The Devil Is In The Details

Enhanced visual processing and language comprehension in autism

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Abstract

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Individuals within the autism spectrum disorder (ASD) tend to show strong local bias when analysing incoming information. Some postulate this could be due to a more detail-oriented cognitive style, which embraces an initial local processing of a scene when viewing events (Mottron & Burack, 2001). It has also been shown that constraining verbs, which can be mapped onto a limited number of objects in a scene, can lead to an anticipation of upcoming nouns in a sentence, as shown by anticipatory eye movements to the target object of the sentence (e.g., Altmann & Kamide, 1999). The goal of the present study was to investigate whether or not linguistic-and-visual synchronized dynamic events could lead to enhanced processing in children with ASD. Using the visual world paradigm (VWP), children with and without ASD watched dynamic scenes (with and without goal-directed action) that were matched with related sentences. Sentences contained either a constraining (causative) or non-constraining (perception/psychological) verb. It was hypothesized that those with ASD, but not neuro-typically developing (NT) children, would show anticipatory eye movements to the (target) object in the scene based on the constraining nature of causative as opposed to perception/psychological verbs. Secondly, we postulated that those scenes with goal directed action would disrupt the ability of children with ASD to find the target object, due to their poor understanding of agent intent. Results showed that while those with ASD could not anticipate upcoming sentential information, they were faster than NT children at locating the target object in the scene when presented causative sentences. In addition, agent goal-directed action did not distract the attention of those with ASD when trying to locate the target object. We suggest that these findings could provide evidence of a detail-oriented cognitive style in ASD when viewing scenes and listening to sentences concomitantly.

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In the mid 1940's, Leo Kanner and Hans Asperger independently published papers discussing a disorder in which a number of children they had observed had shown unusual behaviours (Frith, 1991, Chapter 2, Kanner, 1943). These children tended to withdraw from the world into themselves. Both papers described similar symptomologies such as a need for strict routine, decreased social interactions, lack of social ability and in some cases, what was described as "islets of ability" (e.g., excellent mathematical skills). Both used the word 'autistic' (from the Greek word – autos meaning self) to describe this disorder and believed that these children had an innate fundamental biological disturbance.

Today, Autism Spectrum Disorder (ASD) is described as an innate neuro-developmental disorder and is classified in the Diagnostic and Statistical Manual of Mental Disorders (DSM5) according to a few basic criteria. These criteria include a marked deficit in reciprocal social interaction and communication, restrictive and repetitive patterns of activity and behaviour, and possible language acquisition delays (American Psychiatric Association, 2013, p. 31 - 33). It is called a spectrum disorder because symptomologies can range from mild to severe depending on the individual.

The heterogeneous nature of autism creates challenges not only for understanding the manifest disorder but for investigating its neurological and cognitive bases as well. Scott (2011) has stated that those with autism are like snowflakes; each one's symptomology and nature is unique. This is due not only to the wide range and degree of communicative, social and behavioural deficits seen in this disorder, but to the number of comorbid diagnoses that accompany ASD. While genetic abnormalities have been at the forefront of autism research, recently environmental factors (such as parental age, gestational time, toxins, etc.) have also been studied and shown to be possible risk factors (Waterhouse, 2013, p. 1 - 30). On the cognitive front, children with the spectrum show great heterogeneity. Studies on visual attention (Neumann, Dubischar-Krivec, Poustka, Birbaumer, Bolte, & Braun, 2011) and language (Brock, Norbury, Einav, & Nation, 2008; Gernsbacher, Morton, & Grace, 2015), for instance, point to the nature of these systems in ASD and how they differ from typically developing individuals.

Those with autism have shown an enhanced ability to visually capture details faster than controls (Kemner, Van Ewijk, Van Engeland, & Hooge 2008; Smith & Milne, 2009) because they are prone to processing information (e.g., objects) locally before moving on to a more global appraisal (Brock et al., 2008). These individuals are also able to capture and remember details better than neuro-typicals (Mottron & Burack, 2001). Based on the research in language processing that has found that certain verbs types (e.g., constraining, causative) can be mapped onto to a limited number of objects in a scene which allows for anticipatory looking at the target noun before it is heard (Altmann & Kamide, 1999), we wanted to explore how these two processes (enhanced local processing in vision and verb type) might interact when utilized in real world events. It is possible that the nature of these processes may be different between neuro-typical individuals (NT) and those with autism which could shed light how those with autism process and utilize information gathered in both scenes and sentences. The goal of the present study was to investigate how language and visual attention interact, and in particular how linguistic-visual interaction in NT children and those with ASD might differ. More specifically, we investigated how sentences uttered in naturalistic visual contexts might direct visual attention towards particular objects—and the potential actions that they afford—in dynamic scenes. To this end, we manipulated the verbs in the sentences, using more or less constraining verbs and monitored all participants' eye movements to potentially related objects in these scenes. It has been shown that eye movements can provide a rich source of data on the nature of cognitive processes underlying language interpretation as well as visual attention (Liversedge & Findlay, 2000; Rayner, Smith, Malcolm, & Henderson, 2009). The use of eye-tracking involving visual scenes and simultaneously presented spoken sentences can be particularly informative regarding the nature of interpretive processes because eye movements are taken to be locked with the processes of interpretation, with fixations and saccades to objects occurring even in anticipation of linguistic tokens (e.g., Altmann & Kamide, 1999; Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995).

We start off by briefly discussing six of the main issues that concern our current investigation: (a) the nature of eye movement in ASD, (b) scene perception, (c) local and global processing, (d) the current theories on this enhanced style of cognitive processing in autism and (e) language acquisition. Also, given that social-cognitive variables are said to play a key factor in autism behaviour, a second goal of the present study was to examine how social intent affects those with autism when locating certain objects in scenes. Thus, we also discuss (f) theory of mind and ASD. Given the interdisciplinary nature of the present investigation—bringing together linguistic and visual-attentional variables—the introduction aims at mapping out the key issues that motivated our study. We shall start by examining eye movement research in autism to understand how this may affect the way these individuals see the world.

Eye movement in ASD

Eye movement behaviours in ASD have been widely studied with varied results. Some researchers have found that movement metrics are impaired with respect to latency, velocity, and accuracy, suggesting that this could be indicative of cerebellar and/or brainstem abnormalities (Rosenhall, Johansson, & Gillberg 1988; Schmitt, Cook, Sweeny, & Moscon, 2014; Stanley-Cary, Rinehart, Tonge, White, & Fielding, 2011). Others have found that individuals with ASD who have language acquisition delays exhibit hypo- and hypermetric saccade landing problems (over and undershooting the target location), but no impairments to either velocity or latency (Takarae, Minshew, Luna, & Sweeney, 2003)

A study by Minshew, Luna and Sweeney (1999) examined the eye movements of children with ASD performing tasks which required response suppression and anti-saccade behaviours. It was found that those with ASD made more errors than controls in both types of eye movements, but all other eye movements were the same as NT children. For Minshew and colleagues any eye movement differences were due to cognitive processing problems such as spatial working memory and not saccade metrics. Neocortical models of ASD (Koczat, Rogers, Pennington, & Ross, 2002) and discriminant function analysis also predict intact saccade metrics but impairment on tasks that require higher-level voluntary eye movements (Minshew, Sweeney, & Luna, 2002).

Some studies have found visual and perceptual processing advantages in autism (Neumann et al., 2011; Reed, Lowe, & Everett, 2011). Kemner et al. (2008), for example, examined eye movement behaviour in a visual features search task aiming to understand whether individuals with ASD employed a more effective search pattern or whether they showed enhanced stimulus discrimination abilities. It was found that individuals with ASD had fewer fixations which were of shorter duration. Kenner et al. suggested that individuals with ASD had enhanced abilities when it came to discriminating between different features among stimuli. An fMRI study has shown evidence of this enhanced processing in early visual areas, which could support the idea of shorter fixation times indicating low-level perceptual advantages (Manjaly et al., 2007).

While it appears that eye movement behaviour in ASD is a complex issue requiring further research, some trends appear to be emerging. Eye movement metrics appear to be relatively intact in those with ASD, and observed deficits are likely due to higher cognitive processing difficulties. Visual processing abilities such as enhanced perception is strongly supported but appears to be affected by the severity of symptomology, stimuli variability, and social context. But, while visual research has shown ASD enhanced perception on low level perceptual tasks, much of the world is made up of dynamic scenes that involve the motion of objects and agents in space. We turn now to a brief review of how scenes are viewed, and information extracted in ASD and neuro-typical individuals.

Scene Perception

Scenes have been described as semantically coherent views that contain objects and backgrounds depicting real world environments (Henderson & Hollingsworth, 1999). They can include photographs, line drawings, random object depiction and of course dynamic real-world events. By hypothesis, perceivers view these scenes and form a general semantic understanding or gist of the scene rapidly. They use semantically relevant objects and schema knowledge to be able to identify and categorize the overall scene.

Vanmarcke et al. (2016b) investigated the idea that adolescents with ASD had a reduced preference to extract and report global properties when viewing scenes especially when these scenes were social in nature. Adolescents with ASD were briefly (less than 100 ms) shown pictures containing either social (e.g., social interaction between two individuals) or non-social (e.g., dog, vehicle) scenes and asked a variety of questions about the scenes viewed (e.g., "Is there a dog in the scene"; "Is there a positive interaction (friendship) present in the scene?") . Results showed that those with ASD performed worse than controls identifying all information. This complements their previous studies using similar methodology (Vanmarke et al., 2016a; Vanmarcke et al., 2016c) in which adults had more trouble categorizing only those scenes that contained social information.

Based on these studies, the researchers suggest that those with ASD show an age-dependent improvement in general categorization abilities, but argue that these results dispute the idea of a general deficit in ultra-rapid gist perception in autism and postulate a more specific problem with the fast processing of social information. Vanmarcke and colleagues assume that those with ASD are less efficient, slower to globally process scenes, and have a lower spontaneity when interpreting information that is socially salient.

One reason why people with autism struggle with global perception especially with respect to social scenes, might be that people with ASD process social information in a unique manner. This has been noticed when examining gaze behaviour in children. Song et al. (2016) for instance, examined eye movements in children with autism aiming to understand how these individuals strategize when processing and parsing dynamic social scenes. Song et al. assumed that gaze behaviour can reveal how a person parses and recognizes socially salient information and that individuals use this information to achieve social understand of the situations they are viewing. Children with and without ASD were shown photographs on a computer screen depicting social situations while their eye movements were recorded using an eye tracker. Song et al. found that there were statistically significant differences in how those with ASD parsed social scenes. When visually inspecting the scene, NT participants tend to saccade more widely over the scene and fixate more often on those areas that give the most overall information about the scene. This group tended to have a more social oriented scan path with respect to the key points of the photo. For example, when viewing social interaction scenes, NT individuals focused more on the socially relevant portions of the scene examining things like hand shaking between the social targets and their faces during the interaction. However, children with autism tended to spend less time examining the overall scene, showed longer fixation times on non-social areas, and less time fixating on social significant portions of the scene. This has also been seen when viewing dynamic scenes. Klin, Jones, Schultz, Volkmar & Cohen (2002) found that adolescents with autism who view naturalist video clips tended to spend less time focusing on the eyes of the agent and more time focusing on the outer parts of the face (e.g., mouth), the body of the agents and off-person (e.g., object in the scene). This difference in strategy employed by those with ASD tends to denote a more limited visual inspection of the scene leading to a more local processing strategy. This effect has also been obtained in adults with ASD (O'Hearn, Lakusta, Schroer, Minshew, & Luna, 2011).

The problem that individuals with ASD may have processing socially salient information suggests that while an age-dependent improvement in general global processing tends to occur, there is a longer, or perhaps permanent impairment in processing social cues. Given that online, quick analyses in many social situations is important beginning at an early age, problems with scene parsing and processing social interactions could well lead to a lower level of social cognition, therefore less rewarding and cognitively enriching social experiences. While those with ASD have a unique way of processing information, the ability to process and utilize social information changes depending upon the individual and his or her distinct developmental pathway. Examining both the overall and local information being transmitted by a scene is important and in the next section we will examine how this detail-oriented style of processing information in ASD is different from NT individuals.

Global or Local Precedence in ASD

When we first look at the picture of a farm or view a plethora of trees from the top of a mountain, it takes only a fraction of a second to get the gist (Potter, 1975). Being able to integrate and process information into a coherent whole is known as global processing. After we holistically process a scene, we then begin to break it down or notice the separate parts or details. This ability to breakdown the whole into parts or see the details is known as local or analytic processing. Local processing allows us to take in more information and obtain a complete and complex understanding of the stimuli. It is believed that global processing is mandatory in NT (Mottron, Dawson, Soulieres, Hubert, & Burack, 2006). That is, cognitive processing begins at a higher more global level and only later moves on to local processing where we get to the details. But this does not seem to be the case in those with ASD. It is likely that those with ASD begin at a more low-level perceptual stage and locally process scenes, only moving on to a global processing style at a later stage, if at all (Mottron et al., 2006). It has been hypothesized that early local processing allows those with ASD to gather and remember the details of a scene better than controls and some research supports the idea that global processing in autism is optional (Mottron et al., 2006) as opposed to mandatory. In recent years, there has been a debate about this cognitive processing style and whether it appears to be an advantage or disadvantage when processing information.

Neumann et al. (2011) investigated visual perception utilizing an Embedded Figures task. Individuals with ASD, tested with isolated letters (S or H presented individually) or embedded figures (a digital number 8 made up of all small Ss or Hs), were asked to indicate which of the letters they saw while the researchers monitored brain activity with magnetoencephalography (MEG). Results showed that in both tasks those with ASD showed increased activity in the visual cortex indicating an automatic bottom-up local processing style as opposed to controls whose brain activity peaked in the parietal (isolated condition) and frontal (embedded condition) lobes. Due to the high amount of visual processing in both tasks, Neumann and colleagues suggested that this provides evidence for enhanced visual perception in those with ASD. This enhancement has also been seen in other modalities, including pitch discrimination (Heaton, 2003), low-level speech processing

(Javinen-Pasley, Wallace, Ramus, Happe, & Heaton, 2008) and in adult NT individuals who score high on autistic traits (Reed et al., 2011).

Some authors hold that ASD does not necessarily involve an enhancement of local processing, but that global versus local processing abilities are a matter of timing When those with ASD are explicitly asked to process scenes in the context at a global level, they can perform comparable to NT controls (Brosnon, Scott, Fox, & Pye, 2004). Van der Hallen, Evers, Brewaeys, Van den Noortgate and Wagemans (2015) performed a meta-analysis looking at the research on local/global visual processing in ASD. They examined 56 articles encompassing 1000 participants with ASD using a wide array of stimuli and tasks investigating both local and global processing. Overall, results show no enhanced local visual processing or global deficit. Detailed analysis revealed a difference in the temporal pattern of the local/global balance with slow global processing in those with ASD. That is, individuals with ASD do not display a general deficit in perception for global order as they do not differ in terms of accuracy but are merely slower at grasping the gist. This was especially pronounced when incongruent or confusing information was presented (e.g., asking them to attend to global information that is presented in tandem with local features such as Navon figures). The researchers also found that gender, IQ, and age seem to have no direct influence on task performance. According to Van der Hallen et al. it is possible that there is a local to global interference in those with ASD whereas NT individuals experience a global to local interference when processing stimuli.

There appears to be ample evidence to support the idea that those with autism process information differently than NT individuals and that this difference in processing allows them to perform certain tasks faster and better than controls. It is also possible that this could be an advantage when global processing impairs or is unnecessary for task performance (e.g., change blindness tasks).

However, whether individuals with ASD are advantaged by having this unusual cognitive style is still in debate. This unique processing style and the way in which those with ASD interpret the world has led to the emergence of two recent theories.

Enhanced Perceptual Functioning and Weak Central Coherence Theories: A Debate

Frith (1989) postulated that those with ASD are unable to process global form and meaning and have a bias toward feature and local information processing. According to Frith, those individuals with ASD have an overall cognitive processing deficit when it comes to integrating local and feature information into global and cohesive wholes. She theorized that when these individuals encounter the world at large such as scenes, stories, or discourse they are unable to bring together the details and comprehend the overall meaning. These theoretical postulates, usually referred to as Weak Central Coherence (WCC), assume that central coherence is a natural cohesive force. It encompasses useful characteristics of the cognitive system that bring together a multitude of perceptual modalities and combine them into an overall theme or idea. Frith (2003) revised the original theory which now refers to detail-focused cognitive process. That is, those with ASD have a bias when it comes to cognitive processes and are biased toward local processing instead of global processing which differs from that of NT individuals. She proposes that while they can indeed process globally, this ability it is significantly weaker than in the case of NT individuals. Frith suggests that central coherence is a cognitive style that varies on a continuum from weak to strong in the normal population and can be represented by a normal Gaussian curve. She puts forward that individuals with autism also show this curve distribution but with the mean shifted toward the weaker extreme. Frith has hypothesized that this Gaussian curve overlaps with that of typically developing individuals and proposed that this can explain some of the inconsistent findings seen in the literature that negate the WCC theory (Frith, 2003, p. 160 - 162). The thread running through these ideas is that the high performance of those with ASD on tasks which require stimuli isolation or that favour detachment is a lack of or a resistance to global coherence. Because of this, those with autism exhibit poorer performance on those tasks which favour coherence and the combination of stimuli.

An alternative theory, Enhanced Perceptual Functioning (EPF; Mottron & Burack, 2001) postulates that individuals with ASD show superior perceptual functioning, which encompasses such perceptual tasks as pattern recognition and low-level perceptual discrimination. The assumption is that this superior perceptual functioning leads to atypical cognitive processing with regards to high and low order processing levels leading to a superior performance in local tasks (Mottron & Burack, 2001). It is suggested that while global processing is mandatory in NT individuals, that it is a less urgent concern in those with ASD and therefore is not a cognitive deficit or weaker ability; just a different way of processing information. Mottron et al. (2006) offered eight principles that characterize ASD perception. These included a default setting that is more locally oriented with no obligation to use a global strategy, when a global approach to the task is not necessary or is detrimental to performance.

One of the most important processing tasks in humans is the ability to gather social information. When interacting with other individuals, we must determine what information is socially salient, use this to understand the thoughts, movements and intentions of those around us and determine what our actions may be in return. To accomplish all this requires a 'theory of mind'

Theory of Mind and Social intent in ASD

Theory of mind (ToM) can be defined as the ability to infer states of mind to not only one's own self but to others as well (Wellman, 1990). The ability to understand what others think and feel tends to be based on social cues. Social cues can include facial expressions that can depict thoughts and emotions as well as body kinematics or biological motion. These cues allow us not only to interpret a person's state of mind and emotional state, but also infer what action an individual may be planning to perform in the next few minutes.

One of the main criterion of an ASD diagnosis is the inability to appropriately communicate and understand social interactions (American Psychiatric Association, 2013). Infants are born with sensitivity to social information and referential gaze perception; that could possibly lead to the development of ToM (Brooks & Meltzoff, 2014). While typically developing infants and children seek social stimuli (Fletcher-Watson, Findlay, Leekman, & Benson, 2008; Rose Salva, Farroni, Regolin, Vallortigara, & Johnson, 2011), those with autism have been shown to have impairments or differences in these areas (Chevallier, Kohls, Troiana, Brodkin, & Schultz, 2010; Kaiser, Delmolino, Tanaka, & Shiffrar, 2010). It is believed that this lack of interest in social stimuli affects brain development in early childhood leading to increased social difficulties in those with ASD (Chevailler et al., 2010; Rice, Anderson, Velnoskey, Thompson, & Redcay, 2016).

Social interaction in the real world not only demands the ability to infer the intent and emotions of others, but also includes the ability to convey one's own thoughts and understand the communication of others. With this in mind, it is important to understand how children with autism acquire and understand language and how it relates to the scenes playing out before them.

Language acquisition in children with ASD

It has been a hallmark of linguistic theory and the field of biolinguistics (e.g., Chomsky, 1980; Hauser, Chomsky, & Ficht, 2002; Pinker & Bloom, 1990) that language is an innate mechanism of the human brain. However, relatively little research has been done on how children with autism process language, and what seems to be the prevailing view is that NT children and those with ASD have a similar linguistic-developmental trajectory (Douglas, 2012; Tager-Flusberg et al., 1990).It has been thought that children with autism display two language acquisition processes commonly observed in NT children during language development: a noun bias and the primacy of language comprehension over language production. Noun bias can be defined as the tendency of young children to learn nouns before other word types (Gentner, 1982). Noun bias has been found to be intact in those with autism (Rescorla & Safyer, 2013), although this noun bias is thought to decrease as vocabulary develops over time (Tager-Flusberg et al. 1990). Comprehension before production however, is more controversial. It is generally believed that children comprehend or understand a word or sentence before producing it. Some (e.g., Charman, Drew, Baird, & Baird, 2003; Kjelgaard & Tager-Flusberg, 2001) believe that this process is not likely to be present in those with autism. But, others (e.g., Swensen, Kelley, Fein, & Naigles, 2007) disagree.

In a recent literature review, Gernsbacher et al. (2015) examined findings from studies published since 2000 to try to discern an overall understanding of language development in children with autism. They concluded that while language development may be delayed, it is not deviant, and occurs in exactly the same way as it does in individuals that are typically developing. In fact, NT children who are diagnosed as late-talkers and verbal toddlers with autism are similar in language development (Weismer et al., 2011).

Sentence parsing (e.g., syntactic, structuring) also appears to be similar in children with and without ASD. In an eye-tracking study, Trueswell, Sekerina, Hill and Logrip (1999) examined how very young children process sentences when responding to instructions. They found that children, like adults, show signs of rapid incremental interpretation, but do not have the ability or are reluctant to change their parsing strategy when syntactic ambiguity is present in the sentence. As children age, this ability to override the ambiguity increases due to their ability to use other linguistic and world knowledge information during processing. This is true in the case of those with ASD, who use both verb semantics and plausibility to integrate and process verb information, but tend to take more time, likely due to slower processing abilities (Bavin, Kidd, Prendergast, & Baker, 2016).

It is likely that children with ASD are born with the same innate language toolkit as NT children but that, due to cognitive and anatomical abnormalities, their ability to process language that is usually fraught with social information is problematic. This, along with ToM deficits, could cause those with autism to take more time to process information, which could lead to language acquisition disruptions and poor social communication. Higher levels of symptomology along with decreased opportunities for social interaction could lead to situations in which some with ASD show small or even no language gains as they develop. It appears that those individuals who are less extreme on the spectrum (e.g., higher functioning) are likely to acquire similar language abilities as NT individuals as they develop during their lifetime.

Anticipatory eye movement behaviour and the present study

The goals of the present study were two-fold. We wanted to examine if the local cognitive processing style found in ASD could lead to enhanced visual processing and, moreover, what the role of linguistic information is in directing attention to objects in scenes. Research in visual perception would suggest that due to the local processing default setting in ASD (e.g., local to global processing), individuals will access the details of the scene (e.g., the objects in the scene) and be quicker at finding certain objects present in the scene before NT individuals. It has also been noted that certain verb types (e.g., constraining verbs) can restrict the number of objects in a scene that can be mapped on to the verb used in the sentence. Due to this fact, individuals could be able to anticipate the upcoming noun information (e.g., the name of the target object) and can fixate on the object before the actual name of the object is heard. This ability to attend to an object in a scene based on the verb information alone, before hearing the appropriate noun, is known as anticipatory eye movement. Due to the detail oriented visual perceptual style in ASD, it was postulated that when constraining verb types are utilized, those with autism will be quicker at mapping constraining verbs to the target object in the scenes than NT individuals and in fact, would show anticipatory eye movement behaviour during this task.

Altmann and Kamide (1999) investigated if individuals could anticipate upcoming nouns in sentences using a constraining verb (a verb that limits the particular objects it can relate to; e.g., the verb *drive* is most likely related to the *car* in a scene). Using semi-realistic line drawings paired with sentences containing either a constraining or a non-constraining verb, participants were asked to view scenes and judge whether the accompanying sentences they heard matched the picture in front of them. For example, in one case, participants saw a picture depicting a boy sitting on the floor surrounded by four separate objects: (a) a balloon; (b) a birthday cake; (c) a toy car; and (d) a toy train set. While examining this picture participants heard one of the following sentences *The boy will eat the cake* or *The boy will move the cake*. Participants' eye movements were recorded. Results showed that when participants heard the sentence with the constraining verb type (e.g., *eat*) that first-fixation of the target object (e.g., cake) occurred faster than when participants heard the non-constraining verb (e.g., *move*). Altmann and Kamide concluded that verb type could allow an individual to anticipate upcoming information in a sentence based on a thematic fit between the verb and a potential complement (the object that could be mapped on to that verb e.g., *crack - eggs*). This eye movement behaviour while processing verbs has been seen in similar studies and other languages (Altmann & Kamide 2007; Andreu, Sanz-Torrent, & Trueswell, 2011; Kamide, Scheepers, & Almann, 2003).

In a study employing a similar technique, Brock et al. (2008) investigated the hypothesis that individuals with ASD have difficulty processing ambiguous linguistic context information when listening to sentences. Adolescents with and without ASD were asked to press a button if any of the words in a sentence matched pictures that were displayed on a computer screen. Pictures consisted of the target noun of the sentence, a phonological competitor of the target noun and two distractors. Two different sentence types (e.g., *Joe ___ the hamster quietly.*) were used, one containing a verb (e.g., *stroke*) that constrained the sentence and was strongly associated with the target object (e.g., hamster) and the second that was more neutral and contained a less constraining verb type (e.g., *chose*). While completing this task, the participants' eye movements were recorded. It was found that NT individuals and those within ASD showed the ability to anticipate the target object in the sentence containing the constraining verb. Brock et al. suggested that both groups were able to use the semantic association between the verb and the objects in the scene to map the verb onto the most likely object in that scene.

While these studies show anticipatory eye movement behaviour using constraining verb types, others have not seen this effect. De Almeida, Di Nardo and von Grunan (2010) argue that while the studies above found anticipatory behaviour when processing certain verb types, neither study used dynamic real-world stimuli which could conceivable have an impact on eye movement behavior. De Almeida et al. (2010) examined eye movements using dynamic natural video clips (e.g., a scene of a women cooking in a kitchen). Each video clip was accompanied by a sentence differing only in verb type. Sentences (e.g., *Before making the dessert, the women will examine/crack the eggs that are on the counter*) contained either a constraining (e.g., *crack*) or non-constraining (e.g., *examine*) verb type. In this case, the constraining verb types used were causative verbs. Causative verbs can be defined as verbs that denote a change of state in an object generally brought about by an agent. Because of its nature, the verb is hypothesized to draw attention to only one or a few objects in the scene (e.g., only a small set of objects can be "*cracked*"). The non-constraining verbs used were perception verbs which denote a perceptual or psychological state and can apply to many or all objects within a scene. Using sentences such as the one above, the researchers wanted to know if hearing the causative verb (e.g., *crack*) would direct attention to only certain objects (e.g., objects that could be cracked) and could cause participants to map the verb on to the noun (e.g., *eggs*) before hearing the noun in the sentence. De Almeida et al. found that there was no anticipatory eye movements seen in the causative condition (e.g., constraining verb types) when they were used in sentences.

In the same study, De Almeida et al. (2010) also examined agent motion to determine if it had an effect on eye movements toward the target object. In a third of the video and sentences dyads, the agent in the video moved toward the target object showing social intent which matched the context of the sentence. Although no anticipatory eye movement was found, NT individuals were faster at fixating on the target object when the agent moved toward the target object (signaling goal directed action) as opposed to the agent remaining stationary or moving away from the target object especially when causative verb types were present in the sentence.

Based on the above studies and the idea of a local cognitive processing style in ASD (e.g., the ability to process the details of a scene early; local to global processing style), one of the goals of the present study was to examine whether or not those with ASD would show anticipatory eye movement behaviour when exposed to certain verb types and naturalistic scenes depicted in motion pictures. It was hypothesized that children with ASD would show anticipatory eye movement behaviour when exposed to causative, but not perception, verb types as opposed to controls. That is, we postulated that compared to NT individuals those with ASD would more strongly utilize causative verbs (a constraining verb type) to reduce the number of objects in the scene that could be mapped on to the verb and be better able to saccade to the target object before hearing this noun in the sentence. Our second objective was to examine what role goal intended motion may play in this process. Since individuals with ASD spend less time or have difficulty interpreting social intent and goal directed action, it was postulated that in scenes with agent motion (agent moving toward the target object), children with ASD would likely have greater difficulty, as revealed by delayed saccades, locating the target objects. This second hypothesis also predicted that NT children would be assisted by agent motion and be faster at locating the target object. Anticipatory eye movements were measured as those saccades that were programmed either during or immediately after verb processing but before the name of the target object was uttered.

Method

Participants

Participants were recruited from local schools, advertisements in magazines, and local flyers (both in print and electronically). They ranged from 6 to 12 years old. Participants had been diagnosed with either High Functioning Autism (n = 16, M_{age} = 9.83, SD_{age} = 2.27, $M_{Mental\ Age}$ = 9.49, $SD_{Mental\ Age}$ = 3.15[1]), or were neuro-typically developing (n = 10, M_{age} = 9.35, SD_{age} = 2.38. Those with autism were diagnosed at local hospitals using either the Autism Diagnostic Observation Schedule (Lord et al., 2000), or Autism Diagnostic Interview-Revised (Lord, Storoschuk, Rutter, & Pickles, 1993). The neuro-typical children, the control group, had no history of neurological or psychological illness. All participants were native speakers of English and had normal or corrected to normal vision. Participants were compensated with a $10.00 movie pass for their participation.

Apparatus

[1] Due to confidentiality reasons, our participants with autism were not tested to determine mental age. Therefore current literature was used to determine the average gap between the mental and chronological age. Literature used: Wright, Kelley & Poulin-Dubois, 2016. A review of the references below showed chronological age is commonly utilized especially with high functioning individuals as were used in this study.

Videos and sentences were shown using a Lenovo Pentium (R) Dual Core computer loaded with Windows XP software. A 24” standard monitor and speakers placed 60 cm in front of the participant were used to present the video and auditory sentences to the participants. Eye movements were recorded using the S2 eye tracker (Mirametrix Inc.) with a sampling rate of 60 Hz. This eye tracker is a non-invasive recording device (35 x 4 x 3 cm) that sits below the computer screen and measures binocular eye movements using an advanced computer algorithm. For calibration, it utilizes 9 concentric circles that are displayed consecutively for 10 seconds, each keeping track of the position of the participants’ head in relation to the viewing screen at all times. Its point-of-gaze measurements are accurate to within 0.5 to 1 degree, has a drift of less than 0.3 degrees and automatically reacquires the participants’ eyes if they move out of range. Stimuli presentation and eye movement data were controlled by the Open Gaze and Mouse Analyzer program (Ogama Version 4.3, 2013). The use of an eye tracker to record eye movement is believed to be a window into how the brain processes visual and other types of information (Rayner et al. 2009; Tanenhaus et al., 1995). One technique used when trying to understand how the brain processes and integrates perceptual information is the Visual World Paradigm (VWP) developed in part by Cooper (1974). The VWP is a technique which combines eye tracking with visual and auditory stimuli (Tanenhaus et al., 1995). Tanenhaus et al. postulated that this paradigm can be utilized not only in testing recognition of words but also in understanding goal intention and problem solving. In a recent study (Farris-Trimble & McMurray, 2013), this paradigm has been shown to be very reliable for examining differences between clinical populations in the investigation of how vision, language, and other systems interact.

Materials

Videos and Sentences. Short video clips (See Appendix D), ranging from 10 to 15 seconds, were selected from a previous study (de Almeida, et al., 2010) and modified by removing one second of footage from each clip to accommodate the Ogama recording and analyses software. These video clips had been produced and edited by a film student using FinalCut Pro (Apple Inc.). In total there were 15 different video scenarios available depicting either external or internal naturalistic scenes to mimic everyday events. Each video was duplicated to create two different conditions of agent motion. In the first condition, there was no agent motion, that is, the agent remained neutral and continued performing his/her action without walking or reaching towards the target object, signalling a goal directed action. In the second condition, the agent moved toward a target object (agent towards) signalling a goal directed action. In total 30 videos were available with respect to agent motion.

Each of the 30 unique videos representing 15 motion conditions (neutral, toward object) was paired with a sentence (See Appendix F), one version containing a causative verb, one version containing a perception/psychological verb, thus yielding 60 unique sentence/video stimuli. These sentences were taken from the study by DiNardo (2010) and were more semantically restricted than the sentences used by de Almeida et al. (2010). Sentences had an initial adverbial type clause to help set up a restrictive schema (e.g., *While making the omelets*), followed by the main portion of the sentence in the form of a NP1 (Noun-Phrase1) – *will* – Verb – NP2 (Relative Clause). Included in all main constituents (NP1 – *will* – Verb) of the sentence were a reference to the generic agent (e.g., *the cook*), the future auxiliary verb (e.g., *will*), the main verb (*crack/examine*) and a target object. Verb type in each of the sentences was either causative (e.g., *While making the omelets, the cook will <u>crack</u> the eggs that are on the counter*) or perception (e.g., *While making the omelets, the cook will <u>examine</u> the eggs that are on the counter*). Target objects (e.g., eggs) were common everyday nouns that are most likely encountered on a regular basis by children. All sentences were concluded with a relative clause (NP2) referring to the main noun or target object (e.g., *the eggs)* and its location in the scene (e.g., *that are on the counter)*. See Appendix E for all sentences.

A female radio announcer digitally recorded the sentences using SoundEdit 16 for Mac at 44.100 Hz. Sentences were recorded at a normal pace and pitch. The pre-recorded sentences and movies were synchronized so that the sentence onset occurred 7 seconds after the beginning of the scene onset. The onset of each of the main verbs (e.g., the initial phoneme of either *crack* [causative] or *examine* [perception/psychological] was synchronized with the frame corresponding to the motion of the agent in the towards condition. This was the frame judged by two experimenters to correspond to the beginning of the body motion of the agent towards the target object. For the neutral condition, the onset of the verb was synchronized with a frame corresponding to the same timing of the frame of the towards condition video. This ensured that participant did not have knowledge of the action of the agent in advance of the verb, but only simultaneously to the verb's unfolding.

Screening tasks. Two screening tasks were conducted after conducting the VWP experiment. The first, a picture naming task (See Appendix C, A1) with 8 pictures selected from Snodgrass and Vanderwart (Snodgrass & Vanderwart, 1980) set of stimuli. The stimuli were composed of line drawings of common everyday objects that appeared in the videos as targets. For instance, if the sentence was "*Because it is a windy day, the girl will fly/see the kite, that is on the bench*, a picture of a kite was used. The goal was to test for recognition and understanding of some of the target objects seen. The Picture Naming task has available norms and has been extensively used in the cognitive neuropsychology literature.

Second, children were asked to provide the meanings of all verbs used in the sentences. A separate question and response sheet was also created for this task (See Appendix C, A2). The goal was to assess verb knowledge and participants' understanding of the verbs heard in the sentences. Children were asked to provide definitions only of the specific verbs they heard. In cases where the explanation of verb meanings was unclear, children were allowed to demonstrate their verb understanding by acting out the verb meaning (e.g., for "*drop*" they demonstrated by dropping a pen on the floor).

Experimental Design

The 60 videos were divided into four different lists of trials that contained 15 videos each. All trials were created so that a sentence-verb type/motion type/scene scenario combination appeared only once in each list. Lists were counterbalanced to contain an equal number of verb types and agent motion. Children were randomly assigned to one of the lists and thus saw only one version of each verb type/agent motion scene combination. Trials within lists were pseudo-randomized to avoid two sentences of the same verb (e.g., causative) or two videos of the same motion condition (e.g., agent neutral) from following each other.

Each trial lasted about 25 seconds, which included the watching of the video clip, random questions and the inter-stimulus interval. Each list contained a total of 15 experimental videos and sentences. The entire experiment lasted about 30 minutes including experimental trials, eye-tracking calibration time, screening tasks and questionnaires.

Procedure

Parents were requested to read and signed a consent form (See Appendix B). Also, those parents who had children with ASD were asked about the child's diagnosis (e.g., how they were diagnosed), the identity of their school (e.g., whether their child attended a special needs school or was mainstreamed) and about the types of therapy their children had undergone (e.g., speech, applied behavioural analysis, occupational therapy). Afterwards, children were seated in front of the eye tracking equipment and computer. Before the beginning of the task, children were instructed to pay close attention to both the videos and the accompanying sentences as questions would be asked about both after each trial. They were told that they would be watching a series of 15 videos and listening to accompanying sentences.

Participants were asked to keep their eyes on the computer monitor for the purposes of calibration and each underwent a complete 9 point/10 second calibration. In some cases, the calibration had to be repeated more than once to confirm the eye tracker's ability to track the eye movements of the participant while viewing the videos. After calibration, the experiment began. The space bar on the keyboard of the computer was pressed by the researcher to begin each video clip. At the beginning of each trial, the word "Ready?" on a black background appeared in the center of the monitor. When the participant indicated their readiness, the word was replaced by a red circle (approximately 3.5 cm in diameter) in the middle of the screen. After 1 second, the background was replaced by the first frame of the video with the red fixation cross. Participants were instructed to fixate on the circle and the cross and to move their eyes only after the cross disappeared. The fixation cross then disappeared after 2 seconds, and the video clip began. After each video, children were asked random questions to check their attention to both the video and sentence (e.g., "What colour was the kite in the video?", "What did they say the man was doing?").

Data Analysis

Descriptive statistics are reported using the original raw data, but some inferential statistics (noted below) were conducted using transformed square root data due to non-normality of the distribution. Square root transformation was chosen as it is the most appropriate means of transforming count data that has positive skew and kurtosis (Field, 2013, p. 201 - 204). All data for saccade onset times and duration of fixations are reported in milliseconds (ms).

Data analyses consisted of proportion of looks at the target object and first fixation on the target object after verb onset (saccade onset time) for both causative and perception verb types. Target object first fixation and proportion of looks were altered for one set of video/sentence dyads (4 stimuli). In one sentence (about a car crash), the target object data was expanded to include all cars in the video due to ambiguity in the target object's position. Data was also examined for number and duration of fixations to examine differences in the way each group examined the scenes. Agent motion was also assessed to understand what role it may play and how it may interact with verb type in each group. Finally, group differences between the above conditions and the number of fixations and their duration on the target object were explored.

Fixations or looks at the target object were defined as fixations present on or within 3 degrees of the object's perimeter as measured when sitting 60 cm away from the computer screen. Fixation numbers were counted as the number of times the individual looked at the target object and duration was measured as the amount of time spent dwelling on the target object during the entire video.

Hedge's g has been calculated for all between group conditions (Causative verb/Neutral agent motion - CN, Causative verb/Towards agent motion - CT, Perception verb/Neutral agent motion - PN and Perception verb/Towards agent motion - PT) to examine the effect size or magnitude of difference between the populations in each of these conditions. When sample size is small, it is more likely that Hedge's g is a positively biased estimator (Kline, 2004), therefore a correction factor was used in determining these values (Durlak, 2009). While Cohen's conventions allow for an effect size to be labelled as small (0.2), medium (0.5). or large (0.8 and above), he strongly suggests caution when labelling the strength of an effect size and consulting the literature on similar studies as these 'rule of thumb' conventions may not apply (Cohen, 1988 as cited in Durlak, 2009). To our knowledge, no work been done in this area, therefore all effect sizes reported must be interpreted with caution especially due to the small sample size of both groups. Also, due to lack of fixation and saccade data, two NT children and four children with ASD were excluded from this analysis.

Results

Saccade Onset time

Individuals with ASD looked at approximately 77.8% of the target objects (SD = 4.45) which was not statistically significantly different ($t(21) = 1.53$, $p = .28$) than controls (M = 65.86, SD = 13.59). These results can be seen graphically in Appendix A, Figure 1.

A 2 (ASD vs. NT) x 2 (causative versus perception) x 2 (agent neutral versus agent towards) mixed factorial repeated-measures ANOVA was performed to examine the main effects and interactions on eye movements between the two groups with respect to the verb and motion type (See Appendix A, Figure 4.). Bonferroni main effect comparisons were used to compare the main effects. All saccade onset times are operationally defined as the amount of time needed to saccade to the target object after the onset of the verb. Interestingly, when ASD and NT saccade onset times were compared, it was found that there were statistically significant between-group differences ($F(1, 28) = 4.52$, $p = .042$) That is, those with autism were faster at saccading to the target object than NT individuals in all but one condition (Refer to Appendix A, Table 1 for saccade onset times). However, neither agent motion ($F(1, 28) = 0.12$, $p = .73$) nor verb types ($F(1, 28) = 3.93$, $p = .057$) appeared to differ. Interaction effects of the two factors were found not to be statistically significant ($F(1, 28) = 2.84$, $p = .10$).

Eye movements to the target object were examined to see if causative verbs made participants look at the target object faster than perception verb types due to the semantically restrictive nature of the causatives. Sentences with causative verbs (*M* = 995.06, *SD* = 631.98, 95% CI = [804.36, 1185.75) had a similar saccade onset time as those with perception verbs (*M* = 1148.09, *SD* = 697.03, 95% CI = [879.98, 1416.21]). A similar lack of effect was observed in the control group as can be seen by the saccade onset time in the causative (*M* = 1459.15, *SD* = 590.41, 95% CI = [1268.45, 1649.84]) and perception (*M* = 1129.92, *SD* = 572.40, 95% CI = [807.18, 130.89]) verbs. It appears from these data that the main effect of verb type alone does not enhance looking times to the target object in either group (See Appendix A, Figure 2.).

The main effect of motion was also examined to understand the role it may play in saccade onset times. The agent towards (*M* = 960.31, *SD* = 557.33, 95% CI = [754.54, 1166.08]) and agent neutral conditions (*M* = 1182.84, *SD* = 749.09, 95% CI = [927.84, 1437.85]) in those with ASD showed comparable saccade onset times. NT children did not differ in the agent towards (*M* = 1140.91, *SD* = 535.03, 95% CI = [935.14, 1346.67]) or neutral (*M* = 1448.16, *SD* = 630.24, 95% CI = [1193.16, 1703.16]) movement conditions. It appears that motion alone, which could serve to infer goal-oriented behaviour, did not aid participants in locating the target object faster (See Appendix A, Figure 3).

Upon calculating the Hedge's g effect sizes, it appears that in the causative neutral condition (Corrected *g* = - 0.99), the mean of the distribution of eye movements toward the target object in those with autism is 0.99 standard deviation lower than that of the NT children. With respect to the causative toward condition (Corrected g = - 0.40) in those with ASD, the mean of the distribution in this case is 0.40 standard deviation units below that of controls. It is possible that these two groups of children come from different distributions and that those with autism are faster at locating the target object after hearing a causative verb, especially when combined with a neutral agent. As the causative neutral condition's 95% confidence intervals for both groups do not overlap and have a low p values when comparing causative versus perception verb types between the two groups, this would lead us to reject the null hypothesis that these two groups of children are utilizing the information in the same way.

Number and duration of fixations to target object

Two 2 (ASD versus NT) x 2 (causative versus perception) x 2 (agent neutral versus agent toward) mixed factorial repeated measures ANOVAs examining the same factors as above were performed. These ANOVAs were done using square root transformation due to non-normality of these data groups. The first ANOVA looked at the number of fixations on the target object. Neither the between group ($F_{between\ group}(1, 28) = 1.07$, $p = .31$) nor the within group factors ($F_{verbtype}(1, 28) = 2.45$, $p = .13$; $F_{motion}(1, 28) = 1.01$, $p = .32$) were found to be statistically significant. Also, there was no interactions between these conditions ($F_{interaction}(1, 28) = 0.11$, $p = .75$).

The second ANOVA assessed the overall dwell time on the target object (amount of time spent looking at the target object). Duration of target object fixations were also found not to be different between groups ($F(1, 25) = 1.76$, $p = .20$). All within group fixation durations were comparable between the groups ($F_{verbtype}(1, 25) = 0.72$, $p = .41$, $F_{motiontype}(1, 25) = 0.35$, $p = .56$, $F_{interaction}(1, 25) = 0.93$, $p = .34$). The data can be seen in Appendix A, Tables 2 and 3.

Discussion

It was hypothesized that children with autism would show anticipatory eye movements with causative as opposed to perception verb types and would be faster at saccading to the target object than controls. It was also postulated that agent motion toward the target object in the scene in a goal directed manner would disrupt the attention of those with ASD when trying to locating this object, whereas it would assist neuro-typical children. It was found that neither NT children nor those with autism showed anticipatory eye movement behaviour with causative verb types. According to Land and Tatler (2007), the time it takes to program and initiate a saccade to move from one point to the next is about 200 ms. Data showed that it took those with autism on average about 995 ms to saccade to the target object after the onset of the verb. Those individuals that were NT need even more time,1459 ms, to perform the same action. Since the noun onset times, on average, in causative sentences occurred 370 ms after the verb onset, it is likely that the children heard the noun before saccading to the target object in the scene. This being said, those with autism were approximately half a second faster ($M_{difference}$ = 464 ms) than NT children. This could be evidence of a local processing style. It is possible that due to their having already processed details of the scene, they could saccade faster to this location once the target noun became evident. NT children would have globally processed the scene during this initial viewing and may not have seen the target object, therefore took longer to locate it. Based on the data we obtained it is likely that these two groups are distinct in their ability to use verb information during online sentence processing. With this in mind, number of fixations on the target object before verb onset was analysed. It appears that those children with autism saw the target object approximately one and a half to two times more often than NT children (See Appendix A, Table 4) before hearing the verb. These differences in target object looks were statistically significant both overall ($t(76.96) = 2.81$, $p = .006$) and for each condition ($F(1, 79) = 5.47$, $p = .022$). This is represented graphically in Figures 6 and 7.

One finding was that the NT group showed a faster saccade onset time with perception as opposed to causative verbs ($M_{difference}$ = 329.23 ms). While these data did not rise to the level of statistical significance and did not conform to anticipatory behaviour, it was an unusually occurrence. This finding has been noted before in NT adults (de Almeida et al., 2010). Contrary to the findings in both Altmann and Kamide (1999) and Brock et al. (2008), it appears from our study that verb type does not allow for early mapping of upcoming information in an anticipatory fashion. While our findings are contradictory to previous studies, it should be remembered that Altmann and Kamide (1999) and Brock et al. (2008) presented line drawings and coloured photos, on a computer screen respectively. It could be argued that both types of stimuli lack ecological validity, that is, they do not adequately reproduce the conditions under which participants would observe scenes and understand language simultaneously. Our study employed naturalistic video clips that more accurately depicts real scenes.

NT individuals appeared to be faster at fixating on the target object when the agent moved toward the object in a goal-directed manner than when the agent remained stationary. Surprisingly, those with autism appeared to attend to this socially salient motion. In fact, those with autism showed similar saccade onset times in both movement conditions, which were comparable to those onset times seen by NT individuals in the towards conditions. It is possible that due to a different cognitive processing style that those with autism are employing a unique strategy to unravel the agent's intended goal. With regards to the fixations within each scene, it was observed that the patterns of scanning exhibited by the NT children and those with autism differed with respect to agent seen in the video. Based on this observation, we decided to examine the number and location of fixations on the agent to see if we could elicited how those with ASD were viewing the goal directed action and if a compensatory mechanism could be found.

Upon analysing the number and duration of fixations on the agent overall we discovered that those with autism appeared to spend less time looking at the face of the agent than NT children. On average, data showed that those with autism fixated more often on the bodies of the agents (Body fixations as a percentage of total overall scene fixations = 21.7%) and for longer periods of time on average ($M_{duration\ of\ body\ fixation}$ = 1042.61 ms) than the face (Face fixations as a percentage of total overall scene fixations = 7.1%, $M_{duration\ of\ face\ fixation}$ = 230.41 ms) compared to NT individuals (Body fixations as a percentage of total overall scene fixations = 19.7%, $M_{duration\ of\ body\ fixation}$ = 491.09 ms, Face fixations as a percentage of total overall scene fixations = 16.2%, $M_{duration\ of\ face\ fixation}$ = 238.33 ms). One of the symptoms of ASD includes hypersensitivity to stimuli (American Psychiatric Association, 2013, p. 50) such as eye contact. Since eye contact is rich with information (Kleinke, 1986), it is possible that eye contact is too stimulating and makes it difficult for those with autism to interpret information from this source. Since children with ASD may not be able to utilize this method for understanding the intentions of others, body motion while giving less information may be coming at these children in a more controlled and slower way that allows them time to process what may be happening next. Perhaps the children with ASD in our study were ‘reading’ body language as opposed to facial cues to infer intent. Due to the detailed oriented cognitive style seen in autism, it is possible that when our participants with ASD were processing information from the scenes that small body movements made by the agent were noted (e.g., lifting of the chin or hands in the intended direction, turning of the body toward the target object). These movements could have been utilized by those with ASD and allowed them to interpret goal directed action. This type of ‘goal directed action’ processing could be an indication that those with ASD are using a compensatory mechanism or strategy to infer intent. It is likely that the control children did not notice or use this information (body movements) in this way, as NT children tend to utilize eye contact and joint attention when inferring goals (Chevallier, et al., 2010). There is some research to support this idea of a compensatory strategy.

Exposure of rats to valproic acid (VPA) causes rats to show similar symptoms to autism such as lower social interactions, repetitive behaviours, and brain changes (Markram & Markram, 2010). Using a VPA rat model of autism, a set of researchers developed the Intense World theory (Markram, Rinaldi, & Markram, 2007) which postulates that those with autism are overly sensitive to the world around them due to hyper-functioning of neural circuits. This increased neural firing can lead to a state of over-arousal. Markram and his colleagues discovered that the rats' amygdala and medial frontal cortex have elevated levels of activity, were hyper-connected and show enhanced plasticity. They believe that there is a multitude of neurological circuits that are hyper-reactive to stimuli and these circuits can lead to cognitive disruptions which include hyper-perception, hyper-attention and hyper-emotionality. The amygdala has been implicated in attending to biological motion and understanding facial cues (Adolphs & Spezio, 2006; Bonda, Petrides, Ostry, & Evans, 1996). Given this connection and Markram's hypothesis that those with ASD have an overload of socio-emotional stimuli which causes the individual to feel overwhelmed and withdraw from eye contact, it is possible that viewing body movement in lieu of facial cues could serve as a compensatory mechanism to understand social intent. As the amygdala is hyper-attentive and involved in biological motion, perhaps this increased sensitivity gives those with ASD more information from body cues compared to NT children. This research could support our findings that those with autism are spending more time viewing the body of the agent and our theory that they have developed unique ways of gleaning the intent of another individual. While literature on the biological motion is mixed (Blake, Turner, Smoski, Pozdol & Stone, 2003; Freitag et al., 2008; Murphy, Brady, Fitzgerald & Troje, 2009; Nackaerts et al., 2016), it may be that possible methodological problems in these studies (e.g., use of point light displays instead of other type of stimuli) could be impeding those with ASD (Centelles, Assaiante, Etchegoyhen, Bouvard & Schmitz, 2012) in recognizing this type of animate movement. It has also been noted that individuals with autism spend less time looking at the eyes of people and more time looking at less socially pertinent facial areas (e.g., chin, outer facial regions) and bodies (Pelphrey et al., 2002).

This "Intense World theory" is not embraced by everyone, however (Remington & Frith, 2014). Remington and Frith (2014) posted a rebuff of these findings suggesting that this idea has had too little scientific scrutiny. They argue that Markram et al. have released their findings too early and point out that this research is based on an animal model which may have a tenuous link with humans. Remington and Frith urge caution in accepting this theory until more data are collected and analysed.

There is further evidence supporting Markram et al.'s theory of hyper-functioning neural circuits. Perez Velazquez and Galan (2013) examined the amount of brain activity in the absence and presence of external stimuli using children with or without autism. Using magnetoencephalography (MEG) data, they examined 6 to 14-year-old individuals and discovered that there was approximately 42% more brain 'noise' in the resting brains (brains not receiving external stimuli) of those with ASD than NT children. The researchers state that this increased incoming information could lead to a more intense 'inner world' and conceivably lead to the behavioural withdrawal seen in those with ASD. Velazquez and his colleagues hypothesize that changes in brain architecture and physiology may result in reduced specificity of brain signals leading to less concentrated sensory information therefore more ‘brain noise’. This study complemented another one (Dominquez, Velazquez, & Galan, 2013) showing that adolescents with ASD have altered connectivity and enhanced excitation in several areas of the brain.

Researchers have found links between the ability to recognize and analyze body motion in individuals with ASD and ToM (Rice et al., 2016) and that may allow those with ASD to be better at reading body language as opposed to facial cues (Peterson, Slaughter, & Brownell, 2015). Since our participants were high-functioning children who attended school, it is likely that their levels of first-order ToM were intact and this along with a body kinetics strategy aided with the understanding of the goal directed action of the agents.

Another finding of the present study was an interaction between causative verbs and agent motion factors for saccade onset times in both the CT and CN condition. Although failing to reach statistical significance, NT children showed numerically faster saccade onset times – 535.32 ms when causative verb sentences were paired with the toward agent motion condition as opposed to children with ASD, replicating finding with adults (de Almeida et al., 2010). It is possible that both the restrictive nature of the sentence and verb type in combination with the agent motion allowed NT individuals to glean the intention of the agent. Understanding goal directed actions and targeted objects of these intentions has been well documented and has been shown to be present even in infancy (Woodward, Sommerville, Gerson, Henderson, & Buresh, 2009). By utilizing their understanding of agent motion and intent, our NT participants were able to locate the target object faster than those with autism. When the agent was motionless in relation to the target, there was no motion cues to help these children determine what object in the scene may be relevant until they heard the target noun. This finding partially supports our hypothesis that agent motion would assist NT children to find the object faster, but as it only occur with causative and not perception verbs types, it suggests that restrictive verb types do provide relevant information for locating the correct object in the scene.

One verb and motion interaction condition does require further discussion. While agent motion and causative verb type seem to restrict the domain of reference for the NT individuals, they provided imperfect clues to those with ASD. In those with autism, neutral agent motion and causative verbs types in combination seem to enhance their abilities to saccade to the target object faster than controls. So, while interaction between verb type and motion type did not appear to allow for faster saccading when compared to other combinations within-group, when those with ASD were compared to controls, this type of interaction did appear to enhance their ability to look at the target object. There appears to be no statistically significant difference between the two groups in this condition, however, as seen in the results section the 95% confidence intervals did not overlap, and the *p* value approached $\alpha = .05$ ($p = .057$). Arguments can be made against relying simply on *p* values to make inferences about a given experimental finding (Kline, 2004). Thus, it is possible that that there are underlying differences between the conditions we investigated which could not be captured by the tests we employed. When examining the mean values between those with autism and those that are NT ($M_{difference} = 673.31$) in the causative neutral condition, it appears that the children with autism were on average faster at locating the target object (See Appendix A, Table 1). This trend suggests that while an effect might exist it is not being captured by the data available. This conclusion is bolstered by the high value of the Hedge's g effect size in this condition (Corrected $g = -0.99$). It is likely that the causative verbs do help those with ASD to locate the target object more quickly as this faster saccade onset time is seen in both movement conditions.

In the causative towards condition, the 95% confidence interval in the group with ASD did overlap with that of the NT data. Based on this analysis, it seems that those with autism are just as capable at determining the target object in all conditions as NT children. However, NT children may be better served by those videos where the agent motion occurs as statistically significant findings occurred with adults in this condition (de Almeida et al., 2010). One possible explanation is that the sentences used in this study were quite restrictive in the sense that they led the participants to certain types of schema. For example, in the scene depicting a kitchen, the initial noun phrases (e.g., *In order to make the omelette*) may have conjured up the theme of eggs needed for this process. We wonder whether the restrictive nature of the sentences lent a slight advantage to NT individuals It is possible that these children have more schematic knowledge due to higher levels of social interaction and were able to use this knowledge to locate the required object(s). However, since this initial noun phrase was used with both verb types, this explanation is problematic. When observing the means of all conditions and their interactions, the saccade onset times in those with ASD were similar or even faster, on average, than NT individuals. This fact may suggest that those with autism spent more time locally processing the scene and were only slightly aided by other factors (e.g., agent motion or verb type).

The possibility that those with autism may be processing the scenes in a unique way, led us to explore whether there was a difference in the number and duration of fixations on the target object. When looking at the raw data, the total number of fixations on the target object for those individuals with autism (203) was 28.5% lower than controls (284). The higher number of fixation seen here indicates that the NT children looked at the target object more often. This along with the evidence that NT individuals spent more time looking at the face of the agent (see above), could indicate that the gaze of the NT participants was divided between the target object and more socially relevant areas. NT participants could have been exhibiting joint attention as the agent moved toward the intended object. Joint attention, the ability of one individual to bring certain objects to another's notice by eye gaze, has been shown in children as young as 8 months (Scaife & Bruner, 1975). It is possible that NT individuals were trying to visualize what the agent was going to do and possibly anticipate the situation indicated by the sentence (e.g., take the eggs and put them in the mixing bowl to make the omelettes).

NT individuals spent more time looking at the target object when the agent was moving. This could be explained by a need to locally process the target object. It is likely that when initially viewing the scene, the details were not captured due to the mandatory global processing that occurred. Also, as the viewer did not know what areas of the scene would become important as the sentence unfolded, very little processing of the target object may have been done in advance. Once attention was drawn toward the target object, perhaps further processing was needed to understand the connections between the agent and the objects in the scene which could have led to an increased number of fixations. Those with ASD exhibited 35.5% more dwell time on the target object (Dwell time_{ASD} = 79,229 ms) than controls (Dwell time_{NT} = 51,035 ms). While neither number or duration of fixations in the scenes between those with autism and NT children was found to be statistically significant ($p > .05$), this could again suggest the idea that those with ASD spent more time processing the target object initially even though they fixate it less often. Therefore, while the children with ASD had fewer fixations on the target object, they spent more time looking at it during these fixations. This supports the idea that a more detail oriented processing style was occurring during the video which could be evidence of a different way of processing the scene as a whole. (See Appendix A, Figure 5.).

It has been found that, when viewing social scenes, individuals with autism were less likely to report people in the scenes (Vanmarcke et al, 2016c) and more likely to spend time on non-social details (O'Hearn et al., 2011). In the present study, those with autism had approximately double the number (46.1% more than NT) of fixations ($Fixation_{ASD} = 3985$, $Fixation_{NT} = 2148$) across the entire scene. That is, while NT participants may have spent more time switching their gaze between the target object and more socially relevant and informative areas (e.g., the agent in the scene, joint attention with the agent of the scene, the target object) as suggested by Song et al (2016), those with ASD tended to have increased fixations on different areas of the videos overall. Being that those with autism had a higher number of overall fixations, this could indicate they spent more time moving their eyes around in order to process individual details. This type of visual inspection may provide evidence for a local processing style.

This pattern of fewer fixations on the target object is supported by Kemner et al. (2008) study which found that those with autism showed fewer fixations when searching for a visual target in a discrimination task. However, he also found that these fixations were of shorter duration. This did not occur in our data. Kemner et al.'s study used simple stimuli (e.g., looking for a bar of a different orientation than the bars surrounding it). Our stimuli mimicked real life and dynamic situations that were more socially complex, therefore those with autism may have need more processing time due to their poorer social cognition skills.

Limitation of the study

The fact that statistically significant results (at $\alpha = .05$) were not obtained in some of the conditions could be due to several limitations in this study. One limitation is the sample size. Small samples lead to low power studies and therefore more difficulty in finding statistically significant results. While effect sizes were calculated to try to alleviate this factor, the number of children utilized in this study certainly had an effect on the data produced and the ability to analyse and interpret this data in a meaningful way. However, it must be pointed out that many studies involving children with autism have very small sample sizes (Franchini et al. 2016; Jarvinen-Pasley et al., 2008; Wright, Kelley & Poulin-Dubois, 2016). This could be due to the high demands made on the families, not only by the need for further research, but by their very non-typically lifestyles as well (e.g., many hours of different forms of therapy, meetings with medical facilities, etc.).

Some of the videos and sentences used in this study could also have been problematic (See Appendix F, Tables 5 and 6). For example, one of the perception verbs used was ‘spot’ (e.g., *to spot the vase*). This verb is not used frequently in real-world contexts and could have been confusing to some children. Age of acquisition of certain verb type in autism tend to depend on the type of verb. While perception verbs tended to be acquired before causative verbs in both NT children and those with ASD, a recent study (Douglas, 2012) found that children with autism tend to use more commonly heard perception verbs (e.g., see, hear, smell) in conversation. However, as all children were tested to be sure they understood the verbs heard during the trials, this is an unlikely limitation and the children, while maybe not understanding the actual word, understood the context and the way it was being used in the sentence.

In the case of the videos produced by de Almeida et al. (2010) that were used in this study, a few of the scenarios were slightly unlikely to happen in a real-world situation. In one of the videos (*drop the ball*), the scene pictures a man who is standing beside a soccer ball, as the ball is not located in the man’s hand and the sentence described is not past tense, the children might have conjured up the schema of a man playing soccer (e.g., kicking/playing with the ball) rather than dropping it. This could have led to a longer saccade onset times after hearing the verb as children were looking to see what the man could drop (e.g., out of his hands).

Finally, it is likely that the heterogeneity of the children with autism was a factor. While all children were verbal, attended school and had had extensive therapy which included speech, due to the wide range of symptomologies on the spectrum, some children may have had a harder time with some aspects of the experiment. All children were screened for verb and target object understanding, but some of the social aspects of the videos may have been confusing (e.g., they did better at saccading to the target object in the neutral condition with causative verbs) and this may have affected their ability to perform the task successfully. It must be mentioned that those with ASD tended to have short attention spans coupled with high energy levels, which was witnessed during the experiment by their constant motion in the chair and reminders to look at the screen before the beginning of each trial. Although questioned about the content of both the videos and sentences, key information might have been lost during the times the children were not totally focused on the incoming information.

Future Directions

Future studies should focus on increasing sample size, further exploring the relation between causative verbs and motion and examining the relationship between number and duration of fixations on certain areas of the scene presented. It is possible that a larger sample size would produce different results.

Biological motion and ToM are said to be connected (Rice et al., 2016). It would be beneficial to examine how ToM levels correspond to the ability of those with autism to parse and interpret information during online sentence processing. Perhaps, higher levels of ToM would lead to faster saccade onset times as those with autism would spend less time processing the social aspect of the videos. Examination of how those with autism combine both visual and auditory information while processing verb types and mapping them on to objects in a scene requires further scrutiny. Due to their hypersensitive perceptual brain areas, the VWP may need to be modified to conform to their unusual information processing styles. These lines of enquiry could lead to further advances in understanding how language acquisition, processing and comprehension occurs in this population. It is possible that those with autism are able to anticipate upcoming information and this processing style could be used to help understand events by eye and ear simultaneously. Fine-grained research on language processing in autism could contribute to a variety of language therapies that could bolster the language skills of both those with autism and perhaps other children with language difficulties as well.

Conclusions

The present study provides support for a unique cognitive processing style in autism that utilizes a more detail-oriented form when viewing a scene concomitantly with listening to related sentences. It seems clear from this study that children who are NT and those that have autism are distinct in how they analyze, process and use visual and auditory information with respect to verb and motion types. All of these factors together promote the idea that that those with autism have distinct way of viewing the world, different cognitive systems, and feasibly a different brain morphology. While this study alone does not provide evidence of enhanced abilities or anticipatory skills, it does provide evidence for the concept of a detail-oriented style when viewing everyday scenes and perhaps life events in general.

References

Adolphs, R., & Spezio, M. (2006). Role of the amygdala in processing visual social stimuli. *Progress in Brain Research, 156*, 363 – 378. doi:10.1016/S0079-6123(06)56020-0

Altmann, G. T. M., & Kamide, Y. (1999). Incremental interpretation at verbs: Restricting the domain of subsequent reference. *Cognition, 73*, 247 – 264. doi:10.1016/S0010-0277(99)00059-1

Altmann, G. T. M., & Kamide, Y. (2007). The real-time mediation of visual attention by language and world knowledge: Linking anticipation (and other) eye movements to linguistic processing. *Journal of Memory and Language, 57*, 502 – 518. doi:10.1016/j.jml.2006.12.004

Andreu, L., Sanz-Torrent, M., & Trueswell, J. C. (2011). Anticipatory sentence processing in children with specific language impairment: Evidence from eye movements during listening. *Applied Psycholinguistics, 34*, 4 – 44. doi:10.1017/S0142716411000592

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders* (5th Ed.). Arlington, VA. American Psychiatric Association. Retrieved from http://dsm.psychiatryonline.org/doi/full/10.1176/appi.books.9780890425596.dsm01

Anderson, D. K., Lord, C., Risi, S., DiLavore, P. S., Shulman, C., Thurm, A., Welsh, K., & Pickles, A. (2007). Patterns of growth in verbal abilities among children with autism spectrum disorder. *Journal of Consulting and Clinical Psychology, 75*, 594 – 604. doi:10.1037/0022-006X.75.4.594

Bavin, E. L., Kidd, E., Prendergast, L. A., & Baker, E. K. (2016). Young children with ASD use lexical and referential information during on-line sentence processing. *Frontiers in Psychology, 19*(1), 1 – 12. doi:10.3389/fpsyg.2016.00171

Blake, R., Turner, L. M., Smoski, M. J., Pozdol, S. L., & Stone W. L. (2003). Visual recognition of biological motion is impaired in children with autism. *Psychological Science, 14*, 151 – 157. doi:10.111/1467-9280.01434

Bonda, E., Petrides, M. Ostry, D., & Evans, A. (1996). Specific involvement of human parietal systems and the amygdala in the perception of biological motion. *Journal of Neuroscience, 16*, 3737 – 3744. Retrieved from http://www.psych.mcgill.ca/labs/mcl/pdf/3737.pdf

Brock, J., Norbury, C., Einav, S., & Nation, K. (2008). Do individuals with autism process words in context from language-mediated eye-movements. *Cognition, 108*, 896 – 904. doi:10.1016/j.cognition.2008.06.007

Brooks, R., & Meltzoff, A. N. (2014). Gaze following: A mechanism for build social connection between infants and adults. In M. Mikulincer & P. R. Shavers (Eds.), *Mechanisms of social connection: From brain to group* (pp. 167 – 183). Washington, DC: American Psychological Association.

Brosnan, M. J., Scott, F. J., Fox, S., & Pye, J. (2004). Gestalt processing in autism: Failure to process perceptual relationships and the implication for contextual understanding. *Journal of Child Psychology and Psychiatry, 45*, 459 – 469. doi:10.111/j.1469-7610.2004.00237.00237.x

Centelles, L., Assaiante, C., Etchegoyhen, K., Bouvard, M, & Schmitz, C. (2013). From action to interaction: Exploring the contribution of body motion cues to social understanding in typical development and in autism spectrum disorders. *Journal of Autism and Developmental Disorders, 43*, 1140 – 1150. doi:10.1007/s10803-012-1655-0

Charman, T., Drew, A., Baird, C., & Baird, G. (2003). Measuring early language development in preschool children with autism spectrum disorder using the MacArthur Communication Development Inventory (Infant form). *Journal of Child Language, 30*, 213 – 236. doi:10.1017/S0305000902005482

Chevallier, C., Kohls, G., Troiani, V., Brodkin, E. S., & Schultz, R. T. (2010).The social motivation of autism. *Trends in Cognitive Science, 16*, 231 – 239. doi:10.1016/j.tics.2012.02.007

Chomsky, N. (1980). Rules and representations. *Behavioral and Brain Science, 3*, 1 – 61. doi:10.1017/s0140525X00001515

Cooper, R. M. (1974). The control of eye fixation by the meaning of spoken language: A new methodology for the real-time investigation of speech perception, memory and language. *Cognitive Psychology, 6*, 84 – 107. doi:10.1016/0010-0285(74)90005-X

de Almeida, R. G., Di Nardo, J. C., & von Grunau, M. W. (2010). *Understanding sentences in dynamic scenes: A modularity effect in linguistic and visual processing*. Unpublished manuscript, Department of Psychology, Concordia University, Montreal, Canada.

Di Nardo, J. C. (2010). *Building event meanings from linguistic and visual representations: Evidence from eye movements*. (Ph. D. dissertation). Concordia University, Montreal, QC.

Dominguez, L. G., Velazquez, J. L. P., & Galan, R. F. (2013). A model of functional brain connectivity and background noise as a biomarker for cognitive phenotypes: Application to autism. *PLOS One, 8*, e61493. doi:10.1371/journal.pone.0061493

Douglas, S. (2012). *Understanding actions, states and events: Verb learning in children with autism*. Berlin, Germany: Mouton De Gruyter.

Durlak, J. A. (2009). How to select, calculate and interpret effect sizes. *Journal of Pediatric Psychology, 34*, 917 – 928. doi:10.1093/jpepsy/jsp004.

Farris-Trimble, A., & McMurray, B. (2013). Test-retest reliability of eye tracking in the visual world paradigm for the study of real-time spoken word recognition. *Journal of Speech, Language, and Hearing Research, 56*, 1328 – 1345. doi:10.1044/1092-4388(2012/12-0145)

Field, A. (2013). *Discovering statistics using IBM SPSS statistics*. Thousand Oaks, California: Sage Publications Inc.

Fletcher-Watson, S., Findlay, J. M., Leekman, S. R., & Benson, V. (2008). Rapid detection of person information in a naturalistic scene. *Perception, 37*, 571 – 583. doi:10.1068/p5705

Franchini, M., Wood de Wilde, H., Glaser, B., Gentaz, E., Eliez, S., & Schaer, M. (2016). Brief report: A preference for biological motion predicts a reduction in symptom severity 1 year later in preschoolers with autism spectrum disorders. *Frontiers in Psychiatry, 7*(149), 1 – 8. doi:10.3389/fpsyt.201600143

Freitag, C. M., Konrad, C., Haberlen, M., Klesser, C., von Gontard, A., Wolfgang. R,…Krick, C. (2008). Perception of biological motion in autism spectrum disorders. *Neuropsychologia, 46*. 1480 – 1494. doi:10.1016/j.neuropsychologia.2007.12.025

Frith, U. (1991). *Autism and Asperger syndrome*. New York, NY: Cambridge University Press.

Frith, U. (1989). *Autism: Explaining the enigma*. London, England: Wiley-Blackwell.

Frith, U. (2003). *Autism: Explaining the enigma* (2nd Ed.). London, England: Wiley-Blackwell.

Gentner, D. (1982). Why nouns are learned before verbs: Linguistic relativity versus natural partitioning. In S. Kuczaj (Ed), *Language development: Language, thought and culture* (pp. 301 – 334). Hillsdale, Lawrence Erlbaum Associates

Gernsbacher, M. A., Morson, E. M., & Grace, E. J. (2015). Language development in autism. In G. Hickok & S. Small (1st Ed.), *Neurobiology of Language* (pp. 879 – 886). Retrieved from http://www.gernsbacherlab.org/wp-content/uploads/2012/06/Gernsbacher_HickokChapter_2015_AuthorCopy.pdf

Hauser, M. D., Chomsky, N., & Tecumseh Fitch, W. (2002). The faculty of language: What is it, who has it, and how did it evolve? *Science, 298*, 1569 – 1579. doi:10.1126/science.298.5598.1569

Heaton, P. (2003). Pitch memory, labeling, and disembedding in autism. *Journal of Child Psychology and Psychiatry, 44*, 543 – 551. doi: 10.1111/1469-7610.00143

Henderson, J. M., & Hollingsworth, A. (1999). High-level scene perception. *Annual Review of Psychology, 50*, 243 – 271. doi:10.1146/annurev.psych.50.1.243

Jarvinen-Pasley, A., Wallace, G. L., Ramus, R., Happe, F., & Heaton, P. (2008). Enhanced processing of speech in autism. *Developmental Science, 11*, 109 – 121. doi:10.111/j1467-7687.2007.00644.x

Kaiser, M. D., Delmolino, L., Tanaka, J. W., & Shiffrar, M. (2010). Comparison of visual sensitivity to human and object motion in autism spectrum disorder. *Autism Research, 3*, 191 – 195. doi:10.1002/aur.137

Kamide, Y., Scheepers, C., & Altmann, G. T. M. (2003). Integration of syntactic and semantic information in predictive processing cross-linguistic evidence from German and English. *Journal of Psycholinguistic Research, 32*, 37 – 55. doi:10.1023/A:1021933015362

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child, 2*, 217 – 250. Retrieved from http://neurodiversity.com/library_kanner_1943.pdf

Kemner, C., Van Ewijk, L., Van Engeland, H., & Hooge, I. (2008). Brief report: Eye movement during visual search tasks indicate enhanced stimulus discriminability in subjects with PDD. *Journal of Autism and Developmental Disorder, 38*, 553 – 557. doi:10.1007/s10803-007-0406-0

Kjelgaard, M. M., & Tager-Flusberg, H. (2001). An investigation of language impairment in autism: Implication for genetic subgroups. *Language and Cognitive Processes, 16*, 287 – 308. doi:10.1080/01690960042000058

Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological Bulletin, 100*, 78 – 100. doi:10.1037/0033-2909.100.1.78

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry, 59*, 809 – 816. Retrived from https://jamanetwork.com/journals/jamapsychiatry/fullarticle/206705

Kline, R. (2004). *Beyond significance testing. Reforming data analysis methods in behavioural research.* Washington, DC: American Psychological Association.

Koczat, D. L., Rogers, S. J., Pennington, B. F., & Ross, R. G. (2002). Eye movement abnormality suggestive of a spatial working memory deficit is present in parents of autistic probands. *Journal of Autism and Developmental Disorders, 32*, 513 – 518. doi:10.1023/A:1021246712459

Land, M. F., & Tatler, B. W. (2009). *Looking and acting: Vision and eye movements in natural behaviour*. New York, NY: Oxford University Press.

Landa, R., & Garrett-Mayer, E. (2006). Development in infants with autism spectrum disorders: A prospective study. *Journal of Child Psychology and Psychiatry, 47*, 629 – 638. doi:10.1111/j.1469-7610.2006.01531.x

Liversedge, S. P., & Findlay, J. M. (2000). Saccadic eye movement and cognition. *Trends in Cognition, 4*, 6 – 14. doi:10.1016/S1364-6613(99)01418-7

Lord, C., Storoschuk, S., Rutter, M., & Pickles, A. (1993). Using the ADI-R to diagnose autism in preschool children. *Infant Mental Health Journal, 14*, 234 – 252. doi:10.1002/1097-0355(199323)14:3<234:AID-IMHJ2280140308>3.0.CO;2-F

Lord, C., Risi, S., Lambrecht, L., Cook Jr., E. H., Leventhal, B. L., DiLavore, P. C., Pickles, A., & Rutter, M. (2000). The Autism Diagnostic Observation Schedule – Generic: A standard measure of social and communication deficits associated with the spectrum of autism. *Journal of Autism and Developmental Disorders, 30*, 205 – 223. doi:10.1023/A:1005592401947

Manjaly, Z. M., Bruning, N., Neufang, S., Stephan, K. E., Brieber, S., Marshall, J. C.,…Fink,

G. R. (2007). Neurophysiological correlates of relatively enhanced local visual search in autistic adolescents. *NeuroImage, 35*, 283 – 291. doi:10.1016/j.neuroimage.2006.11.036

Markram, H., Rinaldi, T., & Markram, K. (2007). The intense world syndrome – an alternative hypothesis for autism. *Frontiers in Neuroscience, 1*, 77 – 96. doi:10.3389/neuro.01.1.1.006.2007.

Markram, K., & Markram, H. (2010). The intense world theory – a unifying theory of the neurobiology of autism. *Frontiers in Human Neuroscience, 4*(244), 1 – 29. doi:10.3389/fnhum.2010.00224

Minshew, N. J., Luna, B., & Sweeney, J. A. (1999). Oculomotor evidence for neocortical systems but not cerebellar dysfunction in autism. *Neurology, 52*, 917 – 922. doi:10.1212/WNL.52.5.917

Minshew, N. J., Sweeney, J., & Luna, B. (2002). Autism as a selective disorder of complex information processing and underdevelopment of neocortical systems. *Molecular Psychiatry, 7*(S2), S14 – S15. doi:10.1038/sj.mp.4001166

Mottron, L., & Burack, J. A. (2001). Enhanced perceptual functioning in the development of autism. In J. A. Burack, T. Yirmiya, & N. Zelazo (Eds.), *Development of autism: Perspectives from theory and research* (pp. 131 – 148). Mahwah, New Jersey: Lawrence Eribaum Associates Inc.

Mottron, L., Dawson, M., Soulieres, I., Hubert, B., & Burack, J. (2006). Enhanced perceptual function in autism: An update and eight principles of autistic perception. *Journal of Autism and Developmental Disorders, 36*, 27 – 43. doi:10.1007/s10803-005-0040-7

Murphy, P., Brady, N., Fitzgerald, M., & Troje, N. F. (2009). No evidence for impaired perception of biological motion in adults with autistic spectrum disorders. *Neuropsychologia, 47*, 3225 – 3235. doi:10.1016/j.neuropsychologia.2009.07.026

Nackaerts, E., Wagemans, J., Helsen, W., Swinnen, S. P., Wenderoth, N., & Alaerts, K. (2012). Recognizing biological motion and emotions from point-light-displays in autism spectrum disorders. *PLOS One, 7*, e44473. doi:10.1371/journal.pone.0044473

Neumann, N., Dubischar-Krivec, A. M., Poustka, F., Birbaumer, N., Bolte, S., & Braun, C. (2011). Electromagnetic evidence of altered visual processing in autism. *Neuropsychologia, 49*, 3011 – 3017. doi:10.1016/j.neuropsychologia.2011.06.028

O'Hearn, K., Lakusta, L., Schroer, E., Minshew, N., & Luna, B. (2011). Deficits in adults with autism spectrum disorders when processing multiple objects in dynamic scenes. *Autism Research, 4*, 132 – 142. doi:10.1002/aur.179

Pelphrey, K. A., Sasson, N. J., Reznick, S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders, 32*, 249 – 261. doi:10.1023/A:1016374617369

Perez Velazquez, J. L., & Galan, R. F. (2013). Information gain in the brain's resting state: A new perspective on autism. *Frontiers in Neuroinformatics, 7*(37), 1 – 10. doi:10.3389/fninf.2013.00037

Peterson, C. C., Slaughter, V., & Brownell, C. (2015). Children with autism spectrum disorder are skilled at reading emotion body language. *Journal of Experimental Child Psychology, 139*, 35 – 50. doi:10.1016/j.jecp.2015.04.012

Pinker, S. (1994). *The language instinct: How the mind creates language*. New York, NY. William Morrow and Company.

Potter, M. C. (1975). Meaning in visual search. *Science, 187*, 965 – 966. doi:10.1126science.1145183

Rayner K., Smith, T. J., Malcolm, G. L., & Henderson, J. M. (2009). Eye movements and visual encoding during scene perception. *Psychological Science, 20*, 6 – 10. doi:10.1111/j.1467-9280.2008.02243.x

Reed, P., Lowe, C., & Everett, R. (2011). Perceptual learning and perceptual search are altered in male university students with higher autism quotient scores. *Personality and Individual Differences, 51*, 732 -736. doi:10.1016/j.paid.2011.06.016

Remington, A., & Frith, U. (2014). *Intense world theory raises intense worries* [Peer commentary on the paper "The intense world syndrome – an alternative hypothesis for autism" by H. Markram, T. Rinaldi, & K. Markram]. Retrieved from https://spectrumnews.org/opinion/viewpoint/intense-world-theory-raises-intense-worries/

Rescorla, L., & Safyer, P. (2013). Lexical composition in children with autism spectrum disorder (ASD). *Journal of Child Language, 40*, 47 – 68. doi:10.1017/S0305000912000232

Rice, K., Anderson, L. C., Velnoskey, K., Thompson, J. C., & Redcay, E. (2016). Biological motion perception links diverse facets of theory of mind during middle childhood (Reprinted from Journal of Experimental Child Psychology, vol. 146, pg 238 – 246, 2016). *Journal of Experimental Child Psychology, 149*, 72 – 80. doi:10.1016/jecp.2016.06.001

Rosenhall, U., Johansson, E., & Gillberg, C. (1988). Oculomotor findings in autistic children. *Journal of Laryngology and Otology, 102*, 435 – 439. doi:10.1017/S0022215100105286

Salva, O. R., Farroni, T., Regolin, L., Vallortigara, G., & Johnson, M. H. (2011). The evolution of social orienting: Evidence from chicks (*Gallus gallus*) and human newborns. *PLOS One, 6*(4), 1 – 10. doi:10.1371/journal.pone.0018802

Scaife, M., & Bruner, J. S. (1975). The capacity for joint visual attention in the infant. *Nature, 253*, 265 – 266. doi:10.1038/253265a0

Schmitt, L. M., Cook, E. H., Sweeney, J. A., & Moscon, M. W. (2014). Saccadic eye movement abnormalities in autism spectrum disorder indicate dysfunctions in cerebellum and brainstem. *Molecular Autism, 5*(47), 1 – 13. doi:10.1186/2040-2392-5-47

Scott, R. (2011, August 28). 'Autism's like a snowflake' – doctors study symptoms, possible causes of autism with hopes of learning more. *Gloucester County Times*. Retrieved from http://www.nj.com/gloucester-county/index.ssf/2011/08/autisms_like_a_snowflake_-_doc.html

Smith, H., & Milne, E. (2009). Reduced change blindness suggests enhanced attention to detail in individuals with autism. *Journal of Child Psychology and Psychiatry, 50*, 300 – 306. doi:10.111/j.1469-7610.2008.01957.x

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6*, 174 – 215. doi:10.1037/0278-7393.6.2.174

Song, C., Wang, A., Doody, K., Hartley-McAndrew, M. H., Mertz, J., Lin, F., & Xu, W. (2016, February). *Analyzing dynamic components of social scene parsing strategy in autism spectrum disorder*. Paper presented at 2016 IEEE-EMBS International Conference on Biomedical and Health Informatics, Las Vegas, NV. Abstract retrieved from http://ieeexplore.ieee.org/document/7455852/?arnumber=7455852&tag=1

Stanley-Cary, C., Rinehart, N., Tonge, B., White, O., & Fielding, J. (2011). Greater disruption to control of voluntary saccades in autistic disorder than Asperger's disorder: Evidence for greater cerebellar involvement in autism? *Cerebellum, 10*, 70 – 80. doi:10.1007/s12311-010-0229-y

Swensen, L. D., Kelley, E., Fein, D., & Naigles, L. R. (2007). Processes of language acquisition in children with autism: Evidence from preferential looking. *Child Development, 78*, 542 – 557. doi:10.111/j.1467-8624.2007.01022.x

Tager-Flusberg, H., Calkins, S., Nolin, T., Baumberger, T., Anderson, M., & Chadwick-Dias, A. (1990). A longitudinal study of language acquisition in autistic and Down syndrome children. *Journal of Autism and Developmental Disorder, 20*, 1 – 21. doi:10.1007/BF02206853

Takarae, Y., Minshew, N. J., Luna, B., & Sweeney, J. A. (2003). Oculomotor abnormalities parallel cerebellar histopathology in autism. *Neurology, Neurosurgery & Psychiatry, 75*, 1359 – 1361. doi:10.1136/jnnp.2003.022491

Tanenhaus, M. K., Spivey-Knowlton, M. J., Eberhard, K. M., & Sedivy, J. C. (1995). Integration of visual and linguistic information in spoken language comprehension. *Science, 268*, 1632 – 1634. Retrieved from http://search.proquest.com/docview/213575435/fulltextPDF/AD9956FAA004457EPQ/1?accountid=12339

Tek, S., Mesite, L., Fein, D., & Naigles, L. (2015). Longitudinal analysis of expressive language development reveal two distinct language profiles among young children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44*, 75 – 89. doi:10.1007/s10808-013-1853-4.

Trueswell, J. C., Sekerina, I., Hill, N. M., & Logrip, M. L. (1999). The kindergarten-path effect: Studying on-line sentence processing in young children. *Cognition, 73*, 89 – 134. doi:10.1016/S0010-0277(99)00032-310580160

Van der Hallen, R., Evers, K., Brewaeys, K., Van den Noortgate, W., & Wagemans, J. (2015). Global processing takes time: A meta-analysis on local-global processing in ASD. *Psychological Bulletin, 141*, 549 – 573. doi:10.1037/bul0000004

Vanmarcke, S., Van Der Hallen, R., Evers, K., Noens, I., Steyaert, J., & Wagemans, J. (2016a). Ultra-rapid categorization of meaningful real-life scenes in adults with and without ASD. *Journal of Autism and Developmental Disorders, 46*, 450 – 466. doi:10.1007/s10803-0.15-2583-6

Vanmarcke, S., van Esch, L., Van der Hallen, R., Evers, K., Noens, I., Steyaert, J., & Wagemans, J. (2016b). Gist perception in adolescents with and without ASD: Ultra-rapid categorization of meaningful real-life scenes. *Research in Autism Spectrum Disorder, 29 – 30*, 30 – 47. doi:10.1016/j.rasd.2016.05.007

Vanmarcke, S., Mullin, C., Van der Hallen, R., Evers, K., Noens, I., Steyaert, J., & Wagemans, J. (2016c). In the eye of the beholder: Rapid visual perception of real-life scenes by young adults with and without ASD. *Journal of Autism and Developmental Disorders, 46*, 2635 – 2652. doi:10.1007/s10803.016-2802-9

Waterhouse, L. (2013). *Rethinking autism: Variation and complexity*. London, England: Elsevier.

Weismer, S. E., Gernsbacher, M. A., Stronach, S., Karasinski, C., Eernisse, E. R., Venker, C. E., & Sindberg, H. (2011). Lexical and grammatical skills in toddlers on the autism spectrum compared to late talking toddlers. *Journal of Autism and Developmental Disorder, 41*, 1065 – 1075. doi:10.1007/s10803-010-1134-4

Wellman, H. M. (1990). *The child's theory of mind*. Cambridge, MA: MIT Press

Wright, K., Kelley, E., & Poulin-Dubois, D. (2016). Biological motion and animate-inanimate distinction in children with high-functioning autism spectrum disorder. *Research in Autism Spectrum Disorders, 25*, 1 – 11. doi:10.1016/j.rasd.2016.01.005

Woodward, A. L., Sommerville, J. A., Gerson, S., Henderson, A. M. E., & Buresh, J. (2009). Advances in Research and Theory. In Elsevier (Series Ed. 1), *The Psychology of Learning and Motivation: Vol. 51*. *An emergence of intention attribution in infancy* (pp. 188 – 217). doi:10.1016/S0079.7421(09)51006-7

Appendix A

Figures and Tables

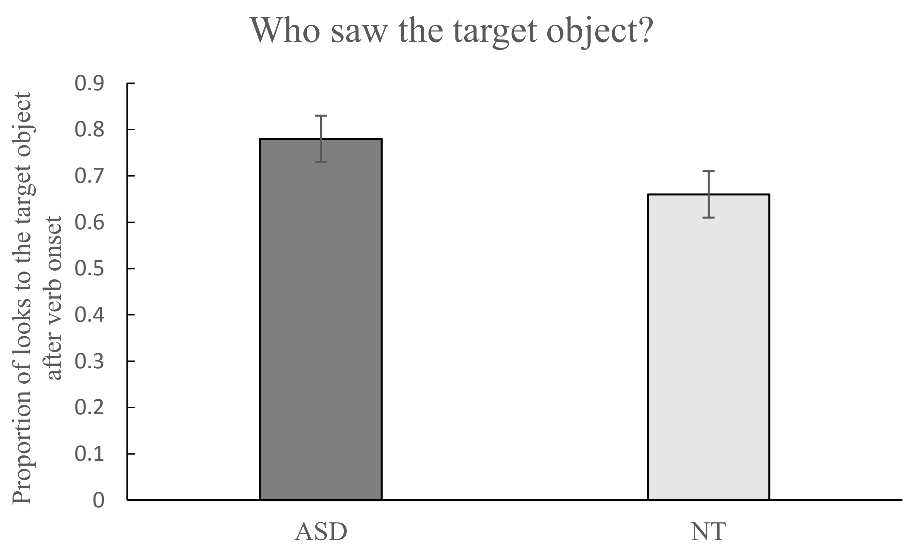


Figure 1. Proportion of time individuals looked at the target object in all condition. Error bars represent the standard error of the mean.

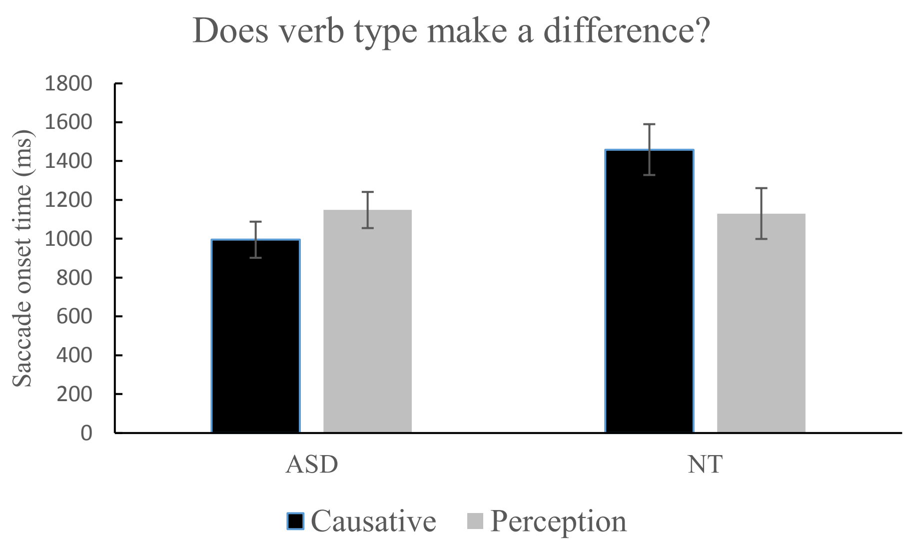


Figure 2. Saccade onset time to the target object after verb onset by each group in different verb conditions. Error bars represent the standard error of the mean.

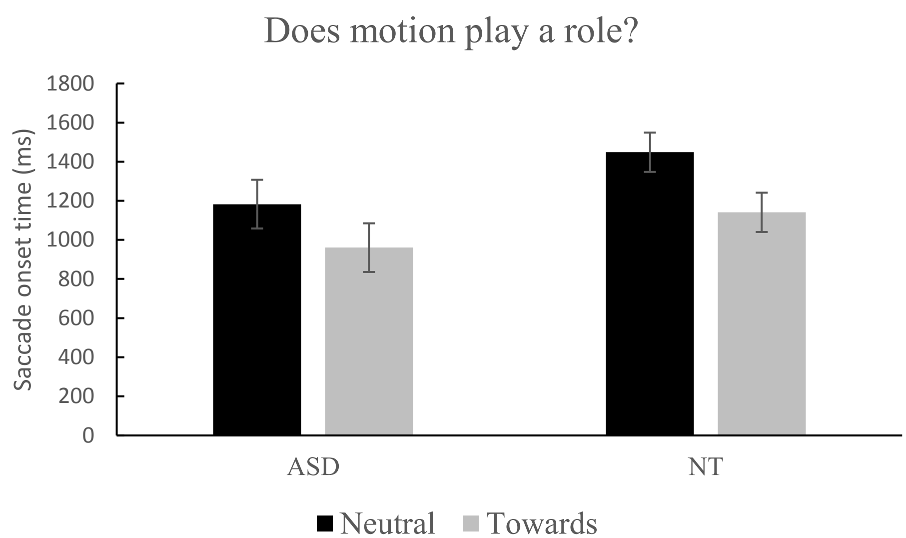


Figure 3. Saccade onset time to the target after verb onset object by each group in different agent motion conditions. Error bars represent the standard error of the mean.

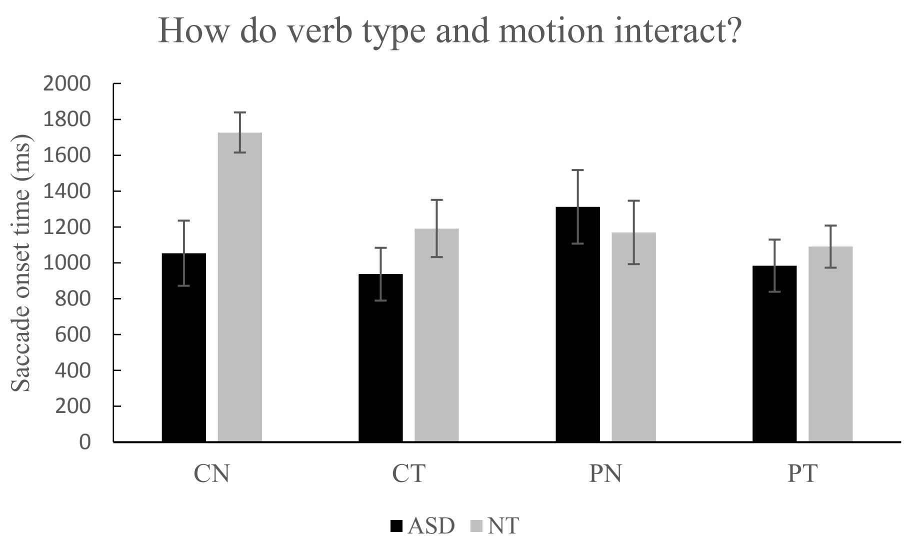


Figure 4. Saccade onset time to the target object after verb onset when verb and agent motion conditions interact. Error bars represent the standard error of the mean. CN = Causative Neutral; CT = Causative Towards; PN = Perception Neutral; PT = Perception Towards.

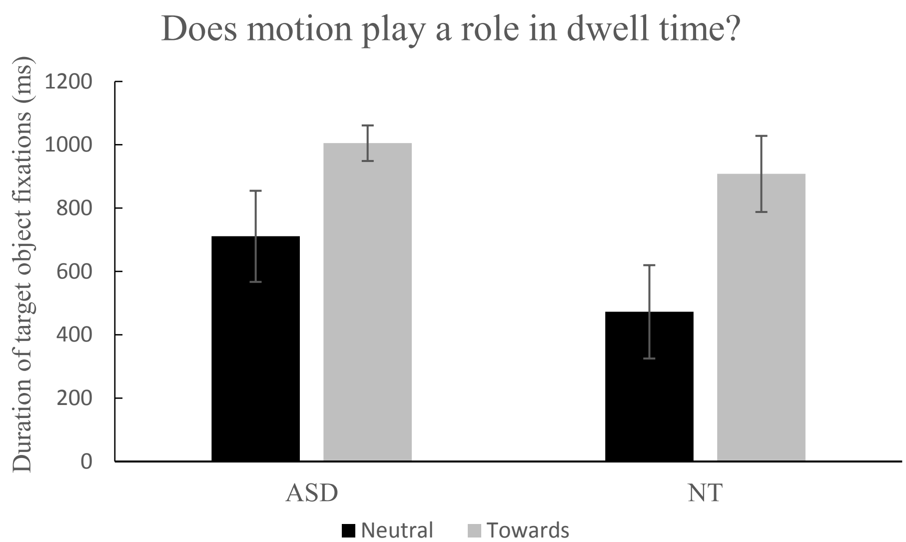


Figure 5. Time spent looking at the target object in the two motion conditions. Error bars represent the standard error of the mean.

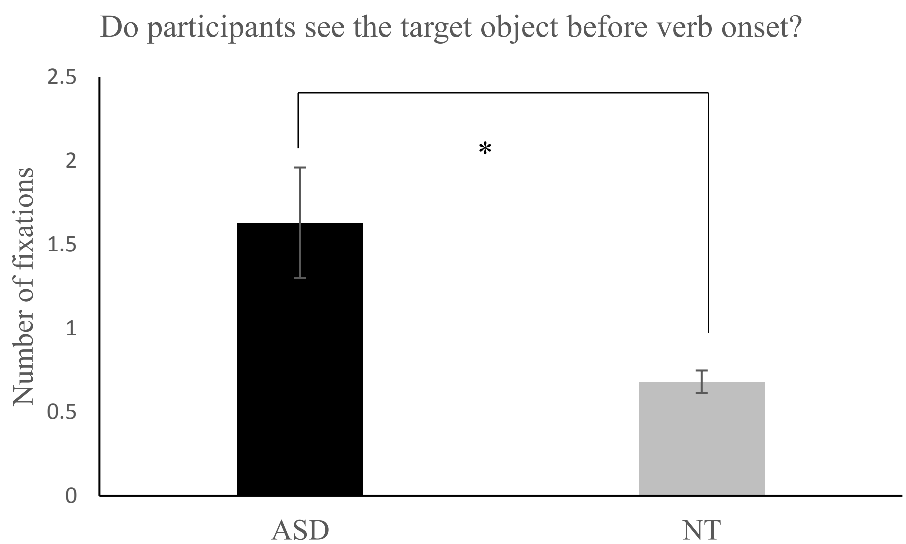


Figure 6. Number of fixations on the target object before verb onset overall. Error bars represent the standard error of the mean.

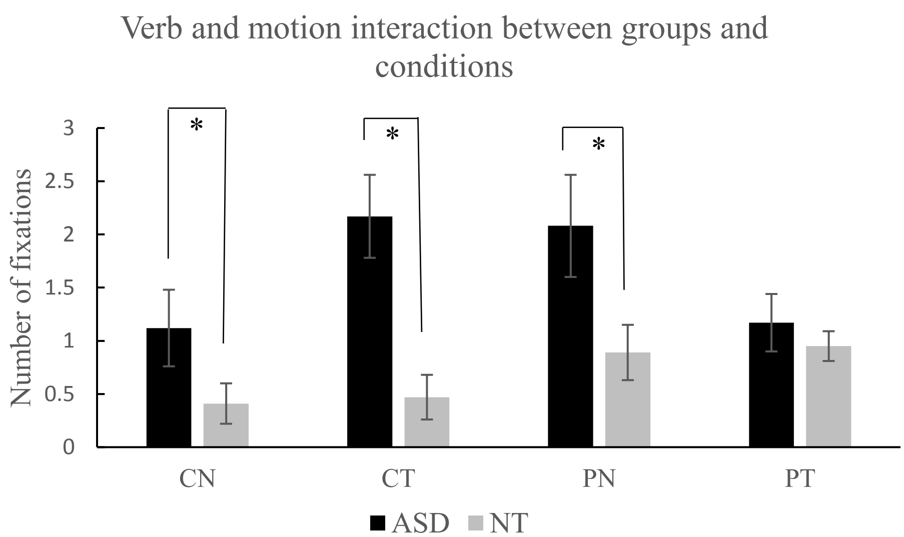


Figure 7. Number of fixations on the target object before verb onset by group and condition. Error bars represent the standard error of the mean. CN = Causative Neutral; CT = Causative Towards; PN = Perception Neutral; PT = Perception Towards.

Table 1.

Interaction effects of verb and motion type on saccade onset time by group

		95% CI		
Variable	*M(SD)*	LL	UL	Hedge's g (corrected)
CN				
NT	1726.81(433.42)	1417.76	2035.85	- 0.99
ASD	1053.50(703.80)	744.45	1362.54	
CT				
NT	1191.49(617.27)	877.32	1505.66	- 0.40
ASD	936.62(569.81)	622.45	1250.79	
PN				
NT	1169.51(684.74)	777.26	1561.75	0.17
ASD	1312.19(794.46)	919.95	1704.44	
PT				
NT	1090.32(454.39)	819.60	1361.05	-0.19
ASD	984.00(563.50)	713.28	1254.72	

Note. CI = confidence interval; LL = lower limit; UL = upper limit; CN = causative neutral; CT = causative toward; PN = perception neutral; PT = perception toward; NT = neuro-typical; ASD = autism spectrum disorder. All descriptives with the exception of Hedge's g are in in ms

Table 2.

Interaction effects of verb and motion type on number of fixations on the target object by group

		95% CI	
Variable	*M(SE)*	LL	UL
CN			
NT	2.22(0.22)	1.35	3.12
ASD	3.17(0.89)	1.75	3.71
CT			
NT	2.88(0.51)	1.88	3.44
ASD	2.76(0.29)	1.92	3.47
PN			
NT	3.08(0.69)	1.82	3.83
ASD	2.63(0.49)	1.53	3.37
PT			
NT	3.61(0.51)	2.60	4.36
ASD	2.35(0.35)	1.52	2.92

Note. CI = confidence interval; LL = lower limit; UL = upper limit; CN = causative neutral; CT = causative toward; PN = perception neutral; PT = perception toward; NT = neuro-typical; ASD = autism spectrum disorder.

Table 3.

Interaction effects of verb and motion type on dwell time on the target object by group

		95% CI	
Variable	*M(SD)*	LL	UL
CN			
NT	387.50(223.06)	164.12	608.26
ASD	856.42(988.77)	430.19	1032.40
CT			
NT	788.39(537.89)	444.28	970.20
ASD	864.32(421.81)	569.35	1126.61
PN			
NT	557.67(324.53)	339.70	727.17
ASD	565.59(425.30)	337.38	707.13
PT			
NT	1027.73(679.20)	557.53	1431.03
ASD	1145.81(1020.97)	572.50	1415.79

Note. CI = confidence interval; LL = lower limit; UL = upper limit; CN = causative neutral; CT = causative toward; PN = perception neutral; PT = perception toward; NT = neuro-typical; ASD = autism spectrum disorder. All descriptives are in ms.

Table 4.

Number of fixations on the target object before verb onset by group

		95% CI		
Variable	*M(SE)*	LL	UL	$M_{Difference}$
CN				
NT	0.41(0.19)	0.41	1.84	
ASD	1.12(0.36)	0.24	0.79	0.71
CT				
NT	0.47(0.21)	0.52	0.89	
ASD	2.17(0.39)	1.39	1126.61	1.70
PN				
NT	0.89(0.26)	0.38	1.40	
ASD	2.08(0.48)	1.12	3.03	1.19
PT				
NT	0.95(0.14)	0.38	1.23	
ASD	1.17(0.27)	0.64	1.71	0.22

Note. CI = confidence interval; LL = lower limit; UL = upper limit; CN = causative neutral; CT = causative toward; PN = perception neutral; PT = perception toward; NT = neuro-typical; ASD = autism spectrum disorder.

Appendix B

Consent Form

CONSENT FORM

Processing events by eye and ear in autism: Effects of verb type in dynamic scenes

Principal Investigators :

Dr. Roberto de Almeida

Deborah Martin

Concordia University

You are asked to participate in a study that will investigate the way in which your child processes language. The purpose of the study is to examine how their eyes move and how they understand sentences while watching a short movie. However, you and your child are free to withdraw your consent at any time without penalty. The people in charge of this study and their assistants will make sure to keep all information from either you and/or your child confidential.

During the study, your child will be asked to sit in front of a computer, watch a variety of short videos and hear some sentences. Below the computer, an eye-tracking monitor will record eye movements as they view the videos on the computer. Afterward, s/he will asked to complete two tasks: (a) Verb definition task, and (b) Picture Naming task.

If you child has autism you be asked questions about your child's schooling, diagnosis and for details about any therapy or treatment your child has had and its duration.

At the end of the study, your child will receive a small gift as a thank you for participating in the study.

If you have any questions, please feel free to ask the research assistants or investigators.

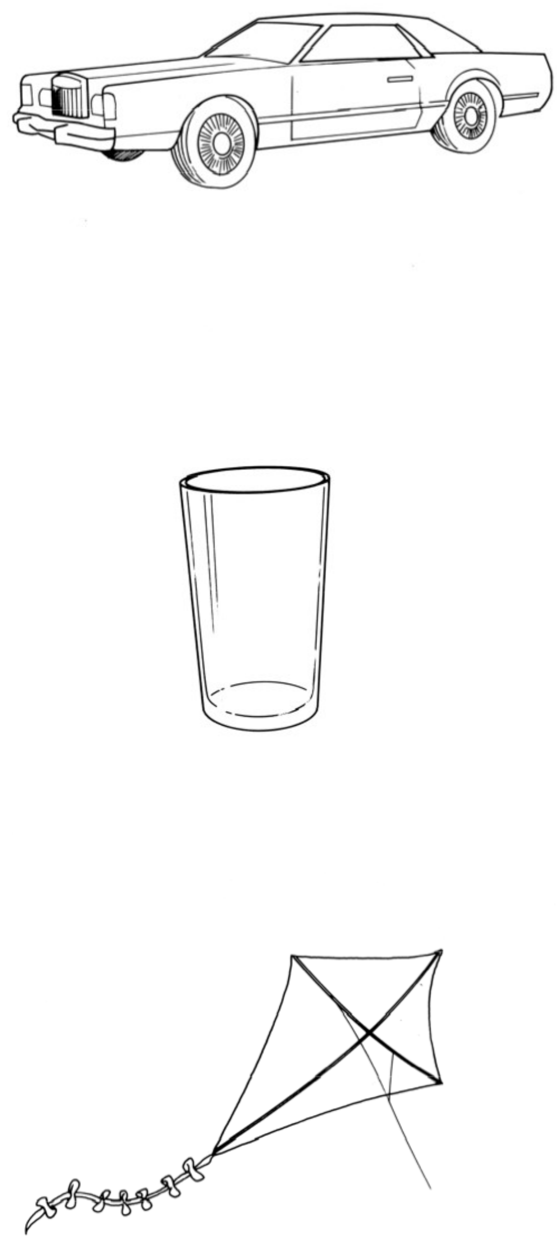
If you agree to participate in the study that has been described above (or) to you, you are asked to sign your name on the line below.

______________________________	______________________________
Signature of the parent	Date
______________________________	______________________________
Signature of investigator	Date

Appendix C

Questionnaires

A1. Sample drawings from Snodgrass and Vanderwart (1980) employed in the Picture Naming Task



A2. Examples from Verb Naming Task

Name: ____________________________ Group: __________________________________

Question: What does it mean to "_____"?

1. Check the Car
2. Melt the Butter
3. Notice the Ice
4. Inspect the Ball
5. Spot the Vase
6. Spot the Milk
7. Dry the Plate
8. Crash the Car
9. See the Chair

10. Heat the Oven

11. See the Shirt

12. Notice the Cube

13. Fly the Kite

14. Examine the Eggs

15. Rip the Paper

Appendix D

Example of Video Clips (Agent Neutral and Agent Towards)

D1. Example of Video and Sentence – Neutral Condition with Causative/Perception (Psychological) Verb type

While making the omelets the cook will crack/examine the eggs that are on the counter.

D2. Example of Video and Sentence – Towards Condition with Causative/Perception (Psychological) Verb type

While making the omelets the cook will crack/examine the eggs that are on the counter.

Appendix E

Causative and Perception/Psychological Sentences

Sentences presented to participants with a Causative or Perception (Psychological) Verb

1. Before playing a game of soccer, the man will drop/inspect the ball that he will use for his match

2. To prevent the muffins from sticking, the woman will melt/check the butter needed to grease the pan.

3. While going on a test drive, the girl will crash/check the car that she wants to buy.

4. After unlocking the door, the woman will start/check the car that is parked on the street.

5. Before sitting down for a rest, the maid will fold/see the chair that is in the living room.

6. After losing interest in the toy train, the toddler will roll/notice the cube that is on the floor.

7. In order to make the omelette, the cook will crack/examine the eggs that are on the counter.

8. In order to cool the drinks, the man will crush/notice the ice that is in the bucket.

9. Because it is a windy day, the girl will fly/see the kite that is on the bench.

10. After playing with the cup's lid, the boy will spill/spot the milk that is on the table.

11. Before baking the cake, the woman will heat/inspect the oven that is in the kitchen.

12. Before recycling it, the secretary will rip/examine the paper that is on the desk

13. After washing the dishes, the man will dry/spot the plate that is in the rack.

14. Before leaving on his trip, the businessman will wrinkle/see the shirt that is on the hanger.

15. While moving on to the next piece of art, the woman will break/spot the vase that is on display.

Appendix F

Limitations of videos and sentences

Table 5

Limitations of videos seen by children (de Almeida et al., 2010)

Videos seen	Limitation
Milk video	The milk was not noticeable in this video as it was on a table quite far from the boy in the video.
	As a large distance separated the boy and the cup, it was unlikely that the boy could spill it from such a distance as the boy was not in the vicinity of the milk container.
	The milk was in a baby's sippy cup not in a glass or cup which is a spillable container.
	The boy played with a toy which was likely distracting to the participants.
Ice video	Ice was in an ice container that is used primarily for cocktails likely not in the participant's schema due to age range.
	Ice type pick used in the agent motion condition to crush ice was problematic. Most children when describing the verb for this video crushed ice using a different strategy so likely had a different schema.
Vase video	During the agent motion condition, there was no eye contact or gaze directed toward the vase as the women backed into the vase.

	This could have been confusing as there was no agent intended goal in this video.
Cube video	Several toys on the floor, as most of the participants are children in an age range who play with toys, this may have been distracting for them, and therefore finding the cube may have been problematic.
Paper video	Woman rips the paper in all conditions (agent neutral and agent towards). Therefore, it is possible the action of ripping the paper will attract the attention of the children to the target object by action alone.

Table 6

Limitations of sentences heard by children

Verb used	Limitation
Spot the ___	This verb may have been unfamiliar or infrequently used in the child's hearing.
Roll the cube	Cubes do not typically roll and this may have confused the children.
Drop the ball	The ball was on the ground ready to play soccer, not in the man's hands (e.g., not droppable) which may lead children to a different schema or to 'anticipate' a different droppable object