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Spatial Cognition and Emotion Recognition as a function of ASD

by

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ABSTRACT

Past research shows that although autism has among its particularities a tendency for lower results on cognitive tasks, especially on the executive functioning skills, people with ASD perform equally well, and sometimes even better than controls on tasks for visuo-spatial cognition. However, there is also evidence suggesting that people on the spectrum might have an impaired emotion recognition mechanism. In addition, there is research on spatial cognition and affect, looking at how emotions provoked by stimuli can change the way in which we perceive the space. In the current study, we will look at spatial cognition and emotion recognition as a function of ASD.

Key words: spatial cognition, emotion recognition, AQ, autism
INTRODUCTION

Spatial locations and emotion recognition in autism

Past research shows that people with ASD have an intact, or even enhanced in some cases visuo-spatial system, and they can perform well on spatial cognition tasks. For example, they can be pretty good at tasks involving maps and mazes (Caron et al, 2004), as well as learning and indicating the location of an item in a virtual maze (Edgin et al, 2005). The literature on spatial cognition and affect also suggests that emotional triggers from items can help people remember better their locations (Crawford and Cacioppo, 2002).

The current study looks at the relationship between spatial cognition and emotion recognition as a function of ASD, and considers the question of whether people with autism would show similar results to controls in tasks involving visuo-spatial cognition and affect. Since one of the deficits in Autism is the impaired social skills system, and past research suggests that people with ASD might have impaired emotion recognition, we would expect emotional content in a visuo-spatial task to affect their performance. We use the spatial-affect task because it is a method to examine how people process social-emotional information. In their study, Norris et al (2011), explain how using affective judgment tasks is a good way to understand individual differences because they show the underlying processes for the reactions to affective stimuli. For this, we adapted the Crawford and Cacioppo (2002) study, and used pictures that show facial emotions.

Since we don’t have access to a population with ASD, we used a subclinical autism population. We administered the Adult Autism Spectrum Quotient (AQ) questionnaire, which measures autistic traits in the general population on a continuum.
Past researched has looked at subclinical populations, mostly in the context of relatives of people on the spectrum to see how they perform on different tasks compared with their siblings with autism for example and with controls. We expect people who score higher on the AQ, thus showing more autistic traits, to perform differently than those who score lower on the AQ.

**Literature Review**

**Autism and spatial cognition**

Baron-Cohen (2002) wrote about the extreme male brain theory of autism, which dates back from 1944 when it was first suggested by Hans Asperger. According to this theory, people with autism suffer from an extreme male brain, where all the male-specific brain functions are enhanced and all the female specific brain functions are diminished. This would explain the low “empathising” which includes dealing with emotions, and other people, verbal skills etc., and it could also explain the high “systemizing” which includes spatial skills, constructing skills etc. (Baron-Cohen, 2002). Thus according to this theory, people with autism should show enhanced performance on visuo-spatial tasks compared to controls.

In addition, Barnes et al (2008) mention that autism is defined by atypical learning in processes that involve social contexts, language, and motor behaviour. The authors suggest that the ability to learn environmental regularities, without conscious awareness supports language and motor skill acquisition, as well as social intuition, all which are impaired in autism. Contextual information learning guides perception of social cues and predicts actions, thus it could mediate cognition in ASD. Thus, in their
study, Barnes et al (2008) looked at learning of contextual information in the spatial domain where repeated experience with spatial relations provides cues for visual attention in a visual search task, and in the perceptual-motor domain where repeated experience with a sequence of stimuli provides cues for predicting responses to serial or alternating reaction time tasks. Their results showed that people with ASD and controls did not differ in the learning of contextual information in either the spatial or perceptual-motor domains (Barnes et al, 2008).

Edgin et al. (2005) tried to clarify the contradiction between results in the literature. On one hand, there was an association found between Asperger’s syndrome and NLD cognitive profiles, suggesting that people with ASD should have spatial deficits. On the other hand, previous research and informal stories suggested that spatial cognition might be instead a strength in ASD individuals. In their study, Edgin et al. (2005) tested whether the Executive Function (EF) theory or the Central Coherence (CC) theory are correct since both these predict that spatial cognition at least on some tasks is impaired, whereas previous research showed that people with autism perform better or at least as good as the control groups. One of the tasks they used in their research was the Computerized Morris Water Maze, in which the ability to learn spatial locations is tested through a computer adaptation of the maze task used with animal models (Thomas et al, 2001). In the computer version, the child uses a joystick to move around an arena, and there are markers on the walls that help the child form a mental map of the arena. A “blue” rug is visible on the arena, and the child must move to the blue rug. After a few trial attempts, the child is told that the rug is now “invisible”, and they must search the arena to find it (when found, it gets coloured to confirm the location). The mean amount
of time the child looks in the correct arena’s quadrant (e.g. north east (NE) quadrant) is the interest variable because if the participant has successfully learned the location, they should spend more time searching in the correct quadrant. Both ASD and control groups spent more time than chance (25%) looking in the correct quadrant during learning trials suggesting spatial learning had taken place. The performance of the ASD group was the same as for the control group, the only difference being that controls improved with age, whereas ASD participants stayed roughly the same, however their performance was always ok.

Caron et al (2004) conducted a new series of experiments with a group of people with high functioning autism (HFA), and a control group in order to test whether HFA individuals have superior visual spatial skills in a non-social context. Most of the tasks in which participants with autism show enhanced performance involve spatio-constructive abilities, and manipulation of components of a 2D or 3D model, however they do not involve executive functions such as planning or switching from one mental set to the other, because executive functioning is usually impaired in autism. In their study, Caron et al (2004) looked only at one aspect of spatial ability, i.e. the spatio-cognitive aspect of navigation skills (cognitive mapping). Their study involved 5 spatial tasks, the first three experiments taking place in a human size labyrinth (route learning, reversing a route and pointing towards unseen locations). The level of difficulty of each task was also changed, to see how that affects performance (Caron et al, 2004). The last two experiments were meant to see how spatial knowledge is transferable from a macro-scale space such a human size labyrinth where information has to be processes in space and time, to a micro-scale space such as a map where all the spatial information can be perceived from
a single point of view. In the fourth task, participants had to memorize a human-scale labyrinth and then draw it on paper, and in the fifth experiment, they had to use spatial knowledge acquired in a micro-scale space (map) to find their way in a macro-scale space (a human size labyrinth). Overall, the results showed that HFA participants performed at least as good as the controls, in tasks such as route learning, reversing a route or pointing task. However, they did show some enhanced performance on tasks involving transfer of spatial knowledge between micro and macro scale spaces, suggesting a better accuracy in graphic cued recall of a path for HFA participants (Caron et al, 2004). The authors suggest that enhanced discrimination, detection and memory for visually simple patterns might be the reason for why HFA participants show enhanced performance on some of these visuo-spatial tasks, since most of them are related to pattern recognition.

All these studies suggest that people with autism, although having impaired executive functioning skills and performing low on some cognitive tasks, have an intact or even enhanced in some cases visuo-spatial ability. This is important because it suggests a system that people with ASD might use to learn, and to adapt to the environment.

**Autism and emotion recognition**

Past research on the topic of facial emotion recognition in autism has provided contradictory evidence. There is evidence that people with ASD are not attending to facial emotions in the same way non-autistic people do. For example, Weeks and Hobson (2006) showed children with ASD and children without ASD photos of people differing on various levels (gender, age, facial expressions, what hat they were wearing) and found
that when asked to sort the people in groups the children without ASD tended to look first at facial expressions whereas children with ASD were more likely to sort them based on the type of hat and neglect facial expressions.

On the other hand, Katsyri et al (2008) also studied facial emotion recognition in ASD from the weak central coherence theory’s perspective, which says that people with autism have a tendency to focus on the local rather than the global features of stimuli. Therefore, in their study they looked at dynamic and static faces whose spatial frequency content had been filtered so that the local parts were not easy to identify in the strong filtering condition for example. In the non-filtered condition controls and ASD participants recognized the emotions similarly but the ASD group was more impaired on the filtered images than the control group. Their results suggested that people with ASD have an intact recognition of basic facial emotions but have an impaired visual processing of global features thus explaining maybe contradictory findings in the literature.

In addition, Homer and Rutherford (2008) found that high-functioning participants with autism performance on a identification task was predicted by their performance on a delayed matching task for angry-afraid, happy-surprised and happy-sad continuums, indicating that they can categorically recognize facial emotions. However, in contrast to this, Teunisse and de Gelder (2010) found that in comparison to controls, the performance of the adults with autism on the identification task did not predict their performance on the discrimination task, therefore showing that individuals with autism do not perceive facial expressions categorically. One of the authors’ suggestions was that participants with ASD with higher social IQ might use compensatory strategies learned during some of their training programs.
One of the reasons for why evidence for the impaired ability of people with ASD to recognise facial emotion expressions is contradictory might be that full-blown face expressions are being used where the emotions are not very subtle and people with ASD might use compensatory mechanisms or perform generally similar to controls on such tasks. Smith et al. (2010) tried to test this by looking at varying intensities of expressions of the six basic emotions (anger, disgust, surprise, fear, happy, sad). They found that participants with ASD recognised anger and surprise at 100% but were less accurate for lower levels of intensity whereas for disgust they were impaired even at 100%. The task they used was the Emotion Recognition Task (ERT) that is a computer-generated program showing ‘video clips’ of varying intensities of facial expressions of emotion, from 20% to 100%. This suggests that maybe people with ASD do have an impairment in facial emotion recognition, but that is compensated through various mechanisms when the emotions are fully shown.

**Spatial location and affect**

Crawford and Cacioppo (2002) addressed the combination of spatial cognition and affect, which is important because many approach and avoidance behaviours need spatial and affective information. They made the distinction between positive and negative affective information, where positive affect can indicate an opportunity, whereas negative affect might indicate danger. As a result, people might react more strongly to negative affective information because it is more important for survival to avoid danger, than to respond to opportunities. In their first experiment, Crawford and Cacioppo (2002) tested whether people can detect correlations between spatial locations of stimuli and the
affective response those stimuli arouse, and whether people are better at this when the stimuli have a negative valence. They had forty-two undergraduate students from University of Chicago who completed a brief section of the experiment both with positive and negative pictures to get used to the task indications, and then they were presented with the test trials. There were four conditions, so that each group of people was shown only one of the four sets of pictures (positive or negative valence, extreme to the right or to the left). Participants saw photos on different parts of the screen and were asked to predict the location of new pictures. They were told that the experimenter made a mistake and forgot to include a few pictures and they had to click on the screen on the location where the picture would go. The hypothesis was that if negative affective stimuli produce stronger impressions, then the participants in that condition should produce stronger correlations between spatial location of the stimuli and the pictures. The two level ANOVA (positive negative for valence and extreme right and extreme left for direction) showed that there was a main effect of valence, thus as hypothesized, the participants in the negative affect condition produced correlations that were a closer approximation than the participants in the positive condition (Crawford and Cacioppo, 2002).

In their second experiment, they wanted to see if the results from experiment one can be attributed to the arousal level of the photos, with the negative photos being maybe more arousing than positive photos, thus making participants remember their locations better. They also wanted to test the sensitivity to the degree of association between affect and location. Thus, they included two conditions, one having a stronger correlation between affect and location, and one as in the previous experiment. They also controlled for the pictures to be similarly arousing. Forty-nine students from University of Chicago
participated, and the procedure was very similar to the first experiment, the difference being that there was a 2X2X2 design now in which participants were assigned to either positive to neutral, negative to neutral pictures, either a weak or a strong correlation between location and affect, and either a left or a right side association with the extreme (non-neutral) photos. The results showed that similarly to experiment one, the participants in the negative condition formed stronger correlations than the participants in the positive condition. There was also an effect of the strength of correlation, with participants in the stronger correlation performing better than the ones in the weaker correlation group. Thus, the overall results showed that people are sensitive to the correlations between spatial locations of items and the affective responses those items provoke in them, especially when the items have a negative affect (Crawford and Cacioppo, 2002).

**Current study and hypothesis**

The current study used the Crawford and Cacioppo (2002) study as basis and presented images to participants where there was a correlation between the emotional valence (in our case the anger level) and the x location of the photo being shown. For the images, we have used facial emotions ranging from neutral to angry. Since past research showed that negative arousing stimuli are better remembered we decided to use anger as the emotion for this study because it might be more arousing than other emotions.

In this study we looked at how participants’ scores on the AQ correlated with their inferred correlation between the location of the images shown and the emotional valence of the images. We hypothesized that people who score higher on the AQ, thus showing
more autistic traits will be less likely to infer a correlation between anger and location.

**Theoretical and practical significance**

The current study would add to the existent literature on spatial cognition in autism by looking at the relationship between this and emotion recognition. Knowing the extent to which people with ASD perform well on spatial cognition tasks, when these involve emotion related stimuli could help future interventions in this area. Past research has already suggested that people with autism might use their visuo-spatial skills as a compensatory strategy, and this study could provide more information on this topic. In addition, this study could provide information on whether the AQ can be used with an online population for example and how scores on the AQ correlate with performance on cognitive tasks.

**METHODS**

**Participants and design**

We recruited 181 participants, aged 18-67, through Mechanical Turk and paid each of them $2.5 for the study, which took approximately 18 minutes to complete. Participants were assigned to one of the two conditions (anger correlated to right side of the space and anger correlated with the left side). Participants viewed sets of pictures that ranged from neutral to angry, and that contained an association between the anger level and the position on the x-axis. Participants also filled in the AQ survey and they had to place 16 new images in the location they considered appropriate for the particular picture shown.
Materials

The Photos

The stimuli were chosen from the NimStim set of facial emotions. The training set included 32 faces: 4 female models and 4 male photographs, each showing 4 emotions ranging from neutral to very angry. The two in-between levels of anger have been obtained by morphing images from neutral to angry with the Fantamorph software and edit them in Photoshop afterwards to look similar to the original neutral and angry images. Each of the 32 photos was presented in 6 different locations therefore in the end we had 192 images presented. Each image had the same size (width = 203, height = 260) and was presented on a blank screen of size (width = 670, height = 503) for 2 seconds. All the images on blank screens were put into a presentation made through the online power point and were inserted in the Qualtrics survey through an iFrame. The size of the presentation was made so that the white screen matches in size the white screen presented during testing phase (width = 700, height = 530). The four x locations we chose were equidistant (204.8, 409.6, 614.4, 819.2). The correlation between the anger level and the x location was .52. The photos also varied on the y-axis in 4 different locations but the y location was not correlated with the anger level.

We had two conditions, one in which anger was correlated with the right side of the space and one in which anger was correlated with the left side. For each of the two orders we had 5 random orders of showing the images during training to make sure no pattern is accidentally introduced.

For testing, we had 16 models (8 male, 8 female), 4 in each anger level. The participants were shown the image in the middle of the screen (the image was the same
size as the image in the training) and then they were shown a blank screen of the same size as the one seen during training and asked to click on the blank screen where the image would have appeared. The order of showing the 16 images was randomized within Qualtrics.

![Fig1. Examples of faces in each of the 4 locations on the x axis.](image)

**The AQ Questionnaire**

We have also used the Adult Autism Spectrum Quotient (AQ) questionnaire, which was developed at ARC (Autism Research Centre within the School of Medicine, in the Department of Psychiatry at University of Cambridge, UK), by researchers such as Simon Baron-Cohen, Rosa Hoekstra, Mike Lombardo, and Bonnie Auyeung etc. The Adult AQ was developed to test whether the high functioning adults with ASD or Aspergers are just an extreme on a dimension of autistic traits that runs through the general population.
Their studies showed that people with a diagnosis score above 32 out of 50 on the AQ, first-degree relatives score higher than average on the AQ, males in general population score higher than females etc. [1]. The AQ also seems to predict clinical diagnosis. However, the AQ is currently studied to see if it can be used as a screening instrument to detect undiagnosed cases of autism or Asperger Syndrome. They have also tested the AQ as a predictor of performance on cognitive tests such as social-attentional cueing. The AQ questionnaire was used to identify the subclinical ASD population, the people who show some tendencies similar to people on the spectrum, although they do not have a clinical diagnosis. We assumed that a subclinical population would perform similarly to the clinical population.

**Procedure**

Participants were told this is a study about faces and they had to fill in the AQ questionnaire first then answer some demographics questions (age, gender). Then they were told to look at the faces presented and form an impression of each person; they were presented the training slideshow of 192 photos, which took 6-7 minutes to run. Afterwards they were asked to imagine that some photos have been excluded from the slideshow and click on the blank screen where each photo would have appeared if included in the slideshow. First the photo would appear in the middle of the screen and then a blank screen would show up automatically. After clicking on the blank space, participants could move to the next question.
RESULTS

Scoring the AQ

The AQ contains 50 questions and for each answer that shows autistic-like tendencies a point is added. On approximately half (2, 4, 5, 6, 7, 9, 12, 13, 16, 18, 19, 20, 21, 22, 23, 26, 33, 35, 39, 41, 42, 43, 45, 46) of the questions 1 point was awarded for a definitely or slightly agree and on the other questions 1 point was awarded for definitely or slightly disagreeing (1, 3, 8, 10, 11, 14, 15, 17, 24, 25, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 40, 44, 47, 48, 49, 50).

Data Analysis

After cleaning up the data we were left with a sample of 166 participants. We excluded everyone that completed the survey in less than 9 minutes because just watching the slideshow would take about 6-7 minutes so we considered that 9 minutes is too short for participants to have carefully attended to all the AQ and testing phase questions. We also took out any subject where more than 3 answers in the testing phase
were missing or where there might have been some technical errors (e.g. the correlation of the location they put down and the anger level was a perfect 1 or -1, no data was recorded etc.).

In the end, we obtained a wide range of scores on the AQ questionnaire, which is important for future research because it shows the mTurk population is diverse enough to get a huge range on such a scale. The graph in Fig. 3 shows the frequency of scores on the AQ questionnaire.

![Fig. 3](image_url)  
**Fig. 3**  
Frequency of AQ scores
We could not find a correlation between the AQ score and the correlation inferred between location and anger level. However, the data was very noisy, with participants scoring very different on both the AQ scale and inferring the correlation at different levels. Overall we can see that people inferred the correlations (see Fig. 4) both in the order 1 when the anger was associated with the right side of the space and in the second order when anger was correlated with the left side of the space. However the inferred correlation average is very small in both conditions. Fig. 5 shows the relationship between the AQ score and the inferred correlation. We expected a line with negative slope so that people scoring low on the AQ would perform better than the people scoring high on the AQ whose inferred correlation between space and anger level would be closer to 0. However the slope is pretty flat due to huge noise in the data.

<table>
<thead>
<tr>
<th>Average of Ang-Lvl Corr</th>
<th>Total</th>
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<tr>
<td>Row Labels</td>
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<tr>
<td>Grand Total</td>
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Fig. 4
Average correlation between location and anger level in each condition
DISCUSSION

Past research in the autism field has looked at the performance of people on the spectrum on different cognitive tasks. Although participants with ASD are usually impaired on cognitive tasks, especially on executive functioning tasks, they usually score similar to controls or even better on visuo-spatial tasks. Previous studies showed that people with autism are very good at transferring information from small size (maps) to real life size (maze) and the other way around (Caron et al., 2004). Other studies (Edgin et al., 2005) have also suggested that participants with ASD perform similar to controls on visuo-spatial tasks.

Another important research area in ASD focuses on emotion recognition and the evidence is contradictory. On one hand there are studies that suggested that participants
with autism are just as good as controls to categorically recognize facial emotions (Homer and Rutherford, 2008) and on the other hand there is research showing that people on the spectrum perform worse than controls on similar tasks (Teunisse and de Gelder, 2010). Although there is no doubt ASD participants do not attend to facial emotions in the same way as controls and they might not use this as a main criterion when sorting people (Weeks and Hobson, 2006), there are also other explanations for why people on the spectrum perform worse on facial emotion recognition tasks. One explanation is that their emotion recognition mechanism is intact but they have a tendency to focus on the local features rather than the global, thus a visual processing impairment could explain some of the contradictory results in the literature (Katsyri et al., 2008). Smith et al. (2010) had another possible explanation for the controversial results: the images used in most of the studies are full blown emotions whereas in real life for example that might not always be the case. They found that people on the spectrum can perform similar to controls on the full blown emotion images, but are less likely to recognize the emotion when it is presented at a lower intensity. Therefore, this could suggest that although there is an impairment in the emotion recognition, high functioning ASD participants could use compensatory strategies for emotions shown at full intensity.

A different area in psychology research looked at space and affect and how the emotional valence of the stimuli can affect the way people understand space. For example, Crawford and Cacioppo (2002) found that people can infer a correlation between the location and the emotional valence of an image, and that pictures arousing negative emotions are better remembered thus leading to higher inferred correlations between space and emotional valence.
The current study was based on previous research on spatial cognition and affect as well as on the research in the autism looking at emotion recognition impairment and enhanced abilities on visuo-spatial tasks. If people with ASD are usually good on visuo-spatial tasks then they should perform similar to controls on a task such as the one in Crawford and Cacioppo (2002) study. However, if the task involves emotion recognition then we would expect them to be less likely to infer a correlation between space and emotional valence. Since access to special population such as ASD is difficult, we have used the AQ questionnaire, designed at Cambridge to measure autistic traits in the general population on a continuum. Therefore, people scoring high on the AQ show more autistic traits: past research has shown that they tend to be male rather than female, scientists (e.g. mathematicians), and that really high scores might come from people with an actual diagnosis of Aspergers or ASD [1]. For the task itself, we chose to focus on anger because of the past research suggesting that negative arousing stimuli are better remembered (Crawford and Cacioppo, 2002).

We hypothesized that people who score high on the AQ questionnaire thus showing more autistic traits would be less likely to infer a correlation between space and anger level since they would have more trouble attending to the emotional content of the images shown. However, our findings did not support the hypothesis. One possible reason is that participants with autistic traits, being very good at visuo-spatial tasks found a pattern in the photos and used that thus compensating for the emotional deficit. Also, overall participants did not seem to infer the correlation therefore our 0.5 correlation between the x location and the anger level might have been too subtle for people to notice. Another limitation of our study is that being an online survey, we couldn’t control if participants
attended to the screen the whole time, and thus it is possible that many did not watch the slideshow completely since it was 6-7 minutes.

Overall we could see a trend in the direction we expected, and we are happy to have obtained a wide range of answers on the AQ. The results are promising for future research planning on using the AQ, as well as looking more into the spatial cognition and affect. In the future we are considering running new versions of this study in which the correlation between location and anger would be stronger (0.7 instead of 0.5 for example), and in which we make the subjects attend the slideshow by having them count the number of times female faces are shown for example.
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