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The University of Hull



The Automaticity of Visual Perspective-Taking in Autism
Spectrum Conditions

Being a thesis submitted in partial fulfilment of the
requirements for the degree of
Master of
Psychology

By

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The Automaticity of Visual Perspective-Taking in Autism Spectrum Conditions

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Abstract

The thesis investigated visual perspective-taking differences between adults on the autism spectrum and a neurotypical control group. In Experiment 1, participants were required to explicitly make a left/right judgement to the spatial location of a target object from two different perspectives, one's own perspective (*self*) and the actor's perspective (*other*). The two perspectives were interleaved in a block of trials. The reaction time findings revealed that the ASC were slower overall compared to the matched control group. In Experiment 2, participants explicitly judged the spatial location of the target object from only the *other* perspective. The reaction time findings showed that there was no difference between the ASC group and the matched control group when making a judgement from the *other* perspective. Experiment 3 was conducted online to measure the proportion of spontaneous *self* or *other* responses to three pictures, each with a corresponding question. The findings suggest that there was no difference between the proportion of *self* or *other* response for the ASC group and control group. There was no evidence found for impaired explicit and spontaneous perspective-taking in ASC. However, the findings demonstrate that when ASC participants have to devote more cognitive resources to shift between the two perspectives, consequently their reaction time suffers. This suggests that visual perspective level 2 appears to be intact, although poorer executive functioning in ASC could partially contribute to worse performance on tasks that are more cognitively demanding.

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The Automaticity of Visual Perspective-Taking in Autism Spectrum Conditions

1 Introduction

Social interaction and understanding the mental states of others often involves inhibiting one's own (egocentric) perspective to understand the thoughts, behaviours and (allocentric) perspectives of others. There is evidence to suggest that neurotypical people often have to inhibit and resist egocentric inferences and this involves effortful executive processes (Samson, Apperly, Braithwaite, Andrews, & Bodley-Scott, 2010). People on the autism spectrum typically show poorer mental reasoning, which might contribute to their difficulties with understanding the mental states of others (Williams, Mazefsky, Walker, Minshew, & Goldstein, 2014). This in turn raises the possibility that this population might have difficulties with perspective taking. The thesis will investigate automatic and spontaneous perspective-taking in adults with autism spectrum conditions (ASC). In what follows the thesis will first discuss the development of theory of mind (ToM). Here, the thesis will discuss implicit and explicit ToM in ASC and some of the theories underlying perspective-taking difficulties typically found in ASC, such as the neurological underpinning of ASC, visual-perspective taking and mirror neurons.

1.1 The Development of Theory of mind (implicit vs explicit)

ToM, also known as mentalising is an umbrella term that is characterised as the ability to understand other's mental states, such as other's thoughts, beliefs and desires (Frith & Frith, 2007). An intact ToM plays a key role in social reasoning - making inferences about other's mental states as well as predictions about people's behaviour (Apperly, 2012). Therefore, difficulties with ToM have been a key area of interest when explaining the social difficulties commonly found in ASC, as many of these difficulties may be related to understanding others' mental states. A common developmental ToM task is the false-belief task - children must acquire the understanding that people can have different thoughts or beliefs even when they are about the same situation (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). The Sally-Anne task is one of the most commonly used false-belief tasks. In the Sally-Anne task (Wimmer & Perner, 1983), children are presented with a story about two characters (Sally and Anne) with Sally having an item. Sally places the item in a basket and leaves the room, whereupon the other character (Anne) places the item in a box. Children were then asked where they think Sally will look for the item when she returns to the room. They found that NT children at the age of four could pass the Sally-Anne task, therefore understanding that Sally would act on her false-belief, but not those below four years old, who believed that Sally and their own beliefs would be the same. Baron-Cohen et al. (1985) compared young NT children to older children with Down's syndrome and ASC and found that the Down's Syndrome and NT children could both pass the false-belief task, but the ASC children, despite being older did not pass the Sally-Anne task. This suggests that children with ASC have significant difficulties ascribing false beliefs.

It has been argued that the verbal component of the Sally-Anne task influences whether a child passes or not, as it relies on having the ability to explicitly verbalise either their own belief or that of the character, hence it is an explicit ToM task (Astington & Jenkins, 1999). Moreover, Bloom and German (2000) suggest that the memory, attentional and linguistic resources required for the Sally-Anne task may explain why children below the age of four fail the Sally-Anne task. Rhodes and Brandone (2014) revealed that children at the age of three have an implicit understanding of false beliefs, as they used this knowledge when performing an intentional action, but they failed to use this false belief understanding in their explicit verbal responses. These findings suggest that even though children fail explicit ToM tasks at the age of three, they implicitly understand false beliefs to the extent that it influences their actions. The findings therefore support the idea that there is an implicit and explicit system for mentalising from a young age, although it is apparent at three years of age (Apperly & Butterfill, 2009; Rhodes & Brandone, 2014).

A study by Senju, Southgate, Snape, Leonard, and Csibra (2011) used a non-verbal false belief story to measure implicit ToM in 18-month old NT children. The NT children were assigned to either an opaque condition where the children wore opaque blindfolds or the trick condition, with the blindfolds being transparent and not obstructing their perception. They were false belief task story where a video sequence was presented using puppets and actors. The younger children were presented with two versions of the false belief task, one of the versions involves the character wearing a blindfold and the item being moved to a different location, although the character could not see this change in location. In the other version, the character could see the item being moved to the new location and the child's anticipatory eye movements was tracked, instead of explicitly asking where the character will look for the item. They found that neurotypical children in the blindfolded condition attributed false belief to the actor, as they anticipated that the

actor would look for the item in the correct location. In contrast, children that were not blindfolded did not attribute false belief to the actor as they did not show this bias. These findings suggest that there could be an implicit system for ToM, which develops at infancy as even 18-month old children demonstrate an implicit understanding of false beliefs.

Several studies have shown that people on the autism spectrum often demonstrate difficulties understanding other's mental states and ToM tasks (Baron-Cohen, Leslie and Frith et al, 1985; Frith, 2001; Senju, 2012). People with ASC typically pass explicit ToM tasks at a later age compared to neurotypical children (Simon-Baron et al., 1985). Even in adulthood, some adults with ASC show some difficulties with ToM tasks, although there is significant variability in ToM performance with adults on the autism spectrum (Brewer, Young, & Barnett, 2017). Brewer et al. (2017) found that on an adult ToM test, some adults with ASC clearly showed no difficulties when they interpreted ToM story task, whereas others clearly showed difficulties with this particular task. This suggests that in adulthood, some people on the autism spectrum may develop compensatory strategies for ToM deficits, to the extent that they can employ explicit reasoning to understand other's mental states. Senju (2012) suggest that even though adults on the autism spectrum can pass a false belief task when they are explicitly asked, they do not show spontaneous false belief understanding. Senju (2012) found that neurotypical adults showed bias anticipatory looking to the correct location compared to the adults with ASC who showed less anticipatory looking to the correct location in a false belief task. This absence of spontaneous ToM could be explained by a failure to process relevant social information that would act as a cue, such as an eye gaze or even emotional expressions and as a consequence, people with ASC do not recruit the cognitive processes needed to implicitly anticipate other's behaviours. This suggest that people with ASC might

perform poorly on tasks that require processing the necessary social information needed to make appropriate inferences about a protagonist's behaviour or mental states. Such information may include taking the perspective of another.

1.2 Neurological Basis of Autism Spectrum Conditions

Autism spectrum conditions are pervasive neurodevelopmental conditions, which are characterised by dysfunction in three core domains; social communication; social interaction, for example, taking another's perspective; and restrictive and/or repetitive patterns of behaviour, interests or activities, such as hand flapping (DSM-V; American Psychiatric Association, 2013; Davey, 2014). Neurological models have underlined these social difficulties to localised dysfunction of intrahemispheric (Anderson et al., 2011) and interhemispheric connectivity (Misra, 2014) within the social cognition network. In particular, neuroimaging studies have found structural and functional differences of brain regions that are associated with atypical self-representation, executive function and body representation in ASC (Lombardo & Baron-Cohen, 2011) as well as dysfunction in the mirror neuron system (MNS) (Perkins, Stokes, McGillivray, & Bittar, 2010). Furthermore, atypical contextual information processing (Skoyles, 2011) and atypical neural processing have been found in ASC, which could account for an altered self-representation in autism (Carmody & Lewis, 2012).

One of the brain regions known to be involved in self-relevant information processing is the ventromedial prefrontal cortex (vMPFC) (Moran, Heatherton, & Kelley, 2009). These authors found that activity in the vMPFC increases the more a person perceives the information to be relevant to one's self, and so is more responsive when

thinking about one's self compared to others. Lombardo et al. (2010) found that people with ASC showed atypical structural and functional development of the vMPFC. They found that the NT group showed more activity in the middle cingulate cortex and the vMPFC when thinking about one's self compared than when they were thinking about others. In contrast, they found that in the ASC group, levels of activity in the vMPFC were about equal when thinking about both one's self and others, with the middle cingulate cortex showing more activity when thinking about others in contrast to when they were thinking about one's self. Lombardo et al. (2010) also reported that the more early childhood social difficulties ASC participants reported, the less vMPFC differentiated between the self and others. This failure to differentiate between the self and other might consequently result in people with ASC having significant difficulties with a range of computations relevant to theory of mind (ToM) and perspective-taking.

1.3 Visual perspective-taking in NT and those with ASC

Visual perspective-taking (VPT) is the ability to understand the visual experience from someone else's perspective (Flavell, 1977). There is evidence to suggest that VPT requires both spatial and social information processing. The spatial information is used as a frame of reference for both the position of an object and a person viewing the object, but a person will also compute the spatial location of the object in relation to both oneself and others (Pearson, Ropar, & Hamilton, 2013). The social information within VPT involves forming a representation that two people are viewing an object differently (Pearson et al., 2013). The literature suggests that there are two different levels of VPT, with each of these levels requiring different computational processing (Michelon & Zacks, 2006).

1.3.1 Visual perspective-taking level one

VPT level one is the ability to recognise whether something is visible or not to another person, for example, *what can the other person see?* (Moll & Tomasello, 2006). VPT level one has been found to develop in neurotypical children at 2.5 years of age typically. Samson et al. (2010) investigated VPT level one in neurotypical *adult* participants using a visual-perspective paradigm. This visual perspective paradigm consisted of a visual scene depicting a three-dimensional room (left, right and back wall) with a human avatar in the centre of the room facing either the left or right wall. Red dots (0-3) were displayed on the left and/or the right wall and participants verified the number of dots from either their own perspective (*self*) or the avatar's perspective (*other*). In 50% of the trials, the avatar saw the same number of dots as participants (consistent trials). In the remaining 50% of trials, the avatar saw a different number of dots to participants (inconsistent trials). Participants had more difficulties verifying the avatar's perspective when the number of dots was inconsistent with their own perspective (egocentric intrusion). Results also revealed an altercentric intrusion effect where participants had more difficulties with verifying the number of dots from their own perspective, if the avatar's perception differed (the avatar perceived a different number of dots from the participant(s)). This suggests that people may spontaneously process other's perspective, even if it is irrelevant and therefore it interferes with explicitly making a judgement from one's own perspective. These findings support the notion that humans have two distinct systems for mentalising, with one being inflexible, efficient and an implicit process which develops relatively early in infancy (Apperly & Butterfill, 2009). In contrast, there is a more controlled, slower and flexible explicit system that develops at a later age. The altercentric intrusion effect suggests that VPT level one may be computed by this low-level, implicit system for mentalising, which relies on limited cognitive control

(Furlanetto, Becchio, Samson, & Apperly, 2016). It has, however, been argued that the observed altercentric intrusion effect may not necessarily reflect implicit mentalising, but sub-mentalising processes - referred to as the sub-mentalising hypothesis which suggests that VPT level one only relies on domain general cognitive processes, such as memory and attention (Conway, Lee, Ojaghi, Catmur, & Bird, 2017; Heyes, 2014).

Furlanetto et al. (2016) investigated whether the altercentric intrusion effect is reflective of implicit mentalising or if it could be solely explained by the sub-mentalising hypothesis. Their study used this Samson et al. (2010) visual perspective paradigm but adapted the stimulus where the avatar was wearing mirrored lensed goggles in two different colours, so the eyes were no longer visible to participants. Using a belief induction procedure, the NT participants were led to believe that one of the coloured glasses meant that the avatar could see the discs (seeing condition), while the other colour meant the avatar could not see the discs (non-seeing condition). If the altercentric intrusion effect is due to implicit mentalising, then the effect should only be seen in the seeing condition, but if the altercentric intrusion effects are observed in both conditions, this would support the sub-mentalising hypothesis. They found that only the seeing condition triggered altercentric intrusion effects, thus supporting the implicit mentalising hypothesis. However, attentional processes are not the only cognitive process that may be involved in VPT level one, as it has been theorised that executive functioning may potentially interfere with implicit mentalising in a VPT level one task. Qureshi, Apperly, & Samson (2010) used a dual-task paradigm to investigate the role of executive function in a VPT level one task. The Qureshi et al. (2010) study administered the Samson et al. (2010) visual perspective paradigm alongside a secondary task to add more executive functioning demands. They found that the secondary executive functioning task did not interfere with spontaneously taking either their own perspective or the avatar's

perspective but did impair selecting which of the perspectives to use for a given trial. Therefore, these findings suggest that calculating perspectives may be more automatic, with executive function processes only being involved in perspective selection.

Another study by Todd, Cameron and Simpson (2017) further supports the idea of independent controlled and automatic processes used in perspective taking. Their study used a process-dissociation procedure technique to disentangle the automatic and controlled processes involved in the Samson et al. (2010) VPT level one task. They were primarily investigating the processes underlying the altercentric intrusion effect found in the Samson et al. (2010) study. Todd, Cameron and Simpson (2017) found that manipulating the response deadline reduced controlled processes (deliberately responding from their own perspective), but the spontaneous computation of the avatar's perspective did not change. Moreover, their second experiment revealed that automatic processing was faster when they used a human avatar compared to a non-social avatar. These results not only support the notion of independent controlled and automatic processes but also suggest that they operate under distinct conditions.

As it is known that people with ASC often show difficulties in ToM tasks, including those based on attributing mental states, it is reasonable to investigate whether people with ASC show any differences in VPT level one. Schwarzkopf, Schilbach, Vogeley, and Timmermans (2014) showed comparable egocentric and altercentric intrusion effects in both adults on the autism spectrum and a neurotypical control group. Schwarzkopf, et al. (2014) used Samson et al's. (2010) visual perspective paradigm to investigate spontaneous (implicit) and intentional (explicit) VPT level one in adults with high- functioning autism (HFA). Schwarzkopf, et al. (2014) found that adults in the HFA group could spontaneously take the perspective of others. However, the HFA group had

a slower reaction time and a higher error rate when they were explicitly asked to assume the avatar's perspective. This suggests that the HFA group have more difficulties with explicit perspective-taking as it involves more effortful processes. Overall, all these findings indicate that VPT level one is automatic and operates independently of other executive functions. In relation to ASC, implicit processes involved in VPT level one appears to be intact in ASC, but they may be impaired when they have to explicitly verify another's perspective.

1.3.2 Visual perspective-taking level two

VPT level two is conceptualised as the ability to understand that if two different people perceive an object simultaneously, each person may have a different visual perspective of that particular object. An example about VPT level two would be, *how is the object different from the other person's viewpoint?* (Flavell, Everett, Croft, & Flavell, 1981). Findings from previous literature suggest that children between 4.5 and 5 years of age develop this understanding of *how* something is seen (Flavell et al., 1981; Kessler and Rutherford, 2010). Performance in ToM tasks has been shown to be a strong predictor for performance on VPT level two tasks, which implies that VPT level two may partially involve some level of mentalising. Therefore, since it is known that ASC children show poor performance in ToM tasks, it may be inferred that they would also perform poorly in VPT level two (Hamilton, Brindley, & Firth, 2009).

As mentioned, these two levels of VPT involve different cognitive processes, with Kessler and Rutherford (2010) suggesting that VPT level two relies more on embodied

processes and the mental simulation of body movements. However, these embodied processes become more effortful with incongruent body posture and increased mental distance. In contrast, VPT level one does not rely on mental simulation of movements or mental distance, so it may be a more efficient and fast cognitive process. Additionally, Surtees, Apperly, and Samson (2013) suggests that VPT level one only involves visual information processing to judge whether something is visible to others, but it does not involve any form of egocentric mental rotation. In comparison, VPT level two is dependent on spatial information processing for an individual to perform an egocentric mental rotation to verify whether an object is on the left or right from another's perspective.

Tversky and Hard (2009) investigated spontaneous spatial perspective-taking in an adult neurotypical sample, in a task that could be classified as a VPT level two. They carried out two between group experiments, where participants were shown pictures of people and objects in a scene. The first experiment consisted of participants answering the question 'in relation to the bottle, where is the book?' in one of three conditions; a *no actor* condition, an *actor looking at the target object* condition and an *actor reaching action toward the target object* condition. They found that participants provided significantly more actor-based responses (*other*) when the actor was present in the photo, compared to the no actor condition, but there was no significant difference between the looking condition and reaching condition. In experiment two, Tversky and Hard (2009) investigated whether phrasing the question in terms of an action elicits more *other* responses compared to a static question (no action mentioned) for conditions where the actor was explicitly referenced versus not being referenced in the question. Overall, they found that the action questions triggered the most *other* response, regardless of whether or not the actor was referenced. These findings suggest that spontaneous perspective-

taking appears to be triggered by the implication of an action taking place. This action-based effect on spontaneous perspective-taking might be explained by the viewer interpreting the actor as having a potential role when interacting with the object, especially when an action is implied. Therefore, taking the actor's perspective could assist with understanding their potential actions and/or intentions.

Mazzarella, Hamilton, Trojano, Mastromauro, and Conson (2012) carried out an experiment similar to Tversky and Hard (2009). However, rather than being shown a single picture to measure spontaneous allocentric perspective-taking, Mazzarella et al. (2012) experiment comprised 60 trials across four conditions; no-gaze/no-action, yes-gaze/no-action, no-gaze/yes-action and yes-gaze/yes-action. They only found main effects for error rate when only an action elicited allocentric perspective-taking, in both implicit and explicit tasks, which contrasts with Tversky and Hard (2009) who suggests that both action and gaze can trigger spontaneous allocentric perspective-taking. Mazzarella et al. (2012) suggest that this is explained by eye gaze only indicating interest in a given object, but not any potential action regarding the object as a grasping motion would imply. However, in Experiment three, they carried out a target detection task which consisted of scenes of an actor grasping and/or gazing towards the left or right side of the table or performing neither of these actions. Participants were required to respond whenever they saw the target object regardless of which side it appeared. Mazzarella et al. (2012) found that unlike their previous two experiments, there was no significant effect of grasping, but there was a significant effect, in which participants were faster to respond when the target was congruent with the gaze direction. These results suggest that eye gaze does not necessarily influence perspective taking but can have a strong influence in orienting attention.

A study by Conson et al. (2015) investigated the embodied processes involved in a VPT level two task. They conducted two experiments to assess whether adolescents with ASC employ embodied strategies during a VPT level two task or resort to more non-embodied strategies where they use visual and spatial processes to resolve the task, for example, mental rotation. In Experiment 1, Conson et al. (2015) used a similar task to Mazzarella et al. (2012) where they included five conditions with different cues; no-actor, no-gaze/no-grasp, no-gaze/yes-grasp, yes-gaze/no-grasp and yes-gaze/yes-grasp. Participants explicitly performed a left/right judgement to verify the spatial location of the target object from their own perspective or the actor's perspective. The Conson et al. (2015) results revealed that in the other-perspective, neurotypical participants' altercentric responses were influenced by different cues, but ASC participants altercentric responses remained similar regardless of whether the actor gazed or grasped the target object. Particularly, when neurotypical participants observed an actor grasp the target object, the action incited more altercentric responses in the neurotypical group, whereas it did not affect rate of altercentric responses in the ASC group. These findings suggest that observing an action did not necessarily facilitate other-perspective taking in the ASC group, which may be underpinned by a lack of activation in embodied simulation processes. In Experiment 2 participants indicated whether the left or right hand was marked on a picture of a human body that either faced towards or away from participants. The human body image was shown in four different spatial orientations; 0°, 90° clockwise, 90° counterclockwise and 180°. The results of Experiment 2 revealed that neurotypical participants were less error prone and faster when judging a back-facing body, but the ASC group showed a slight advantage when judging a front-facing body. These findings suggest that the front-facing body may automatically activate non-embodied strategies in ASC where they recruit more visual and spatial processes to mentally rotate the object (non-embodied strategy). In contrast, people on the autism spectrum may be less inclined

to rely on embodied strategies, which involve a mental simulation of one's own bodily information so they can imagine themselves in the position of the other person. Additionally, Conson et al. (2015) showed that ASC participants not only have difficulties with adopting another's perspective, but maintaining one's own perspective appeared to be cognitively demanding. This suggests that effortful processes are necessary when shifting between perspectives, so ineffective cognitive control processes may partially explain poorer performance on VPT tasks in ASC.

A study by David et al. (2010) investigated mentalising (ToM) and visuospatial perspective taking abilities in adults on the autism spectrum. An avatar would show some type of social cue (facial expressions, body positioning or a gesture) to indicate preference for one of two objects, but one of the objects was elevated. In the mentalising task, participants responded with either their own preferred object or the avatar's preferred object, regardless of whether the object was elevated. In contrast, the visuospatial task required participants to choose which of the two objects were elevated from their own or the avatar's perspective, regardless of preferences. Their results revealed that the ASC group had a slower reaction time and poorer accuracy in the mentalising task, but showed intact visuospatial perspective taking. These findings suggest that people on the autism spectrum might have more difficulties with inferring mental states from non-verbal cues, therefore, the observation of an action might not necessarily facilitate automatic allocentric activation in ASC.

Pearson et al. (2013) reviewed 13 studies that examined VPT in autism and found that the majority of studies suggest that ASC participants show a spared performance in VPT level one. In contrast, people on the autism spectrum show poorer performance on VPT level two tasks, which suggests that VPT level two may be impaired in ASC. This

difficulty in VPT level two might be explained by problems with the transformation of spatial information used to judge how something is seen from another's perspective (Pearson et al., 2013).

1.4 **Mirror Neurons in Autism**

The mirror neuron system is one of the main systems proposed as acting as a neurological basis for understanding one's own and other's mental states (Gallese, Keysers, & Rizzolatti, 2004). It was termed by Rizzolatti, Fadiga, Gallese and Fogassi (1996), who discovered that when a monkey observed a goal-directed action, it activated the visuo-motor neurons in the F5 ventral premotor cortex. Rizzolatti et al. (1996) proposed that the activation in these observed neurons are part of a system responsible for encoding both the motor representation of a performed action and the goal of that action. They coined this the mirror neuron system. There is evidence to suggest that the mirror neuron system is also present in humans (Gallese & Goldman, 1998). Fadiga, Fogassi, Pavesi, and Rizzolatti (1995) administered single-pulse transcranial magnetic stimulation (TMS) to participants while they were observed an experimenter execute different hand actions and motor evoked potentials (MEPs) were recorded from the participants' hand muscles. They found a significant increase in MEPs in the conditions where participants observed movement, but the MEP pattern of activity was similar when participants performed the observed action. This suggests that the observation of an action might facilitate with understanding others' mental states, therefore, you can make inferences based on understanding the intention of an action.

Further support can be seen in Gangitano, Mottaghy and Pascual-Leone's (2004) study, which explored whether premotor mirror neuron activity was triggered when

observing a typical motor action which proceeded to the end regardless of different visual cues, or whether activity changed in accordance to visual cues. They recorded MEP's at the same time points in the three pincer-grab videos. In Experiment 1, they compared MEP's in a typical pincer-grab video to a video where the pincer-grab was delayed. They found that the MEP's activity did not change in accordance to visual cues, but this could be explained by the novelty of an unexpected movement having a weaker motor representation. However, Experiment 2 addressed this issue by comparing MEP's in the typical pincer-grab video to a video where there were two pincer-grab actions in the sequence, and found that the initial activation occurs at the beginning of an observed action and continues until completion of that particular action regardless of changing visual cues. They also noted that images of an unmoving hand at the start of the video resulted in modulation of neuronal activity, suggesting that even a static image implying a motor plan, for example, reaching towards an object, is sufficient in triggering neuronal activity (Gangitano et al., 2004). These findings suggest that mirror neurons are activated similarly when performing an action, as well as when they observe a person executing that particular action, for example, grasping an object (Oberman, Pineda, & Ramachandran, 2007). There are two predominant theories have been suggested to explain the function of mirror neurons, 1) mirror neurons facilitate social imitation and 2) The mirror neuron system forms the basis for action understanding (Rizzolatti, Fogassi, & Gallese, 2001). Therefore, it can be argued that the mirror neuron system plays an important role in social cognition as a basis for the social imitation of others (Gallese & Goldman, 1998) and perhaps facilitates social interaction by helping us to understand others' intentions and by inference their mental states (Obermann & Ramachandran, 2007).

There has been considerable debate into the role that mirror neurons play for the social cognition difficulties in ASC, with the '*broken mirror theory*' theorising that there

is a dysfunctional mirror neuron system in ASC, as they have difficulties with mentally simulating the social goals of other (Obermann & Ramachandran, 2007). However, research on possible global dysfunction in the mirror neuron system in ASC has been inconclusive (Hamilton, Brindley & Frith, 2007; Oberman et al., 2005; Obermann & Ramachandran, 2007), but research has suggested that goal understanding is intact (Marsh & Hamilton, 2011), while social imitation in ASC is impaired (Hobson & Lee, 1999).

A study by Cook and Bird (2012) found that there was no difference in imitations levels when ASC participants were primed with pro-social and non-social words, but NT participants showed more social imitation when primed with pro-social words. These findings suggest that people with ASC could be impaired in modulating social imitation, but these social imitation impairments might be due to poor self-other mapping, which could be a consequence of a dysfunction within the mirror neuron system (Williams, Whiten, Suddendorf, & Perrett, 2001). In contrast, a study by Hamilton et al. (2007) investigated gesture imitation in children with ASC and revealed no evidence for impaired gesture imitation, as they could recognise and interpret the action, which suggests that goal-understanding is intact. These findings suggest that a dysfunctional mirror neuron system cannot account for the imitation difference in ASC.

Furthermore, a review by Hamilton (2013) examined the findings of 25 neuroimaging studies, with each of the studies using various neuroimaging techniques (EEG, EMG, TMS and fMRI etc.). The review found little evidence to support the theory of a global mirror neuron deficit in ASC, but suggested that atypical social imitation in ASC could be a consequence of not processing the relevant social cues and context (top-down response modulation). In other words, such things as perspective taking.

1.5 Aims and Hypotheses of the current study

The general aim of the thesis was to investigate whether there was a difference in VPT-2 performance between adults on the autism spectrum and a neurotypical control group. The thesis consisted of three experiments that aimed to investigate any differences between these two groups.

Experiment 1 investigated whether there were reaction time and error rate differences between an ASC group and an NT control group in responding from their own point of view (self) and the actor's point of view (other) in a perspective taking task based on Mazzarella et al. (2012) and Conson et al. (2015). The two perspectives were interleaved in a series of trials that required participants to make an explicit judgement to the spatial location of a target object. The Cue condition consisted of the actor reaching and gazing for the target object and the No-Cue condition consisted of the actor remaining static.

Based on previous findings (Conson et al., 2015), it was hypothesised that the control group would have a faster reaction time when verifying both perspectives (*self & other*) for all the conditions compared to the ASC group. Previous research (Conson et al., 2015) suggests that ASC participants have more difficulties with maintaining their own perspective, therefore, it can be hypothesised that they will make more error overall in the self-perspective compared to the control group. but both groups will make more errors in the Cue condition than the No-Cue condition. It was also hypothesised that on other-perspective trials, the ASC group would make more errors overall compared to the control group, yet there would be no significant difference between both groups in the Cue and No-Cue conditions.

In Experiment 2, both the ASC group and control group were required to make an explicit judgement to the spatial location of the target object from the actor's perspective only. This removed the requirement for participants to switch between responding from their own perspective and adopting the other person's perspective; this task switching requirement may have affected performance in Experiment 1 in both the NT and the ASC groups. As in Experiment 1, Experiment 2 investigated whether there were reaction time and error rate differences between the groups in processing the actors' perspective, and whether the ASC group were less sensitive than the control group to the presence of the social cues. It was hypothesised that the ASC group would be slower and have more errors than the NT group, if they did have more difficulty with adopting another's perspective. It was also hypothesised that if the implication of an action did trigger taking another's perspective, then reaction time would be faster and error rates should be lower in the cue condition compared to the no cue condition. Finally, it was hypothesised that the size of the above effect should be smaller in the ASC group compared to the NT group, if ASC participants are indeed less sensitive to cues than the NT group.

The aim of Experiment 3 was to investigate spontaneous perspective-taking in an ASC and NT group, using a similar methodology to Tversky and Hard (2009). Participants completed an online study, which consisted of 8 different pictures, each with their own question about the stimuli onscreen. Two of the pictures asked a question that was ambiguous as to whether participants should adopt their own perspective, or that of the actor in the picture. These questions measured whether participants would spontaneously adopt the perspective of another person. It was hypothesised that the ASC group would provide significantly more *self-based* responses across these two questions compared to the control group.

2 Method for Experiment 1

Experiment 1 aimed to extend on the work of Mazzarella et al. (2012) and Conson et al. (2015). In Experiment 1, we were investigating reaction time and error rate differences between adults on the autism spectrum and a neurotypical control group. Specifically, whether the presence of a social cue interfered with their reaction time and error rate when responding from their own perspective (*self*). We expected to observe a different pattern, when they were responding from the other's perspective (*other*). As previous research suggests the presence of a social cue facilitates faster reaction time and fewer errors because it activates automatic allocentric perspective-taking (Mazzarella et al., 2012).

2.1 Participants

Forty-seven right-handed adults completed the study (20 ASC participants, 27 Neurotypical controls). All participants had normal or corrected to normal vision. Participants with a diagnosis of an autism spectrum condition (ASC) were asked to provide evidence, a diagnostic report by a clinician, stating that they have met the criteria for an Autism Spectrum condition diagnosis which verified their eligibility for the ASC group. Of these, three ASC participants were excluded from the final analysis. One ASC participant was excluded because their reaction time exceeded 4000 ms in all conditions, and 2 ASC participants were excluded because of a high number of incorrect responses (error rate more than 30 %). The final ASC group therefore comprised 17 participants, all of which had been previously diagnosed with an autism spectrum condition from a

psychiatrist or clinical psychologist based on the International Classification of Diseases (ICD-10) criteria (8 females and 9 males; M_{age} of 23 years, ranging between 19-54).

This ASC group was compared to an age- and gender-matched subset of 17 Neurotypical participants, taken from the original 27 participants in the Neurotypical group (see **Table 2.1**). There was no significant difference between the ASC group and the control for age, ($U = 1400, p = .874$). All participants were screened with the Autism Quotient (AQ) questionnaire (a 50 item self-administrated questionnaire, to measure the degree of autistic - like traits in the adult population (Baron - Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). The mean AQ score for the ASC group was 34.94 ± 10.19 and the mean AQ score for the control group was 15 ± 8.45 . The ASC group's AQ score was significantly higher than the control group, $t(32) = 6.210, p < .001, d = 2.13$.

All ASC participants were recruited from the disability services at the University of Hull and the National Autistic Society (NAS). Most of the final control group ($N = 11$) were recruited from the University of Hull using the research participation system (RPS) for psychology undergraduate students and received credits for their participation. The 6 control participants that were not recruited by RPS consisted of students from the University of Hull that volunteered to participate in the study.

Table 2.1. Experiment 1 demographic information for the ASC group and the control group. All the data are given as Mean \pm Standard Deviation (range).

	ASC	CON
<i>N</i>	17	17
Age	$M = 23.41, SD = 8.09$ (19-54)	$M = 24.06, SD = 7.95$ (18-52)
Gender	8 female, 9 male	8 female, 9 male
Handedness	17 right	17 right
AQ	$M = 34.94, SD = 10.19$	$M = 15, SD = 8.45$

ASC ASC group, *CON* control group, *N* number of participants, *M* mean, *SD* standard deviation, *AQ* 50 item Autism Quotient

2.2 Apparatus and Materials

A 19 - inch PC-desktop (resolution, 1280 x 1024) using OpenSesame version 3.2.5 (Mathot, Schreij, & Theeuwes, 2012) presented the stimuli and recorded the participants' data. The stimuli consisted of four pictures, as used in Conson et al. (2015). The pictures were in grayscale and approximately measured 17 x 13.5 cm when they were displayed on the screen. Two of the pictures showed a human model (actor) sat at a table in which the actor did not gaze or reach (No-Cue trials) for the target object (the bottle), with the object either on the left or on the right. The other two pictures showed the same actor looking at and reaching towards the bottle (Cue trials), again with the bottle either on the left or on the right (see **Figure 2-1**). An online version of the 50 item AQ questionnaire was administrated to participants.

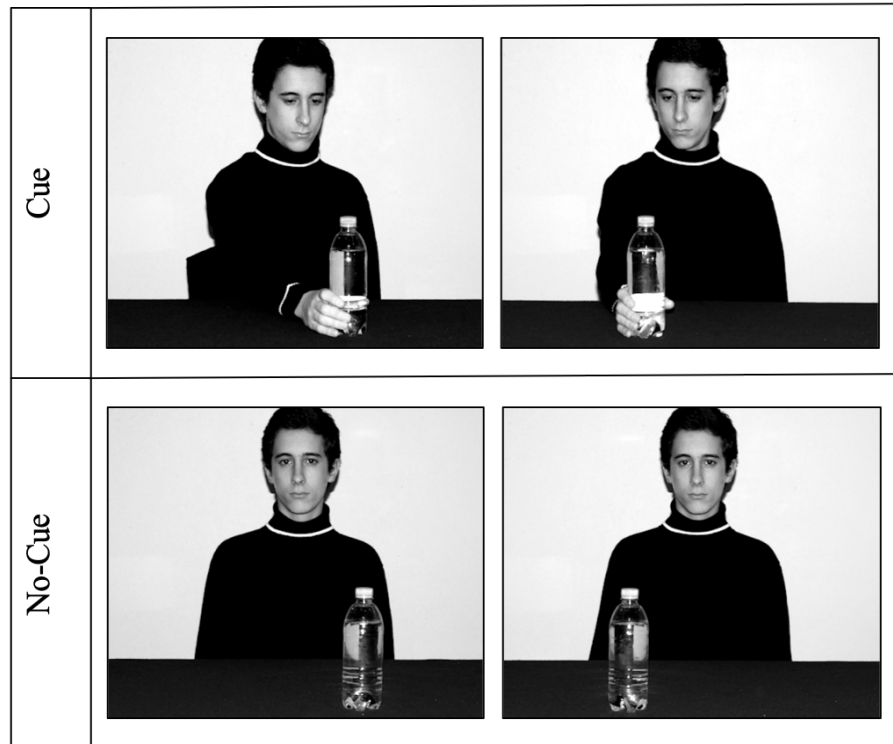


Figure 2-1. A schematic representation of the four pictures used for both Self and Other perspective in Experiment 1 (as used by Conson et al., 2015).

2.3 Design

The experiment had a 2 x 2 x 2 design with *perspective* (Self vs. Other) and *condition* (Cue vs. No - Cue) as the repeated - measures factors and *group* (Autism Spectrum Condition vs. Controls) as the between-measures factor. The two dependent variables were the average reaction time (RT) in milliseconds (ms) and the error rate (ER) in percentage (%) to respond from the respective perspective. *Perspective* (Self vs. Other) was interleaved in one block of 80 trials. Self and Other were presented equally within the block (Self; 40 trials and Other; 40 trials) and the order of the trials within the block

was randomised across all participants to counterbalance the repeated - measures factors, while the *self* or *other* perspective was not presented more than two consecutive times.

2.4 Procedure

All participants were tested individually in a testing lab on the University of Hull campus. Participants were presented with an information sheet, which was read at their own pace. If participants consented to participating in the study, they were given a consent form to sign, which also reiterated their right to withdraw from the study. All participants were screened with a 50 - item online version of the AQ questionnaire, on a 4-point Likert scale preceding the computer-based task for the experiment.

Participants were required to respond from two different perspectives; their own point of view (*Self*) or the actor's point of view (*Other*). Participants were required to explicitly make a left/right judgement to the spatial location of the target object (a bottle) positioned to the left or right on the computer screen from the required perspective. The participants were required to make the left/right judgement quickly and accurately. The computer screen was positioned at an 87° angle at a viewing distance of 48 cm from the participants. Before the computer-based task, the participants' right (Dominant) hand was positioned on the keyboard to make a left/right judgement, with their index finger placed on the 'B' key for a left response and their middle finger on the 'H' key for a right response, with respect to the perspective adopted. Participants were instructed to comfortably position their left hand beside the QWERTY keyboard.

The task instructions for the practice trials were displayed on the screen and participants pressed the 'ok' button on the screen to continue with the practice trials. Participants were given 16 practice trials (Self; 8 trials and Other; 8 trials) and for each practice trial, a fixation dot was presented in the centre of the screen for 800 ms, followed by the word, *self* or *other* for 2000 ms, this indicated which perspective they should respond from. After the presentation of the word, a fixation dot was presented in the centre of the screen for 800 ms followed by one of the four pictures; the picture was presented on the screen until participants responded by pressing one of the two keys that were centrally located on the QWERTY keyboard. Participants were given feedback on their performance on the practice trials (average reaction time and accuracy). If the participant's accuracy on the practice trials was below 75%, the task instructions were verbally reiterated to the participant. However, the 16 practice trials were discarded from the statistical analysis.

The instructions for the experimental trials were displayed on the screen and participants pressed the 'ok' button to continue with the experimental trials (see **Appendix A**). All participants were encouraged to respond quickly and accurately with the computer-based task, and this was reiterated in the task instructions. In the experimental trials, the four pictures were repeated 10 times (4 trials for each of the two perspectives), for a total of 80 trials in one block (Self; 40 trials and Other; 40 trials). In each trial, a fixation dot was displayed in the centre of the computer screen for 800 ms, followed by the word *self* or *other* for 1000 ms, this indicated which perspective to adopt. After the presentation of the word, a fixation dot was displayed in the centre of the computer screen for 800 ms, followed by one of the four pictures. The picture remained on the screen until participants responded with a left/right judgement by pressing one of the two keys with their right (Dominant) hand. The Participant's index finger was placed

on the ‘B’ key for a left response and their middle finger was placed on the ‘H’ key for a right response, with respective to the perspective adopted (see **Figure 2-2**).

All participants were given a break after 40 trials and they resumed the experiment by pressing any key on the QWERTY keyboard. After completing the computer-based task, participants were given a debrief sheet and the opportunity to ask any questions related to the study. The participants’ accuracy was coded according to a binary code, incorrect responses given by participants were scored as a ‘0’, whereas correct responses were scored as ‘1’. The error rate was calculated by subtracting the participants’ average accuracy for each condition from 100 (percent) in Excel. The RT trials were analysed, if they met three criteria, (a) the response was correct (b) the RT > 150 ms, and (c) the RT was above or below 3 standard deviation of the participant's mean RT.

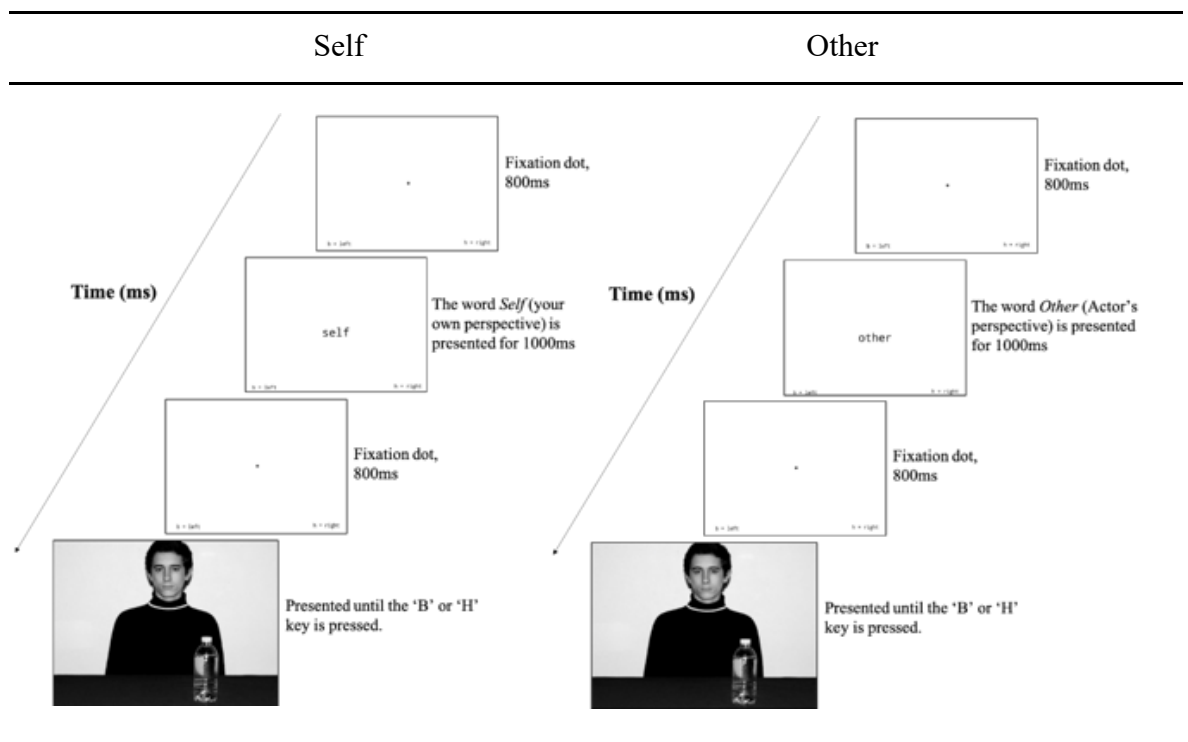


Figure 2-2. An example of the trial sequence for *self* and *other* within a block of 80 trials.

2.5 Ethical Considerations

The study was approved by the University of Hull, Faculty of Health Science whereby the following ethical issues were considered (see **Appendix B**):

Information sheet: Participants were given an information sheet at the beginning of the experiment, this outlined details related to the study; the purpose of the study, procedure, duration of the experiment, potentials risks or ethical considerations.

Right to withdraw: Participants could withdraw from the study until the data was anonymised. However, the right to withdraw from the study was reiterated throughout the experiment.

Debrief: Participants were given a debrief form, after completion of the experiment. The debrief form explained the hypotheses / predictions for the study, while also providing contact information for appropriate services, if the participants experienced any form of psychological distress or concerns.

Protection from harm: Participants with a diagnosis of Autism Spectrum Disorder are considered to be vulnerable adults, therefore, adjustments were made to accommodate any sensory difficulties for example, reduced lighting, and appropriate measures to reduce interference from external noise. The adjustments that were made adhered to the Autism Act, 2009 and the Equality Act, 2010, as participants with a diagnosis possessed equal opportunities to complete the experiment in an optimal environment, which should reflect their cognitive abilities. An Autism Quotient (AQ) questionnaire was administered to all participants to screen for autistic-like traits, therefore, if participants were distressed by their AQ scores, these participants were advised to contact the student well-being centre

or their General Practitioner (GP). Participant's data was securely stored on an encrypted external hard-drive and password protected, which aligned with the data management plan to prevent any misconduct or breach of participants personal information. All means to protect and appropriately use the data for the purposes of the study adhered to the Data Protection Act, 1998 and the General Data Protection Regulation (GDPR), 2018.

Consent: Participants consent was obtained prior to beginning the experiment, all participants signed a consent form, stating that the study has been explained to their satisfaction.

2.6 Results

A 2 x 2 x 2 repeated measure analysis of variance (ANOVA) was conducted for the repeated -measures factors, *perspective* (Self vs. Other) and *condition* (Cue vs. No-Cue) and the between - measures factor, *group* (ASC vs. Controls). Separate analyses were run for the two dependent variables, reaction time (RT) and error rate (ER). Partial eta squared (η_p^2) and Cohen's *d* (*d*) are reported as an estimate of effect size.

2.6.1 Reaction time.

All trials that were incorrect (9.67% of the data) and trials that were above or below 3 standard deviation (1.38% of the data) were removed from the reaction time analysis. The descriptive statistics are shown in **Figure 2-3**. The 2 x 2 x 2 ANOVA was conducted to examine the influence of *group* on *perspective* and *condition*. The ANOVA revealed a main effect of *group*, with the ASC group being significantly slower than the control group, $F(2, 32) = 7.911, p = .008, \eta_p^2 = .198$ and a main effect of *perspective*, with the *self* responses being significantly faster than the *other* responses $F(1, 32) = 38.858, p < .001, \eta_p^2 = .548$. However, there was no significant main effect of *condition*, $F(1, 32) = 2.639, p = .114, \eta_p^2 = .076$. Moreover, there were no significant two-way interactions between *group* and *perspective*, $F(1, 32) = 2.981, p = .094, \eta_p^2 = .085$ and *group* and *condition*, $F(1, 32) = .130, p = .721, \eta_p^2 = .004$. There was also no significant three - way interaction between all factors, $F(1, 32) = 1.910, p = .176, \eta_p^2 = .056$. *Condition* (No-Cue and Cue) was collapsed due to a lack of main effect for this variable.

The lack of interaction between *perspective* and *condition* is somewhat surprising, given previous findings in which viewing the reaching action of another person appeared to activate that person's perspective (e.g., Conson et al., 2015). To follow-up, a 2 x 2 ANOVA was performed for the original full sample of NT participants ($N = 27$) in order to check whether there was an interaction between *perspective* and *condition* within this uniform larger group. However, the 2 x 2 ANOVA only revealed a main effect of *perspective*, $F(1, 26) = 66.484$, $p < .001$, $\eta_p^2 = .719$ and a main effect of *condition*, $F(1, 26) = 9.524$, $p = .005$, $\eta_p^2 = .268$, but no significant interaction between *perspective* and *condition*, $F(1, 26) = .017$, $p = .897$, $\eta_p^2 = .001$.

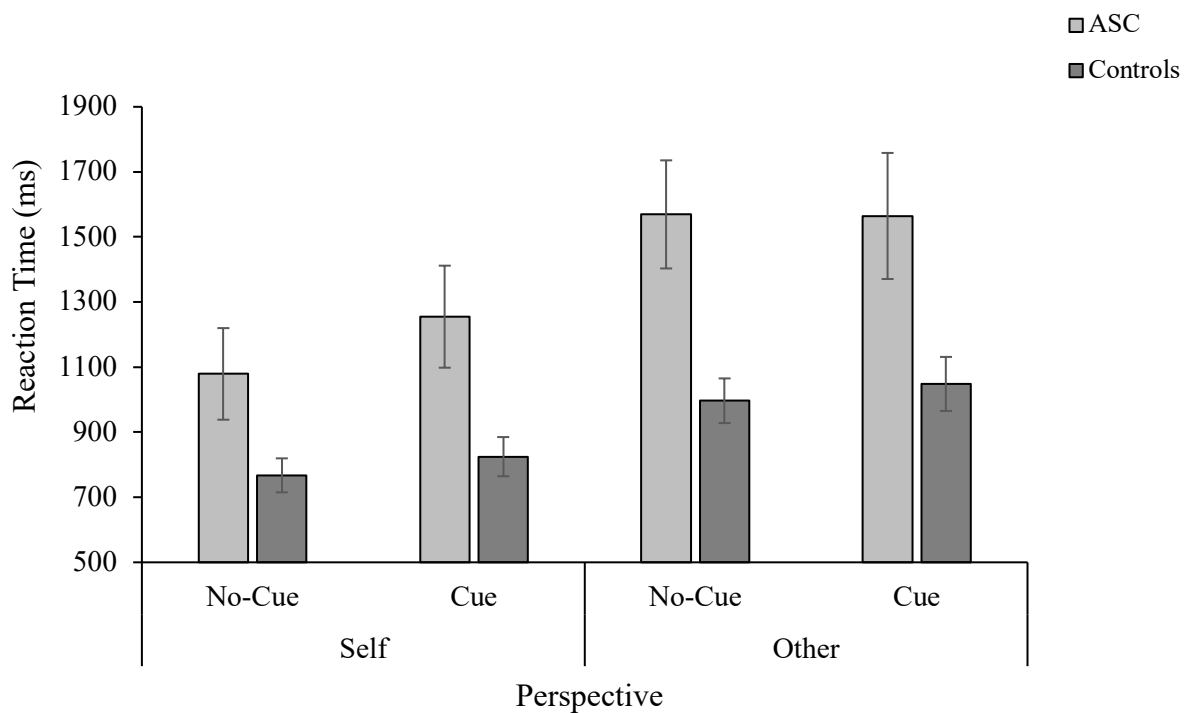


Figure 2-3. Mean RT in milliseconds (ms) for the ASC group and the NT group for the No-Cue and Cue condition for both Self and Other perspective. The error bars indicate the standard error of the mean.

2.6.2 Error rate.

The mean and standard error for the ER data are depicted in **Figure 2-4** for the self-perspective and **Figure 2-5** for the other-perspective. A square-root transformation was performed on the dataset because the data violated normality. The 2 x 2 x 2 ANOVA did not reveal any main effects for *perspective*, $F(1, 32) = 2.313, p = .138, \eta_p^2 = .067$, *condition* $F(1, 32) = .413, p = .525, \eta_p^2 = .013$ or *group*, $F(1, 32) = .1241, p = .274, \eta_p^2 = .037$. Furthermore, there were no significant two-way interactions between *group* and *perspective*, $F(1, 32) = .067, p = .798, \eta_p^2 = .002$, *condition* and *group*, $F(1, 32) = .961, p = .334, \eta_p^2 = .029$ and *perspective* and *condition*, $F(1, 32) = .092, p = .763, \eta_p^2 = .003$. Additionally, there was no significant three-way interaction, $F(1, 32) = .807, p = .376, \eta_p^2 = .025$. A follow-up 2 x 2 ANOVA was performed only for the NT participants ($N = 27$) to investigate whether the presence of a cue facilitated with making fewer errors. The results showed that there were no main effects for *perspective*, $F(1, 26) = .305, p = .585, \eta_p^2 = .012$ and *condition*, $F(1, 26) = 1.494, p = .233, \eta_p^2 = .054$. Additionally, there was a non-significant interaction between *perspective* and *condition*, $F(1, 26) = .1965, p = .173, \eta_p^2 = .070$.

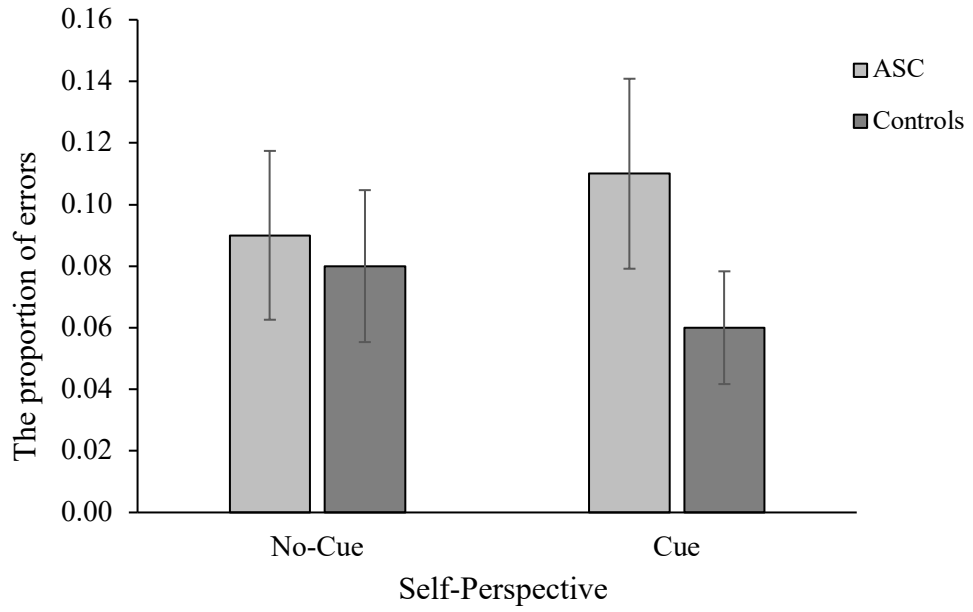


Figure 2-4. Mean ER for the ASC group and Control group in the Cue and No-Cue condition, while judging of the spatial location of the bottle from one's self-perspective.

The error bars represent the standard error of the mean.

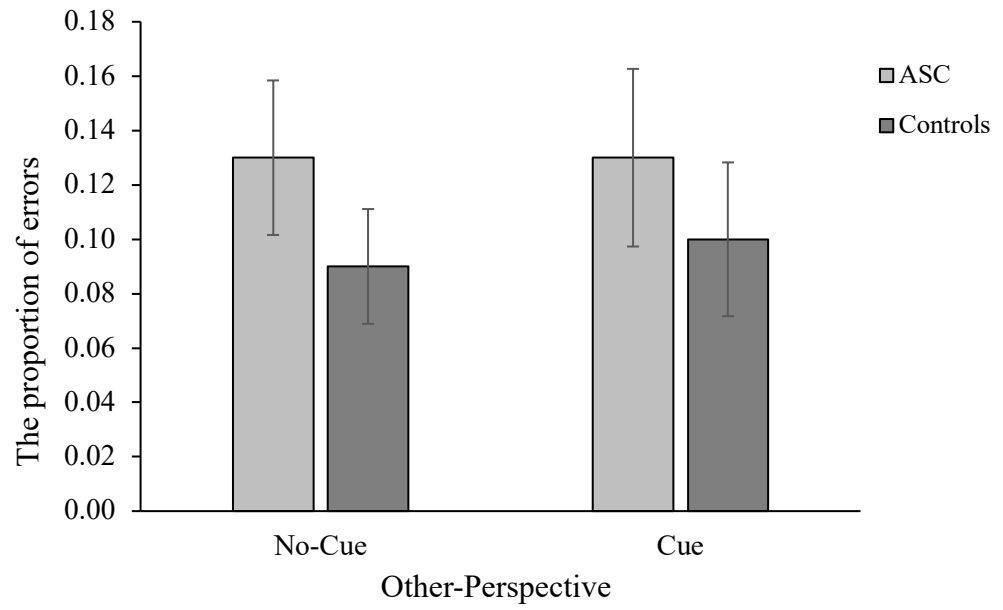


Figure 2-5. Mean ER for the ASC group and Control group in the Cue and No-Cue condition, while making a judgement of the spatial location of the bottle from the perspective of the actor (*other*). The error bars indicate the standard error of the mean.

2.7 Discussion

Experiment 1 investigated whether there was a difference between the ASC group and control group when adopting a perspective (self vs. other) on a VPT-2 task. Participants were required to identify the spatial location of the target object from either their own or the actor's perspective, while they observed a Cue (an actor reaching and gazing towards an object) or No-Cue (the actor was static). The reaction time data revealed that the ASC was significantly slower overall compared to the control group, but the NT control group showed the same broad pattern as the ASC group. Unlike the reaction time data, there was no significant main effects or interactions for error rates. Therefore, this suggests that the ASC and control group performed similarly in both the Cue and No-Cue conditions. In contrast to Mazzarella et al. (2012) findings, there was no evidence of allocentric activation when observing an actor perform an action in both the ASC and control group. To further compare our data with their findings, an analysis was performed on the full 27 neurotypical participants, although this also did not show any evidence of allocentric activation, due to participants being significantly slower to respond in the *other* perspective when they observed a cue in comparison to when the actor was static (No-Cue).

Contrary to Schwarzkopf et al. (2014), a main effect of *group* on reaction time was found, with ASC participants in general responding slower than NT participants. This could be explained by the general demand of the task, as it was measuring VPT level two and involved a task-switching element throughout the trials, due to the two perspectives being interleaved. People on the autism spectrum typically show difficulties with executive functioning and the task might have been more cognitively demanding for the ASC group, hence why they was slower overall to respond, even when they was

responding from their own perspective (Leekam, 2016). Conson et al. (2015) found that in the other-perspective, the reaction time for the ASC participants were slower than controls in the reach and gaze condition. In contrast, we found that ASC participants' reaction time was generally slower on the task (both for the *self* and *other* perspective), therefore, does not replicate the findings of Conson et al. (2015). Moreover, our results from ASC group and the matched neurotypical control group found that the Cue condition did not produce any intrusion effects when participants were responding from their own perspective. Overall, these findings provide support that people on the autism spectrum may experience difficulties with tasks that are cognitively demanding because their reaction time was generally slower regardless of the perspective.

The experiment has some limitations, which should be addressed when conducting future research. It may be beneficial to run each perspective in separate blocks to reduce the cognitive load of the task. This eliminates the cognitive demands involved in shifting from an egocentric to an allocentric perspective or vice versa, as those on the autism spectrum typically demonstrate weaker performance on tasks involving cognitive flexibility (Liss et al., 2001). Furthermore, the contextual processing of the word, *self* or *other* before each trial might have resulted in more cognitively effortful processes, therefore, ASC participants might have devoted more cognitive resources to referencing the word rather than undergoing this egocentric mental rotation process. It may also be recommended to have the actor perform an ipsilateral movement to the target object as opposed to a contralateral movement. This is based on a contralateral movement potentially interfering with mapping the observed action onto a motor representation. Experiment 2 will investigate whether there is a difference between the ASC and control group when adopting only the actor's perspective. Experiment 2 will address some of the

limitations that were found in Experiment 1, such as reducing the cognitive load because participants will only be adopting the actor's perspective.

3 Method for Experiment 2

Similar to Experiment 1, Experiment 2 investigated reaction time and error rate differences between adults on the autism spectrum and a neurotypical control group. The current experiment aimed to further explore whether the presence of a social cue facilitated automatic perspective-taking, as this effect was not found in Experiment 1, however, this could be a consequence of the increased cognitive load. Based on previous research (e.g., Mazarella et al., 2012 & Conson et al., 2015) you would expect to observe this effect of automatic allocentric perspective-taking, with the presence of a social cue as the task involved less cognitive demands.

3.1 Participants

Fifty-six adults completed the study (16 ASC participants, 40 Neurotypical controls). All participants had normal or corrected to normal vision. Participants with a diagnosis of an autism spectrum condition (ASC) were asked to provide evidence, a diagnostic report by a clinician, stating that they have met the criteria for an Autism Spectrum condition diagnosis which verified their eligibility for the ASC group. Of these, two ASC participants were excluded from the final analysis. One ASC participant was excluded because they were a systematic outlier in the dataset, and 1 ASC participant was excluded because of a high number of incorrect responses (error rate more than 30 %). The final ASC group therefore comprised 14 participants, all of which had been previously diagnosed with an autism spectrum condition from a psychiatrist or clinical psychologist

based on the International Classification of Diseases (ICD-10) criteria (8 females and 6 males; M_{age} of 24 years, ranging between 19-54).

This ASC group was compared to an age- and gender-matched subset of 14 Neurotypical participants, taken from the original 40 participants in the Neurotypical group (see **Table 3.1**). Of these, four Neurotypical participants were excluded because of a high number of incorrect responses (error rate more than 30 %). There was no significant difference between the ASC group and the control for age, ($U = 94, p = .852$). All participants were screened with the Autism Quotient (AQ) questionnaire. The mean AQ score for the ASC group was 35.43 ± 10.11 and the mean AQ score for the control group was 12.79 ± 7.33 . The ASC group's AQ score was significantly higher than the control group, $t(23.704) = 6.784, p < .001, d = 2.56$.

All of the ASC participants were recruited from the disability services at the University of Hull, National Autistic Society (NAS) and Mathews Hub. The control group were recruited from the University of Hull using RPS for psychology undergraduate students and received credits for their participation.

Table 3.1. Experiment 2 demographics for the ASC group and the control group. All the data are given as Mean \pm Standard Deviation (range).

	ASC	CON
<i>N</i>	14	14
Age	$M = 24.43, SD = 8.86$ (19-54)	$M = 24.36, SD = 8.58$ (19-52)
Gender	8 female, 6 male	8 female, 6 male
Handedness	12 right, 2 left	14 right
AQ	$M = 35.43, SD = 10.11$	$M = 12.79, SD = 7.33$

ASC ASC group, *CON* control group, *N* number of participants, *M* mean, *SD* standard deviation, *AQ* 50 item Autism Quotient

3.2 Apparatus and Materials

A 19 - inch PC-desktop (resolution, 1280 x 1024) using OpenSesame displayed the stimulus and collected participants' data (Mathot, Schreij, & Theeuwes, 2012). The stimulus consisted of 4 grayscale pictures measuring at approximately 23 x 18 cm when they were presented on the computer screen. Similar to Experiment 1, there were two pictures representing a Cue condition and the two remaining pictures represented the No-Cue condition (see **Figure 3-1**). Participants were screened with an online version of the 50 item AQ questionnaire. All analyses of the data were performed using Microsoft Excel and SPSS (version 23).



Figure 3-1. A schematic representation of the four pictures used in Experiment 2 for the VPT-2 task.

3.3 Design

The experiment had a 2 x 2 design with *condition* (Cue vs. No - Cue) as the repeated - measures factor and *group* (ASC vs. Controls) as the between-measures factor. The two dependent variables were the average RT in ms to respond from the actor's point of view and the error rate (in percentage). The 60 trials within the block were randomised across all participants to counterbalance *condition*.

3.4 Procedure

Participants were tested individually in a testing lab at the University of Hull. All participants were given an information sheet, followed by a consent form to sign, if they consented to participating in the study. All the participants had normal to corrected - normal vision. Participants with a diagnosis of an Autism Spectrum Condition were asked to provide a diagnostic report as evidence to verify their eligibility for the ASC group, similar to Experiment 1. All participants were screened with a 50 item online version of the AQ questionnaire, on a 4-point Likert scale before they began the computer-based task.

Participants were required to explicitly make a left/right judgement of the spatial location of the bottle positioned on the left or right of the computer screen from the actor's point of view (i.e., all trials took the form of the *Other* condition trials in Experiment 1). The participants were instructed to make the left/right judgement quickly and accurately. The computer screen was positioned at an 87° angle at a viewing distance of approximately 48 cm from the participants, as previously mentioned in Experiment 1. Before the computer-based task, participants were instructed to position their index finger on the 'B' key for a left judgement and their middle finger on the 'H' key for a right response. The task instructions for the practice trials were displayed on the computer screen and participants pressed the 'ok' button to begin the practice trials. Participants were presented with 8 practice trials (the four pictures repeated twice) and each trial started with a fixation cross displayed in the centre of the computer screen for 800 ms followed by one of the four pictures, which remained on the screen until participants responded by pressing of the two keys (see **Figure 3-2**). Participants were given feedback on the practice trials (average reaction time and accuracy). If participant's accuracy on

the practice trials was below 80%, the task instructions were reiterated to the participant. However, the 8 practice trials were discarded from any statistical analyses.

In the experimental trials, the four pictures were repeated 15 times for a total of 60 trials in one block of trials. The task instructions for the experimental trials were displayed on the computer screen (see **Appendix C**). All participants were given a break after 30 trials and they resumed the experiment by pressing any key on the QWERTY keyboard. In each trial, a fixation cross was displayed in the centre of the screen for 800 ms, followed by one of the four pictures. The picture remained on the screen until the participant responded with a left/right judgement by pressing one of the two keys that were centrally located on the QWERTY keyboard. However, the keys to indicate a left/right judgement did not differ from the practice trials. The participants were debriefed after they completed the computer-based task, by which a debrief sheet was given to participants followed by the opportunity to ask questions related to the study.

The participants' accuracy was transformed according to a binary code, with incorrect responses being scored as '0' and correct responses were scored as '1'. The RT trials were only analysed, if they met three criteria, (a) the response was correct (b) the $RT > 150$ ms, and (c) the RT was above or below 3 standard deviation of the participant's mean RT. The participants' accuracy was converted to error rate by subtracting the condition's average accuracy from 100 % in Excel.

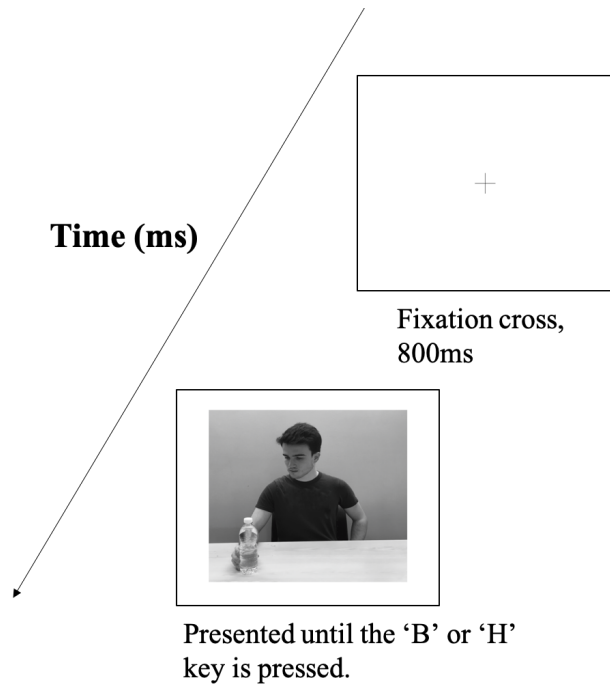


Figure 3-2. An example of the trial sequence for the *other* perspective (60 trials within a block).

3.5 Ethical Considerations

See section 2.5 for the following ethical consideration.

3.6 Results

A 2 x 2 repeated ANOVA was conducted for the repeated -measures factor *condition* (Cue vs. No-Cue) and the between - measures factor, *group* (ASC vs. Controls). Separate analyses were performed for the two dependent variables, RT and ER. Partial eta squared (η_p^2) and Cohen's *d* (*d*) are reported as an estimate of effect size.

3.6.1 Reaction time.

All trials that were incorrect (4.11% of the data) and trials that were above or below 3 standard deviation (2.36% of the data) were removed from the reaction time analysis. The descriptive statistics are represented in **Figure 3-3** for the RT data. The 2 x 2 ANOVA was conducted to examine the influence of *group* and *condition*. The 2 x 2 ANOVA did not reveal any main effects for *group*, $F(2, 26) = .001, p = .973, \eta_p^2 = .000$ and *condition*, $F(1, 26) = 2.815, p = .105, \eta_p^2 = .098$. Moreover, the two-way interaction between *group* and *condition* was found to be non-significant, $F(1, 26) = 1.678, p = .207, \eta_p^2 = .06$.

The lack of any effect of cue could be considered surprising, given previous findings suggesting that viewing the reaching action of another person activates that person's perspective (e.g., Conson et al., 2015). To follow-up, a paired sample t-test was performed for the original full sample of NT participants ($N = 35$) to examine whether the presence of a cue influenced RTs in this uniform larger group. The paired sample t-test revealed that the difference between the Cue and No-Cue conditions were marginally non-significant, $t(34) = -1.977, p = .056, d = 0.101$. However, although there was no

significant difference, NT participants were nominally faster in the Cue condition, $M = 789.71$ ($SEM = 50.49$) as compared to the No-Cue condition, $M = 823.27$ ($SEM = 61.58$).

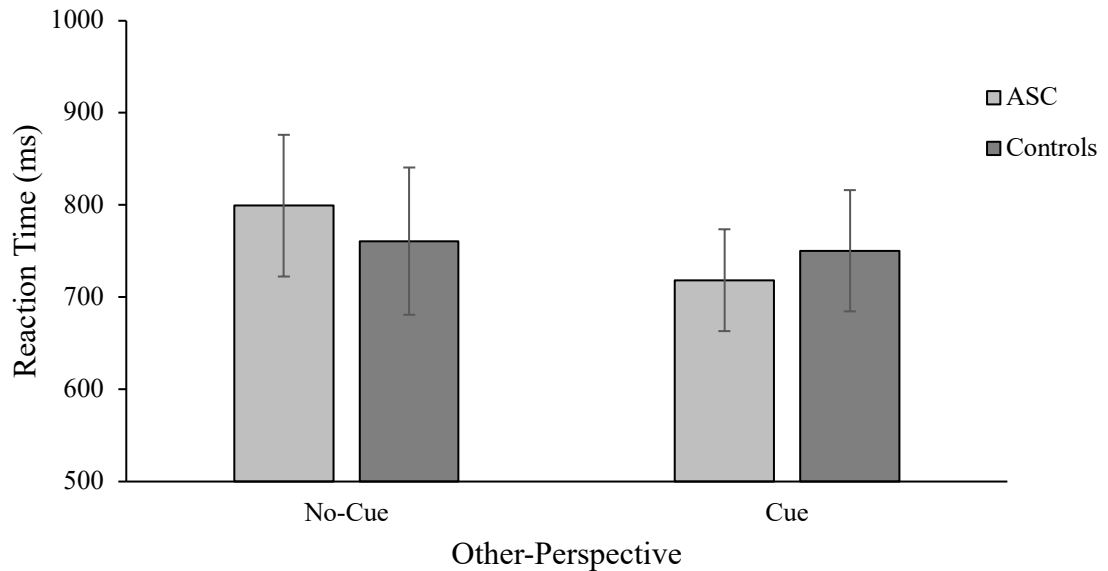


Figure 3-3. Mean RT for ASC group and the Control group in the Cue and No-Cue condition, when they were verifying the perspective of the actor (*other*). The error bars represent the standard error of the mean.

3.6.2 Error rate.

The mean and standard error are depicted in **Figure 3-4** for the ER data. A square-root transformation was performed on the data because normality was violated. The 2 x 2 ANOVA revealed a main effect for *condition*, $F(1, 26) = 6.109$, $p = .020$, $\eta_p^2 = .190$, with participants making fewer errors in the Cue condition compared to the No-Cue condition, but there was no main effect of *group*, $F(2, 26) = .514$, $p = .480$, $\eta_p^2 = .019$. Additionally, there was no significant interaction between *group* and *condition*, $F(1, 26)$

$= .1.291, p = .266, \eta_p^2 = .047$. A post-hoc paired sample t-test, with Bonferroni corrections applied ($p_{crit} = 0.025$) was conducted to compare the difference between the Cue condition and No-Cue condition across groups. Despite the significant overall main effect, within each group the difference between the Cue and No-Cue conditions did not reach significance: for the ASC group, $t(13) = 1.369, p = .194, d = 0.323$; for the control group, $t(13) = 2.067, p = .059, d = 0.038$. To follow-up, a paired sample t-test was conducted only for NT participants from the full original sample ($N = 35$) to explore whether the presence of a cue influenced ER in this larger group. The paired sample t-test revealed that NT participants made fewer errors in the Cue condition, $M = .025 (SEM = .007)$, as compared to the No-Cue condition, $M = .049 (SEM = .009)$, $t(34) = -3.215, p = .003, d = 0.512$.

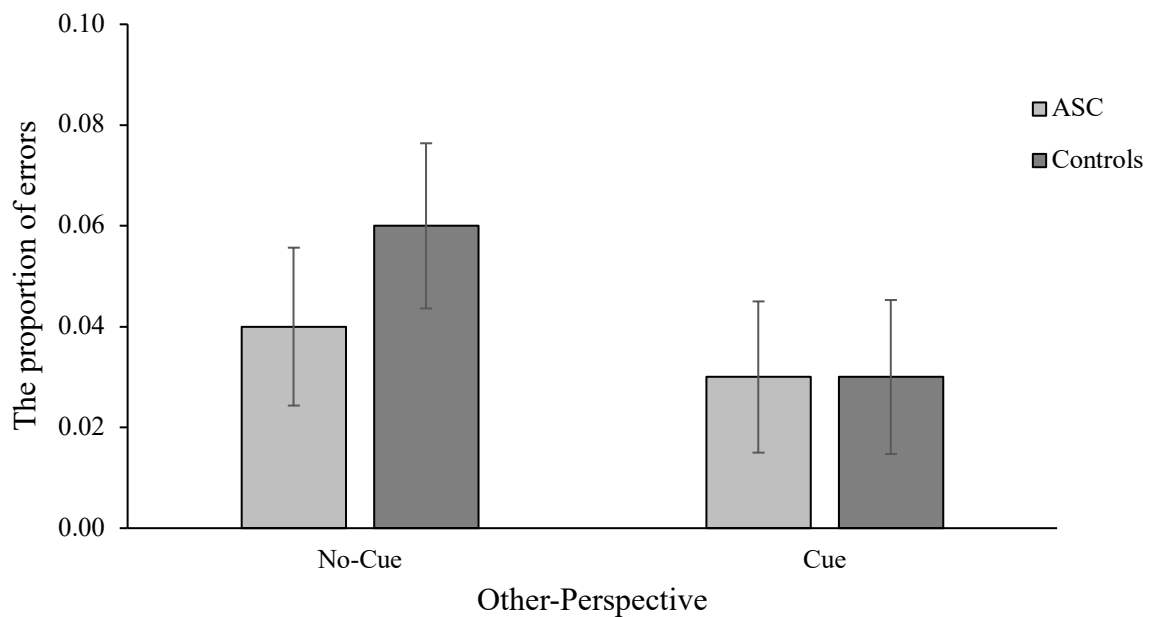


Figure 3-4. Mean ER for the ASC group and Control group in the Cue and No-Cue condition, when verifying the actor's perspective (*other*). The error bars denote the standard error of the mean.

3.7 Discussion

Experiment 2 investigated whether there was a difference between the ASC group and control group in a VPT-2 task where they only responded from the *other* perspective. Participants were required to identify the spatial location of a target object (left/right) in a Cue and No-Cue conditions. In summary, the results revealed no reaction time difference for either *group* or *condition*. These findings failed to support the experimental hypothesis for the reaction time data, as both groups performed similarly across the Cue and No-Cue conditions. Although, the error rate data found a main effect for *condition*. Despite this significant main effect, post-hoc tests revealed no significant difference between the Cue and No-Cue conditions for both, the ASC group and control group.

A follow-up analysis was conducted for neurotypical participants only ($N = 35$) which revealed that the RT data was marginally non-significant. The ER data, however, was found to be significant, as neurotypical participants made fewer errors in the Cue condition, compared to the No-Cue condition. The ER data suggests that the presence of a cue facilitated in making fewer errors, when judging the spatial location of the target object from the *other* perspective. The RT data contradicts Conson et al. (2015) as their findings suggest that ASC were slower at responding from the *other* perspective when observing an actor gaze and reach. Yet, the findings from the current experiment found that both the ASC group and control group performed similarly. The findings suggest that the presence of an actor performing both an action and directing their gaze toward the target object does not necessarily facilitate faster RT when judging the spatial location from another person's perspective. Perhaps, stimulus differences may partially explain the inconsistent findings to Conson et al. (2015). For example, they used an actor interchanging between an ipsilateral and contralateral movement when they are reaching

for the target object. In contrast, Experiment 2 used a stimulus where the actor consistently performed an ipsilateral movement when reaching for the target object. Although, the error rate replicates the findings of Mazzarella et al. (2012) as the Cue and No-Cue condition differ as a main effect, but there was no differences in performance according to group.

Experiment 2 has some limitations that should be addressed in future research. For instance, Experiment 2 only investigated *other* perspective-taking within a block of trials. It may be beneficial to run both *self* and *other* in separate blocks to compare whether there are any differences between ASC and NT participants, when responding from their own perspective. In summary, across the two experiments, there was no evidence for any differences between the ASC and NT groups, apart from Experiment 1 that showed ASC participants had a slower performance overall, but this could be explained by the task-switching demands and the cognitive load of the task because people on the autism spectrum show difficulties with executive functioning. Therefore, these two experiments have followed one method for measuring automatic perspective-taking, which involves repeatedly presenting participants with the same stimuli and asking the same perspective-taking question across multiple trials. Another way of measuring perspective-taking would be to use a more spontaneous perspective-taking task, like that used in Tversky and Hard (2009). It is possible that adults with ASC could show differences in performance on this type of task, but not the repeated-trials RT task that have been used in Experiment 1 and 2, due to compensatory strategies. Hence why Experiment 3 has used this alternative methodology of investigating spontaneous spatial and visual perspective-taking in ASC.

4 Method for Experiment 3

As Experiment 1 and 2 did not detect any differences between the ASC and NT group for automatic perspective-taking, we changed to a different paradigm to measure if there were any differences in spontaneous perspective-taking. In Experiment 3, we investigated spontaneous perspective-taking using a similar methodology to Tversky and Hard (2009). Unlike Tversky and Hard (2009), we explored whether observing a social cue (reaching and/or gazing) and explicitly referencing the actor and the subsequent action would incite any differences in spontaneous actor-based responses in both the ASC and NT group.

4.1 Participants

Overall, one hundred sixty-two participated in the online study. However, seventeen participants were excluded for incomplete responses (6 ASC participants and 11 control participants) and one exclusion for not being fluent in English ($N = 144$). The ASC group comprised 48 participants (29 female, 15 male and 4 other; 2 identified as non-binary, 1 identified as agender and 1 identified as transmasculine, M_{age} of 24 years, ranging between 18-54), all of which selected the *Yes* option specifying that they have received a diagnosis of an autism spectrum condition (*Asperger's Syndrome, autistic disorder or PDD-NOS*). The mean AQ score for the ASC group was 7.52 ($SD = 2.03$). The type of device that was used to complete the survey was recorded for both the ASC and control group. The ASC participants used a desktop-PC (10.42 %), laptop (6.25 %), mobile phone (79.17 %) and a tablet device (4.17 %). In comparison, participants in the control group used a desktop-PC (9.38 %), laptop (15.63 %), mobile phone (71.88 %) and a tablet

device (3.13 %). Most of the ASC participants were recruited from the national autistic society, who circulated an email with the anonymised link to students that were receiving support from the NAS. However, the link was also shared in a University of Hull social group for students on the autism spectrum, but those students shared the link among other students.

The ASC group was compared to 96 neurotypical controls (72 female, 24 male, M_{age} of 26 years, ranging between 18-60). The mean AQ score for the control group was 3.83 ($SD = 2.38$) (see **Table 4.1**). The neurotypical controls were recruited by social media platforms, for example, Facebook and platforms for students conducting online surveys (survey exchange groups etc.). In contrast to the studies that were previously conducted, it was not possible to match by age or gender, due to the recruitment method being online. However, the age of the ASC group and control group were not significantly different ($U = 1950.5, p = .132$).

Table 4.1. Experiment 3 demographic information for the ASC group and the control group. All the data are given as Mean \pm Standard Deviation (range).

	ASC	CON
<i>N</i>	48	96
Age	$M = 24.71, SD = 8.57$ (18-54)	$M = 26.57, SD = 9.65$ (18-60)
Gender	29 female, 15 male, 4 Other	72 female, 24 male
Handedness	39 right, 9 left	86 right, 10 left
AQ	$M = 7.52, SD = 2.03$	$M = 3.83, SD = 2.38$

ASC ASC group, *CON* control group, *N* number of participants, *M* mean, *SD* standard deviation, *AQ* 10 item Autism Quotient

4.2 Material

The online study was conducted using Qualtrics, which displayed eight pictures, but only three of these questions were used to measure spontaneous spatial and visual perspective-taking (see **Appendix D**). The dimensions of each picture was 410 x 547. A shortened version of the 50-AQ questionnaire was also administrated by Qualtrics, with the shortened version only consisting of 10 items (Allison, Auyeung, & Baron-Cohen, 2012) (see **Appendix E**). All participants' data was recorded by Qualtrics.

4.3 Design

The experiment had a *group* (ASC vs. Controls) as the between-measures factor comparing across two critical questions (*what number is he looking at?* And *where on the table does he place his book?*) and a baseline question (*where on the table is the sponge?*) (see **Figure 4-1**) whereas the remaining five pictures were used as filler questions. The dependent variable was the proportion of *self* (their own perspective) or *other* (the actor's perspective) responses for each of the three questions.




Questions	Stimulus
<p data-bbox="416 465 815 501"><i>What number is he looking at?</i></p>	
<p data-bbox="336 797 895 833"><i>Where on the table does he place his book?</i></p>	
<p data-bbox="395 1133 836 1169"><i>Where on the table is the sponge?</i></p>	

Figure 4-1. The three pictures that were used to measure the proportion of spontaneous *self* or *other* responses between the ASC group and the Control group.

4.4 Procedure

All participants accessed the online study by an anonymised link, which directed participants to the information that was read at their own pace. All participants were naïve to the purpose of the study, due to measuring spontaneous responses. The participants were presented with a '*statement by person agreeing to participate in the study*', specifying that they was 18 years or above and informing participants of their right to withdraw from the study at any point by exiting the web-browser. Two options were displayed to participants, the '*Yes, I consent*' or the '*No, I do not consent*', if participants selected the latter, they were immediately displayed with a message '*We thank you for your time*'. However, if participants consented to the study, they proceeded to the demographic information page, this included a series of questions, for example, '*Do you have a diagnosis of an Autism Spectrum Condition? (e.g. Asperger's Syndrome, autistic disorder or PDD-NOS)*' (see **Appendix F**). Participants clicked the arrow at the bottom right of the page to progress through the survey.

After completing the demographic information, participants were presented with task instructions for the picture task (see **Appendix G**). For each of the eight questions, participants were shown the question on their screen with the picture placed directly below it. Participants typed their response to the question into a text box below the picture, and then clicked an arrow to submit their response and move to the next question. Each question was displayed on a separate page and participants could not return to the previous question once they progressed to the next question. All participants were shown the same first (*What colour is the apple?*) and last (*Where on the table is the sponge?*) question. However, the order of presentation for the remaining six questions were randomised across participants.

Following the last question, a 10-item AQ, on a 4-point Likert scale was administered to all participants. The AQ scores were displayed to each participant, followed by the opportunity to contact the research team if they had any questions about their AQ score. Participants were shown a debrief form which highlighted the true purpose of the study, with a submit button located at the bottom of the page to record their response.

4.5 Ethical Considerations

See section 2.5 for the following ethical consideration.

4.6 Results

4.6.1 Scoring.

For the two critical questions and the baseline question, responses were scored as ‘*self*’ if the participant’s answer referred to their own viewpoint and ‘*other*’ if the answer was from the actor’s viewpoint. For the critical question ‘*what number is he looking at?*’ responses that mentioned the number six were scored as *self*, whereas responses that stated the number nine were scored as *other*.

For the critical question ‘*where on the table does he place his book?*’, responses that were scored as *self* for the question include “right,” “right side,” “on the right” etc. For this question, responses that include “left,” “left side,” “to his left” were scored as *other*. One ASC participant (*other* perspective) mentioned both perspectives in their response for this particular question, for example, “On his left (the right as you view the image)”. In cases where participants gave both perspectives in their response, the perspective that was mentioned first would determine the coding category.

For the baseline question ‘*where on the table is the sponge?*’, responses that were scored as *self* include “left,” “on my left,” and “on the left side, whereas responses that include “right,” “the right,” “right edge,” and the “right side” were scored as *other*. One neurotypical control participant (*self* perspective) and three ASC participants (1 *self* perspective and two *other* perspective) mentioned both perspectives, for example “right from the chair, left from the camera” or “my left, their right”. The scored responses were converted into binary variables, with *self* coded as a 0 and *other* coded as a 1.

For both of the questions ‘*where on the table does he place his book?*’ and ‘*where on the table is the sponge?*’, if participants provided an answer that made reference to the spatial location of the target object but did not mention left or right in their answer, it was scored as neutral. An example neutral response would be “to the side”. Neutral responses were excluded from statistical analyses.

4.6.2 *Data analysis.*

The study investigated whether there was a difference between the ASC group and control group in the proportion of *self* or *other* responses across three questions. The proportion *self* and *other* responses for each of these questions are depicted in **Table 4.2**. There was a statistical difference in the proportion of *self* and *other* responses for the critical question ‘*what number is he looking at?*’, $p = .036$, Fisher’s exact test (due to small cell frequency), with ASC participants providing more *self* responses in comparison to the control group.

There were no significant differences between the ASC group and control group for the critical question ‘*where on the table does he place his book?*’, $p = .058$, Fisher’s exact test. Furthermore, there was no significant difference in the proportion of *self* or *other* responses between the ASC group and control group for the baseline questions ‘*where on the table is the sponge?*’, $X^2(1) = 2.629, p = .105$.

Table 4.2. The percentage of *self* or *other* responses that were given by both the ASC group ($N = 48$) and control group ($N = 96$) for each question. The data is given as a percentage (raw number of responses given by participants).

		What number is he looking at?	Where on the table does he place his book?	Where on the table is the sponge?
ASC	Self	10.42% (5)	14.58% (7)	56.25% (27)
	Other	85.42% (41)	81.25% (39)	39.58% (19)
CON	Self	2.08% (2)	10.42% (10)	42.71% (41)
	Other	97.92% (94)	85.42% (82)	54.17% (52)

5 Discussion

In Experiment 3, both the ASC and neurotypical group viewed eight pictures, with three of those pictures used to measure the proportion of spontaneous *self* of *other* responses. The ‘*what number is he looking at?*’ picture depicted the actor looking at a nine from his perspective, whereas it would be a six from an onlooker’s perspective. The remaining two questions asked participants to report the spatial location of a target object, but one picture included an actor looking and reaching for the target object, whereas the other baseline picture only included a chair without the presence of an actor. A significant difference was found with the ‘*what number is he looking at?*’ question where ASC participants gave more *self* responses than the control group, which suggests that the ASC group might be less likely to spontaneously adopt the perspective of the actor when they are faced with an ambiguous question, although 85% of ASC participants did spontaneously adopt the actor’s perspective. There was a slight difference between the proportion of *self* responses, with the ASC group providing 10.42% (5), as compared to 2.08% (2) in the neurotypical control group. These findings may suggest that ASC participants have difficulties with inhibiting their own perspective when reporting visual information from other’s perspective.

However, in response to the ‘*where on the table does he place his book?*’ question, both the ASC and control gave a similar proportion of *self* (14.58% and 10.42%, respectively) and *other* (81.25% and 85.42%, respectively) responses. These results suggest that the ASC and control group did not show any differences between the proportion of *self* and *other* responses when the task instructions are explicit. *Other* responses appear be more prominent in both groups when the task instructions made explicit reference to the actor and/or a potential action. This suggests that the ASC group

can shift from their own egocentric perspective to an allocentric (actor's) perspective given that there are sufficient cues, as the proportion of responses was similar to the control group.

In contrast, the control group showed a different pattern where they gave more *other* responses, even though there was no clear explanation as to why they would adopt the perspective of the chair, an inanimate object, rather than defaulting to their own egocentric perspective. These results are contradictory to previous findings as Tversky and Hard (2009) found that the presence of the actor elicited more *other* responses, but in the no actor scene, participants resorted to their own egocentric perspective. Therefore, the results from this question are somewhat unclear, as it could be assumed that participants would default to their own egocentric perspective if there were no cues to facilitate allocentric perspective-taking. One explanation may be a potential carry-over effect, as this question was always shown last to participants and required speeded judgements, so this may have consequently resulted in participants being more susceptible or even primed to respond from other's perspective rather than their own perspective.

Additionally, the results showed a higher proportion of *other* responses across the three questions in both the ASC group (85.42%, 81.25% and 39.58%) and control group (97.92%, 85.42% and 54.17%) as compared to Tversky and Hard's (2009) study. This difference may be explained by the fact that the present experiment showed 8 pictures, therefore, it is possible that participants became aware of the purpose of the study and as a consequence, gave more socially desirable responses. In comparison, Tversky and Hard (2009) only showed one picture to participants, which may have reduced the possibility of participants no longer being naive to the purpose of the study. Additionally, the

phrasing of the question may have had an effect. Tversky and Hard (2009) asked “*In relation to the book, where does he place the book?*”, but the phrasing of the question for the present experiment may have incited more *other* responses solely because it placed more emphasis on the actor. This suggests that allocentric perspective-taking may be highly sensitive to particular words or even the phrasing of the question, as it is plausible that placing more emphasis on the actor could result in a higher proportion of spontaneous *other* responses. Therefore, for future research, it may be necessary to disentangle the degree of influence that the question may have on the task and, further examine different cues that may potentially trigger spontaneous allocentric perspective-taking.

6 General discussion

6.1 Summary of the findings

Experiment 1 and 2 investigated whether the presence of a social cue would facilitate allocentric activation in an ASC group and a neurotypical control group. As Experiment 1 and 2 did not show any differences between the ASC and neurotypical control group for automatic perspective-taking, Experiment 3 used a task to measure spontaneous perspective-taking to investigate whether there are differences between the groups in spontaneous perspective taking.

In Experiment 1 participants were presented with a word (*self* or *other*) to indicate which perspective to assume, and then made an explicit left/right judgement to the location of the target object from either their own perspective or the actor's perspective. Findings showed that the reaction time of the ASC group was slower overall compared to the NT group. That said, both groups had a faster reaction time when responding from their own perspective compared to the other perspective. The presence of a cue did not appear to affect RT across both groups in either of the two perspectives. The error rate data showed evidence that there was no significant difference between both groups regardless of which perspective they responded from or whether a cue was present.

In Experiment 2 participants had to identify the location of the target object from only the actor's perspective, whereas Experiment 1 required participants to respond from both their own and the actor's perspective. Findings revealed that the ASC and NT control group performed similarly across the Cue and No-Cue conditions when responding from only the other perspective. These RT findings suggest that the presence of a cue did not

have an effect on the ASC or NT group when responding from only the actor's perspective, albeit this effect approached significance when data from the full NT sample was separately analysed. The error rate data from ANOVA did show a main effect of *condition* where the cue facilitated performance, resulting in fewer errors. However, post-hoc tests revealed that this difference was not significant for either group in isolation. When an analysis was performed on the full sample of NT participants only, the results showed that NT participants made fewer errors in the Cue condition compared to the No-Cue condition.

In Experiment 3 participants completed an online study, which involved answering questions about 8 pictures, but only three questions were critical for measuring spontaneous perspective-taking. Results showed that the ASC group gave more spontaneous *self* responses for the '*what number is he looking at?*' question compared to the NT group, although there was no significant difference in the proportion of *self* or *other* responses for the other two critical questions.

6.2 Relation to the literature

The RT results from Experiment 1 were inconsistent with the findings of Conson et al. (2015). Experiment 1 showed evidence that both the ASC and NT group were faster in the self-perspective condition, compared to the other perspective condition, and that the presence of a social cue did not affect either groups RT in either condition. These results suggest that the presence of a cue did not trigger allocentric activation in Experiment 1. Furthermore, the ASC and NT group showed the same broad pattern of responding, albeit with slower overall responding in the ASC group. These findings differ from those of

Conson et al. (2015), as their results suggest that the presence of social cues facilitated allocentric activation specifically in the NT group, but not in the ASC group, with faster RTs when adopting another person's perspective when the actor looked and reached for the object. Results from Experiment 1 shows evidence that both the ASC and NT groups' RT performance was unaffected by the presence of a cue.

The error rate data from Experiment 1 further support the idea that the cue did not trigger allocentric activation in either the NT or ASC group, due to the lack of main effects and interactions. This finding differs from Mazzerella et al. (2012), in which the presence of a cue (the actor looking and reaching at the object) reduced errors when adopting another person's perspective in NT participants. Overall, the lack of any effect of the cue in Experiment 1 is perhaps surprising, given Tversky and Hard's (2009) suggestion that perceiving an actor perform an action towards an object should incite '*potential interaction meaning*', the onlooker should have an understanding of the actor's intention and this understanding should facilitate allocentric perspective-taking.

The RT data in Experiment 2 did suggest that the presence of a social cue elicited a faster response from the actor's perspective, albeit only when analysing data from the entire NT sample. The ER data, however, did produce a significant main effect for *condition*, but despite this main effect, the difference within each group did not reach significance. However, the ER analysis on the full NT sample does suggest that the social cue triggered allocentric activation, with fewer errors with the presence of a cue in comparison to when there was no cue. These findings are consistent with Mazzarella et al. (2012), as the results suggest that observing an action triggers allocentric activation.

Critically, however, there was no interaction between condition and group for either RT or ER: the effect of the presence of a cue did not differ between the ASC and NT

groups. These findings differ from those of Conson et al. (2015), in which their adolescent ASC participants did not give more altercentric responses in the cue condition, but their NT participants did. Their results therefore suggest that observing the actor perform an action towards the target object did not influence the adolescent ASC participants' perspective-taking. The results of Experiment 2 shows evidence that the perspective-taking of adult ASC participants is affected by the presence of a social cue to the same extent as that of NT participants.

In Experiment 3, there was only a difference between the ASC and NT group for the '*what number is he looking at?*' question where ASC participants gave more spontaneous *self* responses as compared to the NT group, although there were no differences across the two remaining questions. The NT findings are consistent with Tversky and Hard (2009), as they found that making reference to an actor and/or a potential action, produces more spontaneous actor-based responses in NT adults. The findings from Experiment 3 also suggest that ASC adults spontaneously adopt the perspective of an actor, when the question explicitly mentions an actor and an implied action. Overall across the three experiments in this thesis, there is little evidence for marked differences in perspective-taking between adult ASC and NT participants.

6.3 Limitations

Here the limitations will be discussed for all three experiments. A general limitation overall is that all three experiments investigated perspective-taking in a sample of people that might be characterised as 'high-functioning' to a degree, due to their being at university and coping with the social demands that it entails. Therefore, this sample of ASC participants might only represent a sub-group of ASC people. It is possible that this

adult university-educated ASC sample might not necessarily show the same degree of perspective-taking difficulties as others on the autism spectrum. As strategies could be employed for left/right judgement task, and participants might have resorted to non-social cognitive strategy to bypass adopting the other's perspective (Livingston, Colvert, Bolton, & Happé, 2019). For example, in Experiment 1 and Experiment 2, when responding from another person's perspective, participants might have employed a non-social strategy by merely pressing the opposite button to where the object was located, without taking the person's perspective. The use of this non-social strategy on the left/right judgement task could explain why there were no significant differences between the ASC and NT's performance.

A potential limitation of Experiment 1 is that the actors performed both an ipsilateral and contralateral movement. This interchanging of reaching movements might have consequently influenced performance on the task as these movements might have appeared unnatural and potentially interfered with the mapping of the observed action onto the participant's own motor representation of the action. This could have resulted in the presence of the cue no longer triggering allocentric perspective taking. This limitation was addressed in Experiment 2, which used only ipsilateral reaches in the cue condition stimuli, and found a main effect of cue on ER and RT. That said, previous research using a mixture of ipsilateral and contralateral reaches has found effects of cues on perspective-taking (e.g., Mazzarella et al., 2012), so the extent to which this affects perspective-taking is somewhat unclear.

Additionally, the cognitive load of Experiment 1 could have had some degree of interference on task performance. Participants were required to make reference to a word (*self* or *other*) to indicate which perspective to assume. Perhaps, the process of referencing

the word throughout the trials could have interfered with the cue facilitating allocentric activation, due to the increased cognitive load of the task. Additionally, both *self* and *other* perspective were interleaved in a block of trials, therefore, ASC participants might have had more difficulties with this task-switching element, as they typically show more difficulties with executive functioning (Liss et al., 2001). These difficulties may have explained the overall slower performance of the ASC group. These limitations were addressed in Experiment 2. Cognitive load was significantly reduced because participants did not have to make reference to a word and participants only responded from the actor's perspective, thus eliminating any task-switching effects that might have influenced their performance. The results of Experiment 2 suggest that when task-switching is eliminated, participants' performance reveals effects of social cues on perspective-taking, albeit these effects appeared not to differ between the ASC and NT groups.

The small sample size for Experiment 1 and 2 is a concern, as both experiments were underpowered, and as a consequence, the study may have failed to detect a true effect. The availability of adults on the autism spectrum is limited, and it becomes increasingly more limited when recruiting ASC participants who are students at the University of Hull. That said, the present study had a similar ASC sample size to previous studies (e.g., Conson et al., 2015 and Schwarzkopf et al., 2014), and the small sample size might have limited the detection of more subtle effects, but despite this, Experiment 1 did, however, detect a group difference.

Experiment 3 had some limitations that could be addressed when conducting future research into spontaneous perspective-taking. One possibility is that performance may have been prone to carry-over effects because participants were shown multiple pictures. As a consequence, participants might have been less naive to the purpose of the study,

thereby reducing the degree of spontaneity in responding. This limitation could be addressed by only showing participants one picture and recording their response in order to accurately measure 'spontaneous' responses. Furthermore, given that Experiment 3 was conducted online, the ASC group consisted of people that self-reported their diagnosis, as compared to Experiments 1 and 2 where participants provided a diagnostic report as evidence that they have met the diagnostic criteria. All participants, however, were screened with the AQ to measure the degree of autistic-like traits and the ASC group reported a higher degree of autistic-like traits compared to the NT group.

6.4 Future work

The results from the three experiments demonstrate that adults on the autism spectrum do not perform differently from neurotypical adults on both automatic and spontaneous perspective-taking. However, findings from Experiment 1 shows evidence that adults on the autism spectrum might perform worse on tasks that are both cognitively demanding and involve some degree of executive functioning. Experiment 2 supports this suggestion as when responding from only the actor's perspective only, they did not show any significant difference in reaction time to the NT group for both the Cue and No-Cue conditions. Therefore, it might be beneficial for future work to investigate the executive demands of particular tasks and how they might affect ASC group performance on perspective-taking tasks. It might also be beneficial for future research to ensure it is more difficult for participants to employ a non-social strategy on a left/right judgement task, as this would be more representative as to whether there are differences in perspective-taking between the two groups, when they employ a social strategy, such as adopting the other's perspective.

6.5 Summary

Collectively, the findings from the present study shows evidence that adults on the autism spectrum did not perform differently on both automatic and spontaneous perspective-taking tasks compared to a neurotypical control group. The findings might however show evidence that when the cognitive load of a task increases, people on the autism spectrum may show more difficulties with the task and as a consequence, their performance worsens.

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Appendices

Appendix A- Task instructions for Experiment 1.

‘Your task is to view pictures and identify the location of a bottle in each picture, QUICKLY and ACCURATELY

When the word 'self' is presented on the screen, followed by the picture, you should respond from your own perspective.

When the word 'other' is presented on the screen, followed by the picture, you should respond from the actor's perspective.

When the bottle is on the Left, from either your own or the actor's perspective, press the 'B' key.

When the bottle is on the Right, from either your own or the actor's perspective, press the 'H' key.’

Appendix B- Ethical approval granted by the University of Hull.



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PRIVATE AND CONFIDENTIAL

Joshua Plant
Faculty of Health Sciences
University of Hull
Via email

10th December 2018

Dear Joshua

REF FHS92 - Investigating visual perspective-taking in Autism Spectrum Condition

Thank you for your responses to the points raised by the Faculty of Health Sciences Research Ethics Committee.

Given the information you have provided I confirm approval by Chair's action.

Please refer to the [Research Ethics Committee](#) web page for reporting requirements in the event of any amendments to your study.

I wish you every success with your study.

Yours sincerely

Professor Liz Walker
Chair, FHS Research Ethics Committee



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Appendix C-Task instructions for Experiment 2.

‘You are about to see a series of pictures. For each picture, please answer the following question:

Where is the bottle? On the left or on the right with respect to the actor’s point of view?

For Left, press the 'B' key.

For Right, press the 'H' key.

You will now start the main experiment. Please respond promptly and accurately.’

Appendix D- The eight pictures with the corresponding questions for Experiment 3.

What colour is the apple?



How many objects are on the table?



Is she happy or sad



What colour is her vest/top?



What number is he looking at?



Where on the table does he place his book?



Which object is bigger?



Where on the table is the sponge?



Appendix E- The shortened 10-item Autism Quotient (AQ).

AQ-10

Autism Spectrum Quotient (AQ)

A quick referral guide for adults with suspected autism who do not have a learning disability.

	Please tick one option per question only:	Definitely agree	Slightly agree	Slightly disagree	Definitely disagree
1	I often notice small sounds when others do not.				
2	I usually concentrate more on the whole picture, rather than the small details.				
3	I find it easy to do more than one thing at once				
4	If there is an interruption, I can switch back to what I was doing very quickly				
5	I find it easy to 'read between the lines' when someone is talking to me				
6	I know how to tell if someone listening to me is getting bored				
7	When I'm reading a story I find it difficult to work out the characters' intentions				
8	I like to collect information about categories of things (e.g. types of car, bird, train, plant etc.)				
9	I find it easy to work out what someone is thinking or feeling just by looking at their face				
10	I find it difficult to work out people's intentions				

SCORING: Only 1 point can be scored for each question. Score 1 point for *Definitely or Slightly agree* on each of items 1, 7, 8, and 10. Score 1 point for *Definitely or Slightly Disagree* on each of items 2, 3, 4, 5, 6, and 9. If the individual scores **more than 6 out of 10**, consider referring them for a specialist diagnostic assessment.

This test is recommended in 'Autism: recognition, referral, diagnosis and management of adults on the autism spectrum' (NICE clinical guideline CG142). www.nice.org.uk/CG142

Key reference: Allison C, Auyeung B, and Baron-Cohen S, (2012) *Journal of the American Academy of Child and Adolescent Psychiatry* 51(2):202-12.

**Appendix F- The block of questions related to the demographic information for
Experiment 3 (survey flow)**

Start of Block: Demographic information

Q3 Are you fluent in English?

Yes

No

Q4 What device are you using to complete this study?

Desktop PC

Laptop

Tablet

Mobile phone

Q5 Gender

Male

Female

Other (Please specify)

Q6 Age

Skip To: End of Survey If Q6 < 18

Q7 Handedness

Left-handed

Right-handed

Q8 Do you have a diagnosis of an Autism Spectrum Condition? (e.g. Asperger's Syndrome, autistic disorder or PDD-NOS)

Yes

No

End of Block: Demographic information

Appendix G-The task instructions for Experiment 3.

‘You will be shown 8 pictures. For each of the pictures, you will be asked to answer a question about that picture.

Please type your answer in the text box provided below the picture.

Answer each question as quickly as you can. We are interested in both your answer and the speed of your response.’