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## **The effect of stimulus salience on over-selectivity**

Geraldine Leader<sup>1</sup>, Ann Loughnane<sup>1</sup>, Claire Mc Moreland<sup>2</sup>, and Phil Reed<sup>2</sup>

<sup>1</sup> National University of Ireland – Galway, <sup>2</sup> Swansea University, U.K.

## Abstract

The influence of stimulus salience on over-selective responding was investigated in the context of a comparator theory of over-selectivity. In Experiments 1 and 2, participants were presented with two cards, each displaying two colors. In comparison to matched control participants, participants with Autistic Spectrum Disorder (ASD) demonstrated more over-selectivity, which increased when the stimuli differed in salience. In Experiment 3, the over-selected color was extinguished, and the previously under-selected color emerged to control behavior. The results suggest that stimuli of different salience may trigger over-selectivity in individuals with ASD, and provide preliminary support that this may be due to the action of an over-sensitive comparator mechanism functioning at the retrieval level of processing.

**Keywords:** Over-selectivity, comparator mechanism, stimulus salience, extinction.

## Introduction

Stimulus over-selectivity occurs when only a limited number of the available stimuli in the environment come to control behavior (Lovaas, Schreibman, Koegel, & Rehm, 1971). Lovaas et al. (1971) presented three groups of children (Autistic Spectrum Disorder, developmentally-delayed, and typically developing) with a compound stimulus that comprised auditory, visual, and tactile elements. The participants received reinforcement for bar-pressing in the presence of the compound stimulus, but not in its absence. Following this training, the individual elements of the compound stimulus were presented separately, and responding in the presence of each element was recorded. Although over-selectivity has been reported a number of times subsequently with participants with Autistic Spectrum Disorders (ASD; e.g., Lovaas & Schreibman, 1971; Reed, Broomfield, McHugh, McCausland, & Leader; Schreibman & Lovaas, 1973; Wilhelm & Lovaas, 1976), this phenomenon is not unique to ASD, and also has been demonstrated in several populations with impaired intellectual functioning (e.g., Dickson, Wang, Lombard & Dube, 2006; Lovaas et al., 1971; McHugh & Reed, 2007).

Several views regarding the nature of over-selectivity propose that such over-selective responding is the product of an attentional deficit (e.g., Lovaas et al., 1971). Such theories can be regarded as implying that over-selectivity is the result of a failure in the pre-processing abilities of the participants. In the limiting case, if not all of the stimuli in the environment are attended to initially, then they cannot be processed, and, thus, they cannot come to control behavior. Evidence for an attentional basis for over-selectivity comes from studies of the eye movements of people with ASD. A study conducted by Dube, Lombard, Farren, Flusser, Balsamo, and Fowler (1999) used an eye-

tracking procedure to investigate whether there were differences in the initial attentional responses of the participants. Participants with intellectual disability, who showed over-selective responding, only looked at about two thirds of the stimulus elements presented compared to a control participant.

However, it should be noted that studies of eye movement have yielded some inconsistent results (cf. Sigman, Mundy, Sherman, & Ungerer, 1986; Van der Geest, Kemner, Camfferman, Verbaten, and Van Engeland, 2002; Volkmar & Mayes, 1990). Van der Geest et al. (2002) found no difference between typically developing children and children with ASD, in terms of how much time was spent looking at pictures. Whereas, a study employing event-related potential (ERP) to investigate eye movement (Kemner & van Engeland, 2006) suggested that individuals with ASD display abnormalities in early visual processing related to the processing of faces, and to the specificity of spatial frequency processing.

In contrast to the suggestions of the above theories, it is possible that over-selectivity is not the result of attentional problems, but may be the product of post-processing differences in individuals with ASD compared to those without ASD (see Broomfield, McHugh, & Reed, 2008a; Reed et al., 2008). This view suggests that initial attention and learning is intact, however, post-learning problems arise in deciding which stimuli best predict the outcome of future events and, therefore, which stimuli should control behavior. Specifically how a post-learning mechanism may impact behavior has been suggested by Miller and Schachtman (1985). When a previously learned-about target stimulus is presented, a memory, or representation, of that learning is directly activated. However, the presentation of the target stimulus also triggers a comparator

mechanism, which indirectly activates representations of other stimuli that have previously been associated with the same outcome, or learned about in the presence of the target stimulus. The strengths of the directly and indirectly learned-about representations are compared, and the outcome of this comparison determines the response to the target stimulus. The stronger the predictive value in relation to the outcome of a response that a stimulus possesses, the more likely the comparator mechanism will select it to control behavior (Miller & Schachtman, 1985). Such a view has been applied to the performance of individuals with ASD (e.g., Reed et al., 2008).

An over-sensitive comparator mechanism may be influenced by differences in the salience of the available stimuli. Previous studies have demonstrated that individuals with ASD are sensitive to differences in stimulus salience. For example, Russell, Mauthner, Sharpe, and Tidswell (1991) concluded that the difficulty among participants with ASD in performing their version of the window-task was that participants with ASD failed to inhibit a response to a salient stimulus (i.e., a box containing a ‘candy’ reinforcer). According to the comparator theory, this difficulty may be due to over-sensitivity to differences in the salience of stimuli, which would result in control being exerted only by one stimulus. An overly sensitive comparator mechanism may more readily detect subtle differences in stimulus salience, which are not, typically, large enough to produce differential responding, and will lead to one stimulus dominating performance, while performance to the less salient stimuli appears inhibited. Thus, if a comparator mechanism in those without ASD is less sensitive than it is in those with ASD, subtle differences in salience will have little-to-no effect.

As the comparator mechanism is postulated to function at the post-processing level, this suggests that all available stimuli (regardless of salience) are attended to, processed, stored, and learned about (Reed et al., 2008). If a problem occurs after these stages have taken place, it seems likely that, by reducing the relative importance of one of the stimuli (that is, the over-selected one), the previously learned-about, but ‘inhibited’, stimulus should be attributed increased importance by the comparator mechanism and, as a result, gain control over behavior. Such a result was found by Broomfield et al. (2008a) and by Reed et al. (2008), where it was found that when the previously over-selected stimulus was extinguished, the previously under-selected stimulus emerged to control behavior.

In the present studies, the above ideas were explored further. Firstly, it was investigated whether over-selectivity could be triggered in response to visually presented stimuli with slight differences in salience. In line with studies of the effects of salience on the performance of individuals with ASD (e.g., Russell et al., 1991), it was expected that participants with ASD would display more over-selectivity than control participants, when the presented stimuli differed in salience. Secondly, it was investigated whether a comparator theory would be supported by extinguishing the control of the over-selected stimulus, and examining whether the previously under-selected stimulus would re-emerge to control behavior.

## Experiment 1

This first experiment investigated whether colors of different salience would impact performance on a trial-and-error learning task conducted with individuals with ASD and with a control group of typically developing individuals. According to the comparator theory, subtle differences in the salience of some colors may result in over-selective responding in participants with ASD, but not in typically developing participants. To this end, it was hoped to produce a discrimination task that did not provoke over-selectivity when the elements were of equal salience, but that would potentially induce such over-selectivity in individuals with ASD, but not in typically-developing individuals, when the salience of the elements was unequal.

### *Method*

*Participants.* Two groups of 16 children participated. The group with ASD (all male) had been independently diagnosed as having ASD, and all met DSM-IV criteria for autism condition (American Psychiatric Association, 2000). Their mean chronological age was 12:2 years, and their mental age estimate, as measured by the Peabody Picture Vocabulary Test, was 8:2 years. The control group (8 male and 8 female) were closely matched in terms of their chronological age to the mental age of the group with ASD, and the control group had a mean chronological age of 7:11 years.

*Apparatus and setting.* Sessions were conducted in a small, quiet, room in the participants' schools. The setting was familiar to participants and, thus, novel distractions were reduced. Participants sat at a small desk, where stimuli were presented



to the participants by the experimenter. The stimuli consisted of white laminated cards, each displaying two stimulus elements, and which measured 22cm by 15cm. One card served as the S+, while another served as the S-. The training stimuli were two white cards (AB and CD), both displayed two colored circles (e.g., a red circle and a purple circle on one card, and a blue circle and a green circle on the other card). The testing stimuli were four cards of the same size as each other, which displayed only one colored circle (A, B, C, or D).

For the purpose of the study, eight colors were chosen from the Microsoft Word color palate. All of the 8 colors were of equal saturation (sat. = 255). These served as the intense colors, and were used for all four stimulus elements in the equal salience condition. Less intense colors were obtained by reducing the saturation level of each color. In the unequal salience condition, three circles were of equal salience, as described above, while the fourth circle (one of the elements of the S+) was 25% less salient, as measured by illumination levels.

*Pilot study.* A pilot study was conducted in order to objectively confirm the subjective intensity of each color. Typically-developing adults (18 in total) rated each color on a scale of 1 (not intense), to 10 (highly intense). Revisions were made to the colors until the total scores for the 8 intense colors were approximately equal to one another, and those for the 8 less intense colors were approximately equal to one another, but these latter colors were rated as less intense than the former colors.

*Procedure.* The procedure consisted of a simple discrimination task. Half of the participants in each group (ASD and control) participated in the equal salience condition, in which all stimuli were of the same, intense salience, while the remaining participants

in each group participated in the unequal salience condition, where the salience of one of the S+ stimulus elements was manipulated.

*Training.* The two training cards were placed simultaneously on the centre of the table, between the participant and the experimenter. The participants were told to point to the correct card (e.g., AB). For the participants with ASD, in addition to the verbal prompt (“point to”), a physical prompt of guiding their finger towards the correct card was provided for the first ten trials, at which point this prompt was faded out completely

On any given trial, if participants pointed to the ‘correct’ compound stimuli (AB), this resulted in positive feedback in the form of the experimenter saying “yes”. In addition to verbal reinforcement, the participants with ASD received tangible reinforcement, such as snacks, or access to games or books. If they pointed at the other card (CD), this resulted in negative feedback (i.e., the experimenter saying “no”).

The positions of the cards were randomized; 50% of the time the S+ was presented on the left, and 50% of the time on the right, to ensure that the participant did not choose the card based on its position in the display. Once the response was scored, the next card was presented. Trials were presented every 10 to 15 s. During the training phase, the reinforced compound (AB) was always paired with the non-reinforced compound (CD), although the component elements of these cards were randomized with respect to the colors that they displayed, and with respect to the color that was less salient. That is, the participants did not all experience the same colors as one another for the S+ and for the S-. Participants were said to have acquired the training discrimination, once they had responded correctly ten times consecutively.

*Testing.* Participants were presented with two cards simultaneously, each card displayed one colored circle, either from the S+ (i.e., either A or B), or from the S- (i.e., either C or D). The circles were paired so that the participants had a choice between a previously reinforced element (A or B) and a previously non-reinforced element (C or D). There were five trials for each combination of previously reinforced and non-reinforced components (i.e., ‘A v C’, ‘A v D’, ‘B v C’, ‘B v D’). Trials were presented in a quasi-random order. The participant received no feedback during the testing session

### *Results and Discussion*

All participants successfully completed the training phase. The participants with ASD took a mean of 28.7 ( $\pm$  5.4) trials to reach criterion, and the control group took a mean of 14.1 ( $\pm$  3.2) trials. An independent *t* test revealed that this difference was statistically significant  $t(30) = 9.36, p < 0.05$ .

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 Figure 1 about here  
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Figure 1 shows the mean percentages of times that the reinforced elements (both for the most and the least selected element, A or B) were chosen in the test. These data show that there was only a small difference between the most and least selected elements for the group with ASD in the equal salience condition, but that there was a large difference between the number of times that the most and least preferred stimuli were picked in the unequal salience condition. There was little evidence of over-selectivity in either condition for the control group.

A two-factor, between-subjects analysis of variance (ANOVA) was conducted, with group (ASD versus control), and condition (equal salience versus unequal salience), as factors. This analysis revealed statistically significant main effects of group,  $F(1,28) = 5.90, p < 0.05$ , and condition,  $F(1,28) = 4.33, p < 0.05$ . There was also a statistically significant interaction effect between group and condition,  $F(1,28) = 4.30, p < 0.05$ . Simple effect analyses revealed that there was a statistically significant difference between most and least chosen stimuli for the group with ASD for the unequal stimulus salience condition,  $F(1,14) = 2.30, p < 0.05$ , but that none of the other most versus least comparisons, for either group, were statistically significant, all  $F_s < 1$ .

These data show little over-selectivity in the equal salience condition for either group, as the response accuracy was about equal to both of the S+ stimuli. There was a lower accuracy overall for the ASD group than for the control group, but the results show that this was not due to over-selecting one of the cues, because both cues were selected about equally. This suggests that some other variable could account for the difference between the ASD and control groups, for example, poor motivation on test trials without feedback. That over-selectivity was not observed in the equal salience condition with these group does not corroborate previous demonstrations of over-selectivity (e.g., Koegel & Wilhelm, 1973), but it should be noted that these previous demonstrations did not specifically attempt to equate stimulus salience across the elements of the stimuli that they employed, making cross-experimental comparison, and conclusion regarding this finding, difficult. However, the main focus of this experiment, and the novel finding to emerge was that the degree of over-selectivity exhibited by the participants with ASD was significantly greater when the stimuli became discrepant in salience, even though

this difference was not enough to trigger over-selectivity in mental-aged matched controls. Thus, the data obtained in the present investigation using a discrimination task with manipulated salience supports the suggestion that over-selectivity is partly dependent on enhanced sensitivity to differences, a finding consistent with the comparator hypothesis (but not uniquely predicted by this mechanism).

## Experiment 2

Prior to further discussion of the potential mechanisms involved in generating this effect, it was thought necessary to ensure the reliability of this result by replicating the finding that slight differences in the salience of stimuli would be enough to trigger over-selectivity in a sample with ASD, but not in a control sample. In this experiment, an older sample was employed to establish the generality of the effect for people with ASD, as age has previously been linked to the emergence of over-selectivity (Schover & Newsom, 1976).

### *Method*

*Participants.* Thirty participants were employed, 15 participants in the group with ASD (13 males and 2 females) with a mean age of 18:6. These participants were recruited from a Day and Residential Services facility for adults with an Intellectual Disability. All met the DSM-IV criteria for autism, and they had a mean mental age (as estimated by the Peabody Picture Vocabulary Test of 4:2 years months. The control

group comprised 15 mental-age matched participants (7 males and 8 females), with a mean chronological age of 5 years.

*Apparatus and Materials.* The apparatus and procedure was as described for Experiment 1.

*Procedure.* Permission to carry out the research was obtained from each of the centers where the participants were recruited, and from the parents or guardians of the participants. In addition, oral assent was also sought from each participant. The training and testing phases were as described in Experiment 1.

### *Results and Discussion*

The mean trials to criterion for the group with ASD was 15.8 ( $\pm$  6.9) trials for the equal salience task, and 25.47 ( $\pm$  15.3) trials for the unequal salience task. The mean trials to criterion for the control group was 12.9 ( $\pm$  3.7) trials for the equal salience task, and 12.0 ( $\pm$  3.4) trials for the unequal salience task. Thus, more trials were required for the ASD group compared to the control group, and fewer trials were necessary for the equal salience condition than for the unequal salience condition. To determine whether this trend was statistically significant, a two-factor ANOVA (group and salience type) was conducted, which revealed a statistically significant main effect of group,  $F(1,28) = 10.10, p < 0.01$ , a statistically significant main effect of salience type,  $F(1,28) = 5.21, p < 0.05$ , and a statistically significant interaction between the factors,  $F(1,28) = 7.67, p < 0.01$ .

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Figure 2 about here  
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Figure 2 shows the mean percentage that the most and least chosen stimuli were chosen by participants in the ASD and control groups, for both the equal or unequal salience conditions. Inspection of these data shows that there was little over-selectivity within the control group, for either the equal, or the unequal, salience conditions. However, within the group with ASD, there was a small degree of over-selectivity in the equal salience task, and much greater over-selectivity in the unequal salience task.

A three-factor, mixed model ANOVA (group x salience type x stimulus) was conducted on these data, and revealed statistically significant main effects of group,  $F(1,28) = 17.11, p < 0.001$ , and stimulus,  $F(1,28) = 48.12, p < 0.001$ . There was a statistically significant interaction between stimulus and group,  $F(1,28) = 34.83, p < 0.001$ , and between salience type and stimulus,  $F(1,28) = 16.12, p < 0.001$ . Finally, there was a statistically significant three-way interaction,  $F(1,28) = 9.49, p < 0.005$ .

In order to determine where the significant differences for the most- and least-chosen stimuli within the experimental and control groups lay, a two-factor ANOVA (salience type and stimulus) was conducted for each group. For the control group, there was no statistically significant main effects, nor an interaction,  $ps > 0.10$ . For the experimental group, there was a statistically significant main effect of salience type,  $F(1,14) = 47.37, p < 0.001$ , and a statistically significant interaction effect between salience type and stimulus,  $F(1,14) = 14.08, p < 0.005$ . Simple effects tests were carried out on the group with ASD, and revealed a statistically significant difference between the

stimuli, for both the equal salience condition,  $F(1,14) = 5.02, p < 0.05$ , and a more pronounced difference for the unequal salience condition,  $F(1,14) = 87.17, p < 0.001$ .

Overall, these results support the suggestion that presenting colors of different salience would impact the performance of participants with ASD, but not the performance of typically-developing mental-age matched control participants. This conclusion is drawn from the fact that there was little over-selectivity among control participants, but that participants in the experimental group displayed over-selectivity in both the equal and unequal salience conditions. However, as expected, the amount of over-selectivity was greater in the unequal salience condition. These results also confirm those obtained in Experiment 1, but use an older sample to extend the generality of the findings. It may also be worth brief comment that the levels of over-selectivity were greater in this second experiment, than in the first experiment. This may be a product of the sample in the second experiment simultaneously having a higher chronological age, and a lower mental age, than those in Experiment 1, which would produce a lower IQ score. Over-selectivity has been noted previously to be correlated with both lower mental ages and lower IQ scores (see Schover & Newsom, 1976; Wilhelm & Lovaas, 1976).

### Experiment 3

The impact of differences in salience on over-selectivity has been shown to be more pronounced in people with ASD. There are many potential mechanisms that could explain such a finding. For example, attention in individuals with ASD may be more easily captured by differences in the salience of stimuli. There is certainly some evidence



that these individuals are more sensitive to discrepancies in visual stimulation (Kemner & van Engeland, 2006). Alternatively, the comparator hypothesis (Reed et al., 2008) would predict that discrepancy in salience would trigger differences in the degree of associative strength accruing to each of the stimuli, which may be enough to trigger a performance difference in individuals with ASD, but not in individuals with a less sensitive comparator mechanism.

In an attempt to test between these different views, in this study, the over-selected color was extinguished, and participants were then retested using the same procedure employed in Experiments 1 and 2. The comparator view would suggest that following extinction of the previously over-selected stimulus, the under-selected stimulus will re-emerge to control behavior as it was attended to, and processed, originally, but, in the first test, has a weaker associative strength than the salient cue which was enough to allow expression of control over behavior (see Broomfield et al., 2008a; Reed et al., 2008). In contrast, theories focusing on attention, executive function, or memory problems, would suggest that extinction should not allow the under-selected color to emerge and control behavior as it was never fully processed to begin with. To this end, the participants with ASD from Experiment 2 received extinction of the previously over-selected stimulus, and were then re-tested for any changes in behavioral control exerted by the stimuli post-extinction.

## Method

*Participants.* Due to the outcome of Experiment 2, which showed that there was little over-selectivity among control participants, and, among experimental participants,

there was significantly more over-selectivity in the unequal than in the equal salience condition, Experiment 3 focused on extinction of the previously over-selected stimulus in the unequal salience task for the group with ASD only. One participant was excluded because they did not display any over-selectivity in the unequal salience condition. Thus, there were 14 participants

*Procedure.* The color that was chosen the most (i.e., the over-selected color) in the unequal salience condition was determined for each participant.

*Extinction phase.* The over-selected color was extinguished in further training trials. In these trials, the over-selected color was presented along with one of four novel colors (*E, F, G, and H*). Participants were given positive feedback (“yes”) for choosing a novel color, and not the previously over-selected color. Each novel color was presented against the previously over-selected color 5 times, thus, there were 20 extinction trials in total.

*Re-testing phase.* Following this extinction phase, the participants were retested using the same testing procedure employed in Experiment 1. The number of times each color was selected was again recorded.

## *Results and Discussion*

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Figure 3 about here  
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Figure 3 illustrates the difference scores for the most- and least-chosen stimulus before and after extinction. This score was computed by subtracting the mean percentage

for the most-selected stimulus before extinction from the mean percentage for the most-selected stimulus after extinction to give the mean change in selection of the over-selected stimulus. Similarly, the mean percentage for the least-chosen stimulus before extinction was subtracted from the mean percentage for the least-chosen stimulus after extinction to give the mean re-emergence of the under-selected stimulus. As can be seen, there was a large decrease in choice for the previously most-selected stimulus after extinction, and there was a re-emergence of the previously under-selected stimulus.

The change in scores for the most- and least-selected stimuli before and after extinction, were compared against zero. This was done to investigate if the reduction in the extinguished stimulus was significant and if the increase in the other stimulus was significant. The results of the paired-samples t-test indicate a significant difference change (after extinction) for the most-selected stimulus,  $t(13) = 7.74, p < 0.001$ . When a paired samples t-test was conducted on the previously under-selected stimulus there was a statistically significant re-emergence effect,  $t(13) = 5.41, p < 0.001$ .

Experiment 3 set out to demonstrate that control exerted by the over-selected color could be reduced by putting it into extinction. The results support this expectation, as there was a statistically significant decrease in the selection of the over-selected stimulus from Time 1 (pre-extinction) to Time 2 (post-extinction). This corroborates previous findings reported in typically developing adults (Broomfield et al., 2008a), and indicates that the extinction of the previously over-selected stimulus was successful. Experiment 3 also set out to investigate whether by extinguishing the over-selected stimulus, the previously under-selected stimulus would be chosen more than it had been pre-extinction. The results do support this prediction, and provides some support for the

comparator theory of over-selectivity (Reed et al., 2008) - all stimuli were attended to, processed and stored, thus, upon extinguishing the control of the over-selected stimulus, the under-selected stimulus gained control of behavior.

## General Discussion

The present study investigated the effect of stimulus salience on over-selectivity in participants with ASD. In Experiments 1 and 2, participants with ASD, and typically developing, mental-aged matched children, completed a trial-and-error discrimination learning task with colors of equal and unequal salience. The aim was to investigate whether participants with ASD would display more over-selectivity than the typically developing participants when the colors presented differed in salience. In Experiment 3, the over-selected color was extinguished, and, by retesting with the original stimulus complex, the possible emergence of control by the stimuli post-extinction was investigated.

The results indicated that, when faced with a learning task in which colors of different salience were presented, participants with ASD displayed more over-selectivity than the control participants, and that they were differentially affected by the difference in salience between the stimuli. The performance of control participants was unaffected by the salience of the colors presented to them. These results are in line with the predictions of the comparator theory (Miller & Schachtman, 1985) as applied to ASD (Reed et al., 2008). From a comparator viewpoint, the observed results can be attributed to the functioning of an over-sensitive comparator mechanism in individuals with ASD.

The difference in salience between the colors in the stimulus complex presented during the training phase was noticed by the sensitive comparator mechanism, but not by the typically functioning comparator in the typically developing participants. As a result, one stimulus was attributed more importance than the other stimulus, and, at test, controlled behavior more strongly.

It is possible, however, that, while the results reported in Experiments 1 and 2 are consistent with the actions of an over-sensitive comparator mechanism, the same result could be attributed to a deficit in a number of other mechanisms. For example, studies suggest that executive dysfunction may result in perseveration in tasks, and a generally limited ability for cognitive flexibility (Hughes, Russell, & Robbins, 1994). In the present study, presenting colors of different salience during the training phase, coupled with a lack of cognitive flexibility, may have inhibited the ability of participants with ASD to choose away from a more salient stimulus, and, thus, to rigidly choose one of the colors in favor of the other stimulus during testing. The present results could also be attributed to a problem of attention. According to studies of attention (e.g., Dube et al., 1999), the observed over-selective responding by participants could be due to a pre-processing failure to look at and therefore, attend to all of the colors. Dube et al. (1999) suggest that individuals experiencing a disability may not observe all relevant stimuli and, thus, when tested with these stimuli, respond in an over-selective manner.

Thus, the observed difficulty among the experimental group when learning about colors of unequal salience could be the result of an executive dysfunction, or an attentional deficit, amongst other possibilities. Experiment 3 attempted to determine the source of this problem. The results of Experiment 3 show evidence of extinction of the

previously over-selected stimulus, and also evidence of re-emergence of the previously under-selected color following this extinction. These results replicate the findings of Broomfield et al. (2008a) who also found that, post-extinction, control by the previously over-selected stimulus diminished, and control by the under-selected stimulus increased. These findings provide support for the comparator theory of over-selectivity (Reed et al., 2008), and are less easily accommodated by other pre-processing or acquisition failure theories. According to the comparator theory, both colors were learned about (attended to, processed, and stored) in the training phase. When the over-selected color was extinguished, the under-selected color spontaneously emerged to control behavior without any additional learning, as there was no longer a stronger stimulus to inhibit performance according to this stimulus. The results argue against a problem connected with executive function, or an attentional deficit, since these views would suggest a problem with the early processing of the stimulus complex. If this had been the case, then extinguishing control by the over-selected stimulus should have had no effect on the amount of control by the previously under-selected stimulus post-extinction.

The results of the above study have potential practical applications. Over-selective responding to a restrictive range of cues is a problem often seen amongst populations with ASD. According to Lovaas and Schreibman (1971), over-selectivity may interfere with learning. For example, learning language may be inhibited if individuals fail to respond to multiple cues at once (i.e., tone, pitch, and voice). The present study suggests that individuals with ASD may notice subtle differences in the salience of environmental cues and stimuli, and that such differences may impact on their subsequent behavior (i.e., result in over-selective responding). The present study also

suggests that this problem can be rectified by determining the over-selected cue, and extinguishing its control. This will also allow the previously under-selected cue to emerge to gain control of behavior. As a result, the individual can respond to more aspects of the surrounding environment. Such an intervention may prove more successful than employing an observing response (for example, naming the stimuli presented), as has been attempted in other studies (for example, Gutowski, Geren, Stromer, & Mackay, 1995; Dube & McIlvane, 1999). In such studies, it was found that over-selectivity was reduced only while the observing response was employed. When the observing response was removed, over-selective responding returned. Thus, an alternative to such an intervention is needed (see also Broomfield et al., 2008b). The present study provides clear support that control by an over-selected stimulus *can* be reduced through extinction. Even after the extinction procedure has ended, the reduction in over-selective responding remains.

In summary, the results of these studies suggest that differences in the salience of stimuli can trigger over-selective responding in individuals with ASD, but not in those without a disability. The results also suggest that control by an over-selected stimulus can be reduced through extinction, and that post-extinction, it may also be seen that a previously under-selected stimulus may gain control over responding. The notion that the action of an over-sensitive comparator mechanism may underlie these observations is supported by these data, and the results of Experiment 3 suggest that over-selectivity may not be due to a problem in attention, processing, or storage abilities. Instead, the observed re-emergence of the under-selected stimulus in some participants with ASD

seems to point to a difficulty at the retrieval level of processing and, most likely, to an atypically functioning comparator mechanism.



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## Author Notes

Geraldine Leader and Ann Loughnane are both currently in the Department of Psychology, National University of Ireland – Galway, University Road, Galway, Ireland.

Claire Mc Moreland and Phil Reed are currently in the Department of Psychology, Swansea University, Singleton Park, Swansea, SA2 8PP, U.K.

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Correspondence concerning this article should be sent to: Phil Reed, Department of Psychology, Swansea University, Singleton Park, Swansea, SA2 8PP, U.K. (e-mail: [p.reed@swansea.ac.uk](mailto:p.reed@swansea.ac.uk)).

## Figure Captions

*Figure 1.* Results from Experiment 1. Mean percentage choice for the most and least selected stimuli for the groups with ASD and the mental-aged matched controls.

*Figure 2.* Results from Experiment 2. Mean percentage choice for the most and least selected stimuli for the groups with ASD and the mental-aged matched controls.

*Figure 3.* Results from Experiment 3. Mean differences between pre and post extinction scores for the most, and least, chosen stimuli.

Figure 1

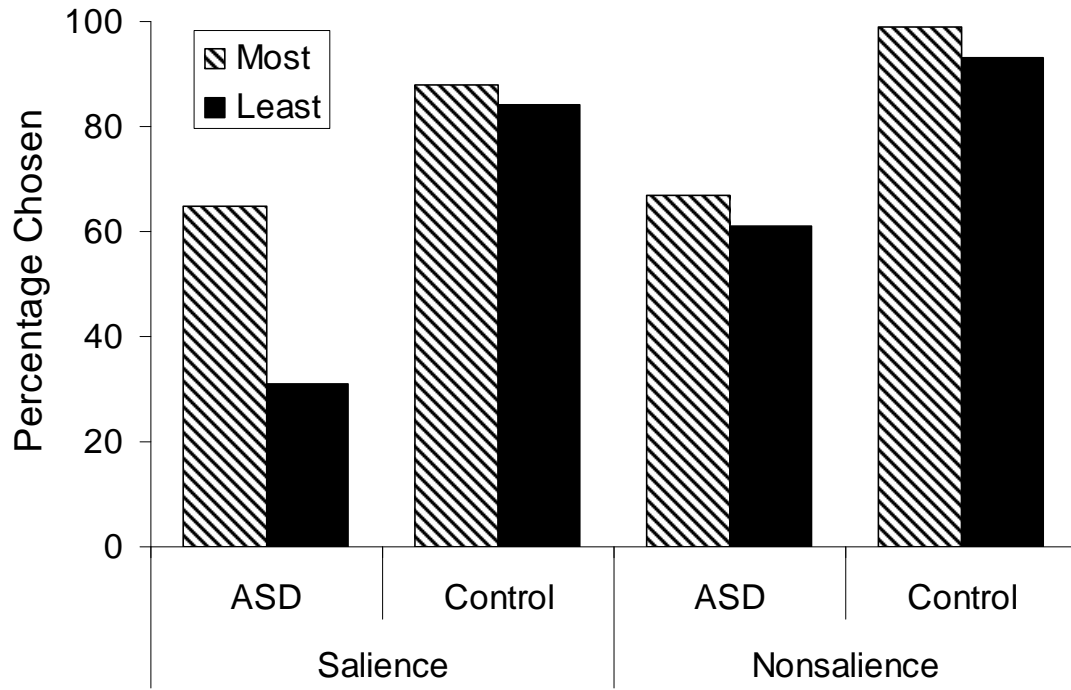


Figure 2

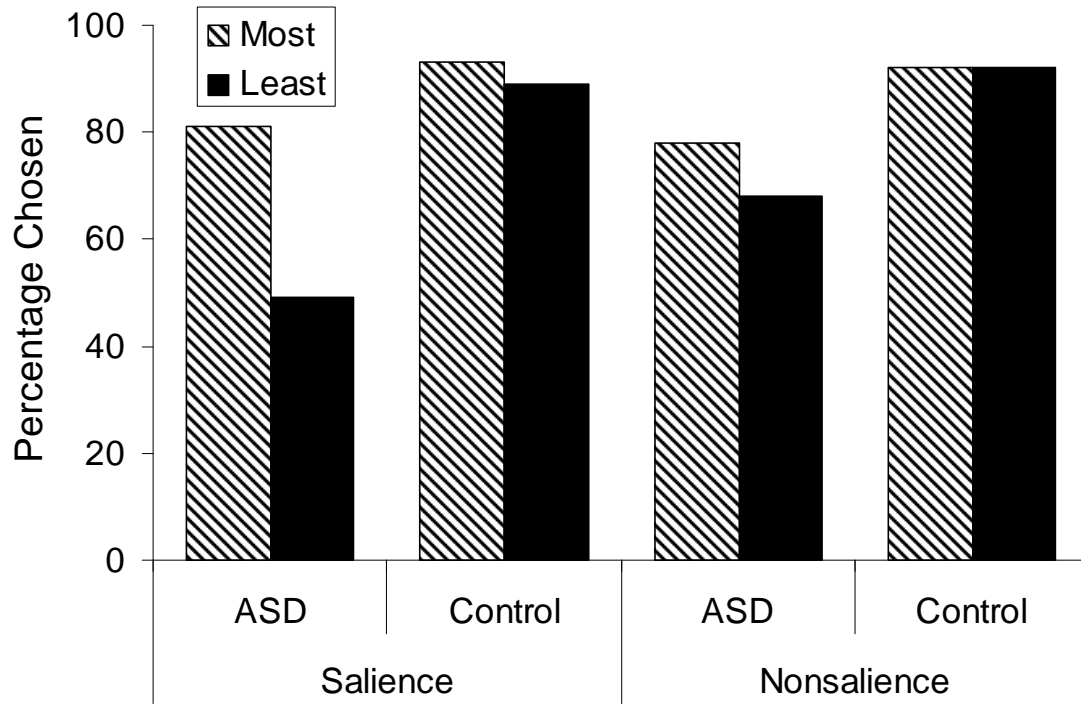


Figure 3

