ORIENTING OF VISUAL ATTENTION AMONG PERSONS WITH AUTISM SPECTRUM DISORDERS: READING VERSUS RESPONDING TO SYMBOLIC CUES

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Abstract

Persons with autism spectrum disorders (ASD) appear to be slower to interpret the meaning of symbolic cues. This could be because they are slower to read the symbolic cue, or because they are slower to select a response to the symbolic cue. Groups of participants with autism (n=11), participants with Asperger syndrome (n=9), and typically developing children (n=16) completed four forced-choice reaction time tasks to examine whether persons with ASD are slower to process the symbolic cue or slower to prepare a response to the cue. The participants completed two control conditions and two orienting conditions using non-predictive central arrow cues. In the Target and Cue conditions, participants gave a speeded response to the appearance of either a target (x) or a central arrow. In the Variable Cue Exposure (VCE) condition, the exposure time to the cue varied (100, 300, 600, or 1000 ms) and was followed by a 100 ms blank screen before the presentation of the target. In the Constant Cue Exposure (CCE) condition, all cues were presented for 100 ms and were followed by blank screens that varied in presentation length (100, 300, 600, or 1000 ms) before the presentation of the target. The results indicated that each group showed a unique pattern of responding. In both the Target and Cue conditions, participants with autism were slower than both Asperger syndrome and typically developing children. In both the VCE and CCE conditions, behavioural effects of the cue were found for participants with autism at longer SOAs than for Asperger syndrome, and at longer SOAs for Asperger syndrome than for typically developing children. These findings support the notion that persons with ASDs are impaired in their preparation of responses as opposed to impaired in reading the meaning of the cue. Further, both the ASD groups showed stronger facilitation effects at longer SOAs than typically developing children, indicating that they were less able to use cue predictability to mediate responding. The differences found between autism and Asperger syndrome are discussed in terms of developmental and clinical distinctions between the groups, and implications for theory and research design.

Résumé

Les personnes atteintes d'un trouble envahissant du développement semblent plus lentes à interpréter la signification d'indices symboliques. Une des raisons pourrait être qu'elles sont plus lentes à lire ces indices ; l'autre pourrait être qu'elles sont plus lentes à choisir une réponse à ces indices. Les participants autistes (*n*=11), ceux atteints du syndrome d'Asperger (*n*=9), et un groupe d'enfants normaux (*n*=16) ont complété quatre types de tâches a choix forcé mesurant leur temps de réaction. Ces tâches ont été complétées dans le but de nous permettre d'étudier la possibilité que les personnes atteintes du syndrome d'Asperger soient plus lentes à traiter l'indice symbolique ou à choisir une réponse à cet indice. Les participants ont accompli deux conditions contrôles et deux conditions d'orientation comprenant des flèches centrales servant d'indices non prédictifs. En conditions de cible et d'indice, les participants ont donné une réponse expédiée face à l'apparition d'une cible (x) ou d'une flèche centrale. Dans la condition 'temps d'exposition à la cible variable', le temps d'exposition à la cible variait (100, 300, 600, ou 1000 ms) et était suivit par un écran vide précédent la présentation de la cible. Dans la condition 'temps d'exposition à la cible constant', les indices étaient présentés pendant 100 ms suivit d'un écran vide dont la durée de présentation avant la présentation de la cible variait (100, 300, 600, ou 1000 ms). Les données révèlent un schéma de réponse unique pour chacun des groupes de participants. En conditions de cible et d'indice, les participants autistes sont plus lents que les deux autres groupes (syndrome d'Asperger et 'normaux'). En conditions de 'temps d'exposition à la cible variable' et de 'temps d'exposition à la cible constant' , des effets comportementaux de l'indice ont été détectés chez le groupe autiste en comparaison avec le groupe Asperger pour des SOAs plus longs, ainsi que chez le groupe Asperger en comparaison avec le groupe normal. Ces résultats suggèrent que c'est la capacité de choisir une réponse à des indices qui est atteinte chez les personnes souffrant de troubles envahissants du développement plutôt que la capacité de lire ces indices. De plus, l'effet de facilitation engendré par de plus longs SOAs semble plus prononcé chez les participants atteint d'un trouble envahissant du développement que chez les sujets normaux, révélant une plus grande difficulté à ajuster leur choix de réponse en fonction de la prévisibilité de l'indice. Les différences révélées entre les participants autistes et ceux atteint du syndrome d'Asperger soulèvent des questions d'ordre cliniques et développementales et ont d'importantes implications théoriques et empiriques.

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Rationale

On tasks of visual shifting, or orienting of attention, persons with autism spectrum disorders (ASDs) appear to have difficulty utilizing symbolic cues (Senju, Tojo, Dairoku, & Hasegawa, 2004; Wainwright-Sharp & Bryson, 1993), whereas performance appears intact with respect to non-symbolic cues (Iarocci & Burack, 2004; Iarocci, Burack, Mottron, Randolph, & Enns, submitted). One hypothesis is that persons with ASDs are slower to *read* the meaning of a symbolic cue (Burack, Enns, Stauder, Mottron, & Randolph, 1997). An implication of this hypothesis is that the problem lies at a *perceptual* level and that longer exposure to a symbolic cue would provide more time to read its meaning. Alternatively, lengthened exposure to a symbolic cue could improve performance because it incidentally provides more time to elicit a behavioural effect of the cue. As such, the difficulties exhibited by persons with ASDs with respect to rapidly presented symbolic cues represents a problem of *response selection* to the symbolic cue.

The purpose of this study was to examine whether the difficulties exhibited by persons with ASDs in processing visual symbolic cues can be explained as a *perceptual* problem, or as a *response selection* problem. This dichotomy was examined within the context of visual orienting, the process of directing visual attention, in response to symbolic cues. In order to test these hypotheses, both the duration of the presentation of a symbolic cue and the duration of a gap (blank screen) between the offset of the cue and onset of the presentation of a target were manipulated in order to separate time needed to perceive the cue from time needed to respond with a shift of visual attention in response to the presentation of a cue.

This distinction between perceptual input and response output was necessary as both explanations offer different implications for both theory and research design with persons with ASDs. If evidence were found for the perceptual hypothesis, the implication would be that increasing the duration of exposure would provide a better opportunity for persons with ASDs to read the meaning of symbolic cues and remediation could be implemented at the level of changes in their environment. In contrast, if evidence were found for the response selection hypothesis, the implication was that persons with ASDs have impairments in the strategic, or voluntary, control of visual attention, and not in any attention or perceptual mechanisms per se. Remediation of such a problem would involve additional skills training, rather than modification of the environment.

The role of visual attention in the development of persons with ASDs as well as the implications of visual attention problems for social and communication impairments will be discussed, followed by a review of the theoretical underpinnings of visual orienting, and evidence of specific deficits in visual orienting among children with ASDs. Finally, evidence from visuomotor experiments with persons with ASDs will be discussed to justify the framework and hypotheses of this study.

The Role of Attention in the Development of Children with Autism Spectrum Disorders

Autism spectrum disorders are pervasive developmental disorders of unknown etiology that manifest in a triad of impairments in social interaction, communication, and restricted and repetitive behaviour (American Psychiatric Association, 2000; World Health Organization, 2005). Included under the umbrella of ASDs are classic or Kanner's autism, usually referred to simply as autism, Asperger syndrome, and atypical autism or pervasive developmental disorder- not otherwise specified. For the purposes of this paper, in the interest of clarity and simplicity the more inclusive term ASDs is used for discussing general theoretical ideas and findings across studies, regardless of the actual terminology used in a given paper, with the exception of discussing potential differences between ASD subgroups and related findings in the literature.

Although ASDs are typically not diagnosed until the third or fourth year (Charman & Baird, 2002), researchers have identified differences in visual attention among children with ASDs by the age of 12 months (Baranek, 1999; Osterling & Dawson, 1994; Zwaigenbaum et al., 2005). Young children with ASDs also show avoidance of looking at people's eyes (Klin, Jones, Schultz, Volkmar, & Cohen, 2002), and increased looking at seemingly irrelevant aspects of a visual scene (Klin, Jones, Schultz, & Volkmar, 2003). This atypical attentional behaviour could contribute to many impairments that are characteristic of ASDs. For example, failure to attend to eyes could lead to a failure to engage in joint attention, a social activity in which two people share an experience about a commonly attended object and which is considered to be an important precursor to language acquisition (Bloom, 2000; Charman, 2003). An impairment of joint attention is thought to reflect social difficulties; however, it may be one of many manifestations of impaired strategic control of visual attention (Kemner, Verbaten, Cuperus, Camfferman, & van Engeland, 1998; van der Geest, Kemner, Camfferman, Verbaten, & van Engeland, 2001). Klin et al. (2003) suggest that from a very young age, children with ASDs misdirect attention in their environment, which would consequently impede learning, as the acquisition of skills and knowledge depends on how well children pay attention to their environment (Ruff & Rothbart, 1996).

Attentional abnormalities are emerging as *red flags* for the early detection of ASDs in both retrospective and prospective longitudinal studies. Children diagnosed with ASDs were found retrospectively to exhibit unusual visual orienting behaviour both to people and objects by 12 months of age (Baranek, 1999; Osterling & Dawson, 1994). Visual attention patterns by 12 months of age were also found to differentiate children with and without ASDs in a prospective longitudinal study by Zwaigenbaum et al. (2005). Of note for the purposes of this study, Zwaigenbaum et al. (2005) reported that every child who showed a decrement in performance on an attention disengagement task from 6 to 12 months was classified as having an ASD at 24 months. In contrast, other behavioural markers at 12 months more commonly associated with ASDs, including atypical eye contact, visual tracking, orienting to name, imitation, social smiling, reactivity, social interest, and sensory-oriented behaviours, only predicted ASD classification at 24 months if seven or more of these markers were present. Those classified as ASD at 24 months were also reported to be more distressed, exhibited language delay, and engaged in less visual exploration instead fixating on particular objects in the environment at the 12 month assessment. Thus, abnormalities in visual attention appear to be prominent and seemingly reliable indicators of ASDs in infancy. The early emergence of these abnormalities of visual attention suggests that problems in the strategic control of visual attention likely contribute to abnormalities in other later emerging skills in social interaction and communication.

Visual Attention and Social Communication Impairments

The failure to make eye contact (gaze aversion) and the failure to follow another's gaze (joint attention) are key symptoms used to diagnose ASDs in the Diagnostic and Statistical Manual –Fourth Edition (DSM-IV; American Psychiatric Association, 2000), International Classification of Diseases –10th Edition (World Health Organization, 2005), and most, if not all, screening questionnaires. Gaze aversion and joint attention impairments have long been considered to be manifestations of social interaction and communication impairments. However, children with ASDs exhibit unusual looking behaviour to objects and to the environment as well as to people, suggesting that gaze aversion and joint attention impairments are not strictly social problems but rather manifestations of a problem in the strategic control of visual attention. In an early example, Hermelin and O'Connor (1970) reported that children with ASDs spent more time gazing around and less time fixated on task stimuli than non-verbal mental age matched typically developing and developmentally delayed children. Three decades later, Klin and colleagues reported that both 2-year-olds (Klin et al., 2003) and high functioning adolescents and young adults (Klin et al., 2002) with ASDs spent more time fixated on irrelevant aspects of the scene than age and IQ matched typically developing peers when viewing naturalistic scenes. This included fixating on the background, as well as fixating on the mouth region of a person speaking, and searching for a verbally referenced object while ignoring the presence of a helpful pointing gesture. Thus, in the presence of informative symbolic cues, such as eye gaze and pointing, the participants with ASDs used less informative verbal cues to guide the direction of their visual attention.

This literature supports a framework that children and adults with ASDs exhibit deficits in joint attention and misdirect gaze when looking at faces as a symptom of a broader impairment in strategic direction of visual attention rather than as a symptom of a social impairment. This impairment in strategic control over the orientation of visual attention compromises the ability to selectively direct attention to pertinent and relevant locations in the visual field.

Visual Orienting

Von Helmholtz (1924) described the voluntary direction of attentional resources independent of eye gaze when he sought to determine how much information could be obtained from a visual array during a momentary flash of light. He found that, while his attentional resources were limited, he could successfully choose to direct his attention anywhere in the visual field. In the constant barrage of incoming stimuli, selective attention determines which stimuli are selected for further processing, and which stimuli are ignored.

Visual attention can be directed either by focusing the eyes, or foveating, on a specific location or by choosing to attend to a location in peripheral vision. Shifts of attention can also precede an eye movement, or saccade, as attention moves faster than the eye. Both eye movements and shifts of attention without an accompanying eye movement are controlled by the same mechanisms (Rizzolatti, Riggio, Dascola, & Umilta, 1987; Smith, Rorden, & Jackson, 2004).

One well-known model of visual attention includes the metaphor of a spotlight beam to explain the movement of attention (Posner, 1980; Posner, Snyder, & Davidson, 1980). As the spotlight is directed to a specific location, events within the beam are detected with enhanced efficiency. Posner (1980) found that cuing participants to direct their attention to a given location facilitated detection of a target at that location and impeded detection of a target at another location. He referred to this directing of the attentional spotlight to a specific location in space as orienting. Visual cues are used to direct attention to the cued location either overtly, with an eye movement, or covertly, without an eye movement (Posner, 1980). Cues that elicit shifts of attention automatically, or unconsciously, are considered to be exogenous, as the shift is in response to the physical properties of the stimulus. Cues that elicit voluntary shifts of attention are endogenous as the shift is in response to the symbolism or meaning of the cue.

Visual orienting is typically measured in the laboratory using variations of Posner's (1980) task. In these tasks, participants are asked to fixate on the centre of a computer screen and press a button when they see a target. Targets can appear either to the left or right of the fixation point. Cues are presented at variable stimulus onset asynchronies (SOAs) before the target, resulting in differential effects on target detection. On an exogenous orienting task, the cue is a stimulus that is presented in either of the regions where the target could appear. A valid, or congruent, trial is when the cue and target appear on the same side. An invalid, or incongruent, trial is when the cue and target appear on different sides. The finding that target detection is faster on valid than on invalid trials is referred to as a facilitation effect (Posner, 1980). Peripheral cues are considered exogenous because they elicit orienting automatically on the basis of physical properties, for example a sudden change in luminance. This facilitation effect is strongest when the SOA is 100-200 ms (Muller & Rabbitt, 1989). At SOAs of more than 400 ms, the facilitation effect reverses. This reversal is referred to as *inhibition of return*, as attention is redirected to a new location when the expected event does not occur and inhibited from returning to the previously attended location (Klein, 2000; Muller & Rabbitt, 1989; Posner & Cohen, 1984).

Orienting is considered endogenous when attention is voluntarily directed to a spatial location by a symbolic cue such as a centrally located directional cue rather than a peripheral cue. As opposed to peripheral cues, which attract attention to the location of the sensory event, central directional cues provide meaningful information to guide attention, and as such require a certain degree of interpretation not required with peripheral cues. As in exogenous tasks, target detection is faster on valid than on invalid trials, although the facilitation effect is not seen among typical adults until 200-300 ms SOA (Muller & Rabbitt, 1989). Endogenous orienting also differs from exogenous orienting as no inhibition of return is seen on tasks with central cues when the shift of attention occurs without accompanying eye or head movement (Klein, 2000; Posner & Cohen, 1984; Rafal, Calabresi, Brennan, & Sciolto, 1989).

Exogenous and endogenous orienting are also differentially affected by the predictability of the cues. Historically speaking, exogenous orienting was considered impervious to predictability as typical adults continue to show facilitation effects under conditions of non-predictive cuing, while endogenous orienting was considered dependent on predictability as the cue has no meaning if it is not predictive. However there is evidence that facilitation effects are strengthened and weakened by manipulations of predictability on exogenous tasks (Brodeur & Boden, 2000; Enns & Brodeur, 1989). As well, there is evidence that over-learned cues, such as arrows, elicit facilitation in conditions where they are not predictive (Eimer, 1997; Friesen, Ristic, & Kingstone, 2004 ; Ristic, Friesen, & Kingstone, 2002 ; Tipples, 2002). Thus, predictability is not necessarily a defining feature of the distinction between exogenous and endogenous orienting, but it is an important consideration.

Visual Orienting in Typical Development

Visual orienting undergoes rapid development in early infancy that continues through childhood. The visual behaviour of newborns is reflexive, and eye movements follow moving stimuli in a saccadic rather than smooth movement (Aslin, 1981). One-month-olds demonstrate difficulties with disengagement of attention, although this is rectified by 2-months-old. Also at 2-months-old, infants begin to show smooth pursuit object tracking, but do not show anticipation in tracking until 3-months-old. The emergence of anticipatory eye movements is concurrent with the ability to learn sequences of looking patterns. According to Johnson (2005), this sequence reflects the emergence and strengthening of cortical pathways between subcortical, posterior, and anterior cortical structures, which enable the development of exogenous and endogenous visual orienting.

Exogenous orienting. Exogenous orienting emerges at 4-months-old. At this age, covert shifting of attention is measured by overt shifts to peripheral stimuli that are preceded by brief 100 ms spatial cues. Hood (1995) reported that 6-month-olds but not 3-month-olds demonstrated covert shifts of attention. Johnson (2002) further specified the point of emergence when he reported that 4-month-olds and not 2-month-olds demonstrated covert shifts of attention with exogenous cues at 200 ms SOA and inhibition of return at 700 ms SOA.

Children as young as 3-years-old have demonstrated covert orienting to exogenous cues using button press responses on tasks similar to those used with adults (Enns, 1990). Age related changes from school-aged children to adults on exogenous orienting tasks were attributed to decreases in both the benefit of a valid cue and cost of an invalid cue relative to a neutral cue (Akhtar & Enns, 1989), and specifically to larger costs of invalid cues for children than adults in a non-predictive cue condition coupled with larger benefits of valid cues for adults than children in a predictive cue condition (Enns & Brodeur, 1989). Wainwright and Bryson (2002) also reported significantly larger costs associated with invalid cues for 6-year-olds than for 10-year-olds, 14-year-olds, and adults, arguing that larger costs are indicative of less efficient disengagement from the invalidly cued location. However, these findings could also reflect age related changes in the velocity of attention shifts (Pearson & Lane, 1990) as target detection following an invalid cue involves two shifts rather than one. Pearson and Lane (1990) reported that the velocity of attention nearly doubled from 8-years-old (57°/sec.) to 11-years-old (104°/sec.) therefore the reaction time difference between groups would also be expected to nearly double between validly and invalidly cued trials, resulting in a greater likelihood to find age related differences due to the costs of invalidly cued trials than the benefits of validly cued trials.

Endogenous orienting. Johnson (2002) reported that endogenous orienting also emerges at 4-months-old based on evidence that, following contingency training to a central cue, 4-month-olds, but not 2- or 3-month-olds, reliably looked to the cued location. Johnson (2002) also reports that 4-month-olds exercise endogenous control over overt orienting on an analogue anti-saccade task, where infants suppress making a saccade to an initial stimulus in order to make a faster saccade to a second, more attractive stimulus. Both of these examples illustrate how endogenous orienting is about control over orienting processes, although it is unclear the extent to which these studies simply measure the developmental emergence of contingency learning.

On endogenous orienting tasks that are methodologically similar to those used with adults, children aged 6, 8, and 10 years demonstrated reliable orienting effects (Brodeur & Enns, 1997); however this effect was only seen on the shortest SOA (133 ms). Adults, on the other hand, demonstrated significant orienting effects at SOAs ranging from 150 ms to 800 ms. Brodeur and Enns (1997) interpreted this finding in terms of children having less efficient sustained attention across the trial in longer SOAs. In contrast, Pearson and Lane (1990) found that children aged 8- and 11-years-old, and adults, demonstrated similar orienting effects to endogenous as exogenous cues, with the size of the orienting effect increasing with SOA and age. Further, Wainwright and Bryson (2005) reported that 6-year-olds demonstrated orienting effects of a constant magnitude at SOAs of 100 ms and 800 ms, while 10- and 14-year-olds, and adults showed significantly larger orienting effects, at the longer SOA, which can be attributed to larger costs associated with invalid cues as there were no differences in the benefits associated with valid cues.

Predictability. On both tasks of exogenous and endogenous orienting, age related improvements are reported in the ability to use the predictability of the cue to facilitate performance (Brodeur & Boden, 2000; Enns & Brodeur, 1989; Friesen et al., 2004; Ristic et al., 2002). However, improvements in the ability to use predictability to guide behaviour are also a factor in age related improvements of other skills such as inductive reasoning (Goswami, 2002) and are not specific to attention. Therefore, like the infant's ability to learn contingencies, the difficulty in taking into account predictability represents a constraint upon children's orienting performance, and not the immaturity of any orienting mechanisms per se.

Visual Orienting in Autism Spectrum Disorders.

The experiments of both exogenous and endogenous orienting with children and adults with ASDs are difficult to compare as they differ in methodology. For example, deficits in exogenous orienting were reported for persons with ASDs in early studies (Casey, Gordon, Mannheim, & Rumsey, 1993; Harris, Courchesne, Townsend, Carper, & Lord, 1999), but not in later ones (Iarocci & Burack, 2004; Iarocci et al., submitted) with better matched groups and an experimental design that more accurately measures exogenous orienting. There are however findings of impairments in endogenous orienting at short SOAs, but not with longer SOAs (Wainwright-Sharp & Bryson, 1993).

Exogenous orienting. The findings from two studies of exogenous orienting were taken as initial evidence of general orienting deficits among persons with ASDs. In one study, Casey et al. (1993) found that a group of adults with ASDs were slower overall to respond but showed facilitation effects with SOAs of both 100 ms and 800 ms that were even larger than those of the comparison group on an exogenous orienting task with predictive peripheral cues (2/3 valid). Similarly, on a task like that used by Casey et al. (1993) but with SOAs of 200 ms and 1000 ms, Harris et al. (1999) found that children with ASDs (mean age 7.5 years) showed a larger facilitation effect at the longer SOA, whereas the comparison group showed a larger effect at the shorter SOA. However, the implications of these two studies are limited by methodological concerns. One, the participants with ASDs in both experiments were matched to typically developing persons only on the basis of chronological age, and had mean full scale IQ scores that were 45 (Casey et al., 1993) and 28 (Harris et al., 1999) points lower. These differences in IQ, and subsequently of developmental level, preclude any interpretation of observed group differences (Burack, Iarocci, Bowler, & Mottron, 2002; Burack, Iarocci, Flanagan, & Bowler, 2004). Two, inhibition of return effects were not found in either study, even among the comparison groups. This could be due to the sequence of events within the tasks; the presentation of the peripheral cue remained on the screen during the full duration of the trial, before and during target onset. This procedure differs from that in the original Posner task, in which the cue did not remain onscreen during target presentation. The persistence of the cue may *hold* attention longer at the cued location than if the cue was a brief flash, indicating a problem with disengagement from a stimulus and not shifting between locations (Fischer & Weber, 1993; Saslow, 1967). As well, the long duration of the cue, coupled with its predictability may actually make it meaningful. Thus the lack of inhibition of return effects may indicate that neither of these tasks were an accurate representation of exogenous orienting.

Both Casey et al. (1993) and Harris et al. (1999) interpreted their findings as evidence of impairment in shifting attention away from the cued location, however in light of the methodological flaws, neither study provides evidence of a general impairment in shifting attention among persons with ASDs. Differences in patterns of performance between groups may reflect impairments in disengagement, not shifting, although the poor matching of groups makes this highly speculative. However, evidence for a specific problem with disengagement and not shifting visual attention is provided by

R. Landry and Bryson (2004). They presented a group of children with ASDs (mean CA 5.6 years, mean IQ 70.2) with three computer monitors as a dynamic pattern appeared on the central monitor, and a second dynamic pattern could appear on either the monitor to the left or on the one to the right. On disengagement trials, the pattern remained on the central screen for the duration of the trial, concurrent with the onset of the pattern on the peripheral screen, and on the shift trials, the pattern on the central screen was turned off 250 ms before the onset of the pattern on the peripheral screen. The children with ASDs were slower to turn their gaze to the peripheral pattern when the central pattern remained on the screen (disengage trials), as their responses were more than twice as long as those of typically developing children and four times as long as children with Down syndrome matched on mental age. R. Landry and Bryson (2004) interpreted these findings as indicative of poor disengagement of attention on the part of the children with ASDs, developmentally equal to typically developing 2-month-olds, and questioned the extent to which children with Down syndrome were attentionally engaged with the central pattern in the first place. However, the children with ASDs did not exhibit different performance from the typically developing children on the shift trials, when the central pattern was turned off before the peripheral pattern appeared, indicating that shifting attention is intact.

Although the children in R. Landry and Bryson's (2004) study were substantially younger than those in the Casey et al. (1993) and Harris et al. (1999) studies, R. Landry and Bryson (2004) provide preliminary evidence that the persistence of the cue and/or central fixation point in orienting tasks may interfere with the ability of children with ASDs to demonstrate shifts of attention in response to cues if they have difficulty disengaging from extraneous aspects of the task, such as a cue or even a central fixation point that overlaps with target onset.

The methodological issues raised with respect to the early exogenous orienting experiments in ASDs appear to account for the reported differences. On a task that more accurately resembles Posner's original tasks, Iarocci and Burack (2004) found that participants with ASDs displayed intact exogenous orienting abilities. In this study, low functioning children and adolescents with ASDs (mean CA 11.6 years; mean MA 7.2 years) and typically developing children matched on mental age were administered an exogenous orienting task in which the peripheral cue and central fixation did not overlap with target onset. A 50 ms peripheral cue, followed by 150 ms blank screen, was presented before the target appeared. Peripheral cues were non-predictive as the ratio of valid to invalid cues was 1:1. There were no significant differences between groups on overall reaction time and no interaction between facilitation effects and group, as both groups demonstrated the expected facilitation effect of valid cues. Further, neither group demonstrated costs of invalid cues as reaction times to invalid cues did not differ from those of neutral cues. Thus, children with ASDs of a mental age of around 7 years do not appear to demonstrate impairments in exogenous orienting when there is no additional requirement to disengage from the central fixation point or an overlapping cue.

Similar findings were obtained by Iarocci et al. (submitted), who also found facilitation effects in exogenous orienting among both a group of high functioning adolescents with ASDs and a group of comparison participants matched on chronological age and IQ. The duration of the peripheral cue was 30 ms, and targets could appear in one of four locations instead of the standard two. Peripheral cues were non-predictive as the ratio of valid to invalid cues was 1:3. Both groups showed similar facilitation effects at an SOA of 100 ms and IOR at an SOA of 800 ms. Thus, the patterns of findings across studies of exogenous orienting in which issues of matching and stimulus presentation are appropriately controlled do not support a general impairment in shifting of attention among persons with ASDs.

Endogenous orienting. In contrast to the findings on exogenous orienting tasks, persons with ASDs display impairments in shifting attention on endogenous orienting tasks that cannot be accounted for by poor matching or disengagement impairments alone. Rather, persons with ASDs do not appear to show facilitation effects to rapidly presented cues when a voluntary shift of attention is required. In one study, Wainwright-Sharp and Bryson (1993) tested a group of high functioning adults with ASDs and age and IQ matched typical adults on a Posner task using central arrows as cues. These cues remained onscreen for 100 ms or 800 ms and were predictive with a valid-invalid ratio of 4:1. Wainwright-Sharp and Bryson (1993) found different facilitation effects in the two groups. Regardless of cue duration, the typical adults responded faster to valid than to invalid trials and the magnitude of this effect was the same at both cue durations, whereas the adults with ASDs only displayed facilitation effects in the long cue duration and the magnitude of this effect was larger than for the typically developing group at the same duration. Wainwright-Sharp and Bryson (1993) concluded that the participants with ASDs were impaired in either disengaging or shifting of attention, or in the voluntary coordination of attention and motor systems. Based on evidence of intact exogenous orienting, a general impairment in shifting attention can be ruled out. The finding of facilitation effects at the longer SOA on the endogenous task suggests that the process of orienting to symbolic cues as a whole is not absent, but merely slowed down.

Burack et al. (1997) suggested that the deficit exhibited on endogenous orienting reported by Wainwright-Sharp and Bryson (1993) might indicate that persons with ASDs are slower to interpret the meaning of the symbolic cue. Consistent with this hypothesis, Iarocci et al. (submitted) found no ASD-related deficits on an endogenous orienting task in which predictive arrows (75% valid) appeared on screen for 280 ms or 980 ms; these trial durations were long enough for the participants with ASDs to demonstrate facilitation effects. Iarocci et al. (submitted) also reported that persons with ASDs displayed a stronger facilitation effect than mental age matched comparison subjects, and an overall slower response time, especially with the longer cue presentation. An overall slower response time suggests that the aspect of interpreting the cue that may be slowed is at the response selection end, rather than the perception end of interpreting the meaning of the cue. If persons with ASDs can be slower at executing a button press, they may also be slower at executing other strategic visuomotor responses including eye movements and shifts of attention.

Perception versus Responding in Visual Orienting

The evidence does not appear to support a general orienting deficit among persons with ASDs, but rather a delayed orienting effect to endogenous cues. The presence of the orienting effect at longer SOAs could reflect a slower reading of the cue, but reports of slower overall reaction times (Casey et al., 1993; Iarocci et al., submitted; Senju et al., 2004; Wainwright-Sharp & Bryson, 1993) should not be dismissed as irrelevant. It may be indicative of other slowed responses that are not observed. Persons with ASDs may be able to read rapidly presented cues as well as typically developing persons, but may be less able to execute a fast enough response in terms of shifting visual attention. For example, on an endogenous orienting trial with a 100 ms SOA, the onset of the cue elicits the onset of a shift of attention. But if a person with an ASD were slower at executing that endogenous shift of attention in response to the cue, the onset of the target might disrupt the in progress endogenous shift and begin a new, exogenous shift directly to the target. Thus, the exogenous shift to the target interfered with the endogenous shift to the cue, a notion supported by findings that when exogenous and endogenous cues are presented in conflict, persons with ASDs are more likely to respond to the exogenous cue (Iarocci et al., submitted). The behavioural results of this hypothetical example would indicate that target detection was accurate, but that the cue did not influence responding because it was superseded by the appearance of the peripheral target. As there are no reports of higher error rates among participants with ASDs in the aforementioned studies of orienting, this hypothetical example may provide a framework for understanding why persons with ASDs fail to show facilitation effects under some conditions but not others. This framework is supported by evidence of atypical performance in persons with ASDs on other visuomotor tasks, including reach-to-grasp (Mari, Castiello, Marks, Marraffa, & Prior, 2003), visual pursuit (Takarae, Minshew, Luna, Krisky, & Sweeney, 2004), and saccadic eye movements (Kemner et al., 1998; Takarae, Minshew, Luna, & Sweeney, 2004). Specifically, the performance of persons with ASDs on these tasks is indicative of impairments in the voluntary control of motor responses rather than of motor impairments. Allport (1989) referred to visual attention as "selection for action" and emphasised that the selectivity of attention is in some way related to or dependent on the need for coherent control of action. Wainwright-Sharp and Bryson's (1993) suggestion of impaired voluntary coordination of attention and motor systems in persons with autism is somewhat consistent with this framework as directing a motor response to a stimuli and directing attention to that stimuli are served by the same mechanisms (Rizzolatti et al., 1987).

Current Study

The study presented here was designed to test Burack et al.'s (1997) hypothesis that persons with ASDs are slower to read the meaning of a symbolic cue, by examining whether persons with ASDs require more time to read the cue or more time to respond to the cue. In either case, the interpretation of meaning is impaired, but the aim here is to understand whether this impairment occurs at a perceptual or a response selection level. Accordingly, adolescents and young adults with ASDs and typically developing children were administered a series of forced-choice reaction time tasks to differentiate reading versus responding to a symbolic cue.

Participants with autism and participants with Asperger syndrome were both included and compared. Although these two diagnostic sub-groups are frequently combined in research, autism is commonly considered to be symptomatically more severe than Asperger syndrome, is diagnosed at an earlier age, and may manifest differently in development, although it is unknown how much of the difference is an artefact of differences in general intellectual development and diagnostic criteria (Happe, 1994; Klin, Volkmar, & Sparrow, 2000). The key diagnostic difference between the two labels, as specified in the DSM-IV (American Psychiatric Association, 2000), is the presence of language delays before the age of 3 years (autism) or the lack thereof (Asperger syndrome). The differential developmental consequences over time of this distinction are unknown. Subtle differences are reported in neuroanatomy and, potentially relevant to this experiment, in motor planning and execution (reviewed in Nayate, Bradshaw & Rinehart, 2005), with both autism and Asperger syndrome exhibiting qualitatively different deficits relative to typically developing persons. Accordingly, participants with autism and Asperger syndrome were considered as separate groups in the present study unless no differences were found between them on these tasks.

The participants completed two control and two experimental conditions to delineate reading the symbolic cue from responding to the symbolic cue. The first control task, Target, was used to measure reaction time to a target, which represents participants' baseline reaction time to an onscreen stimulus. The second control task, Cue, was used to measure reaction time of judgement regarding the directionality of an arrow, which represents the participants' baseline reaction time to interpret the meaning of the symbolic cue. If Burack et al.'s (1997) hypothesis is correct, participants with ASDs should exhibit slower reaction times on the Cue condition and not on the Target condition.

The experimental conditions were used to contextualize reading and responding to cues within visual orienting. Non-predictive cues were used as persons with ASDs are reported to demonstrate facilitation with non-predictive arrows (Senju et al., 2004; Vlamings, Stauder, van Son, & Mottron, 2005) and the use of non-predictive cues also reduces the overall duration of the experiment, thereby reducing the likelihood of participants becoming fatigued. The first experimental condition, which resembles a standard endogenous orienting experiment, represents reading the cue as increases in

SOA reflect a lengthening of the onscreen duration of the cue. This condition is called the Variable Cue Exposure (VCE) condition. The second condition, called the Constant Cue Exposure (CCE) condition, includes a consistently brief cue of 100 ms at all SOAs, which represents responding to the cue, as increases in SOA represent a lengthening gap between the cue offset and the target onset. This brief cue of 100 ms was chosen specifically because Wainwright-Sharp and Bryson (1993) found that 100 ms was the SOA at which persons with ASDs failed to show facilitation with endogenous cues. In accordance with the *perceptual level hypothesis,* if the participants with ASDs require more time to view the cue in order to attribute meaning, as implied by Burack et al. (1997), they would be expected to exhibit facilitation effects on the VCE condition at longer SOAs and not at all on the CCE condition in which all cue presentations are brief. Alternately, in accordance with the *response selection hypothesis,* the briefly seen cue may be perceived and interpreted, but response selection may be slower, in which case participants with ASDs would exhibit facilitation effects on both conditions.

Method

Participants

Eleven participants with a diagnosis of autism, nine with a diagnosis of Asperger syndrome, and 16 typically developing children and adolescents participated in the experiment. The participant characteristics are presented in Table 1. One-way ANOVAs with post hoc Tukey's HSD tests were used to check for differences between groups on measures of age and developmental level. The groups did not differ significantly in chronological age or Block Design raw scores, however the autism group had a lower mean Matrix Reasoning raw score than the Asperger syndrome (p=.019) and typically developing groups (p=.004), and a lower performance IQ than the typically developing group (p<.001). The autism group also had a lower mean performance mental age than the Asperger syndrome group (p=.042), though neither group differed significantly from the typically developing group.

The participants with autism and Asperger syndrome were recruited through special education schools for individuals with autism spectrum disorders, and typically developing children were recruited through the community. Parents completed a questionnaire on which they were asked details about their child's diagnosis, including who performed the diagnosis and at what age this occurred, and whether the child had received any concurrent diagnoses or was taking any medications (Appendix A). Parents of the typically developing children also completed this questionnaire to screen for children with non-ASD learning or behavioural disorders. Most of the participants with ASD had participated in previous experiments and were known to be high-functioning and amenable to this type of research.

Table 1. Participant Characteristics

Independent Measure	Mean			Standard deviation			Sample Size			Differences	Sig.
	Aut	Asp	Typ	Aut	Asp	Typ	Aut	Asp	Typ		
CA	12.00	14.44	11.00	3.07	4.90	2.66	11	9	16	ns	
MR	14.27	23.44	24.07	9.59	6.64	4.92	11	9	15	Aut<Asp, Typ	*ps*<.020
BD	22.27	33.56	38.87	21.33	19.06	17.85	11	9	15	ns	
PIQ	84.73	99.44	114.44	18.69	21.94	13.69	11	9	16	Aut<Typ	*ps*<.001
PMA	10.17	13.79	12.49	3.78	2.84	2.92	11	9	16	Aut<Asp	*p*=.042
ASSQ	24.50	22.75	9.36	2.12	11.34	11.87	9	8	14	Typ<Aut, Asp	*ps*<.030

Note. Aut= autism, Asp= Asperger syndrome, Typ= typically developing children, CA= chronological age, MR= Matrix Reasoning, BD= Block Design, PIQ= performance IQ, PMA= performance mental age, ASSQ= Autism Spectrum Screening Questionnaire score.

Measures

Wechsler Abbreviated Scale of Intelligence (WASI; Harcourt, 1999)

Performance IQ and mental age were measured with the WASI, a brief measure of IQ appropriate for children and adults ages 6 years and older. The WASI includes four subtests, two of which (Block Design and Matrix Reasoning) are used to measure performance IQ. The verbal subscales of the WASI were initially also used with some participants, but as a large number of participants were either not native English speakers or attending schools where the language of instruction was not English, this was abandoned. The reliability coefficients of the WASI were reported to meet or exceeded 0.84 for Block Design and 0.86 for Matrix Reasoning in the child and adult standardisation samples, demonstrating excellent internal consistency (Harcourt, 1999). Test-retest reliability coefficient for PIQ in children was reported to be 0.87 and in adults was reported to be 0.88 (Harcourt, 1999). The coefficient of agreement on performance IQ between the WASI and WISC-III is reported to be 0.76 (Harcourt, 1999). Because the WASI manual provides test-age equivalents for each subtest but not for the verbal, performance, or full-scale composite scores, overall performance mental age was estimated using the standard formula Mental Age = Chronological Age * IQ/100.

Autism Spectrum Screening Questionnaire (ASSQ; Ehlers, Gillberg, & Wing, 1999)

The degree of current symptomotology for each participant was assessed with the ASSQ, a 27 item questionnaire completed by a parent or teacher. The items are rated on a three point scale. Respondents indicate whether the child "stands out" from other children his/her age by responding *no* (0), *somewhat* (1), or *yes* (2) to each item. The range of possible scores is 0-54. The items address social interaction, communication, restricted and repetitive behaviour, and motor clumsiness and associated symptoms. The ASSQ was designed for completion by lay people, and is intended for use with school-aged children of average and high ability. Test-retest reliability coefficients with clinical and typical samples, parent and teacher respondents, are reported to be greater than 0.90 (Ehlers et al., 1999). Inter-rater reliability, divergent validity, and concurrent validity are also reported to be high (Campbell, 2005; Ehlers & Gillberg, 1993; Ehlers et al., 1999).

Apparatus

The stimuli were presented using Superlab Pro v. 1.77 (Cedrus Corporation, 2004) software on a Macintosh G3/333mhz Powerbook computer with a 14.1 inch LCD monitor. The screen resolution was set at 1072x768 and the responses were made on a computer keyboard using the (x) and (.) keys, which were clearly marked with stickers depicting the target (x). The accuracy of the computer keyboard was +/- 16.67 ms. According to Ulrich and Giray (1989), when the number of occurrences of each trial type approaches 30, the imprecision of this timer becomes negligible in accordance with the central limit theorem. As such, 30 trials of each type were included in the design of this experiment.

Stimuli

The computerised orienting task was comprised of two control conditions and two experimental conditions. The stimuli consisted of central arrow cues that were presented in the middle of the screen, and a target X that was presented 200 pixels (61 mm), or approximately 7 degrees of visual angle to the left or right of the centre of the screen (Figure 1). The cues were solid black arrows that measured 20 mm x 20 mm (0.23

degrees of visual angle), and the target was a black letter X that measured 7 mm x 10 mm (0.08 x 0.1 degrees visual angle). The participants were instructed to respond as fast as they could to the target, by responding to targets that were presented on the right side of the screen with a right button press, and to targets presented on the left side with a left button press. In all conditions, targets remained onscreen until the participant made a response, or until three seconds elapsed.

Conditions

The Control Conditions

The Target control condition was used to measure simple reaction time to a target. This condition included the presentation of the same targets used in the experimental conditions, but was not preceded by a cue. It included 16 practice trials and 30 experimental trials. The Cue control condition was used to measure reaction time to make a judgement regarding the directionality of an arrow. In this condition, the same central arrow cues used in the experimental conditions were presented, but not followed by a target.

The Experimental Conditions

The experimental conditions included a VCE condition and a CCE condition, each with SOAs of 200, 400, 700, and 1100 ms (Figure 1). In the VCE condition, the length of the exposure time to the cue varied, while response preparation time remained constant. The central arrow cue was presented for 100, 300, 600, or 1000 ms, followed by a 100 ms blank screen and then the presentation of the target stimulus (X). In the CCE condition, the length of exposure time to the cue was constant, while the response

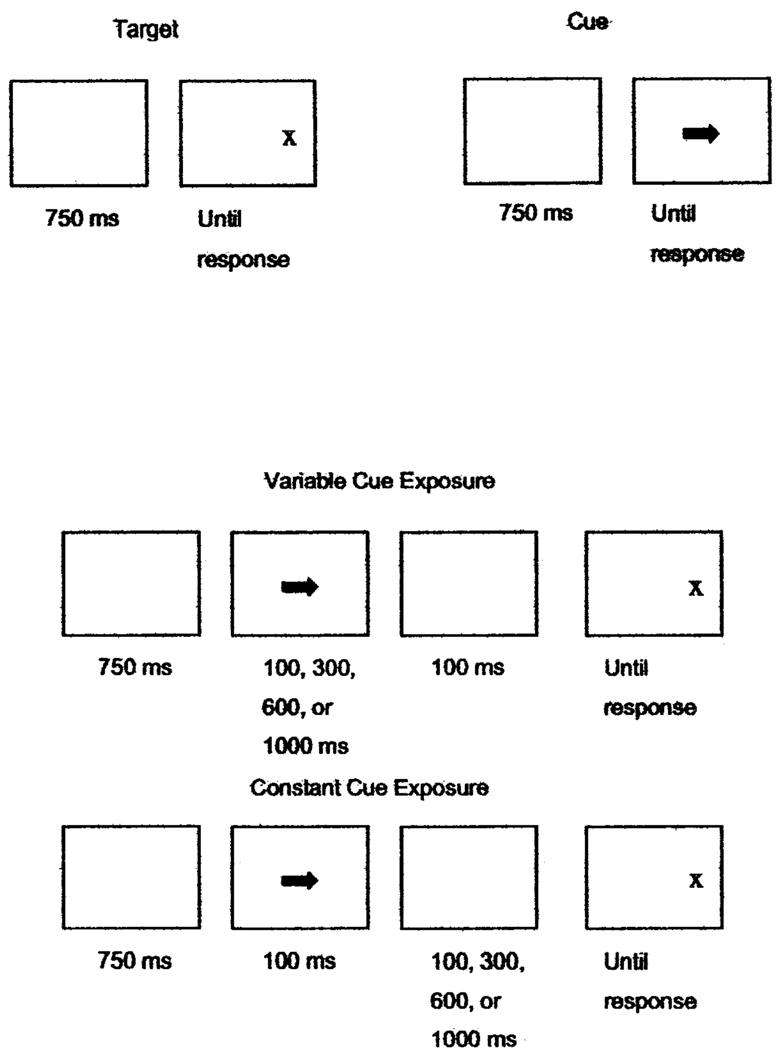

Figure 1. Sequence of events for control (Target, Cue) and experimental (Variable Cue Exposure, Constant Cue Exposure) conditions.

preparation time varied. The central arrow cue was visible for 100 ms, followed by a blank screen of 100, 300, 600, or 1000 ms, and then the presentation of the target. On 50% of the trials in each condition, the direction of the arrow corresponded with the side on which the target appeared (valid), and on 50% of the trials the arrow pointed to the side opposite the side on which the target appeared (invalid). Each experimental condition included 24 practice trials that were not included in the analyses, and 240 experimental trials (30 x 4 SOAs x 2 validity status) that were presented in blocks of 60 randomized trials with breaks in between blocks. The participants were allowed to control the duration of the breaks between each block by pressing any button on the keyboard to continue with the experiment.

Procedure

The participants were tested individually in a quiet room on university premises or in their school. When testing occurred on two of three school properties, the teachers were present and quietly observed as per school regulations. At the university, some parents chose to observe a block of trials on the computer, but most waited in a separate room. No parents were in the testing room with their child during the administration of the WASI. Parents or teachers completed the ASSQ while the participant was being tested.

All the participants were positioned to be at eye level with and 50 cm from the centre of the computer screen. A chin rest was provided to maintain the head position of the participants during the testing. The participants were instructed to try and fixate on the centre of the screen throughout all of the conditions. The conditions were presented in a quasi-counterbalanced order, with the Target condition presented first, followed by the experimental conditions in counterbalanced order, and the Cue condition last. The Target condition was always presented first, which allowed for this condition to also serve as a screening tool to quickly assess whether a potential participant would be able to complete the task. The instructions for this task were to press the button corresponding to the side of the screen on which the target appeared. The complete instructions are provided in Appendix B. The instructions for the experimental conditions were the same as for the Target condition, as the participants were not provided any instructions with respect to the arrows on these tasks. The Cue condition was always presented last, with the instructions to press the button that indicated the direction to which the arrow pointed. This condition was always last because the instruction to attend to arrow direction could potentially affect performance on the experimental conditions. The younger typically developing children and all the participants with a diagnosis of autism or Asperger syndrome were also administered the computer conditions before the WASI. Therefore, no WASI information was collected for the potential participants who were unable to complete the task.

Median reaction times were computed for all correct responses within each trial type and condition for each participant and entered in the analyses. Error rates were too low to be analysed across trial types and were not entered.

Results

Comparisons of Autism, Asperger Syndrome and Typically Developing Children

The Control Tasks

Performance on the two control tasks was compared using a mixed model ANOVA with group (autism vs. Asperger syndrome vs. typically developing) as the between-subjects factor and task (target vs. cue) as the within-subjects factor. A main effect of group, $F(2,33)=6.747$, $p=.003$, and a main effect of task, $F(1,33)=17.338$, $p<.001$, were found, as well as a significant group by task interaction, $F(2,33)=4.613$, $p=.017$. Simple effects tests and pairwise comparisons with bonferroni adjustments were used to examine this interaction. The children with autism exhibited no difference between tasks, whereas performance was faster on the Target than Cue tasks for the children with Asperger syndrome, *Multi* $F(1,33)=17.907$, $p<.001$, and the typically developing children, *Multi* $F(1,33)=7.154$, $p=.01$. An effect of group was found on the Target task, $F(2,33)=7.772$, $p=.002$, whereby the children with autism differed significantly from both the children with Asperger syndrome ($p=.004$) and typically developing children ($p=.007$). An effect of group was found on the Cue task, $F(2,33)=3.915$, $p=.03$, whereby the children with autism differed from the typically developing children ($p=.027$) but not the children with Asperger syndrome. There were no differences between the children with Asperger syndrome and typically developing children (see Figure 2).

The Experimental Tasks

Performance on each of the experimental conditions was examined using a mixed model ANOVA with group (autism vs. Asperger syndrome vs. typically developing) as

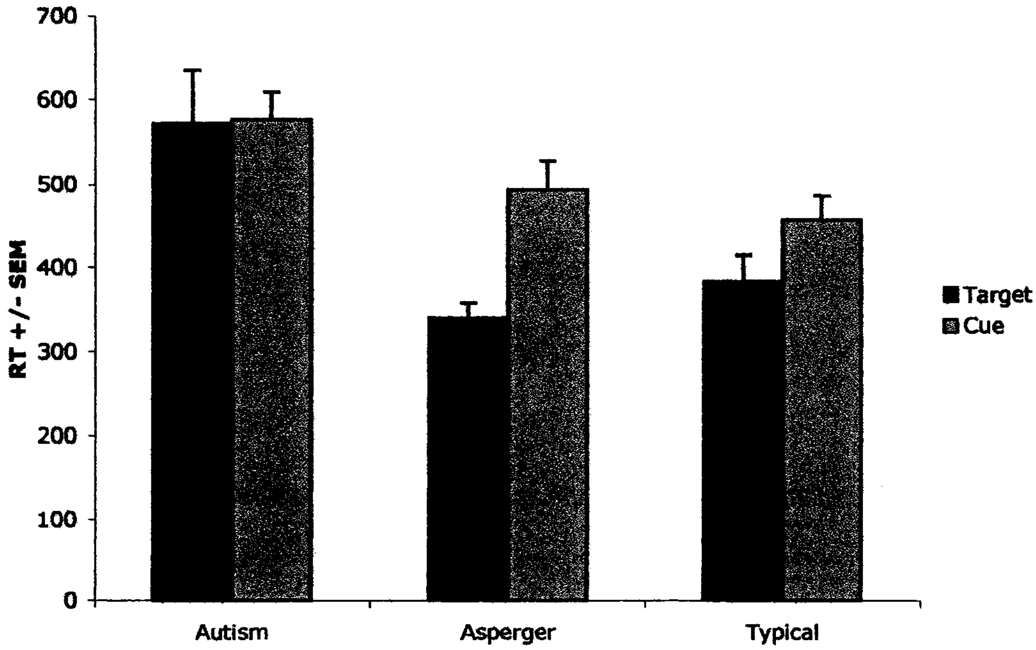

Figure 2. Reaction times to Target and Cue conditions for children with autism, children with Asperger syndrome, and typically developing children. There is a significant interaction between group and condition. The children with autism do not exhibit a differential effect of condition, whereas the children with Asperger syndrome and typically developing children each were faster on the Target than Cue condition. On the Target condition, the children with autism were slower than the children with Asperger syndrome (p=.004) and typically developing children (p=.007).

the between-subjects factor, and validity (invalid vs. valid) and SOA (200 vs. 400 vs. 700 vs. 1100) as the within-subjects factors. In the VCE condition, main effects of validity, $F(1,33)=33.289$, $p<.001$, and SOA, $F(3,99)=26.971$, $p<.001$, were found, as well as an interaction among group, validity, and SOA, $F(6,99)=3.116$, $p=.008$. A priori simple effects tests were used to examine differential facilitation effects across groups. For the children with autism, facilitation was found at 200 ms, *Multi* $F(1,33)=4.503$, $p=.041$, 700 ms, *Multi* $F(1,33)=22.430$, $p<.001$, and 1100 ms, *Multi* $F(1,33)=11.937$, $p=.002$. For the children with Asperger syndrome, facilitation was found at 400 ms, *Multi* $F(1,33)=11.017$, $p=.002$. For the typically developing children, facilitation was found at 200 ms, *Multi* $F(1,33)=7.464$, $p=.010$ (Figure 3).

In the CCE condition, main effects of validity, $F(1,33)=50.077$, $p<.001$, and SOA, $F(3,99)=21.644$, $p<.001$, were found, as well as an interaction between group and validity, $F(2,33)=4.884$, $p=.014$, and an interaction between group, validity, and SOA, *Multi* $F(6,62)=2.903$, $p=.015$. A priori simple effects tests were used to examine differential facilitation effects across groups. For the children with autism, facilitation was found at 200 ms, *Multi* $F(1,33)=5.892$, $p=.021$, 400 ms, *Multi* $F(1,33)=23.912$, $p<.001$, 700 ms, *Multi* $F(1,33)=11.942$, $p=.002$, and 1100 ms, *Multi* $F(1,33)=37.658$, $p<.001$. For the children with Asperger syndrome, facilitation was found at 400 ms, *Multi* $F(1,33)=9.597$, $p=.004$. For the typically developing children, facilitation was found at 200 ms, *Multi* $F(1,33)=11.041$, $p=.002$, and 400 ms, *Multi* $F(1,33)=4.289$, $p=.046$ (Figure 4).

As the children with autism and the children with Asperger syndrome differed in overall performance mental age, it is difficult to determine how much of the difference

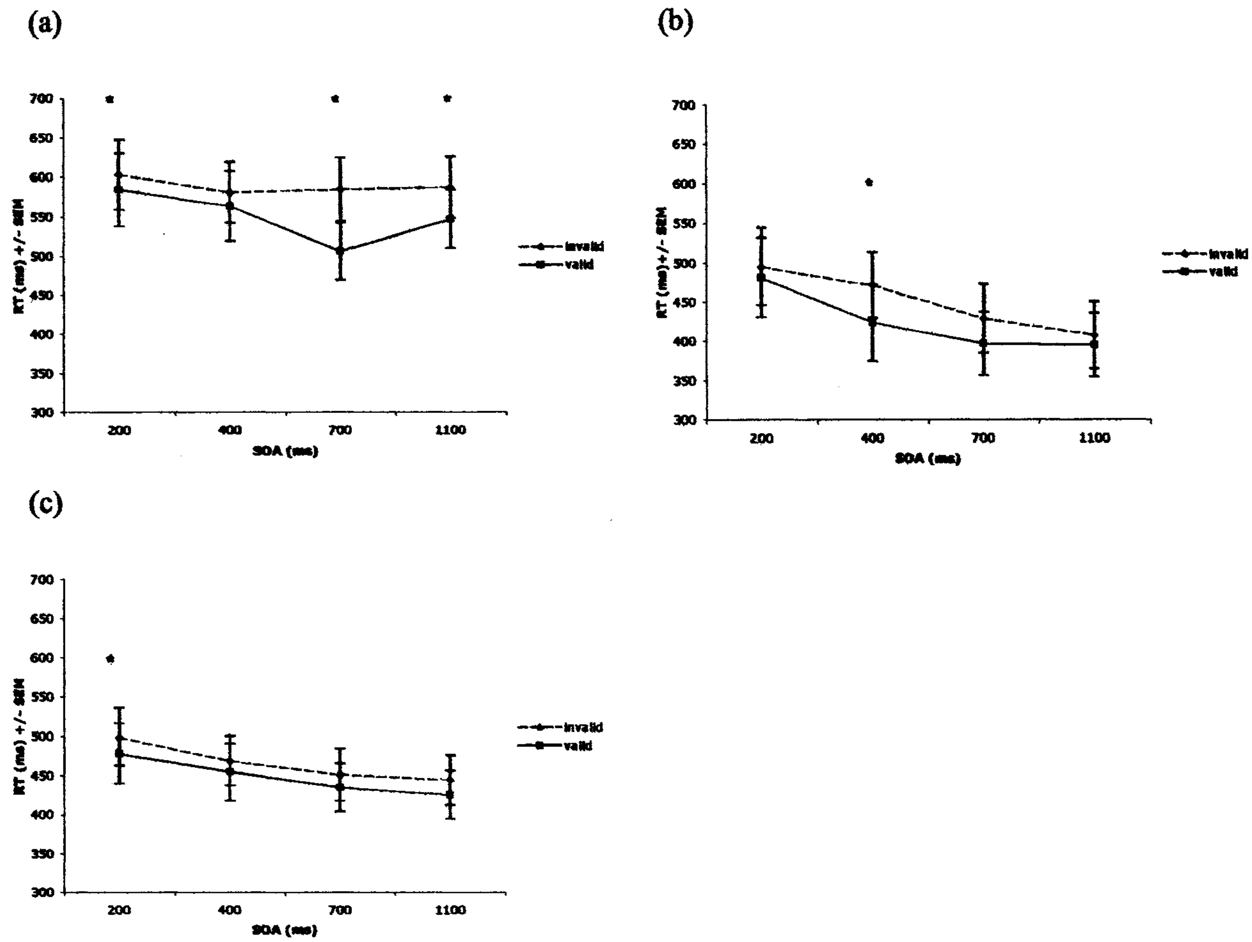

Figure 3. Performance of children with autism (a), Asperger syndrome (b), and typical development (c) on the VCE condition. Facilitation effects (invalid-valid) are statistically significant for children with autism at SOAs of 200, 700, and 1100 ms, for children with Asperger syndrome at SOA of 400 ms, and for typically developing children at SOA of 200 ms.

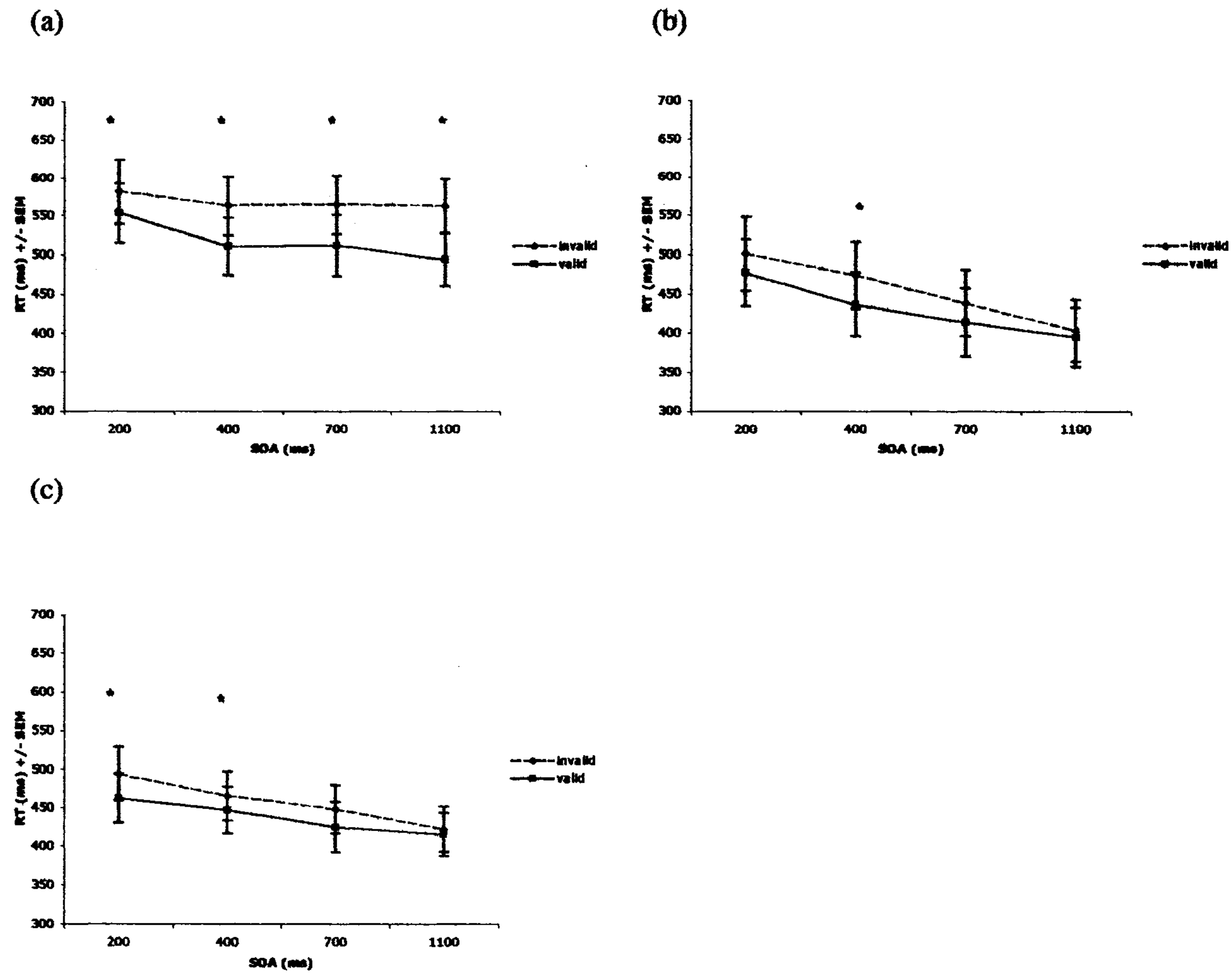

Figure 4. Reaction times of children with autism (a), Asperger syndrome (b), and typical development (c) on the CCE condition. Facilitation effects (invalid-valid) are significant for children with autism at SOAs of 200, 400, 700, and 1100 ms, for children with Asperger syndrome at SOA of 400 ms, and for typically developing children at SOAs of 200 and 400 ms.

between these two groups is attributable to differences in developmental level and how much is attributable to differences in severity of autistic symptoms between the two classifications. Correlations were run to examine the relationships between independent measures (chronological age, Matrix Reasoning, Block Design, performance mental age, performance IQ, and ASSQ scores) and reaction times on control tasks. Any independent measures that were significantly related to reaction time among the children with autism or the children with Asperger syndrome on control tasks could be used as covariates for analyses with the experimental tasks in an attempt to explain the pattern of results.

For the children with autism, a significant correlation was found between Cue and Block Design raw score (r=-.630, p=.038), and between Target and Cue (r=.697, p=.017). For the children with Asperger syndrome, no significant correlations were found for Target or Cue. For the typically developing children, significant correlations were found between Target and chronological age (r=-.629, p=.009), Block Design (r=-.707, p=.003) and performance mental age (r=-.705, p=.002), between Cue and chronological age (r=-.691, p=.003), Matrix Reasoning (r=-.554, p=.032) Block Design (r=-.668, p=.005) and performance mental age (r=-0.775, p<.001), and between Target and Cue (r=.886, p<.001).

Comparisons Between Autism and a Subset of Younger Typically Developing Children

As neither ASSQ scores nor performance mental age was correlated with reaction times for either the children with autism or the children with Asperger syndrome, neither of these measures could be used as a covariate in further analyses. Therefore, the children with autism (n=11) were compared to a subset of the typically developing children

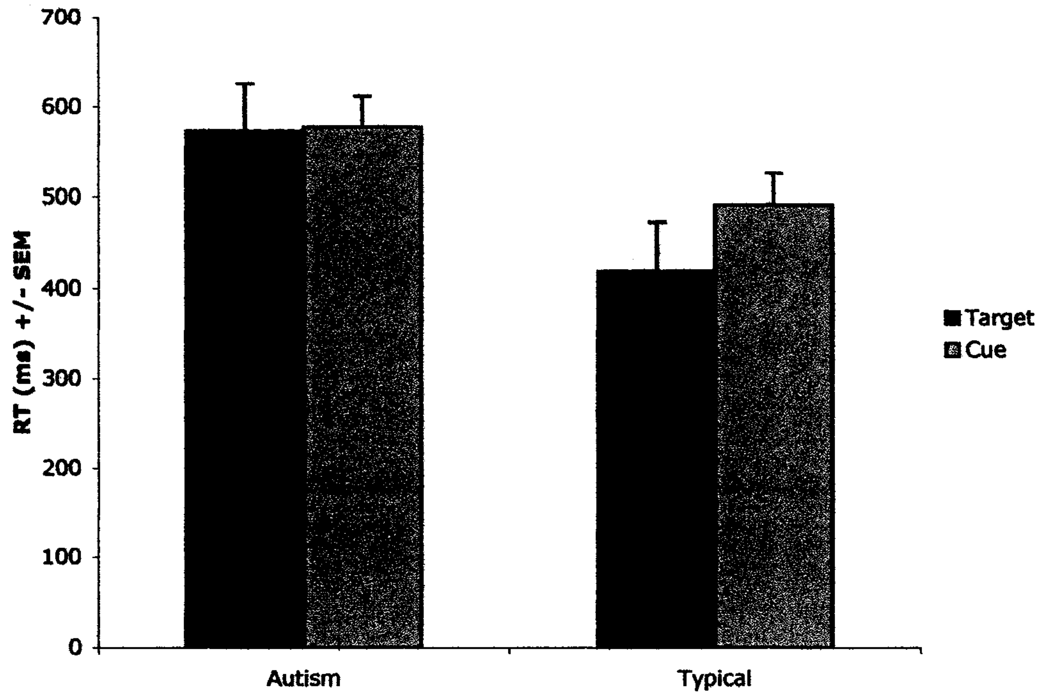

Figure 5. Reaction times of children with autism and performance mental age matched typically developing children on Target and Cue conditions. No significant differences were found, although there is a trend for a difference between conditions among typically developing children (p=.059) and a trend for a difference between groups on the Target condition only (p=.055).

(n=11) selected to better match on performance mental age (M_a=10.16, SD_a=3.78, M_t=11.02, SD_t=2.03, p=.518). While this does not elucidate the observed differences between children with autism and children with Asperger syndrome, this eliminates the possibility that the observed differences between children with autism and typically developing children are due to differences in developmental level.

Control Tasks

A mixed model ANOVA with group (autism vs. typically developing) as the between-subjects factor and task (target vs. cue) as the within-subjects factor was used to examine differences on the control tasks (Figure 5). No significant results were found, although simple effects tests revealed that the difference between tasks approached significance for the typically developing children (p=.059) and the difference between groups on Target approached significance (p=.055).

Experimental Task

Performance on each of the experimental conditions was examined using a mixed model ANOVA with group (autism vs. typically developing) as the between-subjects factor and validity (invalid vs. valid) and SOA (200 vs. 400 vs. 700 vs. 1100) as the within-subjects factors. In the VCE condition, main effects of validity, $F(1,20)$=26.044, p<.001, and SOA, $F(3,60)$=13.419, p<.001, were found, as was an interaction between group and validity, $F(1,20)$=4.377, p=.049, and an interaction among group, validity, and SOA, $F(3,60)$=2.948, p=.040. A priori simple effects tests were used to examine differential facilitation effects between groups. For the children with autism, facilitation was found at 200 ms, *Multi* $F(1,20)$=4.447, p=.048, 700 ms, *Multi* $F(1,20)$=21.031,

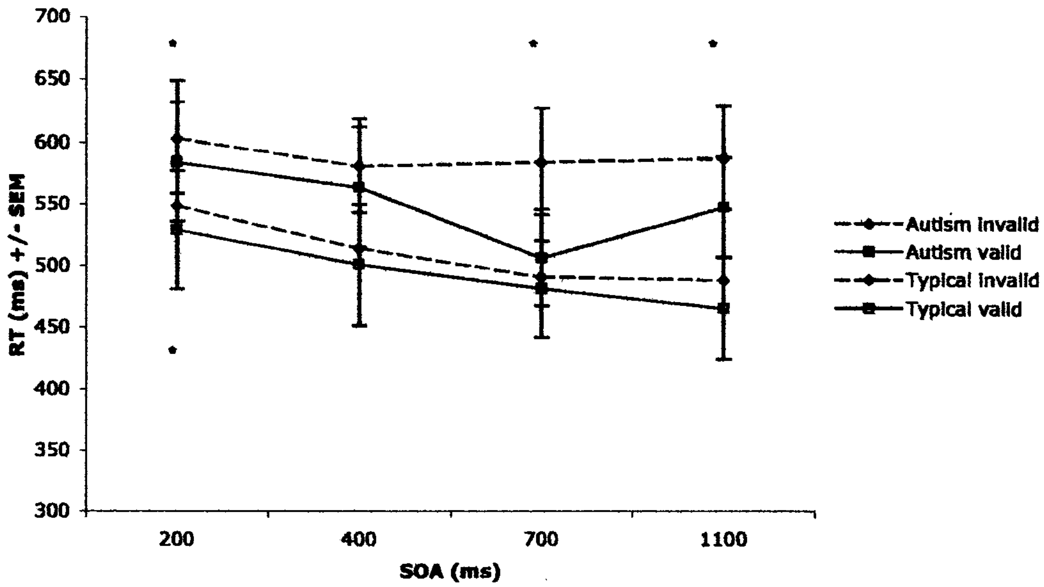

Figure 6. Reaction times on VCE condition for children with autism and performance mental age matched typically developing children. Facilitation effects (invalid-valid) are significant for children with autism at SOAs of 200, 700, and 1100 ms, and for typically developing children at SOA of 200 ms.

$p<.001$, and 1100 ms, *Multi* $F(1,20)=11.218$, $p=.003$. For the typically developing children, facilitation was found at 200 ms, *Multi* $F(1,20)=4.489$, $p=0.047$ (Figure 6).

In the CCE condition, main effects of validity, $F(1,20)=41.051$, $p<.001$, and SOA, $F(3,60)=14.071$, $p<.001$, were found, as was an interaction between group and validity, $F(1,20)=5.323$, $p=.032$, and an interaction among group, validity, and SOA, $F(3,60)=2.876$, $p=.043$. A priori simple effects tests were used to examine differential facilitation effects across groups. For the children with autism, facilitation was found at 400 ms, *Multi* $F(1,20)=27.280$, $p<.001$, 700 ms, *Multi* $F(1,20)=9.187$, $p=.007$, and 1100 ms, *Multi* $F(1,20)=29.952$, $p<.001$. For the typically developing children, facilitation was found at 200 ms, *Multi* $F(1,20)=8.765$, $p=.008$ (Figure 7).

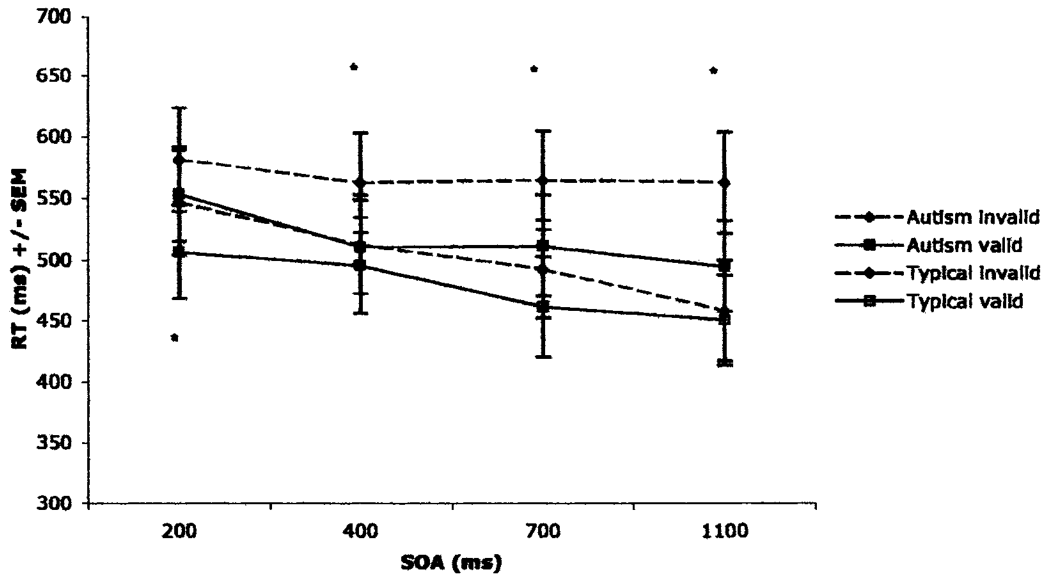

Figure 7. Reaction times on CCE condition for children with autism and performance mental age matched typically developing children. Facilitation effects (invalid-valid) are significant for children with autism at SOAs of 400, 700, and 1100 ms, and for typically developing children at SOA of 200 ms.

Discussion

This experiment was designed to test whether participants with ASDs require more time to view a symbolic cue, or whether a briefly seen cue is perceived and interpreted, but response selection is slower. The results of both the control and experimental tasks support the response selection hypothesis. Performance on the control conditions demonstrated that the participants with autism did not show the same increase in reaction time as the participants with Asperger syndrome and typically developing children between a simple target detection task and reading the meaning of the arrow; however, the participants with autism were slower overall on these control tasks (though not on the experimental tasks). There were no differences between the participants with Asperger syndrome and the typically developing children on simple target detection or in deciding whether the arrow points left or right, reading of the meaning of the arrow. On the experimental tasks, the participants with autism and Asperger syndrome diagnoses showed facilitation effects in both the VCE and CCE conditions. The presence of facilitation in both conditions indicates that the cue, even though non-predictive, affected behaviour. The presence of facilitation effects on the CCE condition demonstrates that the 100 ms cue affected behaviour. This facilitation was seen to peak at different SOAs in each group; it was earliest for the typically developing children (200 ms), then for the participants with Asperger syndrome (400 ms), and latest for the participants with autism (700 & 1100 ms).

The participants with Asperger syndrome and the typically developing children were well matched on performance mental age ($p>.5$); however, the participants with autism were not as well matched ($p=.164$). Therefore, a subgroup of younger typically developing children were selected to better match the participants with autism on performance mental age ($p>.5$) and the analyses were performed again. The results confirmed that the participants with autism displayed a different pattern of responding than the typically developing children, with facilitation effects observed at later SOAs for the children with autism than for the typically developing children.

Differences Between Autism and Asperger Syndrome

The participants with autism showed a very different pattern of responding than those in the other two groups. As there were no reliable differences between conditions, the most prudent conclusion is that the participants with autism showed facilitation across the board, equally on both conditions, however this facilitation was strongest at the later SOAs (700 & 1100 ms). Facilitation on both VCE and CCE conditions supports the response execution hypothesis because it clearly demonstrates that behaviour was influenced even by the 100 ms cue. What is surprising is the clear difference between autism and Asperger syndrome. The participants with autism exhibited facilitation at longer SOAs than the participants with Asperger syndrome, in both conditions. Though the groups differed in overall performance mental age but not ASSQ scores, this would seem to suggest that the difference between the groups is driven by differences in developmental level, not severity of symptoms; however, neither performance mental age nor ASSQ were correlated with performance in either group. Block Design raw scores were correlated with Cue reaction time for the children with autism, which may reflect the common visuomotor component of both tasks that is not relevant to Matrix Reasoning, and perhaps also a common goal-oriented endogenous component that is not relevant to Target reaction time.

Endogenous orienting may represent a skill that varies as a function of the autism spectrum and within the population at large. Subtle differences were found in endogenous orienting as a function of Autism-Spectrum Quotient score (Bayliss & Tipper, 2005), using Baron-Cohen, Wheelwright, Skinner, Martin, and Clubley's (2001) scale for measuring sub-clinical autistic traits in the typically developing population, and between typically developing men and women (Bayliss, di Pellegrino, & Tipper, 2005). These findings, along with the findings of this experiment, support ideas that place autism as an extreme on a normal continuum of behaviour, with Asperger syndrome as a milder manifestation, at least in terms of endogenous orienting.

Voluntary Control of Automatic Responses

The typically developing children ceased to show facilitation effects at longer SOAs. This suggests that participants are better able to mediate responding based on the predictability of the cue with longer SOAs, and that the typically developing children were able to do this with a shorter SOA than the children with Asperger syndrome or autism. Both experimental conditions included cues with 50% valid and 50% invalid cues, making the cues not informative in finding the target. The presence of facilitation effects with non-predictive arrow cues demonstrates the automaticity of responding to such a cue (Eimer, 1997; Friesen et al., 2004; Tipples, 2002), yet this automaticity is not the same as that of peripheral cues.

Jonides (1981) specified that peripheral and not central cues met criteria for automaticity because orienting to peripheral cues was not impaired by manipulating mental capacity, was resistant to deliberate attempts at suppression, and was not effected by expectancy. By expectancy, Jonides meant the expectancy of the occurrence of a certain type of cue (peripheral or central), not predictability of cues. He presented participants with blocks of trials that either contained a high proportion of peripheral cues and low proportion of central cues, or vice versa. The proportion of valid cues was consistent across both peripheral and central cues. However, facilitation effects for non-predictive arrows in conditions with 50% validity are found in both adults (Eimer, 1997; Friesen et al., 2004; Tipples, 2002) and typically developing preschoolers (Ristic et al., 2002).

Further, adults, but not children, can mediate the automatic response to peripheral cues according to the predictability of the cues (Brodeur & Boden, 2000; Enns & Brodeur, 1989). When presented with 80% valid (predictive) peripheral cues, adults displayed a larger facilitation effect than when presented with 33% valid (non-predictive) peripheral cues (Enns & Brodeur, 1989). Children 6 to 8 years old did not display different facilitation effects as a function of the predictability of cues, and at this age also displayed more difficulty on endogenous orienting tasks, while demonstrating adult-like exogenous orienting (Enns & Brodeur, 1989). By 9 to 12 years of age, typically developing children are able to mediate responses to non-predictive arrows, but not non-predictive eye gaze (Senju et al., 2004). This indicates that voluntary control can be exerted over automatic processes with varying degrees of success, depending on the stimuli. Plude, Enns, and Brodeur (1994) suggest that exogenous orienting is a more basic process that develops earlier than endogenous orienting, which requires more strategic or controlled processes.

Despite the evidence in the literature that facilitation is elicited in response to non-predictive central arrow cues, the behavioural patterns reported in such studies do not resemble that of peripheral cues as peak facilitation occurs at longer SOAs and there is an absence of inhibition of return. Further, responses to central cues do not fully meet Jonides' (1981) criteria for automaticity. The assertion that central cues elicit *automatic* responses must therefore be treated with caution as responses to central cues do not meet as strict a definition of *automatic* as those to peripheral cues. Instead, there may be a continuum of automaticity, whereby the degree of automaticity of a process is directly related to the difficulty in bringing that process back under voluntary control. A useful model to adopt is that of Enns and Trick (2006) who distinguish between *reflexive* and *habitual* responding. Reflexive responding meets Jonides' (1981) criteria, as well as neurophysiological definitions of reflex, whereas habitual responding refers to responses that become automatic through learning and practice. According to Enns and Trick (2006), the triggers for reflexes are innate, common to all, emerge on a developmental timetable, and are stable once acquired. However, triggers for habits are learned and thus can be acquired, fade, or replaced at anytime.

In the data presented here, participants with ASDs required longer SOAs than typically developing children to demonstrate both the habitual response to the arrow, and the controlled suppression of that response, as it was a non-predictive cue. Based on Enns and Trick's model, the groups with ASDs in this study displayed impairments in habitual responding, both in exhibiting the habitual response, and in extinguishing it. Perhaps learning of habits is impaired, which suggests more research needs to be done in the area of conditioning. Persons with ASDs demonstrated increased facilitation on an endogenous orienting task when the proportion of valid cues increased (Ristic et al., 2005), suggesting that learning occurs on such a task. Preliminary data by Gaigg and

Bowler (2005) indicate that there is a problem with classical conditioning in Asperger syndrome, and Hermelin and O'Connor (1970) point out that conditioning appeared problematic for many participants with ASDs in early Applied Behaviour Analysis experiments. Although differences between Asperger syndrome and autism observed in this study may be an artefact of differences in developmental level, the same cannot be said for the differences between either ASD group and the typically developing children.

Impaired Response Selection: Implications for Autism Spectrum Disorders

These data support the hypothesis that lengthened exposure to a symbolic cue improves performance for persons with ASDs because it provides more time to respond to the cue, and only a brief cue exposure is needed to trigger a response. Generalization of this hypothesis to typical development cannot be made based on this data as the only SOA level at which typically developing children demonstrated facilitation was 200 ms, which is actually the same trial in both the VCE and CCE conditions. In order to test this hypothesis in typically developing children, more rapidly presented cues within a shorter range of SOAs would have to be used.

In a previous study (Wainwright-Sharp & Bryson, 1993), persons with ASDs were not found to exhibit facilitation effects at 100 ms SOAs, but did exhibit facilitation at 800 ms SOA. The implication was that longer viewing time enabled the facilitation effects (Burack et al., 1997), but the data presented in this study indicate that persons with ASDs take longer to select the response, and a longer cue presentation inherently provides a longer response preparation time. These findings fail to support a perceptual level explanation as increasing the duration of the cue within the SOA had no effect above and beyond simply extending the SOA. Other findings that persons with ASDs exhibit facilitation effects at 800 ms SOA that were larger in magnitude to that of comparison groups (Casey et al., 1993; Harris et al., 1999; Wainwright-Sharp & Bryson, 1993) may be because facilitation effects do not follow a simple linear function, but follow a more complex quadratic function that is not evident when researchers use only two SOAs in their experiments. As the peak of facilitation for persons with ASDs occurs later than for typically developing peers, it is not surprising that persons with ASDs would show a larger orienting effect at 800 ms, as the effect may diminish by this point for the typically developing participants. A comparison of the findings of this study, in which non-predictive cues were used, to findings of studies in which predictive cues were used, is however difficult and speculative. Senju et al. (2004) used non-predictive cues and comparable SOAs to this study, however their arrows were substantially larger (7.5 x 3.5 degrees of visual angle) than those used in this study (less than one degree of visual angle) or by Wainwright-Sharp and Bryson (less than two degrees of visual angle; 1993), which may explain why the participants with autism in Senju et al.'s (2004) study exhibited facilitation at shorter SOAs (100 and 300 ms).

Visuomotor Planning in Autism Spectrum Disorders

The data presented in this study are consistent with a growing body of literature demonstrating problems in visuomotor planning, including reach-to-grasp, visual pursuit, and visual saccades in persons with ASDs that are indicative of impairments in strategic, voluntary, motor control rather than impairments in simple motor function. The results of these studies of other visuomotor skills indicate that the problems exhibited by persons with ASD on endogenous visual orienting tasks reflect general impairments in strategic goal-oriented behaviour. For example, Mari et al. (2003) reported that lower functioning children with ASDs were slower than higher functioning children with ASDs or typically developing children, though accurate, in their performance on a reach-to-grasp task. The lower functioning children showed less simultaneous activation of reaching and grasping, and this delay increased as a function of the precision needed to perform the task. They further reported that higher functioning children with ASDs, relative to typically developing children, executed very fast movements, as though once the action plan was finalized it must be performed quickly to avoid any disruptive feedback mechanisms. Mari et al.'s findings support findings by Masterton and Biederman (1983) that children with ASDs were unable to visually guide reaching movements very efficiently. These findings broadly suggest that children with ASDs have difficulty using external feedback to guide behaviour, at least with respect to visuomotor activity.

Eye movements also appear to be abnormal in children with ASDs. Takarae, Minshew, Luna, Krisky et al. (2004) tested children with ASDs on visual pursuit. The open loop stage of visual pursuit measures initiation of eye movement and is sensory driven, while the closed loop stage measures the ability to sustain the movement, and is feedback driven. Takarae, Minshew, Luna, Krisky et al. (2004) found that children with ASDs were impaired relative to typically developing children on both stages, however the impairments differed as a function of stage. In the open loop stage, impairments were only found for pursuit in the right hemifield, whereas closed loop stage impairments were found bilaterally. For children with ASDs, visual pursuit performance was correlated with motor praxis, as measured with the Grooved Pegboard, however for typically developing children, visual pursuit performance was correlated with motor speed, as measured by Finger Tapping. This suggests the presence of multiple impairments; both in visual perception for the right hemifield and in motor coordination that might impact control over both eye movements and shifting visual attention.

Kemner et al. (1998) speculated that poor control over eye movements might underlie abnormalities in visual attention among children with ASDs. Taking their cue from Hermelin and O'Conner's reports of abnormal looking behaviour during the course of experiments, Kemner et al (1998) measured children with ASDs' eye movements during a visual oddball task. The children were presented with three types of stimuli; frequent, rare, and novel. The children were familiarized with the frequent and rare stimuli at the beginning of the task. The comparison groups included typically developing children and children with ADHD and dyslexia. The children with ASDs made more eye movements between stimuli than all other groups, and during the presentation of the frequent stimuli than ADHD and typical groups. Further, unlike typical and children with dyslexia, the frequency of eye movements of children with ASDs did not differ as a function of stimulus type. Although the children with ASDs appeared to look at all stimuli as though it were novel, the high frequency of eye movements between stimuli suggests that they had a generalized difficulty controlling eye movements.

Kemner et al. (2004) followed these findings by testing smooth pursuit and saccadic eye movements in children with ASDs, but found no differences relative to typically developing children in a sample with a mean age of 10 years. Minshew et al. (1999) also found no differences between high-functioning young adults with ASDs and typically developing peers on a visually guided saccade task, finding instead that the participants with ASDs made more errors on an anti-saccade task and an oculomotor delayed response task. However, Takarae, Minshew, Luna, and Sweeney (2004) found reduced saccade gain, defined as the ratio of saccade amplitude over target distance, with normal saccade latencies in high-functioning adolescents/ young adults with Asperger syndrome, but not autism (mean age 16 years), suggesting that the deficit might be highly specific, subtle, and differ across ASD subgroups.

If persons with ASDs exhibited generalized impairments in visual saccades, this would indicate impairment in oculomotor control. However, the results of the experiments on visual saccade demonstrate that oculomotor control is generally intact, and like the findings on tasks of exogenous orienting discussed previously, excludes any bottom-up explanations of atypical visual attention behaviour. Similar conclusions were drawn by Hadjikhani et al. (2004) who reported that early sensory visual areas are normally organized in the brains of persons with ASDs. Rather, the evidence suggests that visuomotor control falls apart when it is goal-driven (or feedback dependent?) rather than simply sensory driven. Visual orienting differences exhibited by persons with ASDs stem from poor strategic control over visual attention and eye movements, and are a symptom of poor control over visuomotor coordination in general.

Limitations and Future Directions

The unexpected but robust difference found in this study between autism and Asperger syndrome is difficult to interpret due to the developmental level difference between the two groups. Autism and Asperger syndrome are often discussed in terms of a continuum; however, Klin et al. (2000) argue that this continuum is multidimensional and complex. Endogenous orienting might be one of those dimensions. A limitation to examining this continuum is the lack of measures intended to differentiate groups within the spectrum. The goal of researchers developing newer and better ratings scales is to be more inclusive, rather than exclusive, so that more children can be identified to receive services. The purpose of the rating scale used in this study was to identify children who are higher functioning and in general education settings for more comprehensive evaluation, not to differentiate autism from Asperger syndrome, thus it should not come as a surprise that the scores of the two groups did not differ. Despite the fact that differentiating within the spectrum is not the goal of diagnostic ratings scales, a more comprehensive measure such as the Autism Diagnostic Observation Schedule (Lord, Rutter, & Le Couteur, 1994) might have provided more data with which to correlate with performance in an attempt to interpret the differences between the participants with autism and Asperger syndrome in this study. The differences in performance mental age between the groups of children with autism and Asperger syndrome may also be the reason for differential facilitation effects, revealing a single developmental trajectory for endogenous orienting among children with ASDs but that differs from that of typically developing children.

Another consideration is that a key diagnostic difference between autism and Asperger syndrome is the presence or absence of early language delays, and as such a measure of verbal IQ and verbal mental age may have shed light on the differences observed between these two groups. The verbal subscales of the WASI were initially used with some participants, but as a large number of participants were not native English speakers, this was abandoned. Few other differences are reported between persons with autism and Asperger syndrome when matched for developmental level, and Klin et al. (2000) stress that differences in diagnostic criteria often confound the issue, thus more research is clearly needed on this subject.

Two methodological considerations that were beyond the scope of this study, but are worth investigating are the use of eye-tracking technology and laterality. Eye-tracking would provide valuable insight into this task. First, as the participants were instructed to maintain fixation at the centre of the screen throughout the task, eye-tracking technology would have been able to verify if indeed they were able to do so, and if not, it would measure how eye movements corresponded to shifts in attention across groups. Second, several research groups report atypical laterality effects for participants with autism on visual attention tasks (Casey et al., 1993; Takarae, Minshew, Luna, Krisky et al., 2004; Wainwright & Bryson, 1996). In order to examine laterality in this experiment, the number of trials would have doubled. This would have made the task too long for the participants to complete without risk of excessive fatigue, and laterality effects were not a priority for this particular investigation.

Contributions to Knowledge

This thesis provides a unique contribution to scientific knowledge in that basic assumptions about the effects of cue exposure duration and trial duration within visual orienting were challenged. Since Burack et al. (1997) published the hypothesis that persons with ASDs exhibit impaired performance on endogenous orienting due to impairments in reading the symbolic meaning of the cue, the hypothesis has been frequently cited throughout the literature, but neither explicitly tested nor elaborated. This is the first study to examine and attempt to falsify Burack et al.'s hypothesis. There will be differences of opinion regarding whether or not the results of this study do in fact falsify Burack et al.'s original hypothesis based on differences in interpretation of the original hypothesis and at what level, perceptual or response selection, falls reading the meaning of a stimulus. Regardless of how one interprets Burack et al.'s original hypothesis, the results of this study indicate that persons with ASDs require more time to select an appropriate response to a symbolic cue, and that responses are triggered equally by very briefly seen cues. Therefore, the results of this study clarify at what level the problems of interpretation of a meaningful or symbolic cue may occur. The results of this study will inform the design of future experiments that employ visual orienting paradigms as well as the examination of how children with ASDs derive and attribute meaning to symbolic cues. Further, the inclusion of both participants with autism and Asperger syndrome, and the observed differences between the two reported in this study, will inspire further research on attention and symbolic cue use in these two ASD subgroups as separate groups to determine whether the differences reflect developmental differences or ASD spectrum differences.

Conclusion

In conclusion, participants with ASDs exhibited behavioural effects of rapidly presented symbolic cues, but required longer SOAs to exhibit that effect. The results clearly indicate that Burack et al.'s (1997) hypothesis that persons with ASD are slower to read the meaning of a symbolic cue is not a question of reading so much as a question of reacting to symbolic cues. Nonetheless, symbolic cues present a serious obstacle for persons with ASDs navigating a dynamic environment. Remediation should focus on more skills training for persons with ASDs as opposed to modifying their environment. Further, unexpected differences between two ASD subgroups highlight the need for more research on this matter and better tools to distinguish within the spectrum.

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Appendix A

PLEASE ANSWER THE FOLLOWING ABOUT YOUR CHILD:

1. What was your child's diagnosis?
   - ☐ Autism
   - ☐ Asperger syndrome
   - ☐ Pervasive Developmental Disorder (PDD or PDD-NOS)
   - ☐ Other ____

2. By whom was it made?____________________________________

3. How old was your child at the time?__________________________

4a. Does your child have any additional diagnoses that might affect his or her performance in school?
   - ☐ Tourettes syndrome
   - ☐ Attention Deficit Hyperactivity Disorder (ADHD or ADD)
   - ☐ Other ____

4b. Were these made by the same doctor as the autism diagnosis? Y/ N

4c. If not, by whom?_____________________When?___________________

5. Please list any medications your child is currently taking:

____

____

6. Is there anything you would like me to know about your child before participating?

____

____

____

Appendix B

Verbal Assent Script (for participants under 13 years)

You will be asked to do some different things. First you will play a special computer game, then we will play some games with patterns, and then I will ask you to tell me about some words you might know.

Do you understand?

I will tell you how to play each of the games as we go along. If you don't understand you can ask me for help. You may stop at any time. Your performance in the study will not be reported to anyone, including your parents or teachers (if applicable).

Do you understand?

Experimental Instructions

You are going to play four games. In each game you get to practice a bit before it starts.

During the games, try to keep your head still, and keep your eyes on the centre of the screen at all times. You will get to rest your eyes and stretch during several short breaks.

Conditions A, B, & T

Place your fingers on the keys marked with the X stickers. When you see the letter X appear on the screen, press the button for which side it appeared. So if the X appears on this (left) side, press with this (left) finger. If the X appears on this (right) side, press with this (right) finger. Try to press the button as fast as you can when you see the X, without making mistakes.

Condition C

Place your fingers on the keys marked with the X stickers. When you see the arrow appear on the screen, press the button for which side it points. So if the arrow points to this (left) side, press with this (left) finger. If the arrow points to this (right) side, press with this (right) finger. Try to press the button as fast as you can when you see the arrow, without making mistakes.

Appendix C

Parent/Guardian Consent Form

This is to state that I allow my child to participate in the study entitled *The Role of Symbolic Cues in Visual Orienting among Persons with Autism Spectrum Disorders*. This project is conducted under the joint supervision of Prof. Peter Mitchell, University of Nottingham, and Prof. Jacob Burack, McGill University, Montreal, Canada.

1. **Purpose**
   I have been informed that the purpose of this research is to study attentional processes in children. I understand that the data gathered will provide answers to important questions about the development of attention, which is essential to daily life for persons of all ages.

2. **Procedures**
   I understand that my child will be asked to participate in tasks that involve a specially designed computer game, as well as general reasoning and language assessments. I have been informed that the tasks present no known risk and have been used before with children of the same age as my child. Everything my child is asked to do will be explained to him/her beforehand. If my child wishes to stop or not perform the task, he/she may do so at any point. I understand that my child's performance in the study will not affect his or her status within their educational program.

3. **Conditions of Participation**
   I understand the purpose and procedures of this study.

I understand that my child's identity will remain anonymous and all information about him/her will be kept confidential. I have been advised that the data will be used for research purposes only. I consent to the published reporting of this study so long as the results are reported as group averages and my child's name or any other personal information is never used in these reports.

I understand that the researcher involved will be available to answer any questions regarding the procedures of this study.

****

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND MY PARTICIPATION IN THIS AGREEMENT. I VOLUNTARILY AGREE AND FREELY CONSENT FOR MY CHILD TO PARTICIPATE IN THIS STUDY.

________________________ ________________________

Child's Name Child's Date of Birth

________________________ ________________________

Date Signature of Parent or Guardian

Appendix D

Participant Consent Form (for participants over 13 years)

This is to state that I agree to participate in the study entitled *The Role of Symbolic Cues in Visual Orienting among Persons with Autism Spectrum Disorders*. This project is conducted under the joint supervision of Prof. Peter Mitchell, University of Nottingham, and Prof. Jacob Burack, McGill University, Montreal, Canada.

Purpose
I have been informed that the purpose of this research is to study attentional processes. I understand that the data gathered will provide answers to important questions about the development of attention, which is essential to daily life for persons of all ages.

Procedures
I understand that I will be asked to participate in tasks that involve a specially designed computer game, as well as general reasoning and language assessments. I have been informed that the tasks present no known risk and have been used before with participants of the same age as me. Everything I will be asked to do will be explained to me beforehand. If I wish to stop or not perform the task, I may do so at any time. I understand that my performance in the study will not affect my status at school (if applicable).

Conditions of Participation
I understand the purpose and procedures of this study.

I understand that my identity will remain anonymous and all information about me will be kept confidential. I have been advised that the data will be used for research purposes only. I consent to the published reporting of this study so long as the results are reported as group averages and my name or any other personal information is never used in these reports.

I understand that the researcher involved will be available to answer any questions regarding the procedures of this study.

****

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND MY PARTICIPATION IN THIS AGREEMENT. I VOLUNTARILY AGREE AND FREELY CONSENT FOR MY PARTICIPATION IN THIS STUDY.

_________________________ _________________________

Date Signature