scores did not normally distributed (see Appendix 23 for normality checks). See Appendix 15 for the correlation results between the proportion of behaviour-based responses for scenario comparisons and total scores and sub-scale scores from the AQ for each group.

3.3.6. Community Involvement

This project benefited from consultation with autistic people from the Birmingham Psychology Autism Research Team Consultancy Committee at the University of Birmingham.

3.4. Results

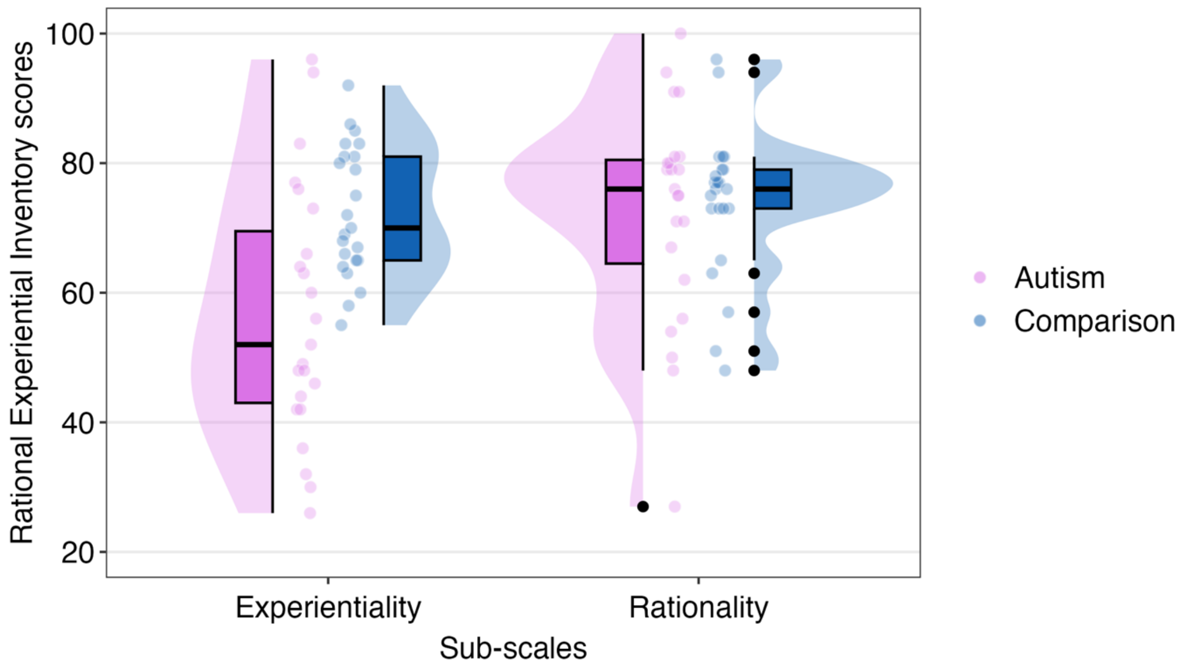
3.4.1. Subjective Thinking Style

The 2 x 2 ANOVA revealed an effect of thinking style ($F(1, 44) = 9.75$, $p = 0.003$, $\eta_p^2 = 0.18$), with participants scoring higher on the Rationality ($M = 73.26$, $SD = 14.23$) than the Experientiality ($M = 64.57$, $SD = 17.40$). Additionally, an effect of group was identified ($F(1, 44) = 6.38$, $p = 0.015$, $\eta_p^2 = 0.13$), with the Comparison group ($M = 73.26$, $SD = 8.45$) scoring higher than the Autism group ($M = 64.56$, $SD = 14.18$). Our hypothesis was supported by significant interaction between group and thinking style ($F(1, 44) = 6.56$, $p = 0.014$, $\eta_p^2 = 0.13$). An independent-samples *t*-test revealed that the Autism group ($M = 56.65$, $SD = 19.66$) scored significantly lower on the Experientiality than the Comparison group ($M = 72.48$, $SD = 10.11$,

$t(44) = 3.43$, $p = 0.001$, $d = 1.01$, two-tailed). There was no significant group difference for the Rationality, $t(44) = 0.37$, $p = 0.714$, $d = 0.11$, two-tailed. See Figure 3.1.

Figure 3.1

Medians and quartiles of total Rationality and Experientiality scores by groups

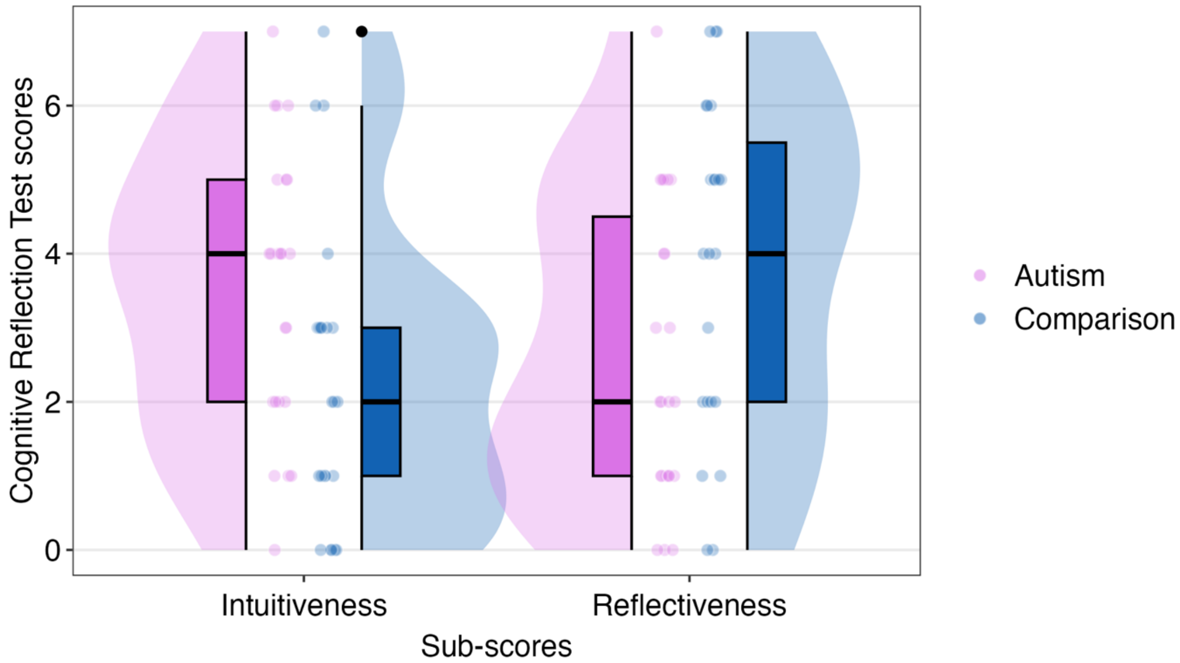


3.4.2. Objective Reasoning Performance

The Mann-Whitney U test revealed a significant difference between groups on Intuitiveness score ($U = 163.50$, $z = -2.24$, $p = 0.025$, two-tailed), with the Autism group scoring higher (*Mdn* = 4.00, *Mean Rank* = 27.89, *Sum of Ranks* = 641.50) than the Comparison group (*Mdn* = 2.00, *Mean Rank* = 19.11, *Sum of Ranks* = 439.50). There was also a trend towards a difference between groups on the Reflectiveness score ($U = 177.00$, $z = 1.95$, $p = 0.052$, two-tailed), with the Autism group scoring lower (*Mdn* = 2.00, *Mean Rank* = 19.70, *Sum of Ranks* = 453.00) than the Comparison group (*Mdn* = 4.00, *Mean Rank* = 27.30, *Sum of Ranks* = 628.00). See Figure 3.2.

Figure 3.2

Medians and quartiles of total Reflectiveness and Intuitiveness scores by groups



3.4.3. Domain-specific Reasoning Performance

The exploratory analysis of 2 x 2 x 2 x 2 x 2 ANOVA revealed no significant effect of domain order ($F(1, 44) = 0.49$, $p = 0.487$, $\eta_p^2 = 0.01$) and a significant effect of outcome type ($F(1, 45) = 20.07$, $p < 0.001$, $\eta_p^2 = 0.32$, Good Outcome > Bad Outcome). See Appendix 16 for the full table.

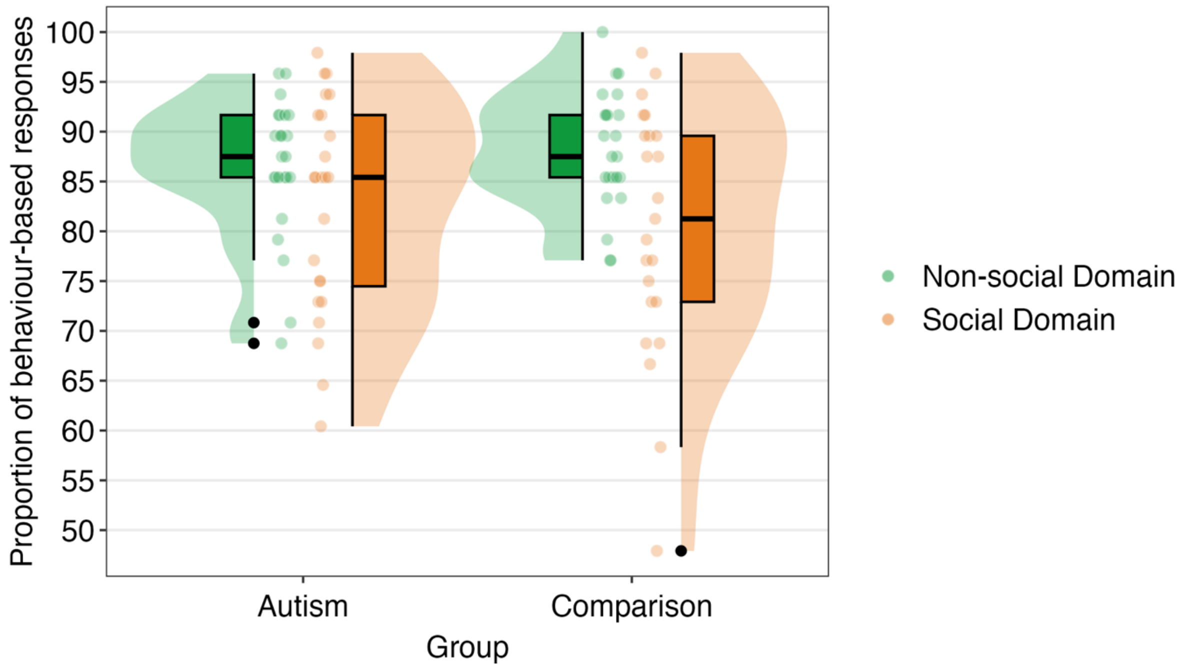
Since there was no effect of domain order, we continued with the analysis of 2 x 2 x 2 ANOVA which revealed an effect of domain type ($F(1, 44) = 13.16$, $p = 0.001$, $\eta_p^2 = 0.23$), with participants providing more behaviour-based responses for the Non-social (*M* = 87.32%, *SD* = 6.54%) than the Social Domain (*M* = 81.11%, *S*D = 11.51%). There was also an effect of consistency ($F(1, 44) = 146.15$, $p < 0.001$, $\eta_p^2 = 0.77$), with participants providing more behaviour-based responses for Consistent (*M* = 94.79%, *SD* = 4.16%) than Inconsistent scenario comparisons (*M* = 73.64%, *SD* = 12.69%). However, there was no effect of group ($F(1, 44) < 0.001$, $p = 0.951$, $\eta_p^2 < 0.001$).

There was a significant interaction between domain type and consistency ($F(1, 44) = 15.62$, $p < 0.001$, $\eta_p^2 = 0.26$). To unpack this interaction, paired-samples *t*-tests were conducted. The paired-samples *t*-tests revealed a significant mean difference for Inconsistent scenario comparisons ($t(45) = 3.99$, $p < 0.001$, $d = 0.59$, two-tailed, Non-social > Social). There was no significant difference for Consistent scenario comparisons ($t(45) = 0.08$, $p = 0.934$, $d = 0.01$, two-tailed). Additionally, neither domain type, consistency, and group interaction ($F(1, 44) = 1.44$, $p = 0.236$, $\eta_p^2 = 0.03$) nor the consistency and group interaction were significant ($F(1, 44) = 1.13$, $p = 0.294$, $\eta_p^2 = 0.02$).

Contrary to our main hypothesis, there was no significant interaction between group and domain type ($F(1, 44) = 1.07$, $p = 0.307$, $\eta_p^2 = 0.02$). In exploratory analysis, to compare the proportions of behaviour-based responses for the Social and Non-social Domains between groups, paired-samples *t*-tests were conducted after splitting the data by group. The paired-samples *t*-tests revealed a significant mean difference between the Social and Non-social Domains for the Comparison ($t(22) = 3.17$, $p = 0.004$, $d = 0.66$, two-tailed; Non-social > Social), and a marginal difference for the Autism group ($t(22) = 1.92$, $p = 0.068$, $d = 0.40$, two-tailed; Non-social > Social). See Figure 3.3.

Figure 3.3

Medians and quartiles of the proportion of behaviour-based responses for each group by domain



3.5. Discussion

Consistent with the literature, we found that the autism group self-reported lower intuition, compared to non-autism group. However, our findings did not support the link between autism and greater deliberation, as assessed with both objective and subjective measures of reasoning. Interestingly, self-reported lower intuition among autism group was not in line with their performance on objective measures, where the autism group scored higher in intuitiveness compared to non-autism group. Although there was a difference in the proportion of behaviour-based responses for social and non-social domains among comparison group, as opposed to autism group, this difference was not statistically significant.

3.5.1. Subjective Thinking Style

Consistent with previous findings (e.g., Morsanyi & Hamilton, 2023; Taylor et al., 2022), autistic people self-reported significantly lower in intuition, measured by experientiality, as opposed to comparison group. Additionally, there was no significant difference for deliberation, measured by rationality, between groups. It is common for highly educated people to score high on this sub-scale (e.g., McLaughlin et al., 2014). The autism and comparison groups in our study were mostly in higher education. This might explain high scores on rationality. The comparison group's rationality and experientiality scores were very close. In contrast, the autism group's rationality score was significantly higher than experientiality, suggesting an overreliance on a particular style.

The REI includes items that reflect real world reasoning and decision-making. While responding to the REI, autistic people might envision situations that demand quick intuitive information processing, such as those involved in social situations (Taylor et al., 2022). Furthermore, Taylor et al. (2022) suggested that the REI might not be measuring the same components for autistic and non-autistic people, possibly due to the use of abstract words for some items related to intuition, such as "hunches" or "gut feelings".

3.5.2. Objective Reasoning Performance

Our results from the updated CRT diverge from previous findings within the Dual Process Theory of autism by using the classical version of the same measure (e.g., Brosnan et al., 2016, 2017; Lewton et al., 2019; for a review, Rozenkrantz et al., 2021). However, our results are consistent with Taylor et al. (2022) and Morsanyi and Hamilton (2023), given that autism group did not score higher on reflectiveness as opposed to comparison group. Specifically, the autism group provided fewer correct responses and more intuitive responses than thecomparison group.

Earlier studies had several limitations, such as lack of replications, unmatched comparison groups, and absence or inconsistent assessment of cognitive ability. Additionally, these studies used the classical CRT, a version that has been widely shared, contributing to increased familiarity with its items. It could be argued that reasoning studies attract people who are already interested in the field, potentially exposing them to the correct responses beforehand. Furthermore, the classical version primarily consisted of numerical problems, while the updated version covers both numerical and non-numerical problems. The greater performance demonstrated by autistic people in previous studies might have been attributed to their ability in numeracy, rather than a difference in reasoning performance.

3.5.3. Domain-specific Reasoning Performance

We found that participants treated the social domain differently from non-social domain on the Scenario-based Comparison Task. Specifically, responses in the non-social domain tended to be more behaviour-based as opposed to social domain. Contrary to our main hypothesis, we did not identify a significant effect of group, nor did we identify an interaction between domain type and group. These findings suggested that there were no substantive differences in approaches employed by groups in their judgments.

Nonetheless, exploratory analysis did show some tentative evidence for group level differences on the task. We observed a trend, suggesting that the autism group exhibited more consistency in their reasoning across domains. In contrast, the comparison group alternated their reasoning strategy by providing a significantly higher proportion of behaviour-based responses for the non-social compared to the social domain. These findings were broadly in line with Komeda et al. (2016), where the autism group displayed a higher reliance on behaviour-based information when making judgments. Notably, any differences here are very subtle and would require larger sample sizes to detect reliability. Any potential influence of these findings on real-world decision-making is likely to be minimal. Furthermore, with such a small effect, there are lots of overlap between groups.

When we carefully match groups based on age, gender, and cognitive ability, it appears that previously observed group differences between autistic and non-autistic people do not manifest (Taylor et al., 2022). The contrasting aspects of reasoning and decision-making between autistic and non-autistic people were most pronounced when autistic people were asked to report on their internal beliefs, such as confidence levels, while their actual decisions did not significantly deviate from comparison group (van der Plas et al., 2023). Given the incongruence between the autism group's subjective *preference* and objective *performance* in our study, it is conceivable that this discrepancy may be due to differences in meta-cognition in autism, rather than stemming from a different reasoning style. For instance, autistic people tend to report inaccurate levels of confidence for their correct choices (Sahuquillo-Leal et al., 2019), and their confidence levels do not correlate with their performance of error-monitoring (Doenyas, Mutluer, Genç, et al., 2019), unlike their non-autistic counterparts who tend to report more precise confidence levels.

Furthermore, greater deliberation in autism might be context sensitive, and autistic people can be instructed to employ intuitive reasoning (Brosnan & Ashwin, 2022b). Taken together, these observations suggest that autistic people can reason intuitively, but might encounter challenges with other aspects of decision-making, such as anxiety arising from time pressure or information overload.

3.5.4. Limitations

While no significant group differences emerged in participants' final responses on the Scenario-based Comparison Task, our understanding of their reasoning approaches remains limited. The results from an artificial environment might not necessarily reflect the complexities of real-world decision-making. The nuances of autistic people's decision-making processes, such as time management and evaluation procedures, remain unexplored. For instance, although we did observe that autistic participants appeared to take longer in responding to scenario comparisons during data collection, we regrettably did not record response times. Future studies can record response times and ask for justifications to facilitate deeper evaluation.

Our samples were reasonably well balanced and represented a wide range of adult age groups. Specifically, the autism group included predominantly highly educated participants, who mostly identified as White. This might be because we recruited most of our autistic participants through a research participant database at the University of Birmingham. This database compromises potential participants who might be affiliated with this university or might be outside of this university. However, it is important to acknowledge that unemployment and drop-out of education or not continuing to higher education are common within the autistic community. Therefore, future studies should aim to recruit a more diverse and larger sample. Additionally, we had to remove one of our participants in comparison group due to being an outlier on one of the measures. The removal of this outlier resulted in our study being slightly under-powered.

3.5.5. Conclusion

We extended the Dual Process Theory of autism by comparing reasoning tendencies of autism and non-autism groups within social and non-social domains. Contrary to previous findings, we did not find meaningful links between autism and greater deliberation in performance outcomes, suggesting we should be cautious when concluding an enhanced rationality among the autistic community. Nevertheless, consistent with existing literature, we found that the autism group, compared to the non-autism group, self-reported lower levels of experientiality—indicative of intuition. Overall, our study suggests a potential disparity between subjective and objective outcomes of reasoning within autism group. However, there is need for further research, involving diverse and larger samples, to increase the representativeness of the results obtained.

3.6. Summary, COVID-19 Statement, and Link to Chapter IV

The first three experiments examined reasoning and decision-making tendencies across social and non-social domains in relation to autism and autistic traits with a focus on moral reasoning. The first experiment supported the Dual Process Theory of autism by showing a relationship between a greater deliberation in the social domain and levels of autistic traits. Following this, an updated version of the main task was created to achieve more in-depth findings with a larger population. This time, such relationship was not found. Therefore, the methodology was kept as similar as possible to the first experiment for Experiment 3 which aimed a between-group comparison. Autistic participants and a well-matched group of non-autistic participants were recruited and tasks measuring both subjective and objective reasoning were used. This time, an interesting pattern was observed. Even though, groups did differ for their subjective evaluation, groups did not differ for their objective performance as much.

At the time COVID-19 lockdown started in March 2020, Experiment 4 was ready to be run in-person. However, this experiment had to wait until the last year of my PhD, because of the complexity of the task making it difficult to be transferred onto an online platform.

For Experiment 4, we aimed to continue exploring reasoning and decision-making across domains with a focus on causal reasoning. Causal reasoning is an important area of reasoning field and has been researched extensively in the general population. This experiment attempted to translate tools and insights from these studies into research on clinical populations. As the first attempt, this study was run with participants from the general population by measuring levels of autistic traits.

Chapter IV

Causal Reasoning in Social and Non-social Domains in Relation to Autistic Traits

4.1. Abstract

Causation is a fundamental way to make sense of both the social and non-social domains. High levels of autistic traits in the general population have been linked to enhanced rationality, suggesting a more normative way of reasoning among people with higher autistic traits. We aimed to systematically compare causal reasoning tendencies across social and non-social domains and its relation to levels of autistic traits. We used a causal reasoning task which had three binary variables (present/absent) forming common cause networks. In a simple common cause network, two effects (X and Y) share a common cause (Z), presented as X←Z→Y. Causal mechanisms in the social domain represented social relationships, while causal mechanisms in the non-social domain represented economics and meteorology. We recruited 76 participants from the general population and measured their thinking styles and levels of autistic traits on self-reports online. Participants also completed the computerised causal reasoning task in-person. We found that participants consistently violated the normative rules of causal reasoning. We identified systematic differences across domains. However, we did not identify meaningful differences of autistic traits and thinking styles between clusters of reasoners based on their performance. We conclude with that people violate the normative rules of causal reasoning differently across domains. However, we cannot conclude with that this relates to autistic traits. Theories of reasoning should consider further individual differences, such as age, gender, education level, thinking style, and psychological and psychiatric history of the reasoner.

4.2. Introduction

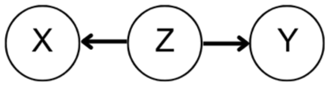
Causation is a fundamental way to make sense of both the social and non-social domains. Causal reasoning refers to the process of understanding and explaining the cause-and-effect relationship between events. There is growing literature on reasoning in autism, translating tools and techniques of causal reasoning into the autism field, by recruiting either clinical or non-clinical samples. Even though autism is diagnosed as a clinical condition (American Psychiatric Association, 2013), autistic traits, measured by self-report questionnaires, are manifested in the general population (Ruzich et al., 2015). Higher levels of autistic traits are linked with enhanced rationality, suggesting a preference for and proficiency in greater deliberation and reduced intuition (Morsanyi & Byrne, 2020; Rozenkrantz et al., 2021). However, there has not been a systematic comparison of causal reasoning across social and non-social domains in relation to autistic traits.

4.2.1. Causal Reasoning

As a simple example of causation, smoking (X) causing lung cancer (Y) indicates a *direct* causal relationship between X and Y. However, introducing a third variable might complicate this relationship. In such cases, X and Y are causally *indirectly* related through another variable, Z. An example of this arises when both X and Y are effects of Z, which is called a *common cause network*. For instance, smoking (Z) causing lung cancer (X) and yellow fingers (Y). See Figure 4.1 for an illustration of a common cause network.

Figure 4.1

A common cause network formed with three variables: X, Y, and Z



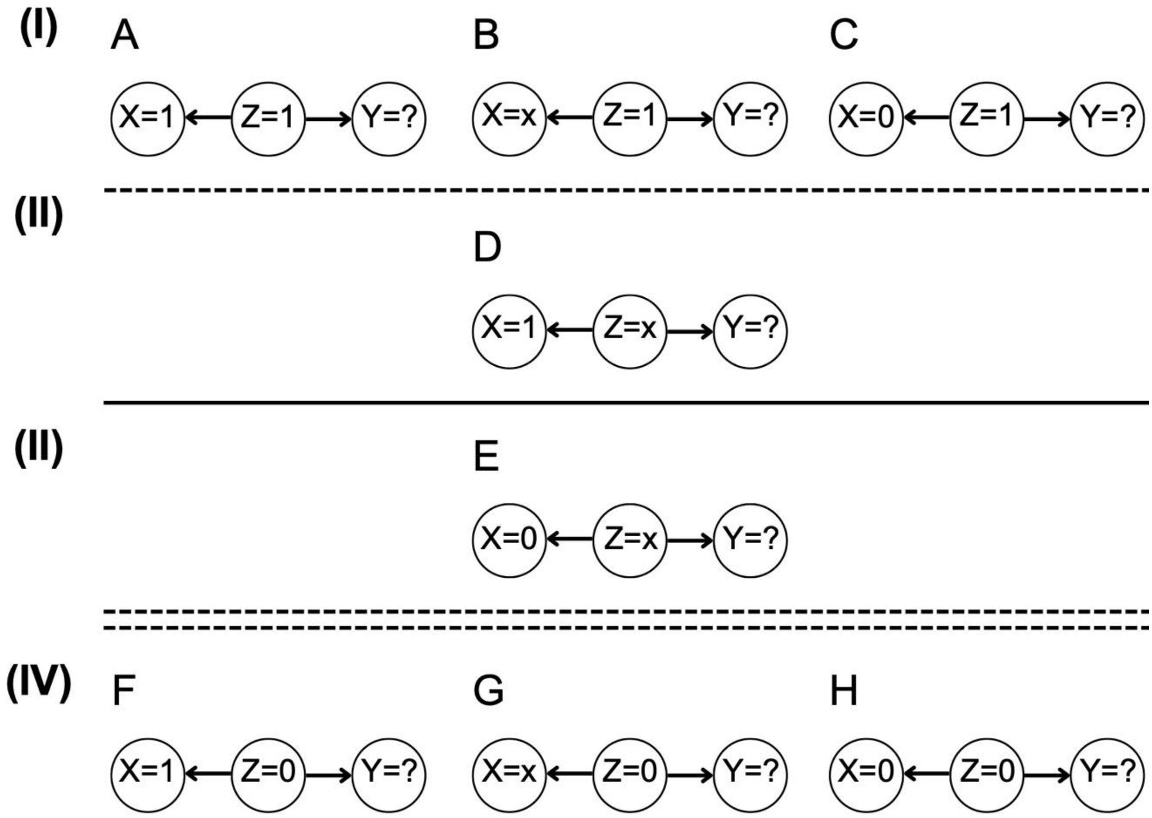
Note. Adapted from Rehder (2014).

Causal graphical models (CGMs) formalise the normative rules of causal reasoning, using nodes for variables and arrows for relations between these variables (Pearl, 2009). The causal Markov condition, as determined by CGMs, defines *conditional independence* between variables (Woodward, 2021). According to the causal Markov condition, in a common cause network of X←Z→Y, X and Y have no impact on each other as they are *screened off* by their direct cause Z. For instance, when we know that a person is smoking (Z), the likelihood of this person having lung cancer (X) becomes irrelevant to whether this person has yellow fingers or not (Y). Figure 4.2 presents this principle with eight causal cases for common cause network.

In Figure 4.2, cases within the same equivalence class provide equal support for Y. In Class I, because Z is present, knowing the state of X provides no additional support for determining the state of Y. In other words, Z *screens off* Y from X. In Class IV, Z is absent. Similarly, Z *screens off* Y from X, resulting in equal support for the state of Y. These classes demonstrate the causal Markov condition.

Figure 4.2

Equivalence classes for common cause network cases



Note. In this graph, X, Y, and Z are binary, meaning they can be present or absent. If a variable has a value of "1", this indicates that the variable is present, "0" indicates that the variable is absent, and "x" indicates that the variable is unknown. The variable Y is always unknown and needs to be predicted. The states of X and Z vary across cases. Adapted from Rehder (2014).

As we move from class I to IV, the support for Y weakens. Class I provides the strongest support for Y, in which Z is present, compared to Class II where Z is unknown, but X is present. However, the strength of causal relations plays a role. For instance, if the link between X and Z is *deterministically necessary* (meaning that cause and effect are always linked), the presence of Z is certain in Class II, making the probability of Y the same as in Class I. Therefore, Class I and II are considered a single class (the distinction is shown with a dashed line in Figure 4.2).

Class III provides weaker support for Y compared to Class II, as the absence of X weakens support for Y, suggesting the absence of Z, and therefore Y is also absent. Finally, Class IV provides the weakest support for Y because Z is absent. However, when the causal link between X and Z is *deterministically sufficient* (meaning that a cause is always presented with its effect), the absence of Z in situation D can be inferred with certainty, making the absence of Y as certain as in F, G, and H. Therefore, Class III and IV are considered a single class (the distinction is shown with a double dashed line in Figure 4.2).

Some studies of causal reasoning have used causal networks, employing both qualitative (e.g., Park & Sloman, 2013; Rehder, 2014; Rehder & Burnett, 2005) and quantitative approaches (e.g., Rehder, 2018; Rottman & Hastie, 2016). These studies consistently demonstrated that people often deviate from the normative rules of causal reasoning (Davis & Rehder, 2020; Kolvoort et al., 2022; Park & Sloman, 2013; Rehder, 2014, 2018; Rehder & Waldmann, 2017; Rottman & Hastie, 2016; for a review Rottman & Hastie, 2014). For instance, people tend to behave as if having yellow fingers (Y) remains relevant to the presence of lung cancer (X) above and beyond knowing whether the person is a smoker or non-smoker (Z).

4.2.2. Dual Process Theories

Several theories have been provided to explain why people might deviate from the normative rules of causal reasoning and whether reasoners share some common and distinct characteristics. Many of these have focussed on multiple possible routes to a given answer–employed by different people consistently or the same people under different circumstances.

To understand this better, two types of thinking processes have been suggested: ‘fast’ intuition and ‘slow’ deliberation (De Neys, 2018, 2022; Evans, 2008; Evans & Stanovich, 2013; but see, Grayot, 2020; Osman, 2004). Broadly, intuition is a fast, effortless, and automatic process, while deliberation is a slow, effortful, yet careful process (De Neys, 2018; Evans, 2008; but see, De Neys, 2021). Rehder (2014, Experiment 1) identified clusters of associative and causal reasoners, who reasoned similarly within their cluster but distinctly from the other cluster. Causal reasoners show a pattern that is more deliberative, by effectively considering the complex information of the normative rules of reasoning. Associative reasoners show a pattern that is more intuitive, by being influenced by information that appears relevant but in fact is not.

4.2.3. Reasoning in the Social and Non-Social Domains

A key distinction between the social and non-social domains is that while the former encompasses animate objects, the latter does not. Glick (1978) argued that, unlike non-social objects, social objects not only *react* but also *act*. Additionally, Gelman and Spelke (1981) suggested that when perceiving non-social objects, we focus on their physical properties, which are often determinate and accurate. On the other hand, when perceiving social objects, we focus on their behaviours and mental states, which are often indeterminate, making this domain more unpredictable. In a study exploring reasoning across domains, participants made faster and more accurate judgments in the social domain compared to the non-social (Mason et al., 2010). Additionally, Strickland, Silver, and Keil (2017) found that participants generated a higher number of causes for psychological events compared to physical ones. These findings suggest a distinction between these two domains in perception, potentially resulting in different reasoning strategies. This was shown by the results of the studies presented in Chapter II and III.

4.2.4. Reasoning in Relation to Autistic Traits

Higher levels of autistic traits have been linked to enhanced deliberation and diminished intuition, resulting in a more normative and consistent reasoning style (Brosnan et al., 2016, 2017; Brosnan & Ashwin, 2022; Levin et al., 2015; Morsanyi & Byrne, 2020; for a review, Rozenkrantz et al., 2021). The literature also demonstrates associations between higher autistic traits and an ability to avoid common reasoning biases, such as jumping to conclusion (Brosnan, Chapman, et al., 2014), the framing effect (De Martino et al., 2008), optimistic bias (Kuzmanovic et al., 2019), and the conjunction fallacy (Morsanyi et al., 2010). However, we do not yet know whether the associations between reasoning styles and autistic traits are consistent across domains and whether it extends to causal reasoning.

A key point here is related to the fact that autism has been associated with relative weaknesses in the social domain and relative strengths in the non-social domain. Broadly, the social domain requires an engagement in intuition, and non-autistic people often engage in this type of processing (Robic et al., 2015). On the other hand, the non-social domain might require an engagement in deliberation. It might be the case that autistic people face difficulties in certain types of information processing, specifically for the situations involved social communication and interaction, or that autistic people prefer engaging in intuition less. In both cases, understanding autistic people's reasoning style can help us understand more about core autistic difficulties characterised by diagnostic manuals (American Psychiatric Association, 2013). Exploring this with a sample from the general population can be a reasonable first step before translating this approach to a sample with autistic people.

4.2.5. Reasoning in Social versus Non-Social Domains in Relation to Autism

Besides autism is being characterised by difficulties in social communication and interaction, *the hyper-systemising view of autism* suggests that autistic people hold exceptional capacities in the non-social domain, particularly in reasoning about systems and causal relationships (Baron-Cohen, 2009; Baron-Cohen et al., 2003, 2009). In a study exploring autistic children's understanding of causation, autistic children outperformed the control groups, comprising typically developing children and children with Down syndrome, when sequencing images of scenarios about mechanical causation. However, this advantage was not observed for scenarios about behavioural causation or mental states (Baron-Cohen et al., 1986). Additionally, autistic children showed better performance than the control group in understanding how a Polaroid camera works, which was a test used as a mechanical equivalent of a mentalising test known as *the false-belief test* (Baron-Cohen et al., 1985). Furthermore, researchers suggested that autistic people engage in hyper-systemising due to its nature of predictability, which leaves no room for uncertainty. Hyper-systemising can also lead to excessive attention to details in autistic people (Baron-Cohen et al., 2009). In educational settings, autistic students may lag behind non-autistic students on tests and exams due to their processing of many details, which might be identified as slow processing by others (Baron-Cohen et al., 2009).

4.2.6. This Study

We adapted a task involving common cause network examples in economics and meteorology, as employed in previous research (e.g., Kolvoort et al., 2021; Rehder, 2014; Rottman & Hastie, 2016). We created a structurally equivalent social domain using social relationship examples. This study explored whether people violated normative causal reasoning rules and whether this was affected by the domain type, social versus non-social. Additionally, this study explored whether the degree of violation was associated with individual differences, such as self-reported thinking style and levels of autistic traits. Following Rehder (2014), we predicted that our participants would be clustered into two groups: causal reasoners and associative reasoners, with the latter demonstrating a greater number of violations of the Markov condition. Additionally, we predicted that causal reasoners would self-report higher levels of rationality and autistic traits compared to associative reasoners.

4.3. Method

See https://osf.io/vxktf/ for pre-registration. This project was conducted following the ethical guidelines of the British Psychological Society and was approved by the Science, Technology, Engineering, and Mathematics Ethical Review Committee at the University of Birmingham (ERN_09-719AP31).

4.3.1. Sample Size and Effect Size Calculations

The sample size was initially determined based on a previous data analysis plan. However, following data collection, the data analysis plan underwent a change due to relatively small number of participants giving enough normatively correct responses to pass the chance level. Nevertheless, the existing sample was still deemed adequate for two reasons. Firstly, Rehder (2014, Experiment 1) employed the same data analysis procedure and achieved statistically meaningful results using 2 x 5 analysis of variance (ANOVA) with 63 participants. Secondly, *a post-hoc* power analysis using G*Power (Faul et al., 2007) indicated that 76 participants would provide 99% power to detect a medium effect size (0.06) and 78% power to detect a small effect size (0.01) at $\alpha = 0.05$ for a 2 x 5 ANOVA. Regarding cluster analysis, Dalmaijer et al. (2022) suggested that for equal or similar-sized clusters, a total sample size of 40–60 with at least 20–30 observations in each cluster would be sufficient. In Rehder’s study (2014, Experiment 1), this analysis was conducted with 63 participants. Assuming a similar distribution of participants across clusters, we expected cluster analysis to be an appropriate approach to analyse our data.

4.3.2. Sample

We recruited 76 participants, consisting of 59 females (77.6% of the sample), 13 males (17.1%), and three who identified as other/non-binary (3.9%). One participant chose not to disclose their gender identity. All participants were 18 years of age or older (M_{age} = 19.87, SD_{age} = 2.63, [18 – 32]). All participants were students at the University of Birmingham, based in the United Kingdom, and were fluent in English. Most participants were enrolled in the Psychology program (*N* = 72, 94.7%). Participants identified with a range of ethnicities, with a plurality identifying as White (*N* = 35, 46.1%; see Appendix 17 for full ethnicity information). Participants were recruited through a web-based research participant recruitment scheme at the same university. No specific inclusion or exclusion criteria were applied regarding clinical diagnosis.

4.3.3. Materials

The Adult Autism-Spectrum Quotient (AQ; Baron-Cohen et al., 2001). This measure was used in the exact same way as in previous experiments presented in previous chapters. The AQ is a 50-item self-report questionnaire, measuring the levels of autistic traits in adults (≥ 16 years of age) with average or higher levels of intelligence. This questionnaire is scored on a four-point scale with response options of "definitely agree", "slightly agree", "slightly disagree", and "definitely disagree". Statements in the direction of autistic traits are scored as 1, while statements in the opposite direction are scored as 0. There is no distinction between responses of "definitely agree" and "slightly agree" or between "slightly disagree" and "definitely disagree" in scoring. Total scores range from 0 to 50, with higher scores indicating higher levels of autistic traits. The AQ is widely used in both clinical and non-clinical samples, showing strong internal consistency ($\alpha \geq 0.7$) and test-retest reliability (REI; Epstein et al., 1996).

The Rational-Experiential Inventory (REI; Epstein et al., 1996). The REI is a 40-item self-report questionnaire, measuring perception of ability and engagement in thinking style. The REI includes four components: rational ability, rational engagement, experiential ability, and experiential engagement. Each component comprises 10 items. For this study, participants receive two scores: 'rationality' (sum of rational ability and rational engagement) and 'experientiality' (sum of experiential ability and experiential engagement). The rationality sub-scale measures the level of deliberation, while the experientiality sub-scale measures the level of intuition. The REI is scored on a five-point scale, with options ranging from "1 – definitely not true of myself" to "5 – definitely true of myself". Each sub-scale ranges from a minimum score of 20 to a maximum of 100. The REI shows strong internal consistency (rationality, α = 0.90; experientiality, α = 0.87) and test-retest reliability, with correlations ranging between 0.86 and 0.91 for rationality and between 0.87 and 0.90 for experientiality (Pacini & Epstein, 1999). In this study, this measure is used to examine whether people's objective reasoning performance aligns with their subjective perception of thinking style. We anticipated that people who self-score higher on the rationality sub-scale to reason more normatively, while those who self-score higher on the experientiality sub-scale to reason less normatively.

Binary Inference Test (BIT; adapted from Rehder, 2014). The BIT consisted of three binary variables, forming common cause networks within the domains of social and non-social reasoning. For the non-social domain, the causal scenarios of economics and meteorology were directly taken from Rehder's (2014) study. See Table 4.1 for an example causal relationship of economics. The social domain was created with two social relationship scenarios in the same structure. See Table 4.2 for an example causal relationship of Social Relationship–1. see Appendix 18 for all variables for each domain. See Appendix 19 for causal scenarios with diagrams and items of the BIT. The BIT covers 20 pairs of situations for each scenario, with five choice problems repeating for each variable (X and Y), and their order reversed. The choice problems in this test are A vs. B, B vs. C, D vs. E, F vs. G, and G vs. H, adhering to the causal Markov condition. Participants were asked to indicate the likelihood of one of the variables (X or Y) being present in a pair of situations. The response options were 1 for the first situation, 2 for the second situation, and 3 for the "equally likely" response. Participants were supposed to choose "equally likely" option if they think the likelihood of situations having the particular variable present is equal. Participants' choices were recorded to measure the degree of violation of the normative rules of causal reasoning.

Table 4.1

Example causal relationship as economics

Causal relationship	Causal mechanism
Low interest rates → Small trade deficits	Low interest rates cause small trade deficits. The low cost of borrowing money leads businesses to invest in the latest manufacturing technologies, and the resulting low-cost products are exported around the world.
Low interest rates → High retirement savings	Low interest rates cause high retirement savings. Low interest rates stimulate economic growth, leading to greater prosperity overall, and allowing more money to be saved for retirement in particular.

Note. Taken from Rehder (2014) with Rehder's permission.

Table 4.2

Example causal relationship as Social Relationship–1

Causal relationship	Causal mechanism
Alex's high work pattern → Bernadette's high music practice	When Alex is working lots, Bernadette and Alex don't see very much of each other. When this happens, Bernadette spends lots of time playing her violin.
Alex's high work pattern → Bernadette's low happiness	Alex hates his job. When Alex is working lots, he can become irritable quite quickly and so he's harder to get along with. This makes Bernadette feel less happy.

4.3.4. Procedure

Data collection started on 18 February 2022 and ended on 13 October 2022. This study involved both remote and in-person parts. Participants received an information sheet and provided informed consent to participate.

The remote part took approximately 30 minutes and was completed in participants' own time using the Qualtrics online survey platform (https://www.qualtrics.com/uk/). During the remote part, participants first filled out a COVID-19 pre-checklist to determine their eligibility for the in-person testing on the following day due to health and safety concerns. After passing the pre-checklist, participants proceeded to complete a demographics form, a consent form, and two self-report questionnaires: the AQ and REI. Participants who did not pass the pre-checklist were informed that they could attempt to resubmit the pre-checklist in 14 days. Those who completed the remote part met with one of the available researchers (either EB or RM, both of whom are female) outside the university building. Another COVID-19 pre-screening was administered to ensure participants could safely enter the university building. Participants who passed the pre-screening were permitted to enter the building to complete the in-person part in a computer cubicle.

The in-person part involved completing the BIT, a computer-based reasoning task, which was designed on E-Prime 3.0. This part took up to one hour to complete. Participants were pseudo-randomly assigned to one of the four versions of the experiment. The versions were created to have the domain and scenario orders counterbalanced across participants. Prior to the computer task, participants received brief verbal instructions from the researcher and had the instructions displayed on the computer screen. The task involved studied specific causal mechanisms with three binary variables which formed common cause networks: one mechanism for economics (see Table 4.1 for an example) and one mechanism for meteorology as the non-social domain, and two mechanisms for social relationships (see Table 4.2 for an example) as the social domain. Participants were presented with a diagram on the computer screen for each causal mechanism. Throughout the study, participants also had printed diagrams for each causal mechanism in front of them and were told that they could use them however they liked. Following the study phase, participants took a forced-choice pre-test in a multiple-choice format to assess their understanding (See Appendix 18 for the multiple-choice tests for each causal mechanism). The multiple-choice test consisted of eight questions, each presented with five options. Participants used the keyboard keys (1, 2, 3, 4, or 5) to provide their answers. There was no time limit. To proceed to the main task, participants had to complete the multiple-choice test without any errors. They received feedback after each question indicating whether their response was correct or incorrect. If an error was made, they had to review the causal mechanism and retake the multiple-choice test. Once the multiple-choice test was completed without errors, participants proceeded to the main task.

In the main task, participants were presented with pairs of situations and were asked to determine which situation was more likely to have a specific value. They were required to make a choice between these two situations or select the "equally likely" option to indicate that the likelihood of the situations to have the specified value was the same. The task followed a forced-choice design with no time limit. Each question appeared at the top of the screen, with two situations stacked vertically, followed by the "equally likely" option. The options were labelled as 1, 2, and 3. The question, situations, and options remained on the screen until the participant provided a response using the keyboard keys (1, 2, 3). The task included five choice problems: A vs. B, B vs. C, D vs. E, F vs. G, and G vs. H. Participants needed to choose D over E for the D vs. E choice problem and select "equally likely" for other choice problems. For instance, in a choice problem asking which situation is more likely to have 'high retirement savings', participants could be presented with option–1: "Low interested rates", "Small trade deficits", and "???", and option–2: "Low interest rates", "???", and "???", and option–3: "equally likely". Here, "???" indicated that the value of this variable was unknown. The five choice problems were repeated twice, with the values X and Y changing. For instance, the question was sometimes asking about retirement savings and sometimes about trade deficits. Each of the ten problems was presented in reverse order. For instance, A vs. B was also presented as B vs. A. In total, participants completed 80 choice problems, with 20 problems for each scenario, which were randomised. See Appendices for the choice problems for each causal mechanism. The domain order (social and non-social domains) and scenario order within domains (economics and meteorology for the social domain, and social relationship–1 and social relationship–2 for the non-social domain) were counterbalanced across participants.

Participants received course credits as compensation and were provided with a debrief form at the end of the study.

4.3.5. Data Analysis

We used SPSS 29 for all statistical analyses and α at 0.05 for significance. Following Rehder's (2014) approach, participants' responses for BIT were summarised into a *single choice score*. Choices in favour of the first alternative (e.g., A in A vs. B) were coded as 1, choices in favour of the second alternative (e.g., B in A vs. B) were coded as 0, and the "equally likely" choices were coded as 0.5.

The domains within the main task (BIT) included different scenario types. For instance, the non-social domain covered *economy and meteorology* as particular scenarios. Before the main analysis, to check whether participants' choices were affected by the scenario type within each domain, we ran two 2 x 5 ANOVAs for the social and non-social domains separately, using participants' choices as the dependent variable (DV). For the non-social domain, we ran a 2 x 5 ANOVA with within-subjects factors of scenario type (Economics, Meteorology) and problem type (A vs. B, B vs. C, D vs. E, F vs. G, G vs. H). For the social domain, we ran a 2 x 5 ANOVA with within-subjects factors of scenario type (Social relationship–1, Social relationship–2) and problem type (A vs. B, B vs. C, D vs. E, F vs. G, G vs. H).

Then, we first ran a mixed 2 x 2 x 5 ANOVA with within-subjects factors of domain type (Social, Non-social), problem type (A vs. B, B vs. C, D vs. E, F vs. G, G vs. H), and between-subjects factor of domain order (Social Domain First, Non-social Domain First) to check whether participants' choices were affected by the domain order. For the main analysis, we ran a 2 x 5 ANOVA with within-subjects factors of domain type (Social, Non-social) and problem type (A vs. B, B vs. C, D vs. E, F vs. G, G vs. H), using participants' choices as the DV.

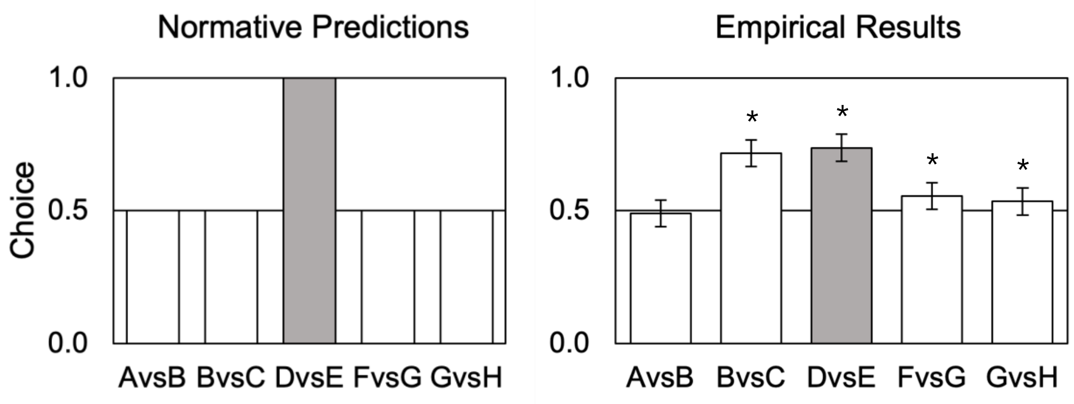
Next, following Rehder's (2014) approach, we ran a two-step cluster analysis on participants' choices to identify sub-groups reflecting individual differences after transforming the data for normal distribution, using Log10 transformation. This analysis aimed to evaluate whether participants' choices were demonstrated by all participants or resulted by averaging over participants with different patterns. We ran two-tailed independent samples *t*-tests to compare AQ and REI scores between clusters. Outliers on the AQ were removed for this comparison. Finally, we ran cluster comparisons across the social and non-social domains using independent samples *t*-test.

4.4. Results

Following Rehder's (2014) approach, participants' responses for BIT were summarised into a *single choice score*. Choices in favour of the first alternative (e.g., A in A vs. B) were coded as 1, choices in favour of the second alternative (e.g., B in A vs. B) were coded as 0, and the "equally likely" choices were coded as 0.5. See Figure 4.3 for participants' choice scores from BIT. See Table 4.3 for the proportions of participants' choices separately for each response (e.g., "A", "B", and "equally likely" responses for "A vs. B") for each choice problem from BIT.

Figure 4.3

The comparison of normative predictions and participants' choice scores



Note. Normative predictions are shown on the left side and participants' choice scores are shown on the right side. Independent choice problems are shown with white bars, and dependent choice problems are shown with grey bars. Errors bars show standard error of the mean. Statistical significance is shown with an asterisk.

Table 4.3

Results of participants' choices

Choice problem	Choice
A vs. B	
A	0.22
Equally likely	**0.54**
B	0.24
B vs. C	
B	0.49
Equally likely	**0.45**
C	0.06
D vs. E	
D	**0.53**
Equally likely	0.41
E	0.06
F vs. G	
F	0.18
Equally likely	**0.75**
G	0.07
G vs. H	
G	0.13
Equally likely	**0.81**
H	0.06

Note. Normative choices are in bold.

4.4.1. Causal Reasoning Performance

The pattern of participants' responses was consistent with having followed normative rules of causal reasoning in some situations, especially when the state of Z was absent. The choice scores for the problems of F vs. G and G vs. H were 0.55 and 0.53, respectively. Additionally, for the dependent choice problem, participants avoided the "equally likely" response in D vs. E more often, scoring 0.74. Their score was significantly different from 0.50 ($t(75) = 11.65$, $p < 0.001$, $d = 1.34$, two-tailed), indicating that participants were willing to make indirect inferences. When the state of Z was unknown, they tended to indirectly infer X from Y or Y from X.

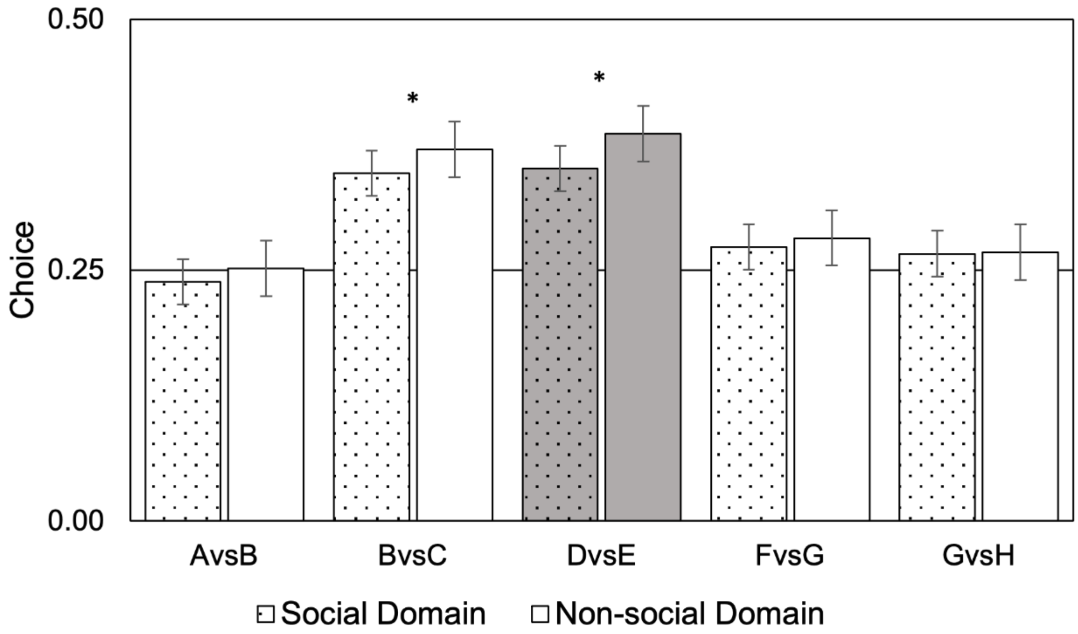
Participants violated the independence rule for the independent choice problems. For the independent choice problems (A vs. B, B vs. C, F vs. G, and G vs. H) the average score was 0.57, which was significantly different from 0.50, as a comparison with chance ($t(75) = 6.75$, $p < 0.001$, $d = 0.77$, two-tailed). This indicates that participants responded as if the presence of one variable made the other variable more likely to be present even though they were supposed to be *screened off* from each other, because the state of Z was known. Participants scored significantly lower on these problems compared to D vs. E ($t(75) = 8.21$, $p < 0.001$, $d = 0.94$, two-tailed), indicating that participants showed some sensitivity to the difference between independence and dependence. However, participants still responded "equally likely" to the dependent choice problem (D vs. E) almost as frequently as they responded "equally likely" to independent choice problem of B vs. C. This was unexpected and resulted many students failing to pass chance level which was included in a previous data analysis approach (see Appendix 20a and 20b for details).

Participants' choices were not affected by the scenario type within each domain and by the domain order of Social and Non-social Domains (see Appendix 21 for details). Therefore, we proceeded with the main analysis. The results from a 2 x 5 ANOVA revealed a significant effect of domain type ($F(1, 75) = 8.32$, $p = 0.005$, $\eta_p^2 = 0.10$), with participants scoring higher for the Non-social Domain ($M = 2.49$, $SEM = 0.05$) compared to the Social Domain ($M = 2.36$, $SEM = 0.05$). We also found a significant effect of problem type ($F(1, 75) = 40.43$, $p < 0.001$, $\eta_p^2 = 0.35$; see Appendix 22 for details). However, we did not find a significant interaction between domain type and problem type ($F(1, 75) = 1.87$, $p = 0.115$, $\eta_p^2 = 0.02$).

We conducted paired-samples *t*-tests between participants' choice scores for the Non-social and Social Domains for each problem type. The scores for the problem types of B vs. C ($M_{diff} = 0.19$, $SEM_{diff} = 0.08$; $t(75) = 2.27$, $p = 0.026$, $d = 0.26$, two-tailed) and D vs. E ($M_{diff} = 0.28$, $SEM_{diff} = 0.09$; $t(75) = 2.95$, $p = 0.004$, $d = 0.34$, two-tailed) significantly differed between the domains, with participants scoring higher for the Non-social Domain for both. See Figure 4.4.

Figure 4.4

Participants' choice scores across domains for each problem type



Note. Patterned bars show participants' choice scores for the Social Domain, and non-patterned bars show participants' choice scores for the Non-social Domain. Independent choice problems are shown with white bars, and dependent choice problems are shown with grey bars. Errors bars are show standard errors. Statistical significance is shown with an asterisk.

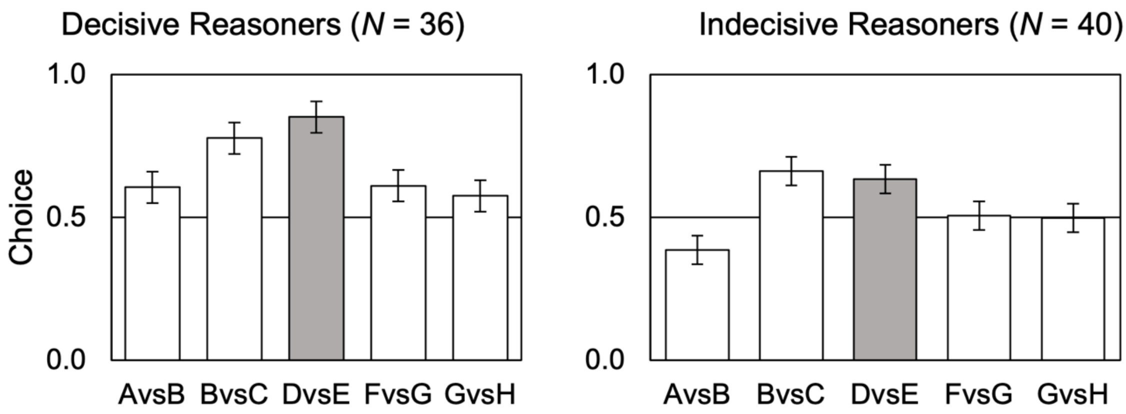
4.4.2. Individual Differences

Following Rehder's (2014) approach, participants were clustered into sub-groups based on their performance on the causal reasoning task. The Two-Step Cluster Analysis revealed two sub-groups. The first cluster consisted of 36 participants (47.4% of the sample, see left side of Figure 4.5). These participants tended to choose the alternative option when more causally related variables were presented. The second cluster consisted of 40 participants (52.6% of the sample, see right side of Figure 4.5). These participants showed less violation of the normative rules for independent choice problems, as they chose the correct "equally likely" option in 68.98% of independent choice problems, in comparison to 57.60% for the other cluster.

However, this cluster showed more violation for the dependent choice problem (choice score for D vs. E was 0.63), compared to the other cluster (choice score for D vs. E was 0.85). For labelling the clusters, we did not follow Rehder's (2014) approach, who used "causal reasoners" and "associative reasoners" as labels for their clusters. Since this distinction was not clear for our clusters, we decided to label them as "decisive reasoners" and "indecisive reasoners" instead.

Figure 4.5

Participants' choices as clusters of decisive and indecisive reasoners



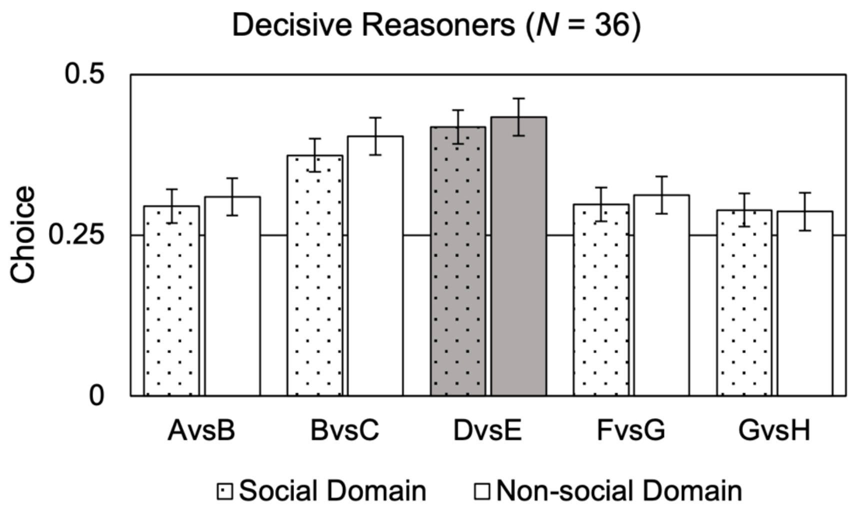
Note. Independent choice problems are shown with white bars, and dependent choice problems are shown with grey bars. Errors bars show standard errors.

All participants completed the Adult Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001) to self-report their levels of autistic traits (*M* = 19.96, *SD* = 6.95, [4 – 42]). All participants also completed the Rational-Experiential Inventory (REI; Epstein et al., 1996) to self-report their engagement and ability in rationality (*M* = 69.80, *SD* = 10.19, [47 – 92]) and experientiality (*M* = 66.62, *SD* = 10.96, [22 – 86]). Contrary to our hypothesis, the independent-samples *t*-test revealed no significant difference between the decisive and indecisive reasoners based on their self-reported levels of autistic traits ($t(72) = 1.60$, $p = 0.115$, $d = 0.37$, two-tailed). Furthermore, we did not identify significant differences between the clusters based on self-reported experientiality ($t(74) = 0.91$, $p = 0.368$, $d = 0.21$, two-tailed) and rationality ($t(74) = 0.72$, $p = 0.476$, $d = 0.16$, two-tailed).

Both clusters responded significantly differently for the dependent choice problem compared to the independent choice problems, suggesting that they showed sensitivity to the dependency of choice problems. The indecisive reasoners responded significantly higher for the dependent problem ($M = 2.54$, $SEM = 0.09$) compared to the independent problems ($M = 2.05$, $SEM = 0.02$; $t(39) = -5.33$, $p < 0.001$, $d = -0.84$, two-tailed). Similarly, the decisive reasoners responded significantly higher for the dependent choice problem ($M = 3.41$, $SEM = 0.09$) compared to the independent choice problems ($M = 2.57$, $SEM = 0.07$; $t(35) = 6.54$, $p < 0.001$, $d = 1.09$, two-tailed). The indecisive reasoners responded significantly higher for the Non-social Domain ($M = 2.22$, $SEM = 0.03$) compared to the Social Domain ($M = 2.08$, $SEM = 0.03$; $t(39) = 3.10$, $p = 0.004$, $d = 0.49$, two-tailed). In contrast, the responses between the Non-social Domain ($M = 2.79$, $SEM = 0.06$) and Social Domain ($M = 2.68$, $SEM = 0.07$) did not significantly differ for the decisive reasoners ($t(35) = 1.40$, $p = 0.169$, $d = 0.23$, two-tailed). See Figure 4.6a for the decisive and 4.6b for the indecisive reasoners.

Figure 4.6a

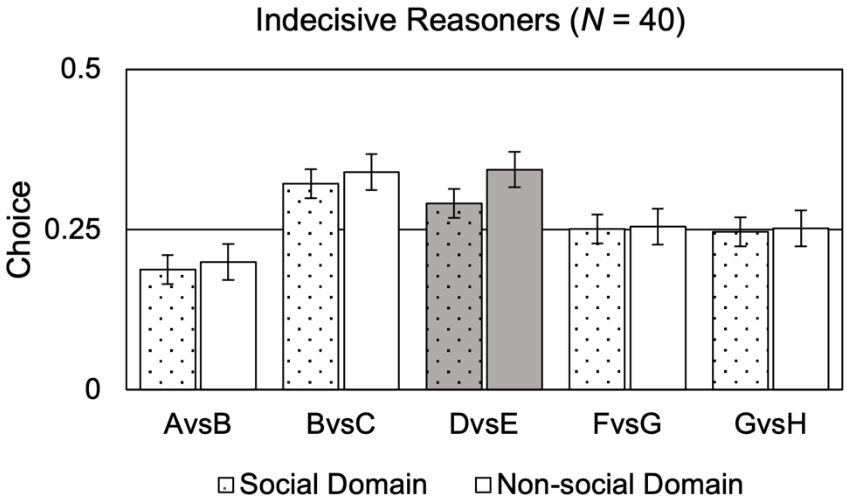
Decisive reasoners' choice scores across domains for each problem type



Note. Patterned bars show participants' choice scores for the Social Domain, and non-patterned bars show the Non-social Domain. Independent choice problems are shown with white bars, and dependent choice problems are shown with grey bars. Errors bars show standard errors.

Figure 4.6b

Indecisive reasoners' choice scores across domains for each problem type



Note. Patterned bars show participants' choice scores for the Social Domain, and non-patterned bars show the Non-social Domain. Independent choice problems are shown with white bars, and dependent choice problems are shown with grey bars. Errors bars show standard errors.

4.5. Discussion

Consistent with the literature (Davis & Rehder, 2020; Kolvoort et al., 2022; Park & Sloman, 2013; Rehder, 2014, 2018; Rehder & Waldmann, 2017; Rottman & Hastie, 2016; for a review Rottman & Hastie, 2014), participants regularly violated the normative rules of causal reasoning. We observed different reasoning strategies across domains. In the social domain, participants violated the Markov condition less, but they also failed to correctly use the causal information given to them. In terms of individual differences, contrary to our hypotheses, we did not observe significant differences between reasoners in their self-reported levels of autistic traits and thinking styles. We also did not identify clear distinction between clusters based on reasoning more causally or associatively. Therefore, we were not able to test our hypotheses stating statistical differences based on self-reported levels of autistic traits and thinking styles between causal and associative reasoners. However, we did report these differences between clusters of decisive and indecisive reasoners.

4.5.1. Replication of Previous Findings

For the dependent choice problem (D vs. E), participants responded correctly 53% of the time, choosing D over E. However, most of the time, they responded incorrectly for this choice problem, by mostly choosing "equally likely" option. Participants chose the correct D answer %53 of the time, and this was lower than Rehder's (2014) participants' score (which was 67%). For the independent choice problems (A vs. B, B vs. C, F vs. G, and G vs. H), they responded correctly 64% of the time, choosing "equally likely". This is consistent with Rehder (2014) who showed that participants honoured the independence of the variables in two-thirds of the trials.

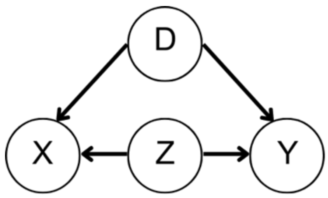
Specifically, participants provided the highest accuracy when the cause was absent (Z = 0, in F vs. G and G vs. H). However, when the cause was present (Z = 1, in A vs. B and B vs. C), they seemed to engage in associative reasoning by not choosing the correct "equally likely" response as much. These findings are also in line with Rehder (2014) who found a more normative reasoning strategy when the state of the cause was absent compared to present. This could be explained by *ambiguity aversion* (Camerer & Weber, 1992), stating that participants tend to choose an option, which was most of the time "equally likely" option, when they feel ignorant under high uncertainty.

Alongside resulting in a highly similar pattern of choices to Rehder (2014), our participants violated the normative rules more often for A vs. B and B vs. C, by choosing the B option more for both. This was an unexpected result, particularly for A vs. B, since although the correct answer was “equally likely”, A provides more information than B. This remains as an open question to follow up in future studies.

Some theories have been suggested to explain why people might violate the normative rules of causal reasoning. For instance, *the leaky gate model* proposes that information non-normatively flows across the causal network’s nodes (Rehder, 2018). Rehder (2014) also suggested that people reason associatively by assuming a *shared disabler* (see Figure 4.7). Disablers refer to causes that might prevent the event from occurring (Strickland et al., 2017). This is in line with our results, showing a larger violation when Z was present versus absent.

Figure 4.7

Shared disabler for a common cause network



Note. Adapted from Rehder (2014).

The violations might also occur due to participants not fully accepting what is provided by the experimenter and adding additional events (variables, nodes), and causal relations to the causal networks (Park & Sloman, 2013; Rehder, 2014; Rehder & Burnett, 2005; Rottman & Hastie, 2016). Furthermore, time, motivation, and sampling have been suggested as natural reasons for violations (Rehder, 2014). The motivation of our sample might not be a willingness to engage in analytical reasoning, but rather to quickly complete the study to gain course credits. However, it is important to note that Rehder (2014) showed that violations sometimes arise even when participants are told to engage in deliberative and careful reasoning.

4.5.2. Domain-specific Causal Reasoning

In the non-social domain, participants responded more accurately for the dependent choice problem (D vs. E), by choosing the correct D response significantly more often compared to the social domain. For the independent choice problems (A vs. B, B vs. C, F vs. G, and G vs. H), participants responded more accurately in the social domain by choosing the "equally likely" option more often compared to the non-social domain. However, this might be due to default responding, with the idea that all the problems require an "equally likely" response, which might show less decisiveness for the social scenarios. Gelman and Spelke (1981) proposed that when perceiving social objects, we tend to consider behaviours and mental states, which are often indeterminate, suggesting the social domain to be more unpredictable compared to non-social. Additionally, in Strickland et al. (2017), participants generated a higher number of causes for psychological events compared to physical events. This might be explained by generating alternative responses for the social scenarios and not using the information provided by the experimenter.

4.5.3. Individual differences

We found two clusters of participants, which we labelled as decisive and indecisive reasoners. The indecisive reasoners showed higher consistency by choosing the "equally likely" response across choice problems, compared to decisive reasoners. However, this pattern showed being less confident and more indecisiveness and choosing "equally likely" option as a result. In their study, Rehder (2014) found that associative reasoners committed more violations compared to causal reasoners, however, causal reasoners also committed a significant number of violations.

It was difficult for us to label our clusters as associative and causal reasoners, because in Rehder's (2014) study, both clusters still tended to choose the correct D option over E and "equally likely" options. However, in our study, the biggest difference between our clusters was that one cluster scored high on all choice problems, labelled as decisive reasoners, while the other cluster scored low on all choice problems, labelled as indecisive reasoners. Previous studies have shown high variability in participants' responses (e.g., Rehder, 2014, 2018; Rottman and Hastie, 2016), along wide significant violations by even more veridical reasoners. Our results are consistent with these findings.

Moreover, indecisive reasoners differed in their reasoning strategy significantly across social and non-social domains, whereas decisive reasoners followed a similar strategy across these domains, showing more consistency. Kolvoort et al. (2021) showed that there is variability in causal reasoning within participants, and higher variability predicts larger violations of normative rules. This is in line with the literature showing that the normative rules suggested by CGMs do not accurately reflect how people causally reason (Rehder, 2014; Rottman & Hastie, 2016). Future studies can identify whether associative or indecisive reasoners tend to show higher variability in their responses compared to causal or decisive reasoners.

Exploring individual differences in relation to causal reasoning has often been neglected, given that even the most influential papers in this area often do not report demographic specifics about their samples, such as age, gender, and ethnicity. It has been suggested that higher violation of the normative rules might be associated with a lower tendency of engagement in deliberative thinking style (Trueblood et al., 2017). Contrarily, our clusters did not differ in their self-reported rationality, indicative of deliberation, and experientiality, indicative of intuition.

Contrary to our hypothesis, participants' levels of autistic traits were not different between clusters. To our knowledge, this is the first study evaluating causal reasoning, by using specific causal mechanisms, such as common cause network, in relation to autistic traits. Although we cannot conclude that autistic traits are linked or unlinked to a more normative causal reasoning, it is important to note that the reasoning differences between autistic and non-autistic people or between people with higher and lower autistic traits might be subtler or might be due to a different characteristic that autistic or people with higher level of autistic traits share. There is growing evidence struggling to replicate previous findings on reasoning differences between these groups, suggesting these differences might not exist or might exist in a subtler way (Morsanyi & Hamilton, 2023; Taylor et al., 2022).

4.5.4. Limitations

Our experiment is limited to only one type of causal network, which is the common cause network. Future studies can use other widely used causal networks, such as common effect ($X \rightarrow Z \leftarrow Y$) and chain ($X \rightarrow Z \rightarrow Y$), to study causal reasoning across domains in relation to individual differences. Additionally, the variables in our experiment have a binary nature (occur or present versus does not occur or absent). However, in real life, often causation links to a continuous or interval concept of cause-and-effect, such as temperature or back pain intensity (Rottman & Hastie, 2016). The *uncertainty model* proposes that the reason for participants committing violations might be due to their disbelief in perfect observations of the variables presented in a binary nature (Rehder & Burnett, 2005). Nonetheless, it is important to note that Rottman and Hastie (2016) found that participants violated the Markov condition at the same level for binary and numerical variables.

Although we carefully counterbalanced the domain order across participants, our participants made judgments on single directions for each scenario. For instance, for economics, they learned that ‘low interest rates cause small trade deficits’ and ‘low interest rates cause high retirement savings’. Prior knowledge has been controlled in previous studies to prevent participants importing their own knowledge, by using abstract or unfamiliar materials (Rehder & Burnett, 2005; Rehder, 2014) or counterbalancing the materials (Rehder, 2014, 2018; Rottman & Hastie, 2016). We did test our participants’ knowledge on causal mechanisms that have studied before moving to the main task.

Finally, our sample might be biased given it is female-dominant and mostly students enrolled in higher education. Future studies can recruit a diverse sample, while considering individual differences. It is also important to note that our results from a general population cannot be generalised to autism (Sasson & Bottema-Beutel, 2021). Future studies can recruit autistic and non-autistic people for a between-group comparison.

4.5.5. Conclusion

We replicated that people often violate the normative rules of causal reasoning. Our study revealed a distinction in reasoning strategies across domains, with higher accuracy for the dependent choice problem in the non-social domain and for the independent choice problems in the social domain. Contrary to our hypotheses, we did not identify significant differences between clusters of reasoners in their self-reported levels of autistic traits and thinking styles. As neither the normative rules of causal reasoning nor the previously proposed theories fully explain people’s responses to causal reasoning tasks (Rottman & Hastie, 2016), it appears that people exhibit irrationality, but in different ways that might be linked to their individual differences. Therefore, theories of reasoning should consider individual differences, such as age, gender, education level, thinking style, and psychological and psychiatric history of the reasoner (Bortoletti, 2014).

Chapter V

General Discussion

5.1. Overview

Three experimental chapters focused on reasoning and decision-making tendencies across social and non-social domains in relation to autism and autistic traits. In this final chapter, I will summarise the findings from the four experiments presented in the previous chapters and discuss how these experiments relate to each other and to existing literature. The results will be presented separately for moral and causal judgments and autism and autistic traits. I will highlight some limitations of these experiments, give suggestions for future studies to overcome these limitations, and conclude.

5.2. Summary of the Research

The aim of this thesis was to explore reasoning and decision-making tendencies across social and non-social domains in relation to autism and autistic traits. Experiments were designed using scenario-based tasks in comparison paradigms for social and non-social domains focusing particularly on moral reasoning and causal reasoning. While Experiments 1 and 2 (Chapter II), and Experiment 4 (Chapter IV) recruited participants from the general population and measured levels of self-reported autistic traits, Experiment 3 recruited autistic and well-matched non-autistic participants for a between group comparison. Levels of autistic traits were measured using the Autism Quotient, which is widely used for adult populations of clinical and non-clinical samples. Experiment 1 recorded forced-choice moral judgments, while Experiment 2 also recorded written justifications for forced-choice moral judgments. Experiment 3 and 4 employed a subjective measure of thinking styles, the Rational-Experiential Inventory. Experiment 3 also employed the recently updated version of an objective measure of reasoning style, the Cognitive Reflection Test.

The studies in this thesis make several contributions to the field. First, these studies systematically compare social and non-social domains for reasoning and decision-making tendencies, which was one of the future research suggestions from previous papers with a focus on the Dual Process Theory of autism (e.g., Brosnan, Chapman, et al., 2014; Brosnan & Ashwin, 2022b). Second, these studies present two extended versions of novel scenario-based tasks that enable systematic comparison, which can be used in future research. Third, these studies present subtle or no differences between autistic and matched non-autistic participants in deliberative reasoning and did not identify any strong correlations between higher autistic traits and deliberative reasoning. With these results, this research extends and contributes to the Dual Process Theory of autism, highlighting caution for confident conclusions and need for further exploration. Fourth, this is the first research to systematically explore causal reasoning in relation to autistic traits, yet, highlighting another area that needs further research.

5.2.1. Reasoning in the Social and Non-social Domains

All experimental chapters presented experiments where tasks with both social and non-social domains were employed. The items presented in the social domain included people and relationships, while the non-social domain included inanimate objects, such as cars, toys and trade deficits. Participants provided moral and causal judgments and justifications across these two domains. For Chapters II and III, participants provided forced-choice judgments for a moral reasoning task. They also provided written justifications for their judgments for Experiment 2 in Chapter II. For Chapter IV, participants provided forced-choice judgments for a causal reasoning task across social and non-social domains.

5.2.1.1. Participants Treated the Social and Non-social Domains Differently

For all experiments, we found an effect of domain type, consistently showing that participants treated these two domains differently. In terms of forced-choice responses, for experiments with moral reasoning, we found that participants relied more on behaviour-based information when making judgments on objects as being better or worse, reflecting a more consistent approach across scenarios, compared to social scenario comparisons. For experiments with causal reasoning, we found that participants provided more normative responses for the dependent choice problem in the non-social domain, while responding more normatively for the independent choice problems in the social domain. Seemingly, participants generated alternative causes more for the social scenarios compared to the non-social ones (leading to responding "equally likely"), suggesting a more associative reasoning style for this domain. Together, findings from all experiments suggested a more deliberative, consistent, and decisive reasoning pattern for the non-social domain, compared to the social domain.

Although written justifications were broadly in line with forced-choice responses, an interesting pattern was observed. Participants provided more justifications that references only character-based information for the social domain, and a combination of both character- and behaviour-based justifications for the non-social domain. This pattern together suggested that, for the non-social domain, participants relied on the actions of the objects when making decisions, while mentioning both the features and actions of the objects to justify their reasoning. On the other hand, participants relied more on both characteristics and behaviours of a child but relied heavily on the characteristics of the child to justify their reasoning.

Experiment 1 in Chapter II and Experiment 3 in Chapter III followed a similar procedure for completion of the moral reasoning task. In these experiments, this task was completed over a video call. However, in Experiment 2 in Chapter II, I followed a different procedure. I used an online platform, Qualtrics, for completion of the task with written justifications. Therefore, it is important to keep in mind that while Experiment 1 and 3 can be seen as socially interactive tasks, Experiment 2 was solely completed in participants' own time, at a place of their preference with no interaction with any researcher.

Contrary to traditional beliefs, which typically state that cognition is a unified process, suggesting a more domain-general and parallel reasoning process across social and non-social domains (Piaget, 1963), later studies have shown that people do engage in different thinking styles across these domains, suggesting more domain-specific processes (Gelman & Spelke, 1981; Glick, 1978; Shultz, 1982). These domains share some similarities, yet present differences. Shultz (1982) argued that reasoning about any event, we rely on the notion that causes produce their effects. However, these two domains have crucial differences. For instance, for social causal reasoning, we attribute the causes of social events to the intentions and actions of social agents. On the other hand, in non-social causal reasoning, causes are often seen as physical forces or interactions between objects (Shultz, 1982).

Moreover, social phenomena are more complicated than non-social. Social interaction involves emotional expression, empathy, and personal experience. Galotti et al. (1990) showed that people generate *superior* reasoning for the causes of social events, compared to non-social events. People's explanations about the causes of social events were more thoughtful and less stereotypical by providing explanations that were higher in flexibility, originality, elaboration, and lower in systematicity compared to non-social events. Further considered, Galotti et al. (1990) found that it was only the elaboration, providing more detailed explanations, which significantly differed between domains. Taken together, there is strong support for suggesting that people consistently treat these domains differently. The findings from the experiments presented in previous chapters support this notion. Differing reasoning styles across domains might be due to the content of the stimuli, social stimuli covering social relationships and non-social domain covering non-social interactions. This might also be due to variation in the perceived complexity of causal relation in social and non-social domains. From personal feedback on moral reasoning task, participants often stressed that they found it challenging to "judge" a kid. However, it is not clear or is not objectively recorded which domain participants found easier to make judgments in. Moreover, definition of *superior* reasoning can be different across researchers. While for Galotti (1990) this might be providing more detailed, including high creativity and flexibility, for some researchers, following a notion of neo-economical behaviouralist, superior reasoning might show being more in line with normative rules of reasoning and providing accurate and expected responses.

5.2.1.2. Other Factors Influenced Reasoning Responses

Participants' responses were affected by other factors which were manipulated in these experiments. These factors are relevant to the first three experiments, which employed a moral reasoning task. These factors were consistency, outcome type, and domain order. I will present these findings across studies briefly.

The scenario comparisons presented in the first three experiments were designed to have both consistent and inconsistent structures, replicating Komeda et al. (2016). It was no surprise that consistency of these items affected participants' responses. For consistent trials, in the social domain, in which a child's behaviour was in line with the child's characteristics, as either both positive or both negative, participants most of the time, responded expectedly (Mean and Standard Deviation scores for consistent scenario comparisons were: M = 96.73%, SD = 3.40%

for Experiment 1; *M* = 94% *SD* = 8% for Experiment 2; and *M* = 95%, *SD* = 4% for Experiment 3). The inconsistent trials, in which a child's behaviour was not in line with the child's characteristics, as one positive and one negative, were the focus of this task. For inconsistent trials, participants varied their responses by either relying on the character-based information or the behaviour-based information. This was in line with Komeda et al. (2016) who found an effect of consistency. The non-social domain broadly followed the same pattern.

The moral reasoning task in Chapters II and III employed scenarios ending with either a positive or negative valence, which was controlled across trials. For all experiments, we observed an effect of outcome type, suggesting that participants provided more behaviour-based responses for the scenarios ending with a good outcome, in contrast to scenarios ending with a bad outcome. This finding was somewhat in line with Komeda et al. (2016), who found the same pattern for their non-autistic comparison group, while their autistic group did not change their reasoning strategy based on the outcome type.

The moral reasoning task also controlled whether participants completed the social domain or the non-social domain first. These domains were introduced as separate blocks. For the Experiments 1 and 2 in Chapter II, responses were affected by the domain order. Participants who completed the non-social domain first changed their reasoning strategy across domains by relying more on character-based information for the social domain, whereas participants who completed the social domain first did not demonstrate such pattern. This could be explained with carry-over effect, which was found in the previous studies in which social and non-social tasks were presented as separate blocks (e.g., Surtees et al., 2012). However, domain order effect was not significant for Experiment 3 in Chapter III. Similarly, participants' responses were not influenced by domain order for the causal reasoning task in Experiment 4.

5.2.2. The Dual Process Theory of Autism and Autistic Traits

The four experiments presented aimed to explore reasoning and decision-making tendencies in relation to autism and autistic traits. The first two experiments and the last experiment explored this by recruiting participants from the general population and measuring their levels of self-reported autistic traits, while the third experiment recruited autistic people and a matched non-autistic comparison group. The reason for recruiting an autistic sample only for the third experiment was because the tasks used in these experiments were adapted and have never been used in their adapted versions. It seemed reasonable to test the tasks and hypotheses before recruiting a sample of autistic people. Moreover, although studies of autistic traits are not studies of autism (Sasson & Bottema-Beutel, 2022), recruiting samples from the general population by measuring the autistic traits enable us to have larger samples (Happé & Frith, 2020) and make predictions over a planned study with autistic samples based on the findings from these studies, and better understand neurodiversity across the general population.

The Dual Process Theory of autism proposes that autistic people and people with higher levels of autistic traits demonstrate enhanced rationality, characterised by greater deliberation and reduced intuition, resulting in less engagement in common reasoning biases (Brosnan et al., 2016; Brosnan & Ashwin, 2021, 2022b; Morsanyi & Byrne, 2020; Rozenkrantz et al., 2021). Yet this theory has never been systematically tested across social and non-social domains. I will separately summarise the findings of the studies conducted in relation to autism and autistic traits.

5.2.2.1. Dual Process Theories and Autistic Traits

The findings from the studies conducted with the general population resulted in a mixed pattern. The first two experiments in Chapter II employed different versions of the same task, which was adapted from Komeda et al. (2016). The first experiment, conducted over video calls with the long version of the moral reasoning task, which did not ask for justifications, revealed confirmative results for the main hypothesis, stating an association between a more deliberative and consistent reasoning approach and higher levels of autistic traits. There was a positive correlation between self-reported levels of autistic traits and more behaviour-based responses in the social, but not in the non-social domain. This result was exciting, given that at the time of experiment conducted, the dominant view on reasoning and autism was emphasising a link between an enhanced rationality and autistic traits (e.g., Brosnan et al., 2016; Lewton et al., 2019; Rozenkrantz et al., 2021). However, these findings were not replicated in the second experiment with the updated version of the same task. There were minor yet crucial methodological differences between these two experiments. First, the moral reasoning task was intended to be updated as a shorter task including 48-trials, given that the first version included 96-trials and took around an hour to complete. Second, the second experiment was conducted online, with no presentation of a researcher, on participants' own time and a selection of place. Third, the second experiment asked for written justifications for forced-choice responses for an in-depth evaluation. Fourth, the second experiment was run with a larger sample. Nevertheless, the findings from the second experiment was in line with more recent studies, stating subtle or no clear evidence for an enhanced rationality and autistic traits (e.g., Taylor et al., 2022).

The last experiment employed a different task, adapted from Rehder (2014). For this task, a social domain was created for a systematic comparison of causal reasoning across domains.

Individual differences, such as age, gender, educational level, psychological, neurological, and psychiatric history, can be highly influential on how people reason (Bortoletti, 2014). For this experiment, a trend was identified towards that was expected, stating that the decisive reasoners cluster self-scored higher on the autistic traits. However, the difference between the decisive and indecisive reasoners were not significant. Therefore, it would not be reasonable to conclude that whether higher levels of autistic traits might associate with a more causal reasoning style or vice versa.

5.2.2.2. The Dual Process Theory of Autism

There is a single experiment in this thesis which was conducted by recruiting an autistic sample and a carefully matched non-autistic comparison group. In line with the Dual Process Theory of autism, suggesting an enhanced rationality among autistic people (e.g., Brosnan et al., 2016; Lewton et al., 2019; Rozenkrantz et al., 2021), the findings of this experiment revealed a subjective preference for reduced intuition among the autism group, as opposed to the comparison group. This experiment also revealed subtle differences between groups on the moral reasoning task, alongside contradictory results for the Dual Process Theory of autism for objective reasoning performance, measured by the CRT.

The only significant link which was identified was between autism and reduced experientiality, indicative of intuition, on the self-report of thinking styles, the REI. This is in line with both the dominant view in relation to enhanced rationaility in autism and later studies (e.g., Taylor et al., 2022). Interestingly, for the rationality, indicative of deliberation, sub-scale of the same measure, the groups did not differ, as both scored highly on this sub-scale. This could also be evidence that the comparison group self-scored unusually high on the rationality sub-scale. Taken together, given that autistic people self-report lower level of intuition, but do not perform meaningfully differently from non-autistic people, this might be due to other variables that might affect reasoning behaviour. These results might be attributed to a meta-cognitive difference between these groups instead of necessarily a crucial difference in reasoning. Meta-cognitive differences in autism have been suggested (van der Plas et al., 2023). For instance, autistic people tend to report inaccurate levels of confidence for their correct reponses (e.g., Doenyas, Mutluer, Genc, et al., 2019; Sahuquillo-Leal et al., 2019).

The discrepancy between autistic people's subjective and objective reasoning might also be attributed to a self-perception or self-awareness difference between autistic and non-autistic groups. Autistic people might face difficulties with psychological (and not physical) self (Huang et al., 2017). This difficulty might arise, for instance, when you do not know what you know and do not know. From a social versus non-social perspective, Elmeso and Happe (2014) found a trend effect showing that autistic participants were more accurate for their own memory for non-social stimuli relative to social stimuli. The opposite pattern was observed for the non-autism comparison group (Elmeso & Happe, 2014). Considering the popularity of the Dual Process Theory of Autism and autism-related societal stigma, autistic participants might have come to believe that they are less intuitive than non-autistic people.

For the moral reasoning task, neither an effect of group nor an interaction between domain and group was identified. Although, autistic participants' responses for the social and non-social domains did not significantly differ, while their non-autistic counterparts differed significantly across domains, this interaction was not statistically significant. This suggests the possibility of at a difference in the direction of the main hypothesis, but it is required to be replicated with a bigger sample, potentially for clearer results and sample sizes.

In terms of the CRT, which was used as an objective measure of reasoning, Experiment 3 provided contradictory results to the dominant view on enhanced rationality in autism which have utilised the classical version of the CRT while either not matching the groups or matching the groups on only insignificant variables, such as age, but not cognitive ability (e.g., Brosnan et al., 2016). However, the results from the updated version of the CRT are in line with Morsanyi and Hamilton (2023) and Taylor et al. (2022) whose autism groups did not provide more correct responses, indicative of deliberation, as opposed to their comparison groups.

The theories attempting to bring explanatory and exploratory insights into social and non-social aspects of autism, such as the ToM and WCC accounts of autism, have several limitations. For instance, they lack universality, explanatory power, external validity, and applicability. Nevertheless, as a relatively modern, multi-dimensional, and strength-based approach, the Dual Process Theory of autism also seems to have limitations. Contrary to the dominant view in this field, the experiments presented here suggest that some autistic people demonstrate similarities to non-autistic people in their moral reasoning, and the relationship between enhanced rationality and higher levels of autistic traits might not be as clear, which is a view supported by recent studies (Morsanyi & Hamilton, 2023; Taylor et al., 2022). Therefore, it is crucial to be cautious when interpreting the results from previous studies, especially when concluding with a strong link between autism and enhanced rationality. If this view is not true, this might add an extra myth as a stereotype to existing ones around autism, which might be potentially providing false positives. However, it is important to keep in mind that each autistic person is different, and a single theory is not enough to explain a diverse manifestation of behaviours among autistic people and people with higher levels of autistic traits.

5.2.3. Moral Reasoning in Relation to Autism and Autistic Traits

The first three experiments presented previously included a moral reasoning task. Moral reasoning is a specific area of reasoning in which autistic people and people with higher levels of autistic traits demonstrate differences to non-autistic people and those with lower levels of autistic traits (Dempsey, Moore, Johnson, et al., 2020; Dempsey, Moore, Richard, et al., 2020; Komeda, 2021; van der Plas et al., 2023)**.** Haidt (2001) proposed a distinction between interventionist and rationalist moral judgments. Considering the Dual Process Theories also propose a similar approach for general reasoning, as a distinction between intuition and deliberation, it seemed reasonable to predict that autistic people and those with higher autistic traits would reason more deliberatively, as opposed to intuitively, in the moral domain. However, while the first experiment revealed a positive correlation between autistic traits and a more deliberative reasoning style for social scenario comparisons, and not for non-social scenario comparisons, these results were not replicated in the next experiment. Additionally, the third experiment showed no clear evidence of differences between autistic and non-autistic people for their moral judgments. This result was contradictory with Komeda et al. (2016) who reported moral judgment differences between autistic and non-autistic late adolescents based on social scenarios. However, null results are equally important as significant results between groups. Additionally, it is possible that there are features that are specific to autistic people and not replicated in a dimensional form in relation to measures of autistic traits. Taken together, it is important to keep in mind that autism is complex and heterogenous and attempts to explain wide manifestations in social and non-social domains in relation to autism with a single theory, will most likely lack universality, explanatory power, and applicability.

5.2.4. Causal Reasoning in Relation to Autistic Traits

Causal reasoning in relation to autistic traits was explored in a single study presented in Chapter IV. To my knowledge, this is the first study exploring causal reasoning in relation to autistic traits by using the common causal network. Causal reasoning research is extensive, and its techniques can be transferred to other fields. I see my study, in this case, as a starter that brings attention to individual differences, such as age, gender, educational level, cognitive level, and psychological, psychiatric, and neurological history, in causal reasoning, which seemingly have been neglected by even most influential causal reasoning publications.

With this experiment, we broadly replicated the current literature on causal reasoning (e.g., Kolvoort et al., 2021; Rehder, 2014, 2018; Rottman & Hastie, 2014), by showing consistent violations of normative rules of causal reasoning. Theories have been offered to explain this violation, including *the leaky gate* (Rehder, 2018) or *specific shared disabler* (Rehder, 2014) models, which have been explained in Chapter IV.

Following a dual approach, the results ended up showing two clusters of reasoners. While one of the clusters seemed more decisive with their responses, which I labelled as decisive reasoners, the other cluster seemed more indecisive, which I labelled as indecisive reasoners. However, the decisive reasoners cluster did engage in various violations too. As predicted, the decisive reasoners cluster scored higher on the autistic traits (M = 20.56, SEM = 0.85) compared to the indecisive reasoners (M = 18.35, SEM = 1.05), but this difference was not significant. For this reason, it would be not reasonable to make strong conclusions from these results. However, this task can be used with autistic and non-autistic people for a between-group comparison across social and non-social domains.

5.3. Limitations and Future Work

This thesis aimed to present reasoning and decision-making tendencies. However, this is a highly broad area of research with several different versions of reasoning and decision-making have been proposed and researched. Even though, I broadly talk about reasoning throughout this thesis, the experimental chapters specifically focus on the moral and causal reasoning, therefore, results from these studies may not be generalised to other areas of reasoning, such as analogical reasoning. This is a limitation of previous studies that tend to generalise their results based on a limited number of tasks and domains. Exploring these areas of reasoning, especially across social and non-social domains, was suggested by currently available studies and dictated by the available evidence. Moreover, even though the tasks in these studies aimed to reflect real-world interactions, the results from these studies may also not be generalised to real-world decision-making. For this purpose, there is a need for an investigation of a broad range of reasoning styles with diverse and larger groups of participants. Investigating other types of reasoning can be informative in whether what similarities or differences in relation to autism are specific or general.

5.3.1. Across Domains

All tasks used in these experiments included a social domain and a non-social domain which were prepared carefully to be structurally equivalent and presented as separate blocks. However, the level of *socialness* can be interpreted differently by different people (Varrier & Finn, 2022). There is also a need to check how participants perceive what we expect them to perceive (Lockwood et al., 2020) because there might be a disparity between what the experiment intends and what the participant perceives. The perception of socialness of participants on the items in these tasks was not checked. Additionally, we do not know how representative the scenarios in domains are respectively of their domains. It would have been more ideal to prepare a task while checking the perception of socialness on each item, but this was not the case for these experiments because of the time constraints. This procedure could be done to decide whether participants really perceive what we think is a social scenario as social, and what we think is a non-social scenario as non-social. For instance, the non-social scenarios in the moral reasoning task included interactions between a "person" and an object. This might still represent a social interaction for some people. It would have been interesting to see whether people's perception of socialness deviate from experimenters' intentions. Another way could be labelling these items as "social" and "non-social" to carefully manipulate participants' perception.

5.3.2. In Relation to Autism and Autistic Traits

The results from these studies cannot conclude confidently with that autistic people and people with higher autistic traits differ or do not differ from non-autistic people and people with lower autistic traits in moral and causal reasoning. These results might not reflect real-world decision-making. Therefore, there is a need for an in-depth evaluation of the approaches taken by these groups, rather than solely evaluation of the final results of their reasoning and decision-making. For this, measuring response times could be a reasonable idea to see whether there are differences between time taken by different people to reach a decision. Previous research consistently reported that autistic people face challenges in quick decision-making (Luke et al., 2011) and can benefit from slowing down the stimuli in some tasks (Tardif et al., 2007). Even though anecdotally it appeared that autistic participants took longer to respond to the scenario comparisons, response times were not recorded. Future studies can benefit from recording response times to clearly see whether autistic participants take longer to respond, which might suggest either a difficulty with reaching a decision or needing to consider each possible option carefully before reaching a decision.

Another avenue of interest would be recording meta-cognitive differences between autistic and non-autistic people in relation to reasoning and decision-making. For instance, recording confidence levels can inform us regarding real-world decision-making, because for a forced-choice experiment setting, a participant must respond with a choice, even in a real setting they might avoid making a choice due to lower level of confidence in their choice. Autistic people previously self-reported that they avoid making decisions due to decision-making challenges they face (Luke et al., 2011). Studies have also found that autistic people report inaccurate levels of confidence in their decisions (e.g., Doenyas, Mutluer, Genc, et al., 2019; Sahuquillo-Leal et al., 2019). This is in line with findings from the studies presented in this thesis showing that a link between autism and high autistic traits with subjectively lower level of intuition yet not objectively lower level of intuition. Additionally, recent reviews showed that the most pronounced difference between autistic and non-autistic people in relation to decision-making was related to meta-cognition (van der Plas et al., 2023). Performance on the reasoning measures, such as CRT, also found to be linked to meta-cognition (Mata et al., 2013). For these reasons, future studies can ask for confidence levels for each trial. This could be particularly interesting for the causal reasoning task, because this task had potentials of being responded in an indecisive manner, e.g., responding “equally likely” for all trials.

Psychology, as a science, struggles with issues around replicability and representability (Tackett et al., 2019). Recruiting student samples, as I did in Experiments 1, 2, and 4, is common and handy for psychological research. However, this raises representability issues as student populations might be highly homogenous (for instance, in terms of female-dominant student groups in Psychology departments) and might differ from the general population (Hanel & Vione, 2016). Except in Experiment 3, I recruited both undergraduate and postgraduate students enrolled at the University of Birmingham. These students were mostly enrolled in higher education to study Psychology and identified as female. For studies of autism, recruiting student samples and measuring levels of autistic traits can help us to recruit large group of participants with ease of time and effort, however, these studies should be interpreted with caution and with no intention to be generalised to the autistic community (Sasson & Bottema-Beutel, 2022). This thesis included a single study conducted with autistic people who were adults with average or above average intelligence. Given the complexity of tasks that have been used, it was required to recruit people with average or higher intelligence. However, reasoning, and decision-making tendencies of people with intellectual disabilities remain unexplored. There is high variability within non-autistic people in their reasoning and decision-making often due to variability in cognitive capacities. Future studies should evaluate how to include people with intellectual disabilities in reasoning and decision-making studies and carefully match the comparison groups on cognitive capacities, such as including but not limited to intelligence level, semantic knowledge, language competence, and working memory.

Given the circumstances of COVID-19, three experiments (Experiments 1, 2, and 3) presented in this thesis were conducted remotely. This might seem as a limitation, since online and remote testing might not reflect real-world interactions and limits the control of testing environment. However, as well as disadvantages, the pandemic of online research had several benefits to both participants and researchers (De Man et al., 2021). From researchers' perspective, while rapid advancing of online testing platforms, online research can be cost-effective for reducing resource costs (e.g., renting testing spaces) and efficient for data collection (e.g., decreasing or eliminating the time for manual input and minimising error). From an autism research perspective, online and remote testing can increase accessibility, comfort, and flexibility, and reduce barriers (e.g., travel barrier). Moreover, autistic people tend to have strong affinity for technology (for a review, see, Valencia et al., 2019). Therefore, online experiments can increase the familiarity, which potentially decreases anxiety and increase comfort and engagement. Researchers should still be careful with ensuring a digital autism-friendly environment and take caution for data integrity (Pellicano et al., 2023) and ethical issues, such as data privacy and security. Nevertheless, future studies can test the Dual Process Theory of autism both online and in-person to validate and replicate the findings presented in this thesis.

5.4. Conclusion

This thesis explored reasoning and decision-making differences across social and non-social domains in relation to autistic traits and autism. Chapter II and III investigated this with three experiments using a moral reasoning task, while Chapter IV presented an experiment using a causal reasoning task. The only significant link that was collectively revealed from the experiments in this thesis in relation to autism and autistic traits was autistic people's perception of reduced intuition for themselves. However, the mismatch between autistic people's subjective and objective results might reflect a response bias or meta-cognitive challenges among autistic participants rather than a strong and clear reasoning difference to non-autistic people. The studies in this thesis support recent research suggesting that although some groups of autistic people or those with high autistic traits seem to show differences on some subjective or objective tasks of rationality, these findings are inconsistent and comparison groups often overlap. This suggests the evidence that though the Dual Process Theory of autism remains an interesting idea, it is unlikely that it explains fundamental differences to non-autistic people or those with low autistic traits. The consistent and strongest finding from the experiments in this thesis was that people treated social and non-social domains differently in both moral and causal reasoning. It was interesting to observe this phenomenon evidenced with different tasks across various samples. Reasoning and decision-making across social and non-social domains in relation to autistic traits and autism remain an open field in which several questions await exploration. The findings from the experiments conducted online or in lab-settings might demonstrate subtle to no differences in reasoning and decision-making across social and non-social domains between autistic and non-autistic people or those with higher and lower autistic traits. However, this does not necessarily imply that there are no differences between these groups in real-life. It is important to exercise caution when describing socialness, considering what constitutes a social context and what does not. Further exploration of autistic people and those who self-report higher levels of autistic traits can be conducted with attention to sample representativeness, real-world reflective tasks, measurement of individual differences, and careful group matching.

6. Appendices

Appendix 1: The Adult Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001)

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

15	I find myself drawn more strongly to people than to things.			1	1
16	I tend to have very strong interests which I get upset about if I can't pursue.	1	1		
17	I enjoy social chit-chat.			1	1
18	When I talk, it isn't always easy for others to get a word in edgeways.	1	1		
19	I am fascinated by numbers.	1	1		
20	When I'm reading a story, I find it difficult to work out the characters' intentions.	1	1		
21	I don't particularly enjoy reading fiction.	1	1		
22	I find it hard to make new friends.	1	1		
23	I notice patterns in things all the time.	1	1		
24	I would rather go to the theatre than a museum.			1	1
25	It does not upset me if my daily routine is disturbed.			1	1
26	I frequently find that I don't know how to keep a conversation going.	1	1		
27	I find it easy to "read between the lines" when someone is talking to me.			1	1
28	I usually concentrate more on the whole picture, rather than the small details.			1	1
29	I am not very good at remembering phone numbers.			1	1
30	I don't usually notice small changes in a situation, or a person's appearance.			1	1

31	I know how to tell if someone listening to me is getting bored.			1	1
32	I find it easy to do more than one thing at once.			1	1
33	When I talk on the phone, I'm not sure when it's my turn to speak.	1	1		
34	I enjoy doing things spontaneously.			1	1
35	I am often the last to understand the point of a joke.	1	1		
36	I find it easy to work out what someone is thinking or feeling just by looking at their face.			1	1
37	If there is an interruption, I can switch back to what I was doing very quickly.			1	1
38	I am good at social chit-chat.			1	1
39	People often tell me that I keep going on and on about the same thing.	1	1		
40	When I was young, I used to enjoy playing games involving pretending with other children.			1	1
41	I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	1	1		
42	I find it difficult to imagine what it would be like to be someone else.	1	1		
43	I like to plan any activities I participate in carefully.	1	1		
44	I enjoy social occasions.			1	1
45	I find it difficult to work out people's intentions.	1	1		

46	New situations make me anxious.	1	1		
47	I enjoy meeting new people.			1	1
48	I am a good diplomat.			1	1
49	I am not very good at remembering people's date of birth.			1	1
50	I find it very easy to play games with children that involve pretending.			1	1

Note. Marked responses score 1, unmarked responses score 0. For total scores, sum all items.

Sum the following items, for each sub-scale score.

Social skill: 1, 11, 13, 15, 22, 36, 44, 45, 47, and 48

Attention switching: 2, 4, 10, 16, 25, 32, 34, 37, 43, and 46

Attention to detail: 5, 6, 9, 12, 19, 23, 28, 29, 30, and 49

Communication: 7, 17, 18, 26, 27, 31, 33, 35, 38, and 39

Imagination: 3, 8, 14, 20, 21, 24, 40, 41, 42, and 50

Appendix 2: Details of scenario comparisons in the Social and Non-social Domains for the Scenario-based Comparison Task, *Experiment 1, 2, and 3*

Social Domain				
ID	**Outcome**	**Gender**	**Names**	
1	GO	B	George	James
2	GO	G	Diana	Linda
3	GO	B	Jack	Jacob
4	GO	G	Jessica	Rebecca
5	GO	B	Thomas	Joshua
6	GO	G	Barbara	Melissa
7	BO	B	Harry	Charlie
8	BO	G	Emily	Betty
9	BO	B	Peter	Oliver
10	BO	G	Karen	Helen
11	BO	B	Albert	Robert
12	BO	G	Emma	Lisa
13	GO	B	Mason	Logan
14	GO	G	Julie	Olive
15	GO	B	Riley	Daniel
16	GO	G	Amber	Anabelle
17	GO	B	Noah	Liam
18	GO	G	Nancy	Cindy
19	BO	B	Max	Lucas

20	BO	G	Laura	Amelia
21	BO	B	Freddie	Archie
22	BO	G	Amy	Mary
23	BO	B	Alfie	Henry
24	BO	G	Ella	Anna

Non-social Domain					
ID	**Outcome**	**Gender**	**Names**		**Object**
1	GO	F	Olivia	Matilda	jumper
2	GO	M	William	Callum	running shoes
3	GO	F	Isabella	Georgia	jigsaw
4	GO	M	Dylan	Adam	novel
5	GO	F	Grace	Alice	painting
6	GO	M	Matthew	Lewis	coffee brand
7	BO	F	Molly	Polly	car
8	BO	M	Alex	Charles	pen
9	BO	F	Daisy	Lily	lipstick
10	BO	M	Alexander	Connor	cell phone
11	BO	F	Jasmine	Rose	slippers
12	BO	M	David	Edward	laptop
13	GO	F	Lottie	Zoe	computer
14	GO	M	Benjamin	Sebastian	cup
15	GO	F	Maria	Maryam	toy
16	GO	M	Joey	Rory	violin strings
17	GO	F	Phoebe	Chloe	headphones
18	GO	M	Jackson	Aaron	glasses
19	BO	F	Sara	Sarah	pillow

20	BO	M	David	Elliot	flat
21	BO	F	Elizabeth	Scarlett	washing machine
22	BO	M	Leon	Owen	video game
23	BO	F	Jasmine	Catherine	town
24	BO	M	Michael	Gabriel	coffee shop

Notes. Gender for Social Domain indicates the gender of the child. Gender for Non-social Domain indicates the gender of the person. Story 19 in Non-social Domain was excluded from data analysis because of a data coding incident. GO: Good Outcome, BO: Bad Outcome, G: Girl, B: Boy, F: Female, M: Male

Scenarios selected for Experiment 2, after Item Validity Check.

Appendix 3: Script of Scenario Comparisons in the Social Domain for the Scenario-based Comparison Task

1) GO B – George x James

(＋) George is a nice boy who likes to please his dad.

(－) James is a selfish boy who only really thinks of himself.

(＋) He said to his dad, “Let’s go watch your favourite football team play!”, when his dad looked bored.

(－) He said to his dad, “Let’s go see my favourite cartoon movie again!”, when his dad was busy.

(＋) His dad smiled when he looked at his son’s happy face.

2) GO G – Diana x Linda

(＋) Diana is a caring girl who likes to help her dad.

(－) Linda is a thoughtless girl who likes to make a mess.

(＋) She wanted to clean her dad’s desk when he wasn’t there.

(－) She rummaged through her dad’s desk to look for something interesting.

(＋) Her dad was delighted because she found his lost watch.

3) GO B – Jack x Jacob

(＋) Jack is a gentle boy who often tidies up his stuff.

(－) Jacob is an aggressive boy who often handles his toys roughly.

(＋) He placed his toys in a box in his room.

(－) He threw his toys in a box in the distance.

(＋) His mum was really delighted with the tidiness of the room.

4) GO G – Jessica x Rebecca

(＋) Jessica is a cheerful girl who likes to make her mum smile.

(－) Rebecca is a grumpy girl who gets angry with people very quickly.

(＋) She gave her mum a loving hug.

(－) She got angry and hit her mum.

(＋) Her mum was glad that her daughter could express her emotions.

5) GO B – Thomas x Joshua

(＋) Thomas is an easy-going boy who eats healthy food often.

(－) Joshua is a picky boy who is fussy about food.

(＋) He enjoyed eating the meal his mum cooked because he thought it was healthy.

(－) He refused the meal his mum cooked because he had a chocolate bar before.

(＋) His mum was happy to have dinner at home with her son.

6) GO G – Barbara x Melissa

(＋) Barbara is a hard-working girl who performs well at school.

(－) Melissa is a lazy girl who performs poorly at school.

(＋) She studied really very hard to get a good score on a test.

(－) She copied her friend's answers to get a good score on a test.

(＋) Her dad was really happy to see her high test scores.

7) BO B – Charlie x Harry

(＋) Charlie is a caring boy who likes making his dad happy.

(－) Harry is an impatient boy who gets frustrated with other people.

(＋) He wanted to give his dad a can of his dad's favourite beer.

(－) He shook his dad's beer-can vigorously before he gave it to him.

(－) His dad's clothes got wet when the beer jumped from the can.

8) BO G – Betty x Emily

(＋) Betty is a considerate girl who likes to help her mum.

(－) Emily is a naughty girl who likes to do dangerous things.

(＋) She cleaned up the table to try to help her mum and knocked over a vase.

(－) She climbed on the table to reach sweets on a shelf and knocked over a vase.

(－) Her mum was sad because her favourite vase got badly broken.

9) BO B – Oliver x Peter

(＋) Oliver is an active boy who likes to help with housework.

(－) Peter is a careless boy who often damages his parents' things.

(＋) He dropped his mum's vase when he was trying to wipe it.

(－) He dropped his mum's vase when he was climbing on the table.

(－) His mum sadly tidied up the broken vase into the bin.

10) BO G – Helen x Karen

(＋) Helen is a kind girl who likes to cook.

(－) Karen is a naughty girl who likes making mischief.

(＋) She gave her mum pasta which she made with juicy ripe tomatoes.

(－) She made her mum a meal with tomatoes she knew were rotten.

(－) Her mum had a stomach ache because the tomatoes were terrible.

11) BO B – Robert x Albert

(＋) Robert is a grateful boy who cares about his family.

(－) Albert is an aggressive boy who likes doing dangerous things.

(＋) He was with his dad on bonfire night and brought him a lit firework to help him.

(－) He was with his dad on bonfire night and pointed a firework at him to scare him.

(－) His dad had a really severe burn from the firework.

12) BO G – Lisa x Emma

(＋) Lisa is a generous girl who likes to do nice things for people.

(－) Emma is an annoying girl who likes to play jokes on other people.

(＋) She put a lot of sugar in her dad's coffee as a treat for him.

(－) She put a lot of salt in her dad's coffee to see her dad's reaction.

(－) Her dad frowned after drinking the coffee, which was disgusting.

13) GO B – Mason x Logan

(＋) Mason is an energetic boy who is good at most sports.

(－) Logan is a naughty boy who often fights with his mum.

(＋) He played baseball in the park with his dad, who likes baseball lots.

(－) He played baseball with his dad because he hates being with his mum.

(＋) His dad was very happy to play baseball with his son.

14) GO G – Julie x Olive

(＋) Julie is an ambitious girl who works hard on various things.

(－) Olive is a lazy girl who doesn't like to work hard.

(＋) She gave her mum a cookie she'd made with delicious chocolate.

(－) She gave her mum a cookie she'd made with rancid butter.

(＋) Her mum ate a bite and said that it was absolutely delicious.

15) GO B – Riley x Daniel

(＋) Riley is a confident boy who really likes making things.

(－) Daniel is a nervous boy who is over-reliant on others.

(＋) He made a plastic model of a car without the help of his dad.

(－) He complained until his dad made a plastic model of a car with him.

(＋) His dad was happy with the completed plastic model of the car.

16) GO G – Amber x Anabelle

(＋) Amber is a generous girl who likes to share her food.

(－) Anabelle is a picky girl who only eats unhealthy junk food.

(＋) She shared some of her ice cream with her mum because she thought it was really delicious.

(－) She tried a little ice cream and thought it was terrible, so gave it to her mum.

(＋) Her mum very much enjoyed eating some refreshing ice cream.

17) GO B – Noah x Liam

(＋) Noah is a lively boy who often helps his dad.

(－) Liam is an impatient boy who does things without thinking.

(＋) When he was fishing with his dad, he tried to help his dad by grabbing a fish he had hooked.

(－) When he was fishing with his dad, he tried to grab a fish that his dad hooked to annoy him.

(+) His dad was happy that his son was helping him with fishing.

18) GO G – Nancy x Cindy

(＋) Nancy is a considerate girl who helps with gardening at home.

(－) Cindy is an annoying girl who likes to irritate other people.

(＋) She gave her dad a delicious looking cucumber she had grown by herself.

(－) She gave her dad a cucumber to eat that was covered in mud.

(＋) Her dad carefully wiped and ate the fresh cucumber happily.

19) BO B – Lucas x Max

(＋) Lucas is a kind boy who likes lots of animals.

(－) Max is a mean boy who likes to tease animals.

(＋) He gave his dad a dog because he thought it was cute.

(－) He wanted to surprise his dad and gave him an untrained dog.

(－) His dad's hand was bitten by the disturbed dog and bled.

20) BO G – Amelia x Laura

(＋) Amelia is a cheerful girl who likes to talk to other people.

(－) Laura is a bullying girl who likes to make fun of people.

(＋) She told her friends about her mum's recent success at work.

(－) She told her friends about her mum's recent failure at work.

(－) Her mum was embarrassed because there were rumours among the parents.

21) BO B – Archie x Freddie

(＋) Archie is an active boy who likes to exercise.

(－) Freddie is a selfish boy who is very demanding.

(＋) He went to the pool with his mum to show her how well he could swim.

(－) He demanded his mum to take him to the pool when his mum was very tired.

(－) His mum caught a cold because the pool was cold.

22) BO G – Mary x Amy

(＋) Mary is a bright girl who has varied interests.

(－) Amy is an impulsive girl who likes making mischief.

(＋) She wanted to help her dad with his jigsaw puzzle but accidentally flipped it over.

(－) She purposely flipped her dad’s one-thousand-piece jigsaw puzzle over and broke it apart.

(－) Her dad got upset because he couldn’t continue the jigsaw puzzle.

23) BO B – Henry x Alfie

(＋) Henry is a helpful boy who does things for other people.

(－) Alfie is a careless boy who does lots of bad things.

(＋) He was trying to fix his mum’s umbrella, but it got broken much worse.

(－) He was playing with his mum’s umbrella, and it got caught in a tree.

(－) His mum couldn't go out on a rainy day without her umbrella.

24) BO G – Anna x Ella

(＋) Anna is a grateful girl who appreciates her parents.

(－) Ella is a spoilt girl who neglects her parents.

(＋) She made a thoughtful gift for her mum’s birthday and gave it to her.

(－) She forgot her mum’s birthday and gave her an unwanted present of her own.

(－) Her mum was sad because of aging.

Script of Scenario Comparisons in the Non-social Domain for the Scenario-based Comparison Task

1) GO F – Olivia x Matilda

(＋) Olivia has a good quality jumper.

(－) Matilda has a low quality jumper.

(＋) It kept its shape after many washes.

(－) It shrank after the very first wash.

(＋) She felt really very stylish wearing such a smart jumper.

2) GO M – William x Callum

(＋) William has a pair of good quality running shoes.

(－) Callum has a pair of low quality running shoes.

(＋) They felt comfortable after a five mile run.

(－) He had a blister after a short run.

(＋) He has been running happily for a month without any injuries.

3) GO F – Isabella x Georgia

(＋) Isabella has a jigsaw which is well manufactured.

(－) Georgia has a jigsaw which is poorly manufactured.

(＋) When she put it together, its pieces fitted each other perfectly.

(－) When she put it together, its pieces didn't fit together well.

(＋) She felt really happy putting all the complicated puzzle pieces together.

4) GO M – Dylan x Adam

(＋) Dylan has a well written novel.

(－) Adam has a poorly written novel.

(＋) It improved his language skills and kept him engaged.

(－) It wasted his time and he got bored easily.

(＋) He was happy that he found free time to read more.

5) GO F – Grace x Alice

(＋) Grace has a beautiful painting in her home.

(－) Alice has an ugly painting in her home.

(＋) When her friends came round, she was happy they complimented the picture.

(－) When her friends came round, she was disappointed they criticised the picture.

(＋) She felt joyful because this painting changed the ambience in her home.

6) GO M – Matthew x Lewis

(＋) Matthew tried a tasteful coffee brand.

(－) Lewis tried a cheap coffee brand.

(＋) It helped wake him up before an important meeting.

(－) It left him feeling sleepy before an important meeting.

(＋) He was delighted to try different brands in the new coffee shop.

7) BO F – Poppy x Molly

(＋) Poppy has a car with a powerful engine system.

(－) Molly has a car with a weak engine system.

(＋) It worked perfectly for a long road trip.

(－) It broke down on a long road trip.

(－) She felt exhausted because she had to drive all the way.

8) BO M – Charles x Alex

(＋) Charles has an expensive pen, made in Switzerland.

(－) Alex has a cheap pen, bought from Tesco.

(＋) It was easy to write instructions on the board with his pen.

(－) It was difficult to write instructions on the board with his pen.

(－) He felt exhausted after writing on the board in a lecture.

9) BO F – Lily x Daisy

(＋) Lily has high quality lipstick.

(－) Daisy has poor quality lipstick.

(＋) It stayed on well when she was at lunch with her friends.

(－) It faded away easily when she was at lunch with her friends.

(－) She thought it was overdressing wearing a lipstick for lunch.

10) BO M – Connor x Alexander

(＋) Connor has a brand-new cell phone.

(－) Alexander has an old cell phone.

(＋) Its battery lasted well during an important call.

(－) Its battery died quickly during an important call.

(－) He worried about how his phone will work during his future calls.

11) BO F – Rose x Jasmine

(＋) Rose has soft and fluffy slippers.

(－) Jasmine has tough and boring slippers.

(＋) It made her feel comfortable wearing them after work.

(－) It made her feel silly wearing them after work.

(－) She felt exhausted after work and slippers didn't help her to relax.

12) BO M – Edward x David

(＋) Edward has a powerful laptop which works fast.

(－) David has a weak laptop which works slowly.

(＋) A feature on the laptop meant that all his work was backed-up.

(－) An error with the laptop caused him to lose all his work.

(－) He couldn’t go out as he had to complete his work.

13) GO F – Lottie x Zoe

(＋) Lottie has a computer which is quick at responding.

(－) Zoe has a computer which is slow at responding.

(＋) It was helpful when she needed to reply to lots of emails.

(－) It was annoying as it needed to install lots of new updates.

(＋) She was very grateful that she could do work on her computer.

14) GO M – Benjamin x Sebastian

(＋) Benjamin has a good quality porcelain cup.

(－) Sebastian has a poor quality porcelain cup.

(＋) It kept his coffee warm this morning until he finished it.

(－) It got broken this morning when he poured his coffee in.

(＋) He was happy he had made time for coffee before work.

15) GO F – Maria x Maryam

(＋) Maria has a new soft toy.

(－) Maryam has an old worn toy.

(＋) She played with it lots this morning without getting bored.

(－) She played with it briefly this morning then got bored.

(＋) She felt excited to show her toy to her friends.

16) GO M – Joey x Rory

(＋) Joey purchased strong strings for his violin.

(－) Rory purchased weak strings for his violin.

(＋) They lasted for a long time when he was practising.

(－) They broke after a short time when he was practising.

(＋) He felt excited to try new strings on his violin.

17) GO F – Phoebe x Chloe

(＋) Phoebe has new headphones, which are very good at noise cancelling.

(－) Chloe has new headphones, which are not good at noise cancelling.

(＋) She enjoyed listening with them in the gym this morning.

(－) She didn't enjoy listening with them in the gym today.

(＋) She had an energetic work out session with her new headphones.

18) GO M – Jackson x Aaron

(＋) Jackson bought an expensive pair of glasses after an appointment with the optician.

(－) Aaron bought a cheap pair of glasses that he spotted while he shopped.

(＋) His eyes felt really comfortable all day at work today.

(－) His eyes felt tired after an hour at work today.

(＋) He felt happy after completing a long day with his glasses.

19) BO F – Sarah x Sara

(＋) Sarah has a memory foam pillow, which is made of silk.

(－) Sara has a very basic pillow, which is made of polyester.

(＋) It helped her to have a better sleep last night.

(－) It was not comfortable and disrupted her sleep last night.

(－) She was afraid that she needs to replace her pillow.

20) BO M – Elliot x David

(＋) Elliot moved to a new flat, which is in a safe area.

(－) David moved to a new flat, which is in a dodgy area.

(＋) It was silent outside, so he had a good night's sleep last night.

(－) It was noisy outside, so he had a bad night's sleep last night.

(－) He felt rubbish this morning and regretted moving into the area.

21) BO F – Scarlett x Elizabeth

(＋) Scarlett has a washing machine which is energy efficient.

(－) Elizabeth has a washing machine which isn't energy efficient.

(＋) This morning it got a nasty stain out of her favourite jumper.

(－) This morning it left a funny black mark on her favourite jumper.

(－) She thought she should probably buy a new washing machine.

22) BO M – Owen x Leon

(＋) Owen has a well-reviewed video game.

(－) Leon has a poorly-reviewed video game.

(＋) It has high resolution graphics, so he had fun playing it.

(－) It has low resolution graphics, so he didn't enjoy playing it.

(－) He thought playing video games is time-consuming, and he should quit.

23) BO F – Catherine x Jasmine

(＋) Catherine lives in Devon, where the weather is clean and fresh.

(－) Jasmine lives in Luton, where the air quality is generally low.

(＋) This morning she had a lovely walk in the park there.

(－) This morning she got stuck in an annoying traffic jam there.

(－) She decided she was getting bored of living in the same town.

24) BO M – Gabriel x Michael

(＋) Gabriel is a regular of a peaceful coffee shop.

(－) Michael is a regular of a noisy coffee shop.

(＋) The Wi-Fi connection there was good yesterday, so he got lots of work done when he went there with his laptop.

(－) The Wi-Fi connection there was rubbish yesterday, so he didn't get any work done when he went there with his laptop.

(－) He thought he should probably try some new places for coffee.

Appendix 4

Means and Standard Deviations of the proportion of behaviour-based responses, in percentages, Experiment 1

	Social Domain First (N = 36)							
	Social Domain				Non-social Domain			
	Good Outcome		Bad Outcome		Good Outcome		Bad Outcome	
	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent
M	97.69	76.85	96.30	71.76	97.45	81.66	92.82	75.00
SD	4.28	17.26	7.03	19.65	5.57	12.99	7.49	13.51
	Non-social Domain First (N = 36)							
	Social Domain				Non-social Domain			
	Good Outcome		Bad Outcome		Good Outcome		Bad Outcome	
	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent
M	99.07	65.97	98.61	57.18	97.45	78.70	94.44	74.77
SD	2.66	23.18	3.73	22.02	4.81	15.87	6.61	13.14

Appendix 5

Summary of the with paired-samples t-test statistics, Experiment 1

Domain Type*Consistency			
	M_{diff} *(SD)*–Consistent minus Inconsistent	*t*	*d*
Social Domain**	29.98% (20.76%)	12.25	1.44
Non-social Domain**	18.01% (12.14%)	12.59	1.48
Outcome Type*Consistency			
	M_{diff} *(SD)*–Consistent minus Inconsistent	*t*	*d*
Bad Outcome**	25.87% (15.90%)	13.81	1.63
Good Outcome**	22.12% (13.90%)	13.51	1.59
Domain Type*Domain Order			
	M_{diff} *(SD)*–Non-social Domain minus Social Domain	*t*	*d*
Non-social Domain First*	6.13% (10.25%)	3.59	0.6
Social Domain First	1.10% (8.97%)	0.74	0.13
Consistency*Domain Order			
	M_{diff} *(SD)*–Consistent minus Inconsistent	*t*	*d*
Non-social Domain First**	28.24% (13.95%)	12.15	2.03
Social Domain First**	19.75% (11.90%)	9.96	1.66
Domain Type*Consistency*Domain Order			

	M_{diff} *(SD)*–Consistent minus Inconsistent	*t*	*d*
Non-social Domain First			
Social Domain**	37.27% (20.82%)	10.74	1.79
Non-social Domain**	19.21% (12.57%)	9.17	1.53
Social Domain First			
Social Domain**	22.69% (18.22%)	7.47	1.25
Non-social Domain**	16.81% (11.75%)	8.58	1.43

Note. ** $p < 0.001$, * $p < 0.01$.

Appendix 6

Correlation results between the behaviour-based judgments and sub-scale scores on the AQ, Experiment 1

			Social Domain		Non-social Domain	
	M	*SD*	r_s	*p*	r_s	*p*
Social skill	2.29	1.95	0.308**	0.008	0.091	0.449
Attention switching	5.35	2.01	0.254*	0.031	0.139	0.244
Attention to detail	5.40	1.87	0.114	0.341	-0.155	0.195
Communication	2.61	1.75	0.264*	0.025	0.105	0.379
Imagination	2.47	1.95	0.332**	0.004	0.224	0.058

*** Correlation is significant at the 0.01 level (2-tailed).*

** Correlation is significant at the 0.05 level (2-tailed).*

Appendix 7

Means and Standard Deviations of the proportion of behaviour-based responses, in percentages, Experiment 2

	Social Domain First (*N* = 108)							
	Social Domain				Non-social Domain			
	Good Outcome		Bad Outcome		Good Outcome		Bad Outcome	
	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent
M	93.67	75.77	90.59	72.99	96.45	81.64	91.98	75.00
SD	12.00	26.80	19.77	26.84	7.91	19.46	18.15	24.28
	Non-social Domain First (*N* = 109)							
	Social Domain				Non-social Domain			
	Good Outcome		Bad Outcome		Good Outcome		Bad Outcome	
	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent	Consistent	Inconsistent
M	94.34	63.30	95.57	61.01	95.41	80.73	91.28	74.62
SD	11.83	31.82	8.68	35.37	11.97	21.66	14.09	23.85

Appendix 8

Summary of the interactions with paired-samples t-test statistics, Experiment 2 (N = 217)

Domain Type*Consistency			
	M_{diff} *(SD)*–Consistent minus Inconsistent	*t*	*d*
Social Domain*	25.31% (30.35%)	12.28	0.83
Non-social Domain*	15.78% (18.69%)	12.44	0.84

Domain Type*Outcome Type			
	M_{diff} *(SD)*–Good Outcome minus Bad Outcome	*t*	*d*
Social Domain	1.73% (18.12%)	1.40	0.29
Non-social Domain*	5.34% (18.21%)	4.32	0.10

Consistency*Domain Order			
	M_{diff} *(SD)*–Consistent minus Inconsistent	*t*	*d*
Non-social Domain First*	24.24% (21.63%)	11.70	1.12
Social Domain First*	16.82% (18.50%)	9.45	0.91

Domain Type*Consistency*Domain Order			
	M_{diff} *(SD)*–Consistent minus Inconsistent	*t*	*d*
Non-social Domain First			
Social Domain*	32.80% (32.37%)	10.42	1.00
Non-social Domain*	15.67% (19.86%)	8.24	0.79

Social Domain First			
Social Domain*	17.75% (25.58%)	7.21	0.69
Non-social Domain*	15.90% (17.52%)	9.43	0.91

Note. * $p < 0.001$.

Appendix 9

Correlation between the behaviour-based judgments and sub-scale scores on the AQ, Experiment 2

			Social Domain		Non-social Domain	
	M	*SD*	r_s	*p*	r_s	*p*
Social skill	2.78	2.52	0.026	0.706	-.146*	0.032
Attention switching	5.26	2.12	0.040	0.561	-0.098	0.151
Attention to detail	4.84	2.13	0.063	0.357	0.012	0.866
Communication	2.78	2.17	-0.022	0.743	-0.091	0.181
Imagination	2.44	1.97	-0.020	0.770	-0.034	0.614

*** Correlation is significant at the 0.01 level (2-tailed).*

** Correlation is significant at the 0.05 level (2-tailed).*

Appendix 10

Descriptive details and paired-samples t-test statistics of the written justifications, Experiment 2

Inconsistent scenario comparisons				
	Social Domain	Non-social Domain		
	M (SD)	*M (SD)*	*t*	*d*
Exclusively character-based*	18.75% (23.73%)	11.68% (15.43%)	4.83	0.33
Exclusively behaviour-based	56.51% (27.92%)	53.63% (26.80%)	1.25	0.09
Both character- and behaviour-based*	18.79% (21.55%)	27.96% (26.21%)	6.06	0.41
Consistent scenario comparisons				
	Social Domain	Non-social Domain		
	M (SD)	*M (SD)*	*t*	*d*
Exclusively character-based*	17.70% (23.31%)	12.68% (15.84%)	3.47	0.24
Exclusively behaviour-based*	57.93% (29.00%)	43.41% (25.58%)	6.02	0.41
Both character- and behaviour-based*	19.09% (20.47%)	39.42% (27.10%)	11.47	0.78

Note. * $p < 0.001$. After Bonferroni correction.

Appendix 11a

Correlation results between the proportion of written justifications in the Social Domain and sub-scale scores on the AQ, Experiment 2

		Inconsistent scenarios		
		Exclusively character-based	Exclusively behaviour-based	Both character- and behaviour-based
Social skill	r_s	-0.047	-0.057	0.126
	p	0.493	0.406	0.064
Attention switching	r_s	-0.093	0.017	0.058
	p	0.170	0.800	0.395
Attention to detail	r_s	-0.070	-0.008	-0.006
	p	0.308	0.911	0.931
Communication	r_s	-0.034	-0.050	0.120
	p	0.614	0.467	0.079
Imagination	r_s	0.001	-0.011	-0.017
	p	0.983	0.871	0.806

*** Correlation is significant at the 0.01 level (2-tailed).*

** Correlation is significant at the 0.05 level (2-tailed).*

Appendix 11b

Correlation results between the proportion of written justifications in the Non-social Domain and sub-scale scores on the AQ, Experiment 2

		Exclusively character-based	Exclusively behaviour-based	Both character- and behaviour-based
Social skill	r_s	0.058	-.179**	0.121
	p	0.398	0.008	0.076
Attention switching	r_s	-0.031	-0.036	0.075
	p	0.645	0.593	0.273
Attention to detail	r_s	0.045	-.181**	0.098
	p	0.513	0.007	0.152
Communication	r_s	0.046	-0.100	0.049
	p	0.498	0.140	0.475
Imagination	r_s	0.044	-0.034	-0.006
	p	0.524	0.614	0.934

*** Correlation is significant at the 0.01 level (2-tailed).*

** Correlation is significant at the 0.05 level (2-tailed).*

Appendix 12a

Participants' ethnicity information, Experiment 3

Ethnic group	Autism (*N* = 23)	Control (*N* = 23)
White—English/Welsh/Scottish/Northern Irish/British	19	17
White—Other (Cypriot)	0	1
Mixed/Multiple Ethnics Groups—White and Black Caribbean	1	0
Mixed/Multiple Ethnics Groups—White and Black African	0	2
Mixed/Multiple Ethnics Groups—White and Asian	1	0
Asian/Asian British—Indian	1	0
Asian/Asian British—Chinese	0	1
Asian/Asian British—Other (Tamil)	0	1
Black/African/Caribbean/Black British—Caribbean	1	0
Prefer not to say	0	1

Appendix 12b

Participants' education levels, Experiment 3

Education level	Autism (*N* = 23)	Control (*N* = 23)
Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS)	5	8
University bachelor's degree	7	8
Some university but no degree	4	3
Vocational or similar	2	0
Completed secondary school	4	4
Some secondary	1	0

Appendix 13: Rational Experiential Inventory (REI; Epstein et al., 1996)

		definitely not true of myself	somewhat not true of myself	neither true nor untrue of myself	somewhat true of myself	definitely true of myself
1	I try to avoid situations that require thinking in depth about something.	5	4	3	2	1
2	I'm not that good at figuring out complicated problems.	5	4	3	2	1
3	I enjoy intellectual challenges.	1	2	3	4	5
4	I am not very good at solving problems that require careful logical analysis.	5	4	3	2	1
5	I don't like to have to do a lot of thinking.	5	4	3	2	1
6	I enjoy solving problems that require hard thinking.	1	2	3	4	5
7	Thinking is not my idea of an enjoyable activity.	5	4	3	2	1
8	I am not a very analytical thinker.	5	4	3	2	1
9	Reasoning things out carefully is not one of my strong points.	5	4	3	2	1
10	I prefer complex problems to simple problems.	1	2	3	4	5
11	Thinking hard and for a long time about something gives me little satisfaction.	5	4	3	2	1
12	I don't reason well under pressure.	5	4	3	2	1

13	I am much better at figuring things out logically than most people.	1	2	3	4	5
14	I have a logical mind.	1	2	3	4	5
15	I enjoy thinking in abstract terms.	1	2	3	4	5
16	I have no problem thinking things through carefully.	1	2	3	4	5
17	Using logic usually works well for me in figuring out problems in my life.	1	2	3	4	5
18	Knowing the answer without having to understand the reasoning behind it is good enough for me.	5	4	3	2	1
19	I usually have clear, explainable reasons for my decisions.	1	2	3	4	5
20	Learning new ways to think would be very appealing to me.	1	2	3	4	5
21	I like to rely on my intuitive impressions.	1	2	3	4	5
22	I don't have a very good sense of intuition.	5	4	3	2	1
23	Using my gut feelings usually works well for me in figuring out problems in my life.	1	2	3	4	5
24	I believe in trusting my hunches.	1	2	3	4	5
25	Intuition can be a very useful way to solve problems.	1	2	3	4	5
26	I often go by my instincts when deciding on a course of action.	1	2	3	4	5
27	I trust my initial feelings about people.	1	2	3	4	5
28	When it comes to trusting people, I can usually rely on my gut feelings.	1	2	3	4	5
29	If I were to rely on my gut feelings, I would often make mistakes.	5	4	3	2	1

30	I don't like situations in which I have to rely on intuition.	5	4	3	2	1
31	I think there are times when one should rely on one's intuition.	1	2	3	4	5
32	I think it is foolish to make important decisions based on feelings.	5	4	3	2	1
33	I don't think it is a good idea to rely on one's intuition for important decisions.	5	4	3	2	1
34	I generally don't depend on my feelings to help me make decisions.	5	4	3	2	1
35	I hardly ever go wrong when I listen to my deepest gut feelings to find an answer.	1	2	3	4	5
36	I would not want to depend on anyone who described himself or herself as intuitive.	5	4	3	2	1
37	My snap judgments are probably not as good as most people's.	5	4	3	2	1
38	I tend to use my heart as a guide for my actions.	1	2	3	4	5
39	I can usually feel when a person is right or wrong, even if I can't explain how I know.	1	2	3	4	5
40	I suspect my hunches are inaccurate as often as they are accurate.	5	4	3	2	1

Note. For total scores on the sub-scale of ‘rationality’, sum scores for these items: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20. For total scores on the sub-scale of ‘experientiality’, sum scores for these items: 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, and 40.

Appendix 14: CRT-7 items with four-options (Sirota & Juanchich, 2018)

Item	Multiple-choice options
A bat and a ball cost £1.10 in total. The bat costs £1.00 more than the ball. How much does the ball cost?	5 pence (correct, reflective) 10 pence (incorrect, intuitive) 9 pence 1 penny
If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?	5 minutes (correct, reflective) 100 minutes (incorrect, intuitive) 20 minutes 500 minutes
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?	47 days (correct, reflective) 24 days (incorrect, intuitive) 12 days 36 days
If John can drink one barrel of water in 6 days, and Mary can drink one barrel of water in 12 days,	4 days (correct, reflective) 9 days (incorrect, intuitive) 12 days 3 days

how long would it take them to drink one barrel of water together?	
Jerry received both the 15th highest and the 15th lowest mark in the class. How many students are in the class?	29 students (correct, reflective) 30 students (incorrect, intuitive) 1 student 15 students
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?	20 pounds (correct, reflective) 10 pounds (incorrect, intuitive) 0 pound 30 pounds
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 lost money. (correct, reflective) is ahead of where he began. (incorrect, intuitive) has broken even in the stock market. it cannot be determined.

Appendix 15

Correlation results between the proportion of behaviour-based responses for scenario comparisons AQ total and sub-scale scores by groups, Experiment 3

		Autism (N = 23)			Comparison (N = 23)	
		Social Domain	Non-social Domain		Social Domain	Non-social Domain
AQ total score	r_s	-0.336	0.091	r	0.023	-0.004
	p	0.117	0.679	p	0.918	0.985
Social skill	r_s	-0.333	0.317	r_s	-0.125	-0.207
	p	0.120	0.141	p	0.571	0.343
Attention switching	r_s	-0.056	0.514*	r	0.154	0.015
	p	0.800	0.012	p	0.482	0.947
Attention to detail	r	-0.294	0.200	r	0.087	0.267
	p	0.173	0.360	p	0.693	0.218
Communication	r_s	-0.141	0.358	r_s	-0.072	-0.216
	p	0.520	0.093	p	0.743	0.322
Imagination	r	-0.390	-0.028	r_s	0.054	0.158
	p	0.066	0.899	p	0.807	0.472

** Correlation is significant at the 0.05 level (2-tailed).*

*** Correlation is significant at the 0.01 level (2-tailed).*

Appendix 16

Results of 2 x 2 x 2 x 2 x 2 ANOVA with domain type, consistency, outcome type, group, and domain order, Experiment 3

	F	p	η_p^2
Domain Type	**12.81**	**0.001**	**0.23**
Consistency	**154.51**	**0.000**	**0.79**
Group	0.00	0.990	0.00
Domain Order	0.49	0.487	0.01
Outcome Type	**20.07**	**0.000**	**0.32**
Domain Type * Group	1.04	0.314	0.02
Domain Type * Domain Order	0.30	0.589	0.01
Consistency * Group	1.04	0.313	0.02
Consistency * Domain Order	2.00	0.165	0.05
Outcome Type * Group	1.28	0.264	0.03
Outcome Type * Domain Order	0.12	0.732	0.00
Domain Type * Consistency	**16.65**	**0.000**	**0.28**
Domain Type * Outcome Type	0.73	0.399	0.02
Consistency * Outcome Type	**17.23**	**0.000**	**0.29**
Domain Type * Consistency * Outcome Type	**38.58**	**0.000**	**0.48**
Domain Type * Consistency * Domain Order	1.96	0.169	0.04
Domain Type * Consistency * Group	1.36	0.251	0.03
Domain Type * Outcome Type * Domain Order	0.00	0.990	0.00
Domain Type * Outcome Type * Group	2.41	0.128	0.05
Domain Type * Domain Order * Group	0.03	0.863	0.00
Consistency * Outcome Type * Group	0.00	0.978	0.00

Consistency * Outcome Type * Domain Order	0.35	0.559	0.01
Consistency * Domain Order * Group	2.15	0.150	0.05
Outcome Type * Domain Order * Group	3.26	0.078	0.07
Domain Type * Consistency * Outcome Type * Group	0.00	0.972	0.00
Domain Type * Consistency * Outcome Type * Domain Order	1.10	0.301	0.03
Domain Type * Consistency * Domain Order * Group	1.66	0.204	0.04
Domain Type * Outcome Type * Domain Order * Group	0.01	0.934	0.00
Consistency * Outcome Type * Domain Order * Group	0.17	0.686	0.00
Domain Type * Consistency * Outcome Type * Domain Order * Group	0.05	0.822	0.00
Domain Order * Group	3.05	0.088	0.07

Note. Significant results are shown in bold.

Appendix 17

Participants' ethnicity information, Experiment 4

	N	*%*
White—English/Welsh/Scottish/Northern Irish/British	29	38.2
Any other White background	6	7.9
Asian/Asian British—Indian	6	7.9
Asian/Asian British—Pakistani	7	9.2
Asian/Asian British—Chinese	10	13.2
Any other Asian background	1	1.3
Black/African/Caribbean/Black British—African	9	11.8
Mixed—White and Asian	4	5.3
Any other—Arab	2	2.6
Any other ethnic group	2	2.6

Appendix 18

Binary variables and values

Domains and variables	Value 1	Value 2
Economics		
Interest rates	Low	High
Trade deficits	Small	Large
Retirement savings	High	Low
Meteorology		
Ozone level	High	Low
Air pressure	Low	High
Humidity	High	Low
Social relationship–1		
Alex’s work pattern	Low	High
Bernadette’s music practice	High	Low
Bernadette’s happiness	Low	High
Social relationship–2		
Andy’s stress level	Low	High
Brian’s food intake	High	Low
Brain’s sleep duration	Low	High

Appendix 19

Material for the Binary Inference Test, Experiment 4

Causal mechanisms and relationships for each scenario with diagrams, MCT questions, and BIT questions

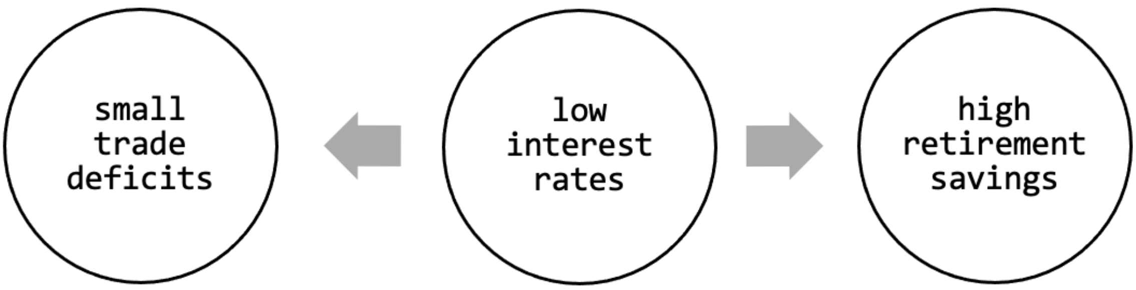
Information about the causal relationships for economics

Some economies have low interest rates. You will read some information below about the causal links between interest rates, trade deficits and retirement savings which are related to this particular country's economy.

Low interest rates cause small trade deficits. The low cost of borrowing money leads businesses to invest in the latest manufacturing technologies, and the resulting low-cost product are exported around the world.

Low interest rates cause high retirement savings. Low interest rates stimulate economic growth, leading to greater prosperity overall, and allowing more money to be saved for retirement in particular.

So, the graph below indicates this particular economy and the causal link between the low interest rates, small trade deficits and high retirement savings as mentioned above.



Multiple Choice Test for Economics

1. What proportion of economies have low interest rates?

- **a.** Some
- **b.** All
- **c.** None

2. What are small trade deficits caused by?

- **a.** High retirement savings
- **b.** Low interest rates
- **c.** All of the above
- **d.** None of the above

3. How do interest rates affect trade deficits?

- **a.** Normal interest rates cause small trade deficits.
- **b.** Normal interest rates cause normal trade deficits.
- **c.** Low interest rates cause small trade deficits.
- **d.** Low interest rates cause normal trade deficits.
- **e.** Interest rates have no effect on trade deficits.

4. How do interest rates affect retirement savings?

- **a.** Low interest rates cause normal retirement savings.
- **b.** Low interest rates cause high retirement savings.
- **c.** Normal interest rates cause high retirement savings.
- **d.** Normal interest rates cause normal retirement savings.
- **e.** Interest rates have no effect on retirement savings.

5. How does trade deficits affect retirement savings?
   a. Small trade deficits cause high retirement savings.
   b. Small trade deficits cause low retirement savings.
   c. Normal trade deficits cause high retirement savings.
   d. Normal trade deficits cause normal retirement savings.
   e. Trade deficits have no effect on retirement savings.

6. What are high retirement savings caused by?
   a. Small trade deficits
   b. Low interest rates
   c. All of the above
   d. None of the above

7. Low interest rates cause small trade deficits because;
   a. The low cost of borrowing money leads businesses to invest in the latest manufacturing technologies, and the resulting low-cost product are exported around the world.
   b. Money is cheap for consumers to borrow (e.g., on credit cards) demand for ‘‘big ticket’’ consumer goods is high and large commercial retailers increase their imports from foreign countries.
   c. Interest rates have no effect on trade deficits.

8. Low interest rates cause high retirement savings because;

a. The good economic times produced by the low interest rates leads to greater confidence and less worry about the future, so people are less concerned about retirement.

b. Low interest rates stimulate economic growth, leading to greater prosperity overall, and allowing more money to be saved for retirement in particular.

c. Interest rates have no effect on retirement savings.

Binary Inference Test for Economics (Non-social Domain)

1. Which situation is more likely to have high retirement savings? **(A vs B)**

1	**2**
Low interest rates Small trade deficits ???	Low interest rates ??? ???

a. 1

b. 2

c. Equally likely

2. Which situation is more likely to have high retirement savings? **(B vs C)**

1	**2**
Low interest rates ??? ???	Low interest rates Large trade deficits ???

a. 1

b. 2

c. Equally likely

3. Which situation is more likely to have high retirement savings? **(D vs E)**

1	**2**
??? Small trade deficits ???	??? Large trade deficits ???

a. 1

b. 2

c. Equally likely

4. Which situation is more likely to have high retirement savings? **(F vs G)**

1	**2**
High interest rates Small trade deficits ???	High interest rates ??? ???

a. 1

b. 2

c. Equally likely

5. Which situation is more likely to have high retirement savings? **(G vs H)**

1	**2**
High interest rates ??? ???	High interest rates Large trade deficits ???

a. 1

b. 2

c. Equally likely

6. Which situation is more likely to have small trade deficits? **(A vs B)**

1	**2**
Low interest rates High retirement savings ???	Low interest rates ??? ???

a. 1

b. 2

c. Equally likely

7. Which situation is more likely to have small trade deficits? **(B vs C)**

1	**2**
Low interest rates ??? ???	Low interest rates Low retirement savings ???

a. 1

b. 2

c. Equally likely

8. Which situation is more likely to have small trade deficits? **(D vs E)**

1	**2**
??? High retirement savings ???	??? Low retirement savings ???

a. 1

b. 2

c. Equally likely

9. Which situation is more likely to have small trade deficits? **(F vs G)**

1	**2**
High interest rates High retirement savings ???	High interest rates ??? ???

a. 1

b. 2

c. Equally likely

10. Which situation is more likely to have small trade deficits? **(G vs H)**

1	**2**
High interest rates ??? ???	High interest rates Low retirement savings ???

a. 1

b. 2

c. Equally likely

11. Which situation is more likely to have high retirement savings? **(B vs A)**

1	**2**
Low interest rates ??? ???	Low interest rates Small trade deficits ???

a. 1

b. 2

c. Equally likely

12. Which situation is more likely to have high retirement savings? **(C vs B)**

1	**2**
Low interest rates Large trade deficits ???	Low interest rates ??? ???

a. 1

b. 2

c. Equally likely

13. Which situation is more likely to have high retirement savings? **(E vs D)**

1	**2**
??? Large trade deficits ???	??? Small trade deficits ???

a. 1

b. 2

c. Equally likely

14. Which situation is more likely to have high retirement savings? **(G vs F)**

1	**2**
High interest rates ??? ???	High interest rates Small trade deficits ???

a. 1

b. 2

c. Equally likely

15. Which situation is more likely to have high retirement savings? **(H vs G)**

1	**2**
High interest rates Large trade deficits ???	High interest rates ??? ???

a. 1

b. 2

c. Equally likely

16. Which situation is more likely to have small trade deficits? **(B vs A)**

1	**2**
Low interest rates ??? ???	Low interest rates High retirement savings ???

a. 1

b. 2

c. Equally likely

17. Which situation is more likely to have small trade deficits? **(C vs B)**

1	**2**
Low interest rates Low retirement savings ???	Low interest rates ??? ???

a. 1

b. 2

c. Equally likely

18. Which situation is more likely to have small trade deficits? **(E vs D)**

1	**2**
??? Low retirement savings ???	??? High retirement savings ???

a. 1

b. 2

c. Equally likely

19. Which situation is more likely to have small trade deficits? **(G vs F)**

1	**2**
High interest rates ??? ???	High interest rates High retirement savings ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

20. Which situation is more likely to have small trade deficits? **(H vs G)**

1	**2**
High interest rates Low retirement savings ???	High interest rates ??? ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

Information about the causal relationships for meteorology

Some countries have high amount of ozone. You will read some information below about the causal links between the amount of ozone, air pressure and humidity which are related to this country's meteorology.

A high amount of ozone causes high air pressure. With more molecules present in the atmosphere, more pressure is exerted.

A high amount of ozone causes low humidity. Ozone accepts extra oxygen atoms, decreasing the amount of oxygen available to form water molecules. With fewer water molecules, there is lower humidity.

So, the graph below indicates this particular country's meteorology and the causal link between the high amount of ozone, high air pressure and low humidity as mentioned above.

Multiple Choice Test for Meteorology

1. For meteorology, which proportion of countries have high amount of ozone?

- **a.** All
- **b.** Some
- **c.** None

2. What is high air pressure caused by?

- **a.** High amount of ozone
- **b.** Low humidity
- **c.** All of the above
- **d.** None of the above

3. How does the amount of ozone affect air pressure?

- **a.** High amount of ozone causes normal air pressure.
- **b.** High amount of ozone causes high air pressure.
- **c.** Normal amount of ozone causes high air pressure.
- **d.** Normal amount of ozone causes normal air pressure.
- **e.** The amount of ozone has no effect on air pressure.

4. How does the amount of ozone affect humidity?

- **a.** Normal amount of ozone causes low humidity.
- **b.** Normal amount of ozone causes normal humidity.
- **c.** High amount of ozone causes normal humidity.
- **d.** High amount of ozone causes low humidity.
- **e.** The amount of ozone has no effect on humidity.

5. How does air pressure affect humidity?

a. High air pressure causes low humidity.

b. High air pressure causes normal humidity.

c. Normal air pressure causes high humidity.

d. Normal air pressure causes normal humidity.

e. Air pressure has no effect on humidity.

6. What is low humidity caused by?

a. High amount of ozone

b. High air pressure

c. All of the above

d. None of the above

7. High amount of ozone causes high air pressure because;

a. Ozone, being an allotrope of oxygen (O3), combines with more atoms. These denser collections of atoms sink from open regions, creating less pressure.

b. With more molecules present in the atmosphere, more pressure is exerted.

c. The amount of ozone has no effect on air pressure.

8. High amount of ozone causes low humidity because;

a. Ozone accepts extra oxygen atoms, decreasing the amount of oxygen available to form water molecules. With fewer water molecules, there is lower humidity.

b. Ozone attracts extra oxygen atoms from water molecules, creating a concentration of water vapour in that region.

c. The amount of ozone has no effect on humidity.

Binary Inference Test for Meteorology (Non-social Domain)

1. Which one is more likely to have low humidity? **(A vs B)**

1	**2**
High amount of ozone High air pressure ???	High amount of ozone ??? ???

   a. 1

   b. 2

   c. Equally likely

2. Which one is more likely to have low humidity? **(B vs C)**

1	**2**
High amount of ozone ??? ???	High amount of ozone Low air pressure ???

   a. 1

   b. 2

   c. Equally likely

3. Which one is more likely to have low humidity? **(D vs E)**

1	**2**
??? High air pressure ???	??? Low air pressure ???

   a. 1

   b. 2

   c. Equally likely

4. Which one is more likely to have low humidity? **(F vs G)**

1	**2**
Low amount of ozone High air pressure ???	Low amount of ozone ??? ???

a. 1

b. 2

c. Equally likely

5. Which one is more likely to have low humidity? **(G vs H)**

1	**2**
Low amount of ozone ??? ???	Low amount of ozone Low air pressure ???

a. 1

b. 2

c. Equally likely

6. Which one is more likely to have high air pressure? **(A vs B)**

1	**2**
High amount of ozone Low humidity ???	High amount of ozone ??? ???

a. 1

b. 2

c. Equally likely

7. Which one is more likely to have high air pressure? **(B vs C)**

1	**2**
High amount of ozone ??? ???	High amount of ozone High humidity ???

a. 1

b. 2

c. Equally likely

8. Which one is more likely to have high air pressure? **(D vs E)**

1	**2**
??? Low humidity ???	??? High humidity ???

a. 1

b. 2

c. Equally likely

9. Which one is more likely to have high air pressure? **(F vs G)**

1	**2**
Low amount of ozone Low humidity ???	Low amount of ozone ??? ???

a. 1

b. 2

c. Equally likely

10. Which one is more likely to have high air pressure? **(G vs H)**

1

Low amount of ozone ??? ???

2

Low amount of ozone High humidity ???

a. 1

b. 2

c. Equally likely

11. Which one is more likely to have low humidity? **(B vs A)**

1

High amount of ozone ??? ???

2

High amount of ozone High air pressure ???

a. 1

b. 2

c. Equally likely

12. Which one is more likely to have low humidity? **(C vs B)**

1

High amount of ozone Low air pressure ???

2

High amount of ozone ??? ???

a. 1

b. 2

c. Equally likely

13. Which one is more likely to have low humidity? **(E vs D)**

1	**2**
??? Low air pressure ???	??? High air pressure ???

a. 1

b. 2

c. Equally likely

14. Which one is more likely to have low humidity? **(G vs F)**

1	**2**
Low amount of ozone ??? ???	Low amount of ozone High air pressure ???

a. 1

b. 2

c. Equally likely

15. Which one is more likely to have low humidity? **(H vs G)**

1	**2**
Low amount of ozone Low air pressure ???	Low amount of ozone ??? ???

a. 1

b. 2

c. Equally likely

16. Which one is more likely to have high air pressure? **(B vs A)**

1	**2**
High amount of ozone ??? ???	High amount of ozone Low humidity ???

a. 1

b. 2

c. Equally likely

17. Which one is more likely to have high air pressure? **(C vs B)**

1	**2**
High amount of ozone High humidity ???	High amount of ozone ??? ???

a. 1

b. 2

c. Equally likely

18. Which one is more likely to have high air pressure? **(E vs D)**

1	**2**
??? High humidity ???	??? Low humidity ???

a. 1

b. 2

c. Equally likely

19. Which one is more likely to have high air pressure? **(G vs F)**

1	**2**
Low amount of ozone ??? ???	Low amount of ozone Low humidity ???

a. 1

b. 2

c. Equally likely

20. Which one is more likely to have high air pressure? **(H vs G)**

1	**2**
Low amount of ozone High humidity ???	Low amount of ozone ??? ???

a. 1

b. 2

c. Equally likely

Information about the causal relationships for Social Relationship–1

Alex and Bernadette are in a relationship.

Alex's working patterns vary. Sometimes he tends to work more than usual.

You will read some information below about the causal links between Alex's work pattern, Bernadette's music practice and her happiness.

Alex working more causes Bernadette to practice her violin more. When Alex is working lots, Bernadette and Alex don't see very much of each other. When this happens, Bernadette spends lots of time playing her violin.

Alex working more causes Bernadette to feel less happy. Alex hates his job. When Alex is working lots, he can become irritable quite quickly and so he's harder to get along with. This makes Bernadette feel less happy.

So, the graph below indicates this particular couple's relationship and the causal links between Alex's work pattern, Bernadette's music practice and Bernadette's level of happiness as mentioned above.

Multiple Choice Test for Social Relationship–1

1. How often does Alex tend to work more?

a. Never

b. Always

c. Sometimes

2. What does affect Bernadette to practice her violin more?

a. Alex's high level of work pattern

b. Bernadette's low level of happiness

c. All of the above

d. None of the above

3. How does Alex's high level of work pattern affect Bernadette's level of practice on her violin?

a. Alex works average causes Bernadette to practice her violin more.

b. Alex works average causes Bernadette to practice her less.

c. Alex works more causes Bernadette to practice her violin more.

d. Alex works more causes Bernadette to practice her violin less.

e. Alex's work pattern has no effect on Bernadette's music practice.

4. How does Alex's high level of work pattern affect Bernadette's level of happiness?

a. Alex works more causes Bernadette to feel happier.

b. Alex works more causes Bernadette to feel less happy.

c. Alex works average causes Bernadette to feel happier.

d. Alex works average causes Bernadette to feel less happy.

- **e.** Alex's work pattern has no effect on Bernadette's happiness.

5. How does Bernadette's music practice affect her happiness?

- **a.** Bernadette high level of music practice causes her to feel happier.
- **b.** Bernadette high level of music practice causes her to feel less happy.
- **c.** Bernadette average level of music practice causes her to feel happier.
- **d.** Bernadette average level of music practice causes her to less happy.
- **e.** Bernadette music practice has no effect on her happiness.

6. What does affect Bernadette to feel less happy?

- **a.** Bernadette practices violin more
- **b.** Alex works more
- **c.** All of the above
- **d.** None of the above

7. Alex working more causes Bernadette to practice her violin more because;

- **a.** When Alex is working lots, Bernadette and Alex don't see very much of each other.
- **b.** When Alex isn't working so much, Bernadette and Alex spend lots of time together.
- **c.** Alex's work pattern has no effect on Bernadette's violin practice.

8. Alex working more causes Bernadette to feel less happy because;

- **a.** Alex hates his job. When Alex isn't working so much, he's much happier and easier to get along with.

b. Alex hates his job. When Alex is working lots, he can become irritable quite quickly and so he’s harder to get along with.

c. Alex’s work pattern has no effect on Bernadette’s happiness.

Binary Inference Test for Social Relationship–1 (Social Domain)

1. Which situation is more likely to cause Bernadette to feel less happy? **(A vs B)**

1	**2**
Alex works more Bernadette practices violin more ???	Alex works more ??? ???

a. 1

b. 2

c. Equally likely

2. Which situation is more likely to cause Bernadette to feel less happy? **(B vs C)**

1	**2**
Alex works more ??? ???	Alex works more Bernadette practices violin less ???

a. 1

b. 2

c. Equally likely

3. Which situation is more likely to cause Bernadette to feel less happy? **(D vs E)**

1	**2**
??? Bernadette practices violin more ???	??? Bernadette practices violin less ???

a. 1

b. 2

c. Equally likely

4. Which situation is more likely to cause Bernadette to feel less happy? **(F vs G)**

1	**2**
Alex works less Bernadette practices violin more ???	Alex works less ??? ???

a. 1

b. 2

c. Equally likely

5. Which situation is more likely to cause Bernadette to feel less happy? **(G vs H)**

1	**2**
Alex works less ??? ???	Alex works less Bernadette practices violin less ???

a. 1

b. 2

c. Equally likely

6. Which situation is more likely to cause Bernadette to practice violin more? **(A vs B)**

1	**2**
Alex works more Bernadette feels less happy ???	Alex works more ??? ???

a. 1

b. 2

c. Equally likely

7. Which situation is more likely to cause Bernadette to practice violin more? **(B vs C)**

1	**2**
Alex works more ??? ???	Alex works more Bernadette feels happier ???

a. 1

b. 2

c. Equally likely

8. Which situation is more likely to cause Bernadette to practice violin more? **(D vs E)**

1	**2**
??? Bernadette feels less happy ???	??? Bernadette feels happier ???

a. 1

b. 2

c. Equally likely

9. Which situation is more likely to cause Bernadette to practice violin more? **(F vs G)**

1	**2**
Alex works less Bernadette feels less happy ???	Alex works less ??? ???

a. 1

b. 2

c. Equally likely

10. Which situation is more likely to cause Bernadette to practice violin more? **(G vs H)**

1	**2**
Alex works less ??? ???	Alex works less Bernadette feels happier ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

11. Which situation is more likely to cause Bernadette to feel less happy? **(B vs A)**

1	**2**
Alex works more ??? ???	Alex works more Bernadette practices violin more ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

12. Which situation is more likely to cause Bernadette to feel less happy? **(C vs B)**

1	**2**
Alex works more Bernadette practices violin less ???	Alex works more ??? ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

13. Which situation is more likely to cause Bernadette to feel less happy? **(E vs D)**

1	**2**
??? Bernadette practices violin less ???	??? Bernadette practices violin more ???

a. 1

b. 2

c. Equally likely

14. Which situation is more likely to cause Bernadette to feel less happy? **(G vs F)**

1	**2**
Alex works less ??? ???	Alex works less Bernadette practices violin more ???

a. 1

b. 2

c. Equally likely

15. Which situation is more likely to cause Bernadette to feel less happy? **(H vs G)**

1	**2**
Alex works less Bernadette practices violin less ???	Alex works less ??? ???

a. 1

b. 2

c. Equally likely

16. Which situation is more likely to cause Bernadette to practice violin more? **(B vs A)**

1	**2**
Alex works more ??? ???	Alex works more Bernadette feels less happy ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

17. Which situation is more likely to cause Bernadette to practice violin more? **(C vs B)**

1	**2**
Alex works more Bernadette feels happier ???	Alex works more ??? ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

18. Which situation is more likely to cause Bernadette to practice violin more? **(E vs D)**

1	**2**
??? Bernadette feels happier ???	??? Bernadette feels less happy ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

19. Which situation is more likely to cause Bernadette to practice violin more? **(G vs F)**

1	**2**
Alex works less ??? ???	Alex works less Bernadette feels less happy ???

a. 1

b. 2

c. Equally likely

20. Which situation is more likely to cause Bernadette to practice violin more? **(H vs G)**

1	**2**
Alex works less Bernadette feels happier ???	Alex works less ??? ???

a. 1

b. 2

c. Equally likely

Information about the causal relationships for Social Relationship–2

Andy and Brian are in a relationship.

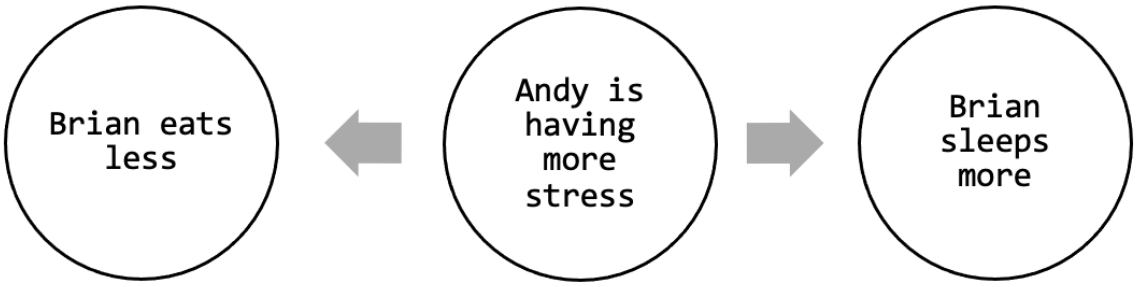
Andy's stress level varies. Sometimes he tends to have more stress than usual.

You will read some information below about the causal links between Andy's stress level, Brian's food intake and his sleep duration.

Andy having more stress causes Brian to eat less. When Andy is really stressed, Brian skips breakfast in the morning to help Andy.

Andy having more stress causes Brian to sleep more. When Andy is really stressed, Andy avoids Brian, causing Brian to go to nightclubs less often, making him sleep longer.

So, the graph below indicates this particular couple's relationship and the causal links between Andy's stress level, Brian's food intake and Brian's sleep duration as mentioned above.



Multiple Choice Test for Social Relationship–2

1. How often does Andy tend to stress more?

a. Sometimes

b. Always

c. Never

2. What does affect Brian to sleep more?

a. Andy is having more stress

b. Brian eats less

c. All of the above

d. None of the above

3. How does Andy's level of stress affect Brian's food intake?

a. Andy is having average level of stress causes Brian to eat less.

b. Andy is having average level of stress causes Brian to eat more.

c. Andy is having high level of stress causes Brian to eat less.

d. Andy is having high level of stress causes Brian to eat more.

e. Andy's stress level has no effect on Brian's food intake.

4. How does Andy's level of stress affect Brian's sleep duration?

a. Andy is having high level of stress causes Brian to sleep less.

b. Andy is having high level of stress causes Brian to sleep more.

c. Andy is having average level of stress causes Brian to sleep less.

d. Andy is having average level of stress causes Brian to sleep more.

e. Andy's stress level has no effect on Brian's sleep duration.

5. How does Brian's food intake affect his sleep duration?

- **a.** Brian's low level of food intake causes his to sleep less.
- **b.** Brian's low level of food intake causes his to sleep more.
- **c.** Brian's average level of food intake causes his to sleep less.
- **d.** Brian's average level of food intake causes his to sleep more.
- **e.** Brian's food intake has no effect on his sleep duration.

6. What does affect Brian to eat less?

- **a.** Brian sleeps more
- **b.** Andy is having more stress
- **c.** All of the above
- **d.** None of the above

7. Andy having more stress causes Brian to eat less because;

- **a.** When Andy is really stressed, Brian skips breakfast in the morning to help Andy.
- **b.** When Andy is relaxed, Andy invites Brian to play video games all evening without eating enough.
- **c.** Andy's stress level has no effect on Brian's food intake.

8. Andy having more stress causes Brian to sleep more because;

- **a.** When Andy is really stressed, Andy avoids Brian, causing Brian to go to nightclubs less often, making him sleep longer.
- **b.** When Andy is relaxed, Andy less often wakes up Brian with phone calls.
- **c.** Andy's stress level has no effect on Brian's sleep duration.

Binary Inference Test for Social Relationship–2 (Social Domain)

1. Which situation is more likely to cause Brian to eat less? **(A vs B)**

1

Andy is having more stress Brian sleeps more ???

2

Andy is having more stress ??? ???

a. 1

b. 2

c. Equally likely

2. Which situation is more likely to cause Brian to eat less? **(B vs C)**

1

Andy is having more stress ??? ???

2

Andy is having more stress Brian sleeps less ???

a. 1

b. 2

c. Equally likely

3. Which situation is more likely to cause Brian to eat less? **(D vs E)**

1

??? Brian sleeps more ???

2

??? Brian sleeps less ???

a. 1

b. 2

c. Equally likely

4. Which situation is more likely to cause Brian to eat less? **(F vs G)**

1	**2**
Andy is having less stress Brian sleeps more ???	Andy is having less stress ??? ???

a. 1

b. 2

c. Equally likely

5. Which situation is more likely to cause Brian to eat less? **(G vs H)**

1	**2**
Andy is having less stress ??? ???	Andy is having less stress Brian sleeps less ???

a. 1

b. 2

c. Equally likely

6. Which situation is more likely to cause Brian to sleep more? **(A vs B)**

1	**2**
Andy is having more stress Brian eats less ???	Andy is having more stress ??? ???

a. 1

b. 2

c. Equally likely

7. Which situation is more likely to cause Brian to sleep more? **(B vs C)**

1

Andy is having more stress ??? ???

2

Andy is having more stress Brian eats more ???

a. 1

b. 2

c. Equally likely

8. Which situation is more likely to cause Brian to sleep more? **(D vs E)**

1

??? Brian eats less ???

2

??? Brian eats more ???

a. 1

b. 2

c. Equally likely

9. Which situation is more likely to cause Brian to sleep more? **(F vs G)**

1

Andy is having less stress Brian eats less ???

2

Andy is having less stress ??? ???

a. 1

b. 2

c. Equally likely

10. Which situation is more likely to cause Brian to sleep less? **(G vs H)**

1	**2**
Andy is having less stress ??? ???	Andy is having less stress Brian eats more ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

11. Which situation is more likely to cause Brian to eat less? **(B vs A)**

1	**2**
Andy is having more stress ??? ???	Andy is having more stress Brian sleeps more ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

12. Which situation is more likely to cause Brian to eat less? **(C vs B)**

1	**2**
Andy is having more stress Brian sleeps less ???	Andy is having more stress ??? ???

- **a.** 1
- **b.** 2
- **c.** Equally likely

13. Which situation is more likely to cause Brian to eat less? **(E vs D)**

1	**2**
??? Brian sleeps less ???	??? Brian sleeps more ???

a. 1

b. 2

c. Equally likely

14. Which situation is more likely to cause Brian to eat less? **(G vs F)**

1	**2**
Andy is having less stress ??? ???	Andy is having less stress Brian sleeps more ???

a. 1

b. 2

c. Equally likely

15. Which situation is more likely to cause Brian to eat less? **(H vs G)**

1	**2**
Andy is having less stress Brian sleeps less ???	Andy is having less stress ??? ???

a. 1

b. 2

c. Equally likely

16. Which situation is more likely to cause Brian to sleep more? **(B vs A)**

1	**2**
Andy is having more stress ??? ???	Andy is having more stress Brian eats less ???

a. 1

b. 2

c. Equally likely

17. Which situation is more likely to cause Brian to sleep more? **(C vs B)**

1	**2**
Andy is having more stress Brian eats more ???	Andy is having more stress ??? ???

a. 1

b. 2

c. Equally likely

18. Which situation is more likely to cause Brian to sleep more? **(E vs D)**

1	**2**
??? Brian eats more ???	??? Brian eats less ???

a. 1

b. 2

c. Equally likely

19. Which situation is more likely to cause Brian to sleep more? **(G vs F)**

1	**2**
Andy is having less stress ??? ???	Andy is having less stress Brian eats less ???

a. 1

b. 2

c. Equally likely

20. Which situation is more likely to cause Brian to sleep more? **(H vs G)**

1	**2**
Andy is having less stress Brian eats more ???	Andy is having less stress ??? ???

a. 1

b. 2

c. Equally likely

Appendix 20a: Choice score comparisons to 0.50 for all choice problems

Participants' scores for all choice problems significantly differed from the value of 0.50, except A vs. B.

Choice score comparisons to 0.50

	t	*p*	*d*	*M*	*SEM*	M_{diff}
AvsB	-0.38	0.703	-0.04	0.49	0.03	-0.01
BvsC*	9.60	< 0.001	1.10	0.72	0.02	0.22
DvsE*	11.65	< 0.001	1.34	0.74	0.02	0.24
FvsG*	4.93	< 0.001	0.57	0.56	0.01	0.06
GvsH*	3.20	0.002	0.37	0.53	0.01	0.03

Note. * $p < 0.05$, *two-tailed*. Test value = 0.50.

Appendix 20b: Choice score comparisons to 0.25 for all choice problems

Participants' scores for all choice problems across social and non-social domains significantly differed from the value of 0.25, except A vs. B for both domains.

Choice score comparisons to 0.25

		t	*p*	*d*	*M*	*SEM*	M_{diff}
Social Domain	AvsB	-0.81	0.422	-0.09	0.24	0.01	-0.01
	BvsC*	7.94	< 0.001	0.91	0.35	0.01	0.10
	DvsE*	8.70	< 0.001	1.00	0.35	0.01	0.10
	FvsG*	3.04	0.003	0.35	0.27	0.01	0.02
	GvsH*	2.43	0.017	0.28	0.27	0.01	0.02
Non-social Domain	AvsB	0.12	0.906	0.01	0.25	0.01	0.00
	BvsC*	9.49	< 0.001	1.09	0.37	0.01	0.12
	DvsE*	11.40	< 0.001	1.31	0.39	0.01	0.14
	FvsG*	4.46	< 0.001	0.51	0.28	0.01	0.03
	GvsH*	2.83	0.006	0.32	0.27	0.01	0.02

Note. * $p < 0.05$, *two-tailed*. Test value = 0.25.

Appendix 21

To evaluate whether there was a significant difference between scenario types within each domain, we conducted two 2 x 5 ANOVAs with the within-subjects factors scenario type (‘Social scenario—1’ and ‘Social scenario—2’ for the social domain, ‘Economics’ and ‘Meteorology’ for the non-social domain) and problem type (A vs. B, B vs. C, D vs. E, F vs. G, and G vs. H). Participants’ choices were used as dependent variable. Our analysis for the non-social domain revealed a significant effect of problem type, $F(1, 75) = 37.39$, $p < 0.001$, $\eta_p^2 = 0.33$. The main effect of scenario type, $F(1, 75) = 3.88$, $p = 0.054$, $\eta_p^2 = 0.05$, and the interaction between scenario type and problem type, $F(1, 75) = 1.62$, $p = 0.168$, $\eta_p^2 = 0.02$, were not significant for this domain. For the Economics, participants’ choices between “B vs. C and D vs. E” and “F vs. G and G vs. H” did not significantly differ, $t(75) = 0.25$, $p = 0.804$, $d = 0.03$, and $t(75) = 0.83$, $p = 0.407$, $d = 0.10$, respectively.

Problem type comparisons for Economics

	t	*p*	*d*	M_{diff}	*SEM*
AvsB - BvsC	-5.98	< 0.001	-0.69	-1.07	0.18
AvsB - DvsE	-8.18	< 0.001	-0.94	-1.11	0.14
AvsB - FvsG	-2.99	0.004	-0.34	-0.33	0.11
AvsB - GvsH	-2.04	0.045	-0.23	-0.26	0.13
BvsC - DvsE	-0.25	0.804	-0.03	-0.04	0.16
BvsC - FvsG	6.25	< 0.001	0.72	0.74	0.12
BvsC - GvsH	7.13	< 0.001	0.82	0.81	0.11
DvsE - FvsG	6.50	< 0.001	0.75	0.78	0.12
DvsE - GvsH	6.72	< 0.001	0.77	0.85	0.13
FvsG - GvsH	0.83	0.407	0.10	0.07	0.09

Problem type comparisons for Meteorology

	t	p	d	M_{diff}	SEM
AvsB - BvsC	-5.10	< 0.001	-0.58	-0.83	0.16
AvsB - DvsE	-6.92	< 0.001	-0.79	-1.05	0.15
AvsB - FvsG	-1.29	0.202	-0.15	-0.16	0.12
AvsB - GvsH	-0.05	0.960	-0.01	-0.01	0.13
BvsC - DvsE	-1.42	0.160	-0.16	-0.22	0.15
BvsC - FvsG	6.04	< 0.001	0.69	0.67	0.11
BvsC - GvsH	7.54	< 0.001	0.86	0.82	0.11
DvsE - FvsG	7.46	< 0.001	0.86	0.89	0.12
DvsE - GvsH	7.72	< 0.001	0.89	1.04	0.13
FvsG - GvsH	1.68	0.096	0.19	0.15	0.09

Similarly, our analysis for the social domain revealed a significant effect of problem type, $F(1, 75) = 26.01$, $p < 0.001$, $\eta_p^2 = 0.26$; see Table 4.5A and 4.5B. The main effect of scenario type, $F(1, 75) = 2.47$, $p = 0.120$, $\eta_p^2 = 0.03$, and the interaction between problem type and scenario type, $F(1, 75) = 0.79$, $p = 0.530$, $\eta_p^2 = 0.01$, were not significant for this domain.

Problem type comparisons for Social Relationship–1

	t	*p*	*d*	M_{diff}	*SEM*
AvsB - BvsC	-5.09	< 0.001	-0.58	-0.90	0.18
AvsB - DvsE	-7.41	< 0.001	-0.85	-0.95	0.13
AvsB - FvsG	-3.36	0.001	-0.39	-0.38	0.11
AvsB - GvsH	-1.83	0.071	-0.21	-0.23	0.13
BvsC - DvsE	-0.33	0.740	-0.04	-0.05	0.14
BvsC - FvsG	4.73	< 0.001	0.54	0.53	0.11
BvsC - GvsH	5.88	< 0.001	0.67	0.67	0.11
DvsE - FvsG	5.86	< 0.001	0.67	0.57	0.10
DvsE - GvsH	6.89	< 0.001	0.79	0.72	0.10
FvsG - GvsH	1.60	0.115	0.18	0.14	0.09

Problem type comparisons for Social Relationship–2

	t	*p*	*d*	M_{diff}	*SEM*
AvsB - BvsC	-4.12	< 0.001	-0.47	-0.83	0.20
AvsB - DvsE	-6.58	< 0.001	-0.75	-0.86	0.13
AvsB - FvsG	-1.33	0.187	-0.15	-0.18	0.13
AvsB - GvsH	-1.57	0.121	-0.18	-0.22	0.14
BvsC - DvsE	-0.18	0.857	-0.02	-0.03	0.15
BvsC - FvsG	5.21	< 0.001	0.60	0.65	0.12
BvsC - GvsH	5.36	< 0.001	0.61	0.61	0.11
DvsE - FvsG	5.89	< 0.001	0.68	0.68	0.11
DvsE - GvsH	5.31	< 0.001	0.61	0.64	0.12
FvsG - GvsH	-0.38	0.704	-0.04	-0.04	0.10

Participants' choices were not affected by the between-subjects factor domain order, $F(1, 74) = 0.70$, $p = 0.405$, $\eta_p^2 = 0.01$, as analysed by a mixed 2 x 2 x 2 ANOVA with the within-subjects factors domain type (Social, Non-social) and problem type (A vs. B, B vs. C, D vs. E, F vs. G, and G vs. H), and the between-subjects factor domain order (Social domain first, Non-social domain first), using participants' choices as our DV.

Appendix 22

The 2 x 2 ANOVA revealed a significant effect of problem type, $F(1, 75) = 40.43$, $p < 0.001$, $\eta_p^2 = 0.35$.

Problem type comparisons

	t	p	d	M_{diff}	SEM
AvsB - BvsC	-5.94	< 0.001	-0.68	-0.91	0.15267
AvsB - DvsE	-9.00	< 0.001	-1.03	-0.99	0.10985
AvsB - FvsG	-2.73	0.008	-0.31	-0.26	0.09505
AvsB - GvsH	-1.77	0.081	-0.20	-0.18	0.10047
BvsC - DvsE	-0.68	0.497	-0.08	-0.08	0.12043
BvsC - FvsG	7.56	< 0.001	0.87	0.65	0.08547
BvsC - GvsH	8.42	< 0.001	0.97	0.73	0.08658
DvsE - FvsG	9.26	< 0.001	1.06	0.73	0.07865
DvsE - GvsH	9.37	< 0.001	1.07	0.81	0.08655
FvsG - GvsH	1.60	0.114	0.18	0.08	0.05149

Appendix 23: Normality Checks

Shapiro Wilk normality tests were run to indicate evidence of normality in the data sets for each experiment. Normality checks were checked carefully for *r* tests. In case of normality, Pearson's Correlation Test was conducted. In case of non-normality, Spearman's Rank Order Test was conducted.

Experiment 1

Shapiro Wilk normality test indicated evidence of normality for the total scores on the AQ ($p = 0.168$) and proportion of behaviour-based responses in the Social Domain ($p = 0.149$), but evidence of non-normality for proportion of behaviour-based responses in the Non-social Domain ($p = 0.053$). For the sub-scales of the AQ, there was normal distribution for only attention to detail ($p = 0.67$). other sub-scales did not show evidence for normal distribution; social skill ($p < 0.001$), attention switching ($p = 0.024$), communication ($p = 0.001$), and imagination ($p < 0.001$).

Experiment 2

Shapiro Wilk normality test indicated evidence of non-normality for the total scores on the AQ ($p = 0.030$), proportion of behaviour-based responses in the Social Domain ($p < 0.001$) and Non-social Domain ($p < 0.001$). For written justification, none of the categories of written justifications for inconsistent scenario comparisons was normally distributed, each category scoring lower than 0.001 as p value. None of the sub-scales of the AQ was normally distributed, each sub-scale score scoring lower than 0.001 as p value.

Experiment 3

Shapiro Wilk normality test indicated evidence of normality for the total scores on the AQ for the Comparison Group ($p = 0.701$) and not for the Autism Group ($p < 0.001$). The proportions of behaviour-based responses in the Social Domain were normally distributed for both groups (Autism: $p = 0.338$, Comparison: $p = 0.213$). The proportion of behaviour-based responses in the Non-social Domain was normally distributed for the Comparison Group (p = 0.649) and not for the Autism Group (p = 0.021). The experientiality sub-score for REI was normally distributed for both the Autism (p = 0.490) and Comparison Group (p = 0.473). The rationality sub-score was normally distributed for only the Autism Group (p = 0.147) and not for the Comparison Group (p = 0.031). The reflectiveness sub-score for CRT was normally distributed for the comparison Group (p = 0.100) and not for the Autism Group (p = 0.036). The intuitiveness sub-score was normally distributed for the Autism Group (p = 0.403) and not for the Comparison Group (p = 0.012). Accuracy percentages for MaRs-IB were normally distributed for both groups (Autism: p = 0.509, Comparison: p = 0.325). For the sub-scales of the AQ; social skill did not show evidence for normal distribution (Autism: $p < 0.001$), Comparison: p = 0.009), attention switching normally distributed only for the Comparison Group (p = 0.172, Autism: $p < 0.001$), attention to detail was normally distributed for both groups (Autism: p = 0.235, Comparison: p = 0.572), communication was not normally distributed for either groups (Autism: p = 0.003, Comparison: p = 0.009), and imagination only normally distributed for the Autism Group (p = 0.406, Comparison: p = 0.44).

Experiment 4

Shapiro Wilk normality test indicated evidence of non-normality for the total scores on the AQ (p = 0.015). The rationality sub-score for REI was normally distributed (p = 0.489), but not the experientiality sub-score (p = 0.001). Neither the proportion of behaviour-based responses in the Social Domain ($p < 0.002$) not Non-social Domain (p = 0.001) was normally distributed. For the sub-scales of the AQ, only attention to detail was normally distributed (p = 0.074), while other sub-scales were not normally distributed (social skill: $p < 0.001$, attention switching: p = 0.012, communication: $p < 0.001$, and imagination: $p < 0.001$).

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