Slow Motor Responses to Visual Stimuli of Low Salience in Autism

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ABSTRACT. The authors studied 2 tasks that placed differing demands on detecting relevant visual information and generating appropriate gaze shifts in adults and children with and without autism. In Experiment 1, participants fixated a cross and needed to make large gaze shifts, but researchers provided explicit instructions about shifting. Children with autism were indistinguishable from comparison groups in this top-down task. In Experiment 2 (bottom-up), a fixation cross remained or was removed prior to the presentation of a peripheral target of low visual salience. In this gap-effect experiment, children with autism showed lengthened reaction times overall but no specific deficit in overlap trials. The results show evidence of a general deficit in manual responses to visual stimuli of low salience and no evidence of a deficit in top-down attention shifting. Older children with autism appeared able to generate appropriate motor responses, but stimulus-driven visual attention seemed impaired.

Keywords: autism, manual responses, reaction time, visual attention

Human motor behavior is often elicited by visual stimuli. Thus, the ability to generate an appropriate movement in response to visual information is a key aspect of human performance. The generation of an appropriate response frequently requires the detection of a visual stimulus and the orientation of gaze (because humans are foveate animals). For example, swatting a fly often requires the fly to be detected in peripheral vision, the fly to be fixated, and then the hand brought to the point of fixation. The mechanisms of detection and gaze orienting are often referred to as processes of visual attention (Posner, 1980). In the example provided, the change in gaze direction is driven by detection of the fly in peripheral vision. This is often referred to as a bottom-up shift in visual attention where some salient feature of the surround draws gaze. In some cases, however, top-down processes produce shifts in visual attention, where humans make a strategic sequence of fixations to explore the surrounding environment, searching for task-relevant information prior to generating a response (e.g., with the hand).

Autistic spectrum disorders (ASD) have been associated with problems in shifting visual attention (e.g., Tager-Flusberg, Joseph, & Folstein, 2001; Townsend, Harris, & Courchesne, 1996; Wainwright-Sharp & Bryson, 1993). Past research with children with autism has shown problems with over-focused attention. Riconder and Ducharme (1987) found that children with autism were overly selective in how they generalized learning for pairs of cues defined by physical separation. If the cues were connected to each other, the children with autism were less able to treat the pair as separate. Townsend, Courchesne, and Egaas (1996) suggested there is a neuroanatomically defined subset of autism defined by parietal abnormalities producing a specific deficit in shifting visual attention (see also Townsend et al., 1999). Therefore, it has been hypothesized that attention dysfunction is a central feature of autism (van der Geest, Kemner, Camfferman, Verbaten, & van Engeland, 2001).

One phenomenon used to investigate visual attention in autism is the gap effect. This phenomenon occurs when participants respond to a peripheral target in trials where the presentation duration of a central fixation point is manipulated. In gap trials, the central fixation is removed prior to the target onset, whereas in overlap trials, the fixation point remains in place for the entire trial. Reaction times are faster for ‘gap’ trials (e.g., Reulen, 1984a, 1984b; Reuter-Lorenz, Hughes, & Fendrich, 1991; Saslow, 1967). The gap effect was initially shown in eye movements (Saslow) but also occurs with manual responses (e.g., Bekkering, Pratt, & Abrams, 1996; Iwasaki, 1990; Tam & Stelmach, 1993).

Landry and Bryson (2004) explored the gap effect in children with autism (15 children, aged 3–7 years, M age = 5.6 years) in two conditions. Landry and Bryson reported that the magnitude of the gap effect was much larger in the autistic group relative to the comparison group (i.e., the overlap trials showed much longer reaction times; RTs) and suggested that this was evidence of a deficit in shifting visual attention. The gap effect is essentially a test of bottom-up stimulus-driven attention shifting (i.e., the response must be triggered by detection of the peripheral stimulus). However, as noted previously, visual attention can also be shifted strategically—in a top-down fashion—such as when individuals visually explore a scene for information. These are related but distinct processes, and the difficulties reported by Landry and Bryson for the children with autism may (or may not) only reflect a problem with bottom-up attention shifting rather than both top-down and bottom-up attentional processes.

There is little work in autism research that separates out top-down processing. One exception is Greenaway and Plaisted (2005). Children with autism in this study were able to make top-down modulations of bottom-up attention shifting, but only when the top-down cue was color; the children with autism were unable to be cued by an onset cue. This suggests that top-down processes may be

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intact if the cue that allows the top-down process to work is detected. Greeneway and Plaisted note that children with ASD are known to have difficulty processing rapidly moving stimuli—if this is the case then their failure to use the cue may reflect less on their top-down abilities and more on their bottom-up, detection difficulties.

Therefore, there is a sparse and mixed literature on visual attention in autism that addresses the differences in top-down versus bottom-up processes. In the present study, we explored both these processes in a sample of children with autism, looking for differences in RTs relative to comparison groups in two tasks. We decided to test slightly older children with autism (7–15 years) than Landry and Bryson (2004) to investigate the hypothesis that attention deficits are a stable feature of individuals with autism (i.e., the deficits can still be detected at a later developmental stage; van der Geest et al., 2001). However, we were particularly interested in exploring whether there were differences in top-down (Experiment 1) versus bottom-up (Experiment 2) attention shifts. Experiment 1 used a condition where participants had to voluntarily shift their gaze in a top-down fashion to succeed at the task. On the basis of Greenaway and Plaisted (2005), we predicted that if the top-down cue we provided was comprehended, the children with autism should show normal reaction times. Experiment 2 used a version of the gap effect paradigm to investigate bottom-up attention shifting. Here we expected to replicate the exaggerated gap effect Landry and Bryson described in their (younger) sample of children with autism, assuming this effect reflects a stable feature of autism. In both experiments, participants were adults, a broad age range of typically developing children, and a group of children with autism. This provided a context of the typical developmental path for performance in this task and allowed us to identify where along this path the children with autism lie, relative to their expected performance given their chronological age. All participants had normal or corrected-to-normal eyesight and no history of ophthalmological problems. The adults all first read and signed an information sheet and consent form and were briefed by the experimenter and then tested. The parents of the children were sent information, signed, and returned a consent form before their child was included in the study. All children gave verbal consent to participate at the beginning of the experiment. After testing, the participants (or parents) were free to ask questions regarding the experiment. The experiments received ethical approval from the local University and National Health Service Research Ethics Committees and were performed in accordance with the principles in the Declaration of Helsinki.

**EXPERIMENT 1: BASELINE RT AND TOP DOWN**

**Method**

The first task in Experiment 1 was a straightforward RT task, where participants fixated a target and indicated the direction it had moved as quickly as possible. The second task was an extension of this in which the response required determining the location to which two stimuli (separated by 32° of visual angle) had moved, forcing a top down driven gaze shift (see Figure 1).

**Participants**

Five groups participated in Experiment 1. Group 1 (adults; aged 21–26 years, M age = 23.2 years; 10 women, 9 men; n = 19) were from the University of Aberdeen. Group 2 (5–8 years, M age = 7.5 years; 6 boys, 6 girls; n = 12), Group 3 (aged 9–11 years, M age = 10.3 years; 9 boys, 6 girls; n = 15) and Group 4 (aged 12–15 years, M age = 13.2 years; 9 boys, 11 girls; n = 20) were students from a primary school and a high school. Group 5 (aged 9–15 years, M age = 11.1 years; 14 boys, 3 girls; n = 17) were children diagnosed with autism (i.e., met the criteria for autism on the Autism Diagnostic Observation Schedule [ADOS]; Lord et al., 2000) and were high-functioning. These children were recruited through the Department of Child and Family Mental Health of the Royal Aberdeen Children’s Hospital, having been diagnosed by a child psychiatrist using the Autism Diagnostic Interview–Revised (ADI-R; Lord, Rutter, & Le Couteur, 1994), the ADOS (Lord et al., 2000), and clinical observation. All scored normally (i.e., performance fell within the age-appropriate range and can be considered normal verbal IQ for the age; see Table 1) on the British Picture Vocabulary Scale (BPVS) and attended mainstream schools. The BPVS is not a comprehensive test of IQ but allowed us to confirm that the children had the necessary verbal skills to understand the task instructions. These participants were the same as in Experiment 2, with the exception of 2 who did not complete both experiments due to fatigue.

**Apparatus**

Stimuli were displayed on a Toshiba Tecra M4 tablet laptop screen (14.1-in. monitor, 1,280 × 1,024 pixel resolution, 32-bit True Colour, 60 Hz refresh rate). All experiments were run in Superlab Pro, which presented the stimuli and recorded RT. A USB keyboard used for the key-press responses was placed on the table. Adults and older children used a headrest to maintain a constant viewing distance, but the younger children were unable to use the headrest and were therefore monitored by the experimenter. All the younger children were able to hold adequately still for the duration of the experiment, and there were no task relevant problems noted.

**Procedure**

In a dimly lit room (~100 lux), participants sat 20 cm from the monitor. They rested their index finger of their left hand on the A key (for left responses) and the index finger of the right hand on the L key (for right responses) on the USB keyboard in front of them. The stimuli (illustrated schematically in Figure 1) consisted of two frames animations depicting a black X and two black circles (all ~1.4
Manual Response Gap Effect

The X was placed ~32° of visual angle above the dots, which were ~14° from each other. A thin black line went vertically through the starting position of the upper X and horizontally through the starting position of the lower dots. The black line was used to provide participants with a reference frame for both the X and the circles.

There were two blocks in which the rules governing the correct response changed. In Block 1 (baseline; 20 trials), only the X moved in the second frame (by ~0.2° to the left or right) and the correct response was the direction in which it moved: left (by pressing the A key) or right (by pressing the L key). In Block 2, both the X and the dots moved in the second frame (again, ~0.2°). The dots could move either up or down; if the dots moved up, the correct response was the direction in which the X moved (congruent; 20 trials). If the dots moved down, the correct response was the opposite direction to the direction in which the X moved (incongruent; 20 trials). Having both congruent and incongruent trials randomly presented in Block 2 forced the participants to attend to both locations to be able to generate the correct response at more than chance levels.

The distance between the X and the dots (32°) was large enough to force a gaze shift to foveate and identify the behavior of the stimuli, and this gaze shift was made explicit in the instruction set. This manipulation ensured that the participants (including the autism group, who had BPVS scores in the normal range) had comprehended the top-down cue (cf Greenaway & Plaisted, 2005). Participants could therefore explore the stimulus using top-down control of attention. The mix of congruent and incongruent trials also meant that the response was not simply contingent on detecting the change in the stimulus—the change had to be interpreted after appropriate exploration of the stimulus (i.e., checking the final location of the X and the dots).

Each trial began with the X and dots on their respective lines. Participants were instructed to make an initial fixation on the cross but that their gaze was free to vary after that. This frame remained for 1,250 ms before the X moved either to the left or right (Block 1) or both the X and the dots moved (Block 2). The second, final frame (depicting the final, static position after the change) stayed on the screen until the participant responded “as quickly but as accurately as possible.” There were 6 practice trials before each block to familiarize the participants with the rule, followed by a block of 20 trials (10 requiring a left response, 10 requiring a right response). Trials were presented in a random order within the block, and the session lasted approximately 3 min. The main

FIGURE 1. Schematic of Experiment 1 design (stimuli not drawn to scale). In the baseline and congruent trials, the correct response was the direction the X had moved. In the incongruent trials, the correct response was opposite to the direction the X had moved. The second, final frame remained on the screen until there was a response.
dependent measure was the average RT to respond with the correct button press.

The task tested (a) whether the autistic group showed a normal baseline choice reaction time (baseline trials in Block 1) and (b) whether a large spatial separation (which forced a top-down driven attention shift) affected if the autistic group could use the two pieces of information to generate the correct response (congruent and incongruent trials in Block 2).

**Results and Discussion**

Errors were low overall (< 1% of all trials) and data from these trials were omitted from the analysis. We performed two repeated-measures analyses of variance (ANOVA)s on the average RT data, first looking at baseline performance and then at performance that required a shift of visual attention. The data for the two analyses are presented in Figure 2.

The first ANOVA had direction, (two levels: left, right) as a within subject factor and group (five levels: adults, 5–8 years, 9–11 years, 12–15 years, children with autism) as a between subject factor, and analyzed only the data from the baseline condition. There were no statistically reliable main effects or interactions (all \(p > .25\), all partial \(\eta^2 < .056\)).

The second ANOVA compared data from the congruent and incongruent conditions and had condition (two levels: congruent, incongruent) and direction as within subject factors and group as a between-subject factor. There was a significant main effect of condition, \(F(1, 78) = 15.5, p < .01\), partial \(\eta^2 = .166\), and of group, \(F(4, 78) = 6.4, p < .01\), partial \(\eta^2 = .246\). No other effects or interactions were significant (all \(p > .13\), all partial \(\eta^2 < .086\)). The main effect of condition was driven by RT in the congruent condition being smaller than in the incongruent condition—the most likely reason is that the required response is congruent with the movement of the X, combined with the fact that in the congruent condition the dots move up (towards the X) and thus make the required gaze shift slightly smaller and therefore faster. The main effect of group is driven by two effects—adults showed significantly smaller RTs than all other groups (all post hoc pairwise comparison \(p \text{ values } < .05\)), whereas the 5- to 8-year-old group’s RTs were significantly larger (i.e., slower) than all groups (all post hoc pairwise comparison \(p \text{ values } < .01\)). Most importantly, the autism group was not different from either of the older groups of children (i.e., the comparison children they were the same age as). This comparison is relevant because of the normal verbal IQ of the children with autism.

There are two main conclusions from these data. First, the children with autism did not have any baseline RT deficits, and second, they were not different from the other groups in their ability to perform a top-down attention shift to detect and use two sources of information. Overall, therefore, the children with autism performed at an age-appropriate level on both tasks, and we can conclude their top-down attention shifting mechanisms appear intact.

### Table 1. Participant Information for Children With Autism

<table>
<thead>
<tr>
<th>Identification</th>
<th>Age at testing (years, months)</th>
<th>BPVS score</th>
<th>Age equivalent</th>
<th>Percentile</th>
<th>Rank</th>
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<tbody>
<tr>
<td>P1</td>
<td>10, 8</td>
<td>79</td>
<td>7.06</td>
<td>8</td>
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</tr>
<tr>
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<td>13, 7</td>
<td>98</td>
<td>13.04</td>
<td>45</td>
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<tr>
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<tr>
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<td>34</td>
<td>Average low</td>
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<tr>
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<td>11, 7</td>
<td>129</td>
<td>16.04</td>
<td>97</td>
<td>Moderate high</td>
</tr>
<tr>
<td>P6</td>
<td>11, 6</td>
<td>91</td>
<td>10.02</td>
<td>28</td>
<td>Average low</td>
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<tr>
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<td>11, 2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>P8</td>
<td>13, 11</td>
<td>105</td>
<td>14.07</td>
<td>63</td>
<td>Average high</td>
</tr>
<tr>
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<td>14.01</td>
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<td>Average low</td>
</tr>
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<td>75</td>
<td>9.08</td>
<td>5</td>
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<td>P11</td>
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<td>88</td>
<td>7.07</td>
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<td>Average low</td>
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<td>14, 3</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>P13</td>
<td>12, 4</td>
<td>116</td>
<td>14.10</td>
<td>86</td>
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<tr>
<td>P14</td>
<td>9, 1</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>P15</td>
<td>10, 2</td>
<td>94</td>
<td>9.01</td>
<td>34</td>
<td>Average low</td>
</tr>
<tr>
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<td>12.07</td>
<td>32</td>
<td>Average low</td>
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<tr>
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<td>85</td>
<td>12.01</td>
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<td>7, 6</td>
<td>84</td>
<td>5.06</td>
<td>14</td>
<td>Moderate low</td>
</tr>
</tbody>
</table>

*Note.* British Picture Vocabulary Scale (BPVS) data not available for P7, P12, and P14 as they declined to participate on the BPVS at the time of testing.
Because a known fixation bias to the right (Jordan & Patching, 2006) can otherwise affect error, subtending approximately 3.6° of visual angle. Moving to one side or another prior to these risks going the wrong way and missing a target at the other edge, which would reveal itself in abnormally long RTs. Top down, exploratory eye movements are therefore inefficient and unlikely—the task is best achieved by maintaining fixation and waiting to detect the peripheral stimulus.

**Procedure**

There were two types of trial: gap and overlap (Figure 3 depicts the task structure). In the gap trials, the central fixation cross appeared in the center of the screen and remained for 2 s before disappearing. After a variable interstimulus interval (ISI) of 600, 800, 1,000, 1,200, or 1,400 ms (randomized across trials), the imperative stimulus (small cross) was presented on either the left or the right side of the screen. The imperative stimulus remained on the screen until the participant responded with the correct key press (A or L key for left and right stimuli, respectively).

We used a variable ISI because when the timing of the displays is constant, participants are able to respond much faster as they anticipate when a response is expected. The variable ISIs used here meant that the offset of the fixation cross in the gap trials did not predict the specific onset of the peripheral targets. We used these longer ISIs to increase the temporal uncertainty. This then means that the measured RT is directly related to the characteristics of the independent variables, with less contribution from uncontrolled variables such as anticipation. Therefore, this task is now a strong test of the ability of participants to have their attention shifted by stimulus properties, in a bottom-up fashion.

Overlap trials were identical except that the central fixation point remained on the screen during the variable interval and presentation of the peripheral stimuli. Participants pressed the spacebar to progress to the next trial.

There were a total of 60 trials: There were two conditions (gap, overlap), two imperative stimuli (left, right), and five ISIs, with three repetitions of each trial type. The 60 trials were presented in a random order over a session that lasted approximately 10 min. Participants were also given five practice trials so they had experienced the possible trial types at least once. The participants were given verbal encouragement when required. The main dependent measure was the average RT to correctly respond with the A or L key for left and right stimuli, respectively.

**Results and Discussion**

A repeated-measures ANOVA was carried out on the average RT data, with condition (two levels: gap, overlap) and imperative stimulus (two levels: left, right) as within subject factors, and group (five levels: adult, 5–8 years, 9–11 years, 12–15 years, autism) as a between subject factor.

There was a main effect of both condition, $F(1, 93) = 8.2, p < .01$, partial $\eta^2 = .081$, and imperative stimulus, $F(1, 93) = 8.7, p < .01$, partial $\eta^2 = .086$, but these were modified by

![Image of a bar chart](image.png)

**FIGURE 2.** Average reaction time data from Experiment 1, plotting the baseline data (black columns) and the congruent (grey columns) and incongruent (white columns) data. Error bars indicate between group variability (standard error). Post hoc tests confirmed that adults were faster than all other groups, the 5–8 year-olds were slower than all other groups, and the autism group was not different from the older comparison groups.

**EXPERIMENT 2: GAP EFFECT AND BOTTOM-UP**

**Method**

As in Experiment 1, Group 1 (adults; aged 21–26 years; $n = 12$) from the University of Aberdeen participated. Group 2 (aged 5–8 years, $M$ age = 6.1 years; 18 boys, 12 girls; $n = 30$), Group 3 (aged 9–11 years, $M$ age = 9.8 years; 7 boys, 13 girls; $n = 20$), and Group 4 (aged 12–15 years, $M$ age = 13.3 years; 12 boys, 6 girls; $n = 18$) were different students from a primary school and a high school (recruited as described in Experiment 1). Group 5 (aged 9–15 years, $M$ age = 12.3 years; $n = 18$) was the same group of children with autism as in Experiment 1, with the addition of 1 male child.

**Apparatus**

Stimuli were displayed with the same equipment and software as in Experiment 1. A black cross ($51 \times 52$ pixels, subtending approximately $3.6 \times 3.6^\circ$ of visual angle) served as the central fixation stimulus. The fixation cross was located off center ($2^\circ$) because a known fixation bias to the right (Jordan & Patching, 2006) can otherwise affect the gap effect. Two smaller crosses ($12 \times 15$ pixels, subtending approximately $0.7 \times 1.0^\circ$ of visual angle) served as the imperative stimuli, appearing on the outer border of the screen 14 cm ($38.65^\circ$) from the center. Again, this distance is sufficient to necessitate an overt gaze shift, but this time it is stimulus driven (i.e., only occurs when a stimulus is detected in the periphery). Moving to one side or another prior to these risks going the wrong way and missing a target at the other edge, which would reveal itself in abnormally long RTs. Top down, exploratory eye movements are therefore inefficient and unlikely—the task is best achieved by maintaining fixation and waiting to detect the peripheral stimulus.

**Procedure**

There were two types of trial: gap and overlap (Figure 3 depicts the task structure). In the gap trials, the central fixation cross appeared in the center of the screen and remained for 2 s before disappearing. After a variable interstimulus interval (ISI) of 600, 800, 1,000, 1,200, or 1,400 ms (randomized across trials), the imperative stimulus (small cross) was presented on either the left or the right side of the screen. The imperative stimulus remained on the screen until the participant responded with the correct key press (A or L key for left and right stimuli, respectively).

We used a variable ISI because when the timing of the displays is constant, participants are able to respond much faster as they anticipate when a response is expected. The variable ISIs used here meant that the offset of the fixation cross in the gap trials did not predict the specific onset of the peripheral targets. We used these longer ISIs to increase the temporal uncertainty. This then means that the measured RT is directly related to the characteristics of the independent variables, with less contribution from uncontrolled variables such as anticipation. Therefore, this task is now a strong test of the ability of participants to have their attention shifted by stimulus properties, in a bottom-up fashion.

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a significant interaction between condition and imperative stimulus, $F(1, 93) = 9.07, p < .01$, partial $\eta^2 = .089$. The interaction is graphed in Figure 4. RTs were smaller for gap trials than they were for overlap trials (the gap effect), but the interaction showed that this effect was driven solely by responses to the left imperative stimulus in the overlap condition, which were substantially slower than responses to the right imperative stimulus. The gap trials showed no RT difference between left and right targets. The observed gap effect in the current data is therefore caused by the increase in response time to overlap trials in which the response was to the left imperative stimulus only. This interaction is consistent with previous results in our lab using these stimuli (Mills, Wilson, Williams, Plumb, & Mon-Williams, 2008) and can be accounted for by a fixation bias (Jordan & Patching, 2006).

A main effect of group was found, $F(4, 93) = 16.6, p < .01$, partial $\eta^2 = .417$, as can be seen in Figure 5. The results show a clear developmental trend whereby RT decreases in both types of trial with increasing age. There was not any interactions involving group (all $p$s > .1), suggesting that there were no qualitative differences between the groups. Therefore, in contrast to the findings of Landry and Bryson (2004), the gap effect found in the autistic group did not significantly differ to that of the comparison groups. However, the overall performance of the children with autism did not reflect those of the older age-matched comparison
Overlap ePub Ahead of Print 7 Manual Response Gap Effect

Research (Greenaway & Plaisted) has suggested is the key in cue was detected and therefore usable, which previous study can be interpreted as suggesting that children with autism have intact top-down attention shifting mechanisms but a general deficit in bottom-up, stimulus-driven attention shifting. This deficit does not seem to be due simply to a generic difficulty in producing a response (as evidenced by normal baseline performance in Experiment 1). Instead, it suggests that currently attended objects are especially salient.

**FIGURE 5.** Average reaction time (RT) data from Experiment 2 plotted as a function of group. Error bars indicate between group variability (standard error). Post hoc tests confirmed that although the autism group showed a normal magnitude gap effect, their overall RTs were slower than all the comparison groups except the youngest (5–8 year-olds). ASD = autistic spectrum disorder.

GENERAL DISCUSSION

Although problems in shifting attention have been studied previously in autism, there has been little work that experimentally separates out top-down versus bottom-up processes (Greenaway & Plaisted, 2005). Therefore, in the current study, we looked at both top-down (Experiment 1) and bottom-up (Experiment 2) shifts of visual attention in children with autism. In Experiment 1, we found no evidence of any response deficit in the autistic population using a baseline RT task. There are a number of studies in the research literature that suggest that children with autism do not have simple response deficits (e.g., Swettenham, Condie, Campbell, Milne, & Coleman, 2003). Likewise, the top-down condition did not reveal any RT differences among the clinical and aged matched groups. Children with autism were able to shift their attention between spatially separated locations and use the resulting information to produce a correct response. However, the key feature of this task that was that the rule for producing the correct response was explicitly explained to all participants. Participants knew whether they needed to attend to one or both locations, and this was constant for a given block. This ensured that the top-down cue was detected and therefore usable, which previous research (Greenaway & Plaisted) has suggested is the key in autism. With the locations clearly visible at all times on the screen, the task could be accomplished using a top-down strategy (Fecteau & Munoz, 2006). This aspect of attention shifting seems to be intact in children with autism.

Contrary to the results of Landry and Bryson (2004), there was no evidence in Experiment 2 to suggest that the gap effect was larger in the autistic group than the comparison group (i.e., no interaction between condition and group). Nevertheless, the autistic group showed slower overall RTs than their age-matched comparison group across all trials, suggesting that they had problems detecting the imperative stimuli. Thus, it appears that the targets were functionally less salient for the children with autism than for the other groups; therefore, a new visual stimulus needs a greater relative salience to compete with a currently fixated target in children with autism.

One reason why we may have found different results from Landry and Bryson (2004) might be related to the age of the participants. We conducted this experiment with a group of older children with autism than did Landry and Bryson, and the fact that we did not find any specific difficulty with overlap trials suggests that this difficulty may reflect a greater problem with this task in younger children with autism. Older children may have developed top-down exploratory strategies to compensate for a problem with bottom-up detection problems. Informal observations of the children in this task suggested the children with autism often made very overt exploratory head (and therefore gaze) movements in the gap, overlap task. This is consistent with previous data that noted a tendency to make back and forth eye movements even to adjacent stimuli (Hermelin & O’Conner, 1967).

The specific problem with overlap trials in Landry and Bryson (2004) may therefore be restricted to younger children who have yet to develop a reliable top-down exploratory strategy and were not cued to start one by the disappearance of the fixation point. In addition, the magnitude of the RT difference reported in Landry and Bryson might be exaggerated because of the way in which the RTs were calculated. In overlap trials, children with autism failed to respond on 18% of trials (vs. 7.7% in the comparison group), but these trials were included in the analysis as a RT of 8,000 ms (i.e., the point at which the trial timed out). Although there was clearly something of interest about overlap trials leading to this high rate of nonresponses, the magnitude of the effect may be smaller than Landry and Bryson reported, making it more likely that top-down strategies could remove the effect in our older group.

In conclusion, the overall pattern of results in the present study can be interpreted as suggesting that children with autism have intact top-down attention shifting mechanisms but a general deficit in bottom-up, stimulus-driven attention shifting. This deficit does not seem to be due simply to a generic difficulty in producing a response (as evidenced by normal baseline performance in Experiment 1). Instead, it suggests that currently attended objects are especially salient.
landmarks for children with autism, with competing objects being functionally less salient than for a comparison population. It is sometimes noted that the social difficulties that are diagnostic of autism may be underpinned by problems in shifting attention (e.g., Greenaway & Plaisted, 2005). The precise mechanism underpinning the present results is not clear. However, these results, and the suggestion that these attentional differences may be a key factor in the behavioral manifestations of autism, strongly suggest that this mechanism should be a topic for future research on visual attention and motor responses in autism and that in the future, researchers should always distinguish between these two types of processes (i.e., top-down vs. bottom-up).

REFERENCES

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