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Attention bias to faces in Asperger Syndrome: a pictorial emotion Stroop study

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ABSTRACT

Background. Emotional Stroop tasks have shown attention biases of clinical populations towards stimuli related to their condition. Asperger Syndrome (AS) is a neuropsychiatric condition with social and communication deficits, repetitive behaviours and narrow interests. Social deficits are particularly striking, including difficulties in understanding others.

Method. We investigated colour-naming latencies of adults with and without AS to name colours of pictures containing angry facial expressions, neutral expressions or non-social objects. We tested three hypotheses: whether (1) controls show longer colour-naming latencies for angry *versus* neutral facial expressions with male actors, (2) people with AS show differential latencies across picture types, and (3) differential response latencies persist when photographs contain females.

Results. Controls had longer latencies to pictures of male faces with angry compared to neutral expressions. The AS group did not show longer latencies to angry *versus* neutral expressions in male faces, instead showing slower latencies to pictures containing any facial expression compared to objects. When pictures contained females, controls no longer showed longer latencies for angry *versus* neutral expressions. However, the AS group still showed longer latencies to all facial picture types, compared to objects, providing further evidence that faces produce interference effects for this clinical group.

Conclusions. The pictorial emotional Stroop paradigm reveals normal attention biases towards threatening emotional faces. The AS group showed Stroop interference effects to all facial stimuli regardless of expression or sex, suggesting that faces cause disproportionate interference in AS.

INTRODUCTION

Attention is important for engaging with the environment, particularly in the fast and complex social world. The Stroop task (Stroop, 1935) is a cognitive paradigm used to study attention. This simple task has led to 70 years of research producing highly consistent results across a range of designs and stimuli (Perez-Edgar & Fox, 2003). The traditional Stroop design uses colour words displayed in different coloured text. Participants are simply asked to name the colour that a word is written in and ignore the actual meaning of the word. The words and the colour of the text are either congruent or incongruent with the meaning (semantics) of the word. Incongruent text colour and meaning typically lead to longer colour-naming latencies. For example, the word 'red' written in red font would be named faster than the word 'red' written in green font.

The original Stroop test has since been modified to investigate aspects of emotion processing in various clinical and non-clinical populations. The emotional Stroop test usually involves subjects naming the colour of neutral and emotional words. A consistent finding is that patients are slower to say the colour of words that are threatening or are related to the concerns focus of their clinical problems

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(Williams *et al.* 1996). This has been most extensively studied for anxiety and depressive disorders, but the effect has also been shown in subclinical populations (Perez-Edgar & Fox, 2003). For example, spider phobics show a large Stroop effect for spider-related words (e.g. *hairy* and *crawl*), but they do not show a Stroop effect for general emotional words (Watts *et al.* 1986). Furthermore, the Stroop effect is significantly reduced by desensitization treatment, suggesting it is measuring an abnormal cognitive process underlying the condition. The interpretation of the emotional Stroop effect is that the affective nature of the emotional words captures attention resources and thus interferes in naming the colour of the text (Williams *et al.* 1996). There are two types of attention biases reported in emotional Stroop studies. When participants are slower to colour name a stimulus, this is known as an 'interference' effect. If response latencies are quicker then this is referred to as a 'facilitation' effect. Interference effects are thought to show that the emotional stimuli captured attention, while a facilitation is usually interpreted as a sign of avoidance in processing the emotional stimuli (Williams *et al.* 1996). Because these effects operate so rapidly and automatically, they are thought to reflect attention processes at an involuntary, pre-conscious level.

Words have traditionally been used as stimuli for emotional Stroop paradigms. However, linguistic stimuli only have symbolic threat value, compared to more ecologically valid threatening stimuli such as angry facial expressions (Bradley *et al.* 1997; van Honk *et al.* 1998, 2001). Recent experiments have tested the emotional Stroop effect and its relationship to hormones and anxiety using pictures of facial expressions with transparent colours overlaid on these, with participants being asked to name the colour of the picture containing the face (van Honk *et al.* 1999, 2000, 2001). These results have shown attention biases to displays of threatening facial pictures correlated with levels of cortisol and testosterone and various traits in typical control participants (van Honk *et al.* 1999, 2000, 2001). The results are thought to reflect an evolved attention bias to threat (Ohman, 1986), which may have been adaptive. Dysfunction of the attentional mechanism to threat is thought to play a role in the causation and maintenance of anxiety disorders (Williams *et al.* 1996; Mogg & Bradley, 1998).

One population that has not been studied to date using the emotional Stroop paradigm is people with autism spectrum conditions (ASC). This includes the neuropsychiatric conditions of autism and Asperger Syndrome (AS), which are characterized by social and communication deficits, repetitive behaviour and restricted interests (APA, 1994). One of the central features of ASC is apparent lack of social interest (Kanner, 1943; Asperger, 1944), and many theories view a primary aspect of the condition to be a lack of the normal drive to interact with others (Baron-Cohen, 1995, 2003; Dawson *et al.* 1998; Schultz *et al.* 2000; Grelotti *et al.* 2002). Early descriptions of people with ASC included interacting with others as if they were objects (Kanner, 1943; Asperger, 1944). Many studies have reported abnormal processing of emotional stimuli by people with ASC (Hobson, 1993), although deficits may be more evident when tests involve recognition of complex rather than basic emotions (Baron-Cohen, 2003). This is particularly true in the case of higher-functioning participants (Baron-Cohen *et al.* 1993*a*, 1997; Loveland *et al.* 1997; Grossman *et al.* 2000). Although ASC are not classified as anxiety disorders, they are associated with co-morbid anxiety (Muris *et al.* 1998; Gillott *et al.* 2001). The pictorial emotional Stroop test thus allows us to test predictions related to face-perception by people with ASC.

As autism is characterized by impaired social interaction and communication and deficits in understanding others' mental states, people and faces may represent a stimulus of high concern or anxiety. Currently it is unclear whether faces elicit high-arousal and avoidance, or may be of no interest, or if faces might be of interest to those with autism even if they have a limited understanding about mental and emotional states. The present experiment used a pictorial emotional Stroop paradigm in adults with and without autism to investigate attention biases to social and non-social stimuli. Previous findings from Stroop-like tasks involving non-social stimuli have been reported in autism (Hill, 2004), showing an equivalent interference effect in children and adolescents with autism compared to controls (Eskes *et al.* 1990; Ozonoff & Jensen, 1999). Given these previous results in

Stroop tasks and the simple nature of the task, this may be a fruitful paradigm for investigating attention biases in processing *social* stimuli in autism.

The use of pictorial material in studies of attention biases is still very new (van Honk *et al*. 1998). Pictorial emotional Stroop paradigms have been used with spider phobics and revealed an attention bias to the pictorial material similar to linguistic spider material (Kindt & Brosschot, 1997). Additionally, van Honk and colleagues reported that elevated testosterone, cortisol and trait anger correlated with attentional biases to angry faces (van Honk *et al*. 1998, 1999, 2001). However, we are unaware of any published pictorial emotional Stroop data not involving a correlational analysis with another measure that shows a significant attention bias to threatening compared to neutral facial expressions in typical volunteers. Finding an attention bias to threatening facial pictures in control participants would lend support to the idea of an evolved automatic attention system oriented to social threat (Ohman & Soares, 1993), and provide a foundation for simple computer-generated case-control studies to investigate attentional biases in various clinical populations using the pictorial emotional Stroop with social stimuli.

Another issue related to pictorial stimuli used in studies of attention to threat is the sex of the actors in the photographs. Studies of threat processing have mostly involved pictures of males (van Honk *et al*. 1999, 2000), with the hypothesis that males provide a more potent form of social threat compared to females, particularly for male participants (Ohman, 1986). However, little research has been done on the effects of the stimuli actor's sex in studies of attention bias to social threat. In the present experiment we have included female faces as an initial investigation of sex in pictorial studies of attention biases to social threat.

In the present study, we had three main aims: (1) to test whether the control group would show slower colour-naming latencies to pictures with angry expressions compared to neutral expressions with photographs of male actors; (2) to test whether people with AS would show differences in response latencies for any of the social and non-social pictures with the photographs of male actors; and (3) to investigate if the same pattern of response latencies in each group exists with photographs of female actors.

We predicted that the controls would show longer response latencies to name colours on trials with angry facial expressions, compared to trials with neutral expression stimuli when the photographs contained male actors, based on previous research with threatening pictures. We further expected no difference in response latencies to chairs compared to neutral faces for the control group. Making predictions about the AS group was not straightforward. If participants with AS are avoiding the facial expressions then we might expect to see a facilitation effect. If faces represent a normal, evolved emotionally relevant stimulus then we expect to see an interference effect for colour-naming latencies. If emotional expressions are not processed in the normal way, or if faces trigger anxiety, then we might expect to see an interference effect of faces with any expression, relative to non-social pictures of chairs. For example, it is often the spider phobic person in a group who notices a spider crawling across the ceiling. If faces are of no interest to people with AS, then we expect to see no difference in response latency across any of the conditions.

We further predicted the controls would not show a Stroop effect when the stimuli involved female photographs. This is because there are evolutionary reasons why threat from a male face might be more potent. In the AS group we expect to see the same Stroop effect, or lack of it, across both the male and female faces.

METHOD

Participants

Seventeen adult male participants with a diagnosis of AS and 17 adult male control subjects with no history of psychiatric conditions were recruited for this study (see Table 1). All participants had normal or corrected-to-normal vision, and performed an intelligence test (Wechsler, 1999). The participants with AS also completed the Autism-Spectrum Quotient (AQ), a self-administered questionnaire for measuring the number of autistic traits an individual possesses (Baron-Cohen *et al*. 2001). The scores for our participants with AS ($n=17$, mean AQ $=33{\cdot}9$, S.D. $=7{\cdot}7$, $73{\cdot}3\%$ scoring 32+) matched very closely to the scores found by

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Table 1. *Demographic characteristics and mean colour-naming response latencies for the participant groups*

Characteristics and tasks	Controls	Asperger Syndrome
Age (years, mean ± s.d.)	26·4 ± 7·7	27·1 ± 6·6
IQ (mean full scale IQ ± s.d.)	115·9 ± 19·6	115·6 ± 15·7
Gender (male/female)	17/0	17/0
Handedness (right/left)	14/3	14/3
Mean RTs (s.d.) for photographs with male actors		
Angry faces	779·72 (167·40)	820·87 (172·59)
Neutral faces	740·48 (126·62)	828·17 (166·860)
Chairs	749·87 (142·43)	777·30 (125·86)
Mean RTs (s.d.) for photographs with female actors		
Angry faces	767·06 (151·02)	827·22 (166·17)
Neutral faces	760·79 (140·62)	836·64 (170·92)
Chairs	749·87 (142·43)	777·30 (125·86)

RT, Reaction time.

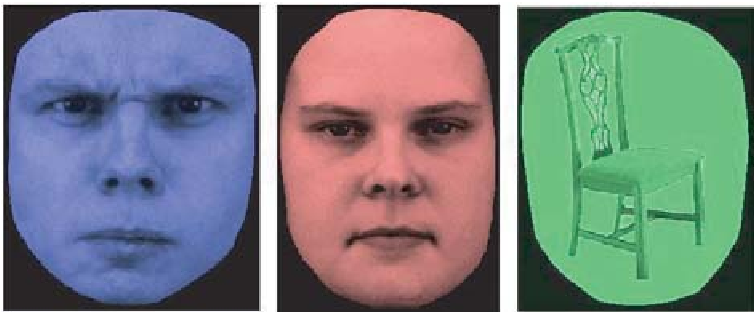

Fig. 1. Examples of stimuli used in the experiment (angry expression, neutral expression and non-social object).

Baron-Cohen *et al.* (2001) ($n = 58$, mean AQ = 35·8, s.d. = 6·5, 80% scoring 32+).

Materials

Stimuli were taken from a standard set of facial pictures (Lundqvist *et al.* 1998). Ten judges (five male, five female) were shown photographs of angry and neutral faces, and they chose from a list of basic emotion terms (afraid, angry, sad, happy, surprise, disgust, and neutral) which one they thought best described each of the pictures. Only photographs labelled correctly by all 10 judges were included, and pictures were chosen of the same actor showing both neutral and angry faces. Pictures of 12 different faces (six male, six female), each displaying a neutral and an angry expression, were used. Pictures of chairs were downloaded from the internet and used for the non-social control stimuli.

Faces were cropped by hand using Paint Shop Pro© (http://www.corel.com). The crop outlines for faces were then also used as the outlines for the chair pictures. Four copies of each facial photograph and chair were created using the layer option, using the four colours red, blue, green and yellow (see Fig. 1). An extra set of stimuli was made for practice trials. In total, 48 neutral faces and 48 threat faces were shown during the experiment (24 male and 24 female each), as well as 48 pictures of chairs. The pictures were presented in randomized order in three blocks during the experiment.

Experiment design

The colour-naming task was carried out in a dimly lit experimental room. Participants were instructed to ignore the content of the picture and name the colour as quickly as possible. Eight practice trials were administered first, to ensure that each participant understood the task. Participants saw each stimulus once, and the experiment was divided into three equal blocks of 48 trials with two rest periods in between the blocks. Pictures from the different conditions were equally probable during each block. This created a total of 144 trials for the experiment.

The experiment was run on a Dell Inspiron 7500 laptop computer using DMDX (Forster & Forster, 2003) and projected to a 20-inch monitor situated 60 cm in front of the participants at eye level. One trial consisted of a fixation cross that was shown for 750 ms, followed by a picture. Participants wore headphones with a microphone attached, which was moved in front of their mouth before the experiment began. Initiation of the participant's vocal response was registered by the computer and target presentation was subsequently terminated.

Statistical design

Errors are rare in emotional Stroop tasks, and accounted for less than 1% of the trials in this experiment. The latencies on the error trials were not included in the analyses. We ran repeated measures analysis of variance (ANOVA) on the response latencies to the male faces and the chair pictures with *Condition Type* (Angry face *versus* Neutral face *versus* Chairs) as the within-subject factor and *Group* (Controls *versus* AS) as the between-subject factor. *Post-hoc* paired-samples *t* tests were run for each group where appropriate. Independent samples *t* tests were carried out on response latencies between groups for the three conditions, to directly test group differences in task performance.

We ran repeated measures ANOVA on the response latencies to the female faces and the chair pictures with *Condition Type* (Angry face *versus* Neutral face *versus* Chairs) as the within-subject factor and *Group* (Controls *versus* AS) as the between-subject factor. *Post-hoc* paired-samples *t* tests were run for each group where appropriate. Independent samples *t* tests were carried out on response latencies between groups for the three conditions, to directly test group differences in task performance.

To test whether controls were showing different response latencies for angry *versus* neutral faces in the photographs, with female photographs compared to photographs with males, a repeated measures ANOVA was run on the control group data with *Face Expression* (Angry *versus* Neutral) and *Gender of Photograph* (Male *versus* Female) as the within-subject factors.

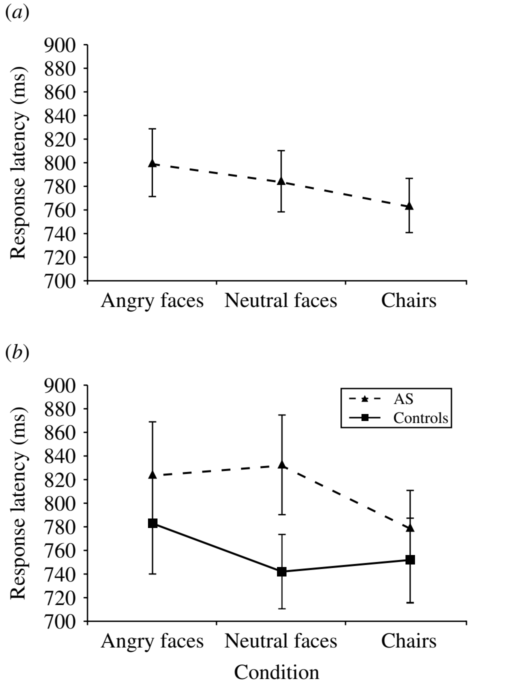

FIG. 2. (*a*) Mean response latencies for all participants across the three conditions for the photographs with male actors. (*b*) Mean response latencies by each group across the three conditions with male actors.

RESULTS

The statistics from the analysis involving the male pictures showed that there was no main effect of group [$F(1, 32) = 1{\cdot}06$, N.S.]. However, a main effect did emerge for condition type [$F(2, 31) = 7{\cdot}65$, $p < 0{\cdot}01$], with response latencies being longest to the angry faces, followed by neutral faces, and the fastest latencies to the chairs (see Fig. 2*a*).

Importantly, there was an interaction between condition type and group [$F(2, 31) = 4{\cdot}80$, $p < 0{\cdot}02$]. Paired-samples *t* tests on the data for the control group revealed significantly longer response latencies to the angry compared to the neutral expressions [$t(16) = 2{\cdot}86$, $p < 0{\cdot}02$] (see Fig. 2*b*). The response latencies to the angry expressions were also significantly longer than those to the chairs [$t(16) = 2{\cdot}91$, $p < 0{\cdot}02$], while the latencies to the neutral expressions did not

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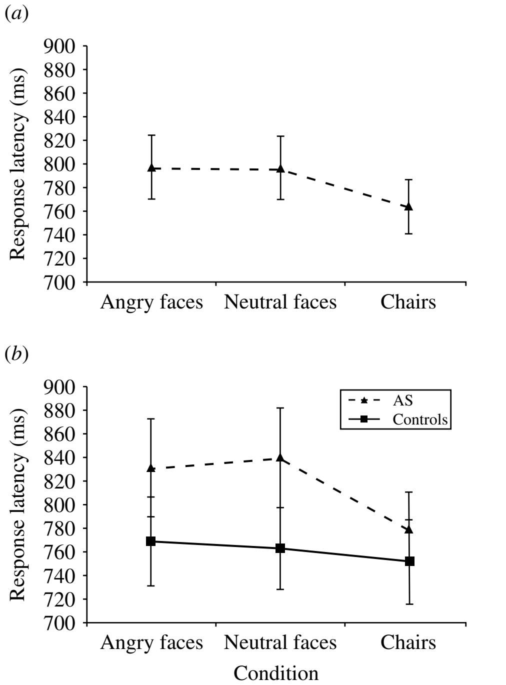

FIG. 3. (*a*) Mean response latencies for all participants across the three conditions for the photographs with female actors. (*b*) Mean response latencies by each group across the three conditions with female actors.

differ from the chairs [$t(16) = 1{\cdot}17$, N.S.]. Paired-samples t tests on the data for the AS group revealed there was no difference in response latencies to the angry compared to the neutral expressions [$t(16) = 0{\cdot}50$, N.S.]. However, there were significant differences between the chair pictures and both the neutral [$t(16) = 2{\cdot}82$, $p < 0{\cdot}02$] and the angry expressions [$t(16) = 2{\cdot}81$, $p < 0{\cdot}02$].

The analysis involving the female pictures showed that, like the photographs with males, there was no main effect for group [$F(1, 32) = 1{\cdot}17$, N.S.]. There was a main effect for condition type, with response latencies once again being longest for angry faces, with responses to neutral faces being somewhat faster, and latencies shortest for the chairs (see Fig. 3*a*).

Once again there was an interaction between condition type and group [$F(2, 31) = 3{\cdot}40$, $p < 0{\cdot}05$]. Paired-samples t tests on the data for the control group revealed no significant differences between any of the conditions (all $p > 0{\cdot}05$). Paired-samples t tests for the AS group showed there was no significant difference in response latencies between the angry and the neutral expressions [$t(16) = -0{\cdot}67$, N.S.]. However, once again the autism group showed significant differences between latencies to the non-social chair pictures and both the neutral [$t(16) = 3{\cdot}59$, $p < 0{\cdot}01$] and the angry expressions [$t(16) = 2{\cdot}75$, $p < 0{\cdot}02$].

The statistics on the control group data for emotional expressions across different sex of actors showed there was a main effect of face expression [$F(1, 16) = 7{\cdot}44$, $p < 0{\cdot}02$], with angry faces having longer response latencies than neutral faces. Importantly, there was an interaction for face condition and gender of photograph [$F(1, 16) = 4{\cdot}57$, $p < 0{\cdot}05$]. *Post-hoc* paired-sample t test comparisons showed that response latencies to the angry faces were significantly longer than the neutral faces when photographs contained male actors [$t(16) = 2{\cdot}86$, $p < 0{\cdot}02$], but were not significantly different when photographs contained female actors [$t(16) = 0{\cdot}05$, N.S.].

DISCUSSION

This study confirms that typical control participants show an attention bias towards threatening compared to neutral facial expressions when the photographs were of males. This is consistent with previous studies of attention bias using pictorial stimuli and the idea that social threat automatically captures attention (Ohman, 1986; van Honk *et al.* 1998, 2000, 2001; Vuilleumier, 2000; Vuilleumier & Schwartz, 2001). The participants with AS did not show a Stroop effect for latencies to angry *versus* neutral expression faces, but instead showed an attention bias for *any* facial expression compared to the non-social condition. This suggests that faces have a general attention-capturing effect for people with AS, resulting in a perceptual bias. This is consistent with findings from emotional Stroop experiments involving linguistic stimuli showing that patients with anxiety disorders are slower to name the colour of words that are threatening or related to the concerns of their clinical problems (Williams *et al.* 1996). It extends the findings to include pictorial stimuli and to ASC.

When the pictures contained female photographs, the control participants no longer showed a Stroop effect across the three conditions, consistent with previous ideas that male faces are a more potent threat (van Honk *et al.* 1999, 2000). However, when the stimuli contained female photographs the AS group still showed an attention bias for both the neutral and angry facial expression conditions compared to the chairs. This lends further support to the notion that faces capture attention in ASC, as the Stroop effect persisted even in a condition that showed no attention bias for the control participants.

These results suggest that faces have relevance to people with AS, and involuntarily capture attention regardless of whether they have threatening emotional expressions or not. We can assume that this strong capture effect of faces for people with AS may be the consequence of faces being harder for them to decode (Baron-Cohen *et al.* 1997; Shultz *et al.* 2000). Being harder to 'read', faces may therefore be more anxiety inducing, much like reading words may trigger anxiety in an individual with dyslexia. For the control participants, only the angry facial expressions produced interference effects on response latencies, and controls showed no difference in latencies to pictures with neutral expression faces compared to those with chairs. These findings lend further support to the notion that in the typical brain, threat automatically captures attention. This experiment also further validates the use of pictorial emotional Stroop tasks in the study of emotion processing and attention in both normal and psychiatric populations.

Previous research on attention biases with clinical and non-clinical populations has shown the importance of personal relevance of the stimuli to the concerns of the participants, in order to show the Stroop effect. AS is characterized by difficulties in social and communicative functioning, particularly in understanding the mental and emotional states of others (Baron-Cohen *et al.* 1993*b*; Baron-Cohen, 1995). Our results suggest that faces may be highly relevant or concerning stimuli for people with AS, and produce an attention bias compared to non-social stimuli. However, it is important to consider other possible explanations for these findings. First, as people with AS are reported to have deficits in emotion recognition (Tantam *et al.* 1989; Hobson, 1993; Baron-Cohen, 1995, 2003), they may simply not have been able to detect a difference in emotional expression between the two conditions. We consider that this is unlikely as the emotions used in this experiment were basic, and people with high-functioning autism and AS show intact performance with basic emotions (Baron-Cohen *et al.* 1993*a*, 1997; Loveland *et al.* 1997; Grossman *et al.* 2000; Golan *et al.* in press).

Another possible explanation for these findings is that people with AS may generally have a higher state of anxiety than the controls (Muris *et al.* 1998; Gillott *et al.* 2001). Therefore, the Stroop effects in our study could be seen as emerging from a general negative state, rather than a specific response to the facial stimuli. However, if participants with autism were exhibiting high state or trait anxiety, we would have expected to see Stroop effects for the angry compared to the neutral faces, based on previous research (Mogg & Bradley, 1998), or even no Stroop effect at all for any of the conditions. Neither of these patterns was seen, rendering this explanation unlikely.

A possible explanation for previous emotional Stroop effects found in clinical populations towards stimuli related to their condition is that they might be due to extended exposure, practice or expertise in processing the information (Williams *et al.* 1996). Essentially, people may become 'experts' at processing information related to their condition. However, this does not appear to explain the current findings, as people with AS have difficulty understanding other faces and, if anything, *avoid* social contact from a very early age. Some researchers argue that a central aspect of ASC is a *failure* to develop the normal expertise in face processing (Grelotti *et al.* 2002). The cognitive style of people with ASC is thought to favour the non-social (systemizable) world, and this appears to occupy many of their obsessions and their expertise (Baron-Cohen & Wheelwright, 1999; Baron-Cohen, 2002, 2003; Baron-Cohen *et al.* 2003).

Is it possible that the participants with AS did not have *slower* response latencies to name the colour of the facial pictures, but in fact had *faster* latencies for the non-social chair pictures? This idea would be consistent with the notion that people with ASC have strengths in processing the non-social world, and may become experts with systems (Baron-Cohen, 2003; Baron-Cohen *et al.* 2003). The design of the experiment does not allow us to directly answer this question. However, the response latencies for the chair pictures were not different for the AS group compared to the control group, suggesting that both were processing these stimuli in a similar way. The non-social stimuli used in this experiment (chairs) were not selected as a category that people with ASC might be experts in or be able to systemize, and so we consider that this explanation is unlikely. In fact the ANOVA and group comparisons showed no overall differences between the groups in general performance, suggesting that task difficulty also does not explain any of the results.

A final possibility is that faces might not have drawn attention to produce a colour-naming interference, but may have caused an aversion from the pictures, resulting in attention being directed away from the pictures including the colour. If this was occurring we would have expected to see an overall group difference in response latencies and higher error rates for the AS group, neither of which occurred. Errors in the study were very rare for both groups, and there was no group difference on the task, merely a differential pattern of response across the conditions. However, further work is needed to investigate attention mechanisms in ASC during the task. Studies involving eye tracking, galvanic skin response, and neuroimaging could help to answer this question.

Limitations of the present study include the fact that we took no measures of anxiety, mood or hormone levels, given the known influence of these variables on performance in the emotional Stroop task. We also did not include a clinical control group other than AS, which would test the specificity of the results. Finally, we included only male participants in the current study, and it would be interesting to investigate whether females show the same pattern of results. Future studies can address these issues.

CONCLUSION

The results reveal an attention bias to threatening facial expressions in typical control participants, demonstrating the value of the pictorial emotional Stroop as a paradigm for investigating attention and emotion in normal and psychiatric populations. The results also show an attention bias to faces in AS, regardless of the emotional expression or sex of the actor. These findings are consistent with studies of other clinical populations showing a Stroop effect for stimuli related to the concerns relevant to their condition. This preliminary study of the emotional Stroop in ASC suggests that this paradigm may be a fruitful avenue for further research.

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DECLARATION OF INTEREST

None.

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