Are the eyes a window to the soul or merely a piece of it? Investigation into whether abnormal eye-gaze or weak central coherence causes the greatest impairments in emotion expression recognition

Jessica Williams

Supervised by: Simon Davies

April 2011

Are the eyes a window to the soul or merely a piece of it? Investigation into whether abnormal eye-gaze or weak central coherence causes the greatest impairments in emotion expression recognition.

ABSTRACT

It is unclear whether emotion recognition deficits, in particular those found in autism, are due to a failure to extract salient social information from the eye region or a difficulty in combining all facial cues into a coherent whole. To evaluate which ability is most vital to successful emotion recognition, the availability of these processes were manipulated in non-clinical participants. Participants were presented with six basic expressions of emotion from the Ekman and Friesen Facial Affect set (1976) and performed a six alternative forced choice response task to facial expressions of emotion.

In **condition 1**, the effects of a failure to attend to the eye region were tested through a mask being placed over the eye region. In **condition 2**, the effects of weak central coherence were tested using a gaze contingent window in which holistic processing was disrupted and the observer was restricted to viewing one fixated feature at a time. Eye fixation data was recorded to examine the influence of information from the eyes and mouth on correct recognition of emotions.

Clear differences were seen between the conditions, with emotion recognition most impaired when the eye region was not available. However, the results demonstrated that each emotion was differentially affected by experimental manipulation, in particular recognition of disgust was most impaired in the second condition when holistic processing was disrupted. The results suggest that deficits in emotion recognition can generally be attributed to a failure to attend to the eye region yet local level processing may also play a significant role, depending upon the emotion in question.

KEY WORDS	**AUTISM**	**FACIAL EXPRESSIONS OF EMOTION**	**THEORY OF MIND (ToM)**	**WEAK CENTRAL COHERENCE (WCC)**	**EYE-TRACKER**

Introduction.

The ability to understand others' thoughts and feelings and to use this knowledge to predict behaviour is vital to our successful participation in the social world. An important cue to such inner mental states is widely accepted to lie in facial expressions which offer a window to such affective states (Russell & Fernandez-Dols, 1997). The ability to recognise and understand emotional cues from facial expressions, and use these to make appropriate judgements is integral to adaptive social cognition, and the normal population is impressively proficient at such tasks (Adolphs, 2003). Further, not only are we remarkably perceptive of these cues, but we harbour an adept appreciation of the importance of context in interpreting them, which is used to modulate our judgements of what such expressions may signify (Adolphs, 2003).

However, the typically developing population cannot claim faultless possession of this ability. Significant individual differences exist in the normal population in the ability to correctly infer and understand the inner mental states of others (Kinderman, Dunbar, & Bentall, 1998). Within clinical populations, deficits in such social cognition are characteristic of autistic spectrum disorders (ASD), and are believed to stem from difficulties in the perception of emotional expressions (Rutherford & McIntosh, 2007).

Dominant theories of ASD are of two types - those hypothesising a domain-specific impairment in social cognition and those hypothesising the core deficit lies in a more general non-social processing system (Happe, Ronald & Plomin, 2006). The primary domain-specific theory of autism is that they possess poor 'theory of mind' (ToM), the ability to attribute and understand inner mental states. This is claimed to stem from a failure to recognise social information communicated through the eyes which leads to difficulties recognising facial expressions of emotion (Baron-Cohen, 1995).

The principal domain-general theory of autism is that of Weak Central Coherence (WCC) (Frith, 1989). WCC is defined as an impairment in the ability to combine diverse information into a single, coherent concept (Frith, 1989). Recent studies showing autistics do have global processing abilities has led to a modification of the theory with the detail-focussed processing style found in autism now accounted for as a cognitive bias towards the local level (Happe & Frith, 2006). This theory proposes that where typically developing individuals focus their attention on the global, meaningful aspects of the visual world, the autistic individual focuses on local detail. Research suggests that it may in fact be this processing bias that leads to the social impairments in autism (Pellicano, 2010).

Both poor ToM and WCC are proposed to affect emotion recognition in autism. In the typically developing population, an individual's score on the Autistic-Spectrum Quotient (ASQ) (Baron-Cohen, Wheelwright, Skinner, Martin & Chibley, 2001), designed to measure autistic like traits in the normal population, has been found to be related to individual differences in both gaze cueing and holistic processing ability (Frischen, Bayliss & Tipper, 2007). A higher score on the ASQ, indicating a higher number of autistic traits, was found to be negatively correlated with the ability to respond to social cues relayed through the eyes and positively correlated with a local processing bias (Frisher, Bayliss & Tipper, 2007). The foremost issue of debate is whether these impairments are related or independent in the development of autism and the social difficulties that ensue (Frischen, Bayliss & Tipper, 2007).

As Happe, Ronald and Plomin (2006) acknowledge, it is difficult to establish the relationship between the numerous deficits found in autism as they co-occur to a significant degree. This further impedes the task of establishing the causal relationship between social deficits and the simultaneous cognitive and gaze abnormalities. In order to untangle this web of impairments Happe et al. (2006) suggest investigating the occurrence of these deficits in the normal population. However, studies of how normal individuals process faces have left an open question regarding whether holistic processing of the face or local processing of the eyes come first, and which is most important for emotion recognition. For example, Bentin et al. (2006) presented non-clinical participants with line drawings of faces. In one condition the eyes were replaced with drawings of small objects. In a second condition the eyes were replaced with small faces. Electroencephalography (EEG) recordings were taken, which measure the electrical potential of neurons in the brain. An evoked response, or event related potential, indicates neural activity specifically related to a cognitive task. A common finding from studies which have employed this to investigate the neural substrates of face recognition is a signature negative evoked response at approximately 170 ms from stimulus onset for participants viewing faces compared to non-face stimuli. This is commonly referred to as the N170 response. The results found that when the eyes were replaced with objects, no N170 response was elicited. However, the response returned when the eyes were replaced with small faces, and subsequent tests ruled out the possibility that this was due to the small faces attracting attention. This suggests that holistic processing of the face, and local processing of the eyes, occur in parallel. Thus, as Itier and Batty (2009) acknowledge, the results are consistent with either the ToM hypothesis- that poor emotion recognition results from a deficit in extracting salient mental state cues from the eyes, or, the WCC hypothesis- that it is the result of a problem integrating the eyes with information extracted from other parts of the face. The ability of each hypothesis to fully account for emotion recognition deficits in autism, and successful emotion recognition in typical individuals, will be discussed.

Theory of Mind Mechanism.

The ToM theory (Baron-Cohen, 1995) claims that the emotion recognition deficits in autism are the consequence of deficits in processing social information from the eyes. This then results in a poor theory of mind. The theory posits an innate eye direction detector (EDD) mechanism in the brain. The EDD is responsible for detecting eyes, determining what an agent's gaze is directed towards, and inferring the intentions and mental states of the agent from these cues. Baron-Cohen (1994) considers this mechanism to be fundamental to later development of ToM as it enables the individual to detect salient social information from the eye region. Attending to social gaze in childhood enables the adult to recognise emotional expressions and the inner mental states which they communicate (Frischen, Bayliss, & Tipper, 2007). Thus, a failure to attend to such cues would leave the autistic brain without the social information they need to develop adaptively (Rutherford & McIntosh, 2007).

Support for this theory comes from recent research into autism which has employed eye-tracking technology. The benefit of this tool is that it enables an insight into the strategies adopted in processing social information (Boraston & Blakemore, 2007). These studies show a significant relationship between abnormal eye and face gaze and poor social abilities.

For example, Neumann et al. (2006) found that individuals with autism, when viewing facial expressions of emotion, fixated more on the mouth region than the eyes compared to typically developing individuals. This indicates that autistic individuals use facial information differently from normal adults. Neumann et al. (2006) concluded from this that it is the differences in visual field pattern when viewing faces which lead to the characteristically poor ToM in autism. Research by Klin et al. (2002) mirror these findings. Their results showed that autistic individuals spent less time fixating on the eye region than controls, and more time fixating on the mouth, body and objects when viewing dynamic video clips of social scenes. Fixation time on the body and objects was significantly correlated with poor social competence. This lends support to the ToM theory (Baron-Cohen, 1995) that early impairments in the EDD prevents the autistic child from experiencing and learning from social information communicated through the eyes, consequently hindering ToM development (Baron-Cohen, 1994). This is further supported by research using the ‘reading the mind in the eyes task’ (Baron-Cohen, 1997). Participants were presented with photographs of a person’s eyes and were to judge which of four mental state terms described the expression of the eyes. Individuals with autism performed significantly worse than normal adults in the task. In the normal population eye-gaze perception has been found to be a crucial skill in emotion recognition, and thus the foundation for social competence (Slessor, Phillips & Bull, 2008). However, it is also acknowledged that normalising the face gaze of individuals with autism to increase gaze to the eyes may not be sufficient to overcome the numerous social deficits (Speizo et al., 2007). This implies that the ToM mechanism may not fully account for the development of successful, or dysfunctional, social cognition.

Weak Central Coherence.

The modified Weak Central Coherence (WCC) theory (Happe & Frith, 2006), may also account for the above findings. Coherent processing is required to integrate information and form meaning from the constituent parts (Iarocci et al, 2006). It involves automatic processing, enabling a rapid interpretation of information (Frith, 1989). Lahaie, et al. (2006) suggest that an enhanced focus on facial features may account for the eye avoidance typically seen in the viewing patterns of autistic groups. A local processing bias may enhance the amount of information extracted from parts of the face other than the eyes and would therefore reduce the need to fixate on the eyes. This local processing bias would explain findings that individuals with autism show significantly decreased performance in emotion recognition when face parts are obscured, a reliance on local cues would put then at a severe disadvantage in such tasks (Lahaie, et al, 2006). A focus on detail in a visual scene would also impede the ability to rapidly deploy attention when bombarded with dynamic information. With the recognition of emotion from facial expressions requiring rapid, online perception of subtle cues, a piecemeal strategy of analysing individual features would plausibly impede this ability (Rutherford & McIntosh, 2007).

A longitudinal study of children with autism by Pellicano (2010) supports this theory. WCC was found to predict the developmental trajectory of poor ToM. WCC may limit the ability to integrate visual cues to determine the intention and direction of an agent's gaze. This bias towards local detail may also prevent the autistic individual from developing the ability to generalise perceptions and experience across diverse contexts (Iarocci et al, 2006). Such a cognitive bias would account for the findings that autistic individuals have been found to show typical fixations to the eye and face region (Khun et al., 2010),) yet these were not shown to be related to social ability (Klin et al., 2002). Thus, autistic people may demonstrate the ability to attend to the eye region, yet the absence of a more parsimonious processing strategy accounts for the deficit in generalising what is learnt from such perceptions to other contexts and incorporating eye expressions with other information from the face.

There is strong evidence that holistic processing does underlie the ability to process facial expressions of emotions. Using the composite face paradigm, Durand et al. (2007) presented non-clinical participants with a face stimulus created by joining the top half of a face expressing one emotion with a bottom half expressing a different emotion, with the two parts either vertically aligned or misaligned. Participants were instructed to identify the emotion expressed by the top half of the face and ignore the bottom half. Previous studies of facial identity recognition have shown that adults are slower to identify either half when they are aligned compared to misaligned due to the aligned face being processed as whole. The results showed that correct emotion recognition for aligned faces was significantly poorer than for misaligned faces. The evidence supports the WCC theory that holistic processing is necessary for the extraction of emotion from faces.

The current study.

The debate is ongoing as to whether the poor social abilities found in autism are best explained by a specific impairment in the theory of mind mechanism, or a more general cognitive failing due to a detail-driven processing style (Pellicano, 2010). Further, there is still debate regarding the roles of the ToM mechanism and holistic processing in emotion recognition for the non-clinical population. The main issues are whether its success is predominantly due to attending to, and understanding mental state cues from the eyes, or whether it is the integration of the eyes with the information extracted from other parts of the face which plays the greater role (Itier & Batty, 2009).

As discussed, it is difficult to determine the individual effects of a dysfunctional ToM mechanism and WCC on the characteristic poor social cognition in autism due to the co-morbidity of the symptoms. These symptoms are not open to manipulation.

The current study will therefore investigate the independent effects of a deficit in recognising information from the eye region- as a dysfunctional ToM mechanism would manifest itself, and a local processing bias- as WCC would manifest itself, on emotion recognition in the non-clinical population. Investigating which strategy is vital for the non-clinical population to be proficient in emotion recognition should enable insight into what may be impaired in a clinical population who have difficulty with this skill.

Typically developing adults use information from the eye region for emotion recognition, whilst individuals with autism fail to use this information (Speizo et al, 2007). Typically developing adults also tend to process visual images on a global level, processing faces holistically, whilst autistics tend to focus on individual features of a face (Frith, 1989). The present study will manipulate the availability of each of these abilities separately. Participants will perform two forced-choice response tasks in which they will be required to correctly identify facial expression of emotion.

In **condition 1** the tendency of autistic individuals to fail to direct attention towards the eyes will be induced through a mask being placed over the eye region of the facial images. This will enable us to mirror the tendency of autistic individuals to rely on emotional information from other regions of the face. In **condition 2** holistic processing of the faces will be restricted using a gaze-contingent window in which the participant's visual field is restricted to the area the observer fixates on. This has been validated as a method of restricting holistic processing of faces by Van Bell et al. (2010).

In order to probe how facial information is used in recognising emotion expressions, fixations to the eye and mouth regions will be recorded. This will help to determine whether there is a relationship between the amount of information extracted from each area and correct emotion recognition.

Thus, the main aim of the current study is to examine whether WCC, as reflected in a bias toward local detail, or a dysfunctional ToM mechanism, as reflected in failure to extract information from the eye region, results in the greatest impairment in emotion recognition. Through determining which process is the most vital for competent emotion recognition in the normal population, it may shed light on whether the Theory of Mind mechanism or the Weak Central Coherence theory best accounts for the emotion recognition impairments in autism.

Methods.

Design.

Analysis of Performance.

A 2x6 repeated measures ANOVA was carried out to test the difference between conditions in accuracy rates for each emotion. The independent variables (IV's), condition (ToM and WCC), and emotion expression (happiness, fear, surprise, anger, sadness, surprise, disgust). Emotion recognition was the dependent variable (DV) and was a measure of how many times each emotion expression was correctly recognised.

Analysis of the use of facial information in recognising facial expression of emotion.

A 2x2 repeated measures ANOVA was carried out to test the difference in dwell time on the mouth and eyes between the two conditions. There were two IV's, experimental condition: ToM and WCC, and interest area (IA): eyes and mouth. Percentage dwell time on each interest area was the DV.

To investigate the influence of information from the eye region and mouth region on the ability to identify facial expressions of emotion, total dwell time was calculated for each interest area and then averaged over correct trials, excluding dwell time for incorrect trials in the WCC condition. The same method was repeated for incorrect trails. A 2x2 repeated measure ANOVA was performed for each emotion. The IV's were interest area (IA) which had two levels (eyes and mouth) and accuracy (correct and incorrect). The DV was percentage dwell time on each IA. This analysis was not carried out for the ToM condition as the aim was to analyse the contribution of each IA to participant's ability to correctly recognise emotions. For the ToM condition, the eyes were not available and so participants were only able to obtain information from the mouth region

Participants.

16 participants (5 Male and 11 Female) consisting of undergraduate psychology students volunteered to participate in the study and received course credits for their participation. All participants had normal to corrected normal vision. The study was approved by the Liverpool Hope University ethics committee. All participants gave informed consent before commencing the study (see Appendix 1 for an example consent form and information sheet). The data of participant 12 was removed due to a problem in calibrating their eye preventing them from viewing faces in condition 2.

Materials.

Emotion recognition from facial expressions used 6 identities (3 male, 3 female) from Ekman and Friesen Facial Affect set (Ekman & Friesen, 1976), each displaying 6 basic emotions (happiness, surprise, fear, sadness, anger and disgust). A trial block consisted of 6 faces expressing a neutral expression. All images had a width of 290 pixels and height of 428 pixels and were centrally displayed on the computer monitor with a location of location 367w, 170 h, measured in pixels from top left. The eye to screen distance was 48.4cm from top to top and 64.3cm from top to bottom.

Experiments were built using SR Research Experiment Builder version 1.5.201. Eyelink data was analysed with Data Viewer version 1.8.1. Two forms of data were collected. Choices of emotion for each facial expression were collected using a results file programmed within the SR Experiment Builder which records mouse data. Eye-tracking data was recorded using the Data Viewer to extract eye movement data from the Eyelink 1000 desktop mounted eyetracking system.

In discriminating fixations thresholds were set at 7ms. The eye-data of interest was dwell time, measured at a sample rate of 1000hz. Percentage time during the viewing of each face spent fixating on a given area was the measure of interest.

Interest areas (IA) were programmed into the experiment using the Date Viewer with the same areas for each face. IA's were not defined after the experiment as adjusting IA's after participants had viewed an image may have introduced a bias. The IA's specified were the eye region and the mouth region (see Figure 1.2 for a visual depiction of the regions). The IA's were 290w, 90h. The location of the eye IA was 367w, 295h, the location of the mouth IA was 367w, 443h.

Procedure.

As participants arrived in the laboratory they read an information sheet and signed a consent form. Participants were instructed that they would perform 3 computer based tasks- a trial block and 2 experimental blocks.

As the categories of emotion were used in the ToM task and the WCC task, order effects were controlled by counterbalancing the order of trials, with half of the participants performing the ToM task first followed by the WCC task, and half performing the WCC task first and the ToM task second.

Nine-point calibrations and validations were performed using the Eyelink prior to the start of the experiment for each participant.

Trial Block.

A trial block was used to ensure that participants were familiar with the procedure before commencing the experimental blocks. Participants were presented with 6 identities (3 male, 3 female) taken from the Ekman and Friesen Facial Affect set (1976) each displaying a neutral expression. Each face was presented separately and was displayed for 5 seconds, following which a screen was displayed listing all 6 emotion labels and participants were to use the mouse to select an emotion they believed best described the expression seen in the face. Once a selection was made, the next face would appear.

Condition 1: Theory of Mind (ToM).

Emotion judgement of facial expressions in the "Theory of Mind" (ToM) task used faces with the eye region masked (see Figure 1.1 for a visual example). The mask covering the eye region was 290 pixels w, 428 pixels h, at a location of location 367w, 170h, pixels.

3 of the 6 identities chosen (1 male, 2 female) from Ekman and Friesen Facial Affect set (1976) were used, with each of the 6 basic emotions represented 3 times. Expressions and identities were presented in random order within the experimental block. Each face was presented separately and was displayed for 5 seconds, following which a screen was displayed listing all 6 emotions and participants were to use the mouse to select the emotion seen in the face. Once a selection was made, the next face would appear.

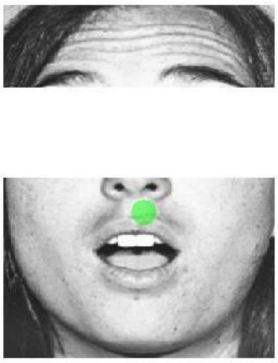

Figure 1.1 An example of the stimuli used in the ToM condition.

Condition 2: Weak Central Coherence (WCC).

Emotion judgement of facial expression in the ‘Weak Central Coherence” (WCC) task used the 3 remaining identities (2 female, 1 male) from the Ekman and Friesen Facial Affect set (1976). Expressions and identities were presented in random order within the experimental block. In this condition, only the fixated feature was visible through a gaze-contingent window, which was 100w by 100h pixels. The researcher experimented with different sizes of the window and found that 50w by 50h pixels did not reveal enough detail and 200w by 200h pixels revealed too much detail, to be valid tests of holistic processing.

The position of the window was continuously adjusted to the gaze position of the participant (see Figure 1.2 for a visual example of the stimuli). As in the first task, each face was presented separately and was displayed for 5 seconds, following which a screen was displayed listing all 6 emotions and participants were to use the mouse to select the emotion seen in the face. Once a selection was made, the next face would appear.

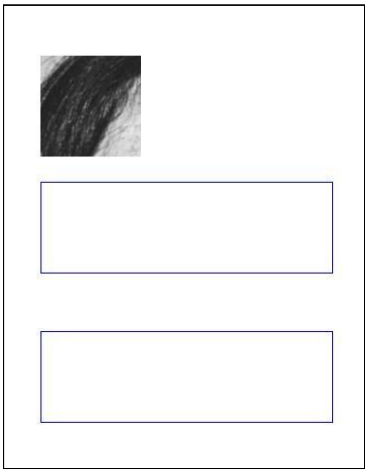

Figure 1.2. An example of the stimuli used in the WCC condition. The interest areas are also shown.

Results.

Accuracy between conditions.

A 2 x 6 repeated measures ANOVA was used to analyse mean correct recognition of each emotion in each condition. The independent variables were experimental condition (ToM and WCC), and emotion (happy, sad, disgust, fear, anger, surprise). The dependent variable was mean correct recognition of each emotion. The mean scores for participants correct recognition of each emotion for the ToM condition and WCC condition are displayed in **Table 1** (see Appendix 2 for a full copy of the descriptive statistics).

Table 1. **Descriptive statistics showing mean scores (maximum 3) and standard deviations on an emotion recognition task for each emotion in the ToM condition and WCC condition.**

Emotion	**Correct responses:**	**ToM**	**WCC**
Surprise	*M* ± *SD*	2.87 ± 0.35	2.60 ± 0.51
Sad	*M* ± *SD*	1.13 ± 1.06	2.01 ± 0.96
Anger	*M* ± *SD*	0.93 ± 0.70	2.60 ± 0.51
Disgust	*M* ± *SD*	2.01 ± 0.70	0.73 ± 0.70
Fear	*M* ± *SD*	0.87 ± 0.83	2.00 ± 0.93
Happy	*M* ± *SD*	2.87 ± 0.35	2.60 ± 0.63

Mauchly's Test of Sphericity was significant for the experimental condition factor ($p < .001$) and so the corrected Greenhouse Geisser degrees of freedom and significance levels are reported. The analysis revealed a significant main effect of condition ($F(1, 14) = 6.43$, $p= .024$) with more correct in the WCC condition ($M=2.10$, $SD= .10$) than the ToM condition ($M= 1.79$, $SD= .06$) (***Figure 2.1***). The main effect of emotion was also significant ($F(3.38, 47.27) = 18.96$, $p < .001$) indicating that mean correct responses varied between the emotions (see Appendix 3). The interaction (see Figure 6.2) between condition and correct response to each emotion was also significant ($F(3.41, 47.67) = 23.42$, $p < .001$) indicating that participants ability to correctly identify a particular emotion expression varied between the ToM and WCC condition. The effect size (partial eta^2) was .48 showing 48% of the variance in correct recognition of emotion can be explained by experimental condition (see Appendix 3 for a fully copy of the statistical output).

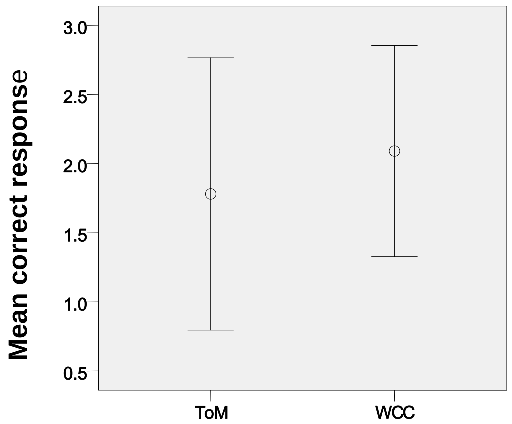

Figure 2.1. **Error bar chart illustrating the difference in confidence intervals for mean correct recognition of emotion in both the ToM and WCC conditions.**

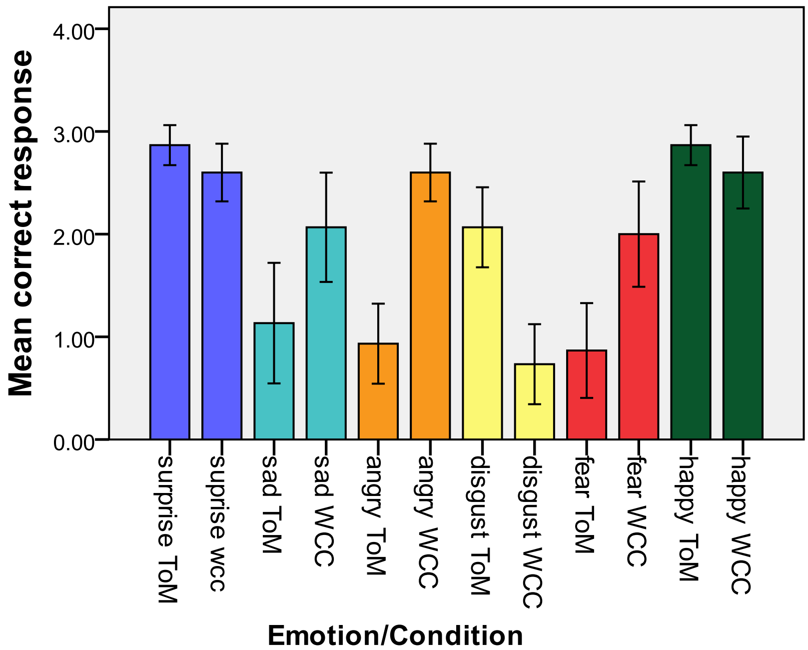

Figure 2.2. Error bar chart illustrating the difference in confidence intervals for mean correct recognition of each emotion (out of a maximum 3) in both the ToM and WCC conditions.

Post hoc comparisons were used to analyse the interaction further. Criterion for significance was set at $p \leq 0.008$ to reduce the possibility of a Type I error due to multiple comparisons (Appendix 4). Post hoc comparisons were performed for each emotion separately (sad, angry, fear, surprise, happy, disgust) to test for a significant difference in correct recognition of each emotion between the two conditions.

The analysis revealed that recognition of anger was higher in the WCC condition (M= 2.60) than the ToM condition (M= 0.93), with the difference being significant (t (14)= 8.92, $p < .001$). Recognition of fear showed the same pattern, being better in the WCC condition (M= 2.00) than the ToM condition (M= 0.87), the difference being significant (t (14)= -3.90, p= .002). Correct recognition of sad was better in the WCC condition (M= 2.07) than the ToM condition (M=1.13), however, the difference was non-significant (t (14)= -2.25, p= 0.017), due to the adjusted criterion for significance.

Differences between conditions in recognition of surprise and happy, however, did not mirror this trend. Correct recognition of surprise was better in the ToM condition (M= 2.87) than the WCC condition (M= 2.60) but was not significant (t (14)= 2.25, p= 0.041) due to the adjusted criterion for significance, and correct responses to happy was also better in the ToM condition (M= 2.87) than the WCC condition (M= 2.60) but again, this was not significant (t (14)= 1.47, p= 0.164). The difference between conditions in correct responses to disgust was also better in the ToM condition (M= 2.07) than the WCC condition (M= 0.73), and the difference was highly significant (t (14)= 4.93, $p < .001$).

Analysis of the use of facial information in recognising facial expression of emotion.

Participants mean percentage dwell time (expressed in decimals) on each interest area (eyes and mouth) in each condition (ToM and WCC) were analysed using a 2 x 2 repeated measures ANOVA to test the difference in dwell time on the mouth and eyes between the two conditions. Post hoc Bonferroni comparisons were requested for main effects to correct for multiple testing. The analysis was performed to investigate where participants looked in order to obtain information on which to base their emotion judgements. Appendix 5 contains a full copy of the descriptive statistics for the mean dwell time on each interest area in both conditions.

The independent variables were interest area (IA) (eyes and mouth) and experimental condition (ToM and WCC). Mean percentage dwell time over all trials on each IA was used as the dependent variable (see Appendix 6 for a full copy of the statistical output). Mauchly's Test of Sphericity was significant for the experimental condition factor ($p < .001$) and so the corrected Greenhouse Geisser degrees of freedom and significance levels are reported. There was a significant main effect of condition (F (1,14)= 12.66, p= 0.003)
with a greater dwell time in the WCC condition (M=37) than the ToM condition (M= 31).

There was no main effect of interest area (F (1,14)= 1.57, p= 0.231). However, the interaction between interest area and experimental condition was significant (F (1,14)= 64.54, $p < .001$) (see ***Figure 2.3***), indicating that participants used facial information differently between the two conditions. The effect size (partial eta^2) was large (.82) showing 82% of the variance in dwell time could be accounted for by experimental manipulation.

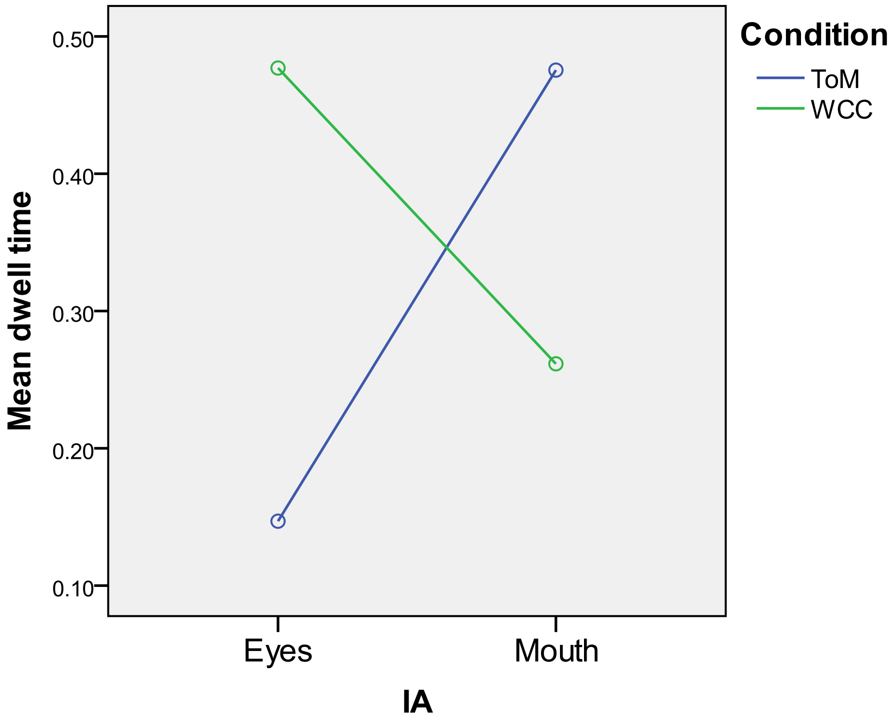

Figure 2.3. Graph illustrating the mean percentage dwell time (expressed in decimals) on each interest area for both the ToM and WCC conditions.

This interaction was further investigated using related t-tests to analyse simple main effects. The analysis was performed for each interest area (eyes and mouth) to test the difference in percentage dwell on these areas between conditions. Criterion for significance was set at $p = 0.025$ to reduce the possibility of a Type I error.

The results revealed a significant difference in percentage dwell time on the eyes between the conditions ($t\ (14) = 5.17$, $p < .001$) with the greater dwell time in the WCC condition (M= 48, SD= 11), than the ToM condition (M= 15, SD= 10). This result is not surprising considering the eye region in the ToM condition was masked. There was a significant difference between conditions in percentage dwell time on the mouth region ($t\ (14) = 5.17$, $p = <.001$). When the eye region was obscured in the ToM condition participants fixated on the mouth region 48% of the time (SD= 18). When the eye region was available for scrutiny however, percentage dwell time on the mouth fell to 26% (SD= 8). For a full copy of the statistical output see Appendix 6.

Analysis of the use of facial information in recognition of each emotion.

A repeated measures 2x2 ANOVA was performed for each emotion to determine the contribution of eye fixations and mouth fixations on correct responses in the WCC condition. Bonferroni post hoc tests were requested for main effects to correct for multiple testing. This analysis was not carried out for the ToM condition as the aim was to determine whether there was an effect of dwell time on each IA on participants' ability to correctly recognise an emotion. For the ToM condition, the eyes were not available and so participants were only able to obtain information from the mouth region.

For correct responses, total dwell time was calculated for each interest area and then averaged over correct trials, excluding dwell time for incorrect trials. The same method was repeated for incorrect trials. The independent variables were interest area (IA) which had two levels (eyes and mouth) and accuracy (correct and incorrect). The dependent variable was percentage dwell time on the each interest area. Appendix 8 contains the descriptive statistics for participants mean percentage dwell time (expressed in decimals) for each emotion when correctly recognised (Table 2), and when incorrectly recognised (Table 3).

Descriptive statistics obtained for mean percentage dwell time on the two IA's revealed skew in mean fixations (see Appendix 9), however ANOVA was still performed on the data as it is robust for violations of parametric assumptions. **Table 4** summarises the results of the 2x2 repeated measures ANOVA for each emotion (see Appendix 10 for the full statistical output for each emotion).

Table 4. Main effects due to interest area on mean dwell time, main effects due to accuracy on mean dwell time and the interaction between the interest area and accuracy variables.

Emotion	Main effect of Interest area	Mean dwell Eyes	Mean dwell Mouth	Main effect of accuracy	Mean Dwell correct	Mean Dwell incorrect	Interaction
Anger	F(1,1)= 5.92, p=0.29	31	19	F(1,1)= 41.21, p<.001	38	12	F(1,1)= 5.40, p=.036
Happy	F(1,1)=20.04, p=.001	32	16	F(1,1)=26.70, p<.001	37	10	F(1,1)=0.43, p=.523
Sad	F(1,1)= 9.35, p=.009	33	18	F(1,1)= 5.99, p=.028	33	18	F(1,1)= 7.49, p=.016
Surprise	F(1,1)= 2.22, p=.159	32	24	F(1,1)= 4.15, p=.061	36	21	F(1,1)= 2.51, p= .135
Fear	F(1,1)=17.99, p=.001	40	18	F(1,1)= 1.61, p=.225	33	24	F(1,1)= 4.74, p= .047
Disgust	F(1,1)= 4.60, p=.050	36	23	F(1,1)= .302, p =.104	24	35	F(1,1)= .62, p= .444

Significant interactions were explored using related t-tests to analyse simple main effects. Criterion for significance was set at $p \leq .006$ to reduce the possibility of a Type I error (see Appendix 11 for a full copy of the statistical output).

Anger.

The significant interaction (see ***Figure 2.4***) between accuracy and interest area indicates that whether participants correctly recognised 'anger' was dependent upon duration of dwell time on each interest area. Related t-tests revealed a significant difference in mean dwell on the eyes between correct (M= 0.49) and incorrect (M= 0.13) recognition of anger (t (14)= 5.12, p < .001) (see ***Figure 2.5***), and a significant difference in mouth dwell time (t (14)= 3.39, p= 0.004) (see ***Figure 2.6***) between correct (M= 0.27) and incorrect (M= 0.11) suggesting both areas are important in the recognition of anger.

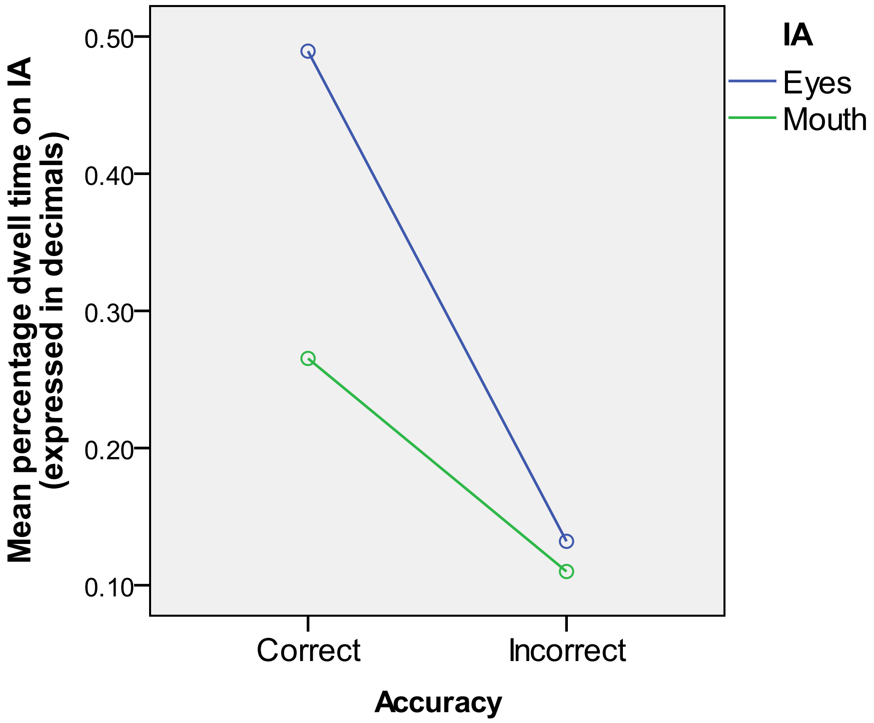

Figure 2.4 Graph illustrating the mean dwell time on each interest area for correct and incorrect recognition on anger.

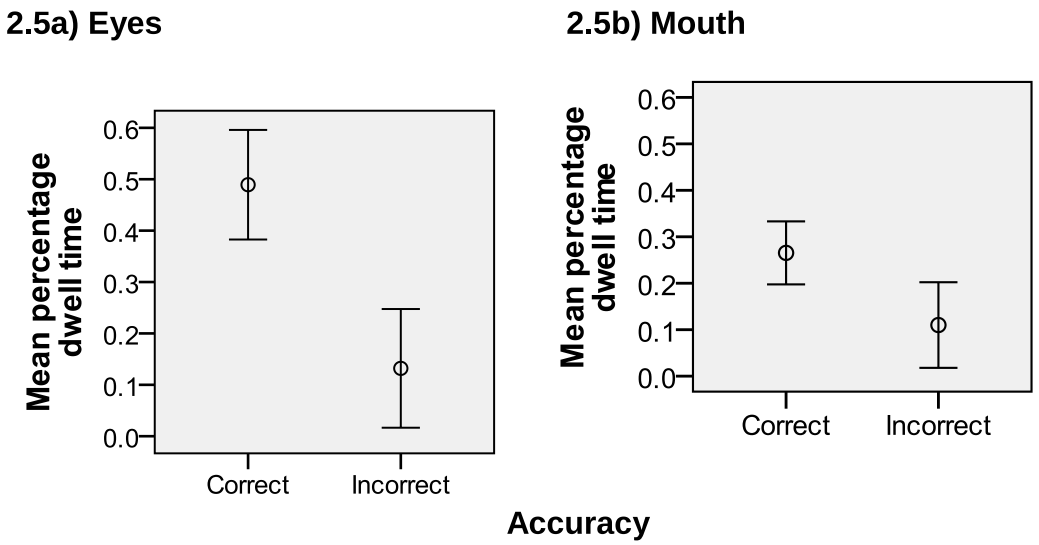

Figure 2.5. Error bar charts illustrating the difference in confidence intervals for mean percentage dwell (expressed in decimals) on the eye region (2.5a)

and the mouth region (2.5b) for both correct and incorrect recognition of anger.

Sad.

The interaction (see ***Figure 2.7***) between interest area and accuracy suggests recognition of sad was dependent on dwell time on each IA. Related t-tests revealed no significant difference between dwell time on the eye region for correct (M= 0.45) and incorrect (M= 0.22) responses to sad (t (14)= 2.78, P= 0.015) due to the adjusted criterion for significance, or between dwell time on the mouth between correct (M= 0.21) and incorrect (M= 0.14) responses (t (14)= 1.52, p= 0.151) suggesting that both the eyes and mouth contribute towards its correct recognition.

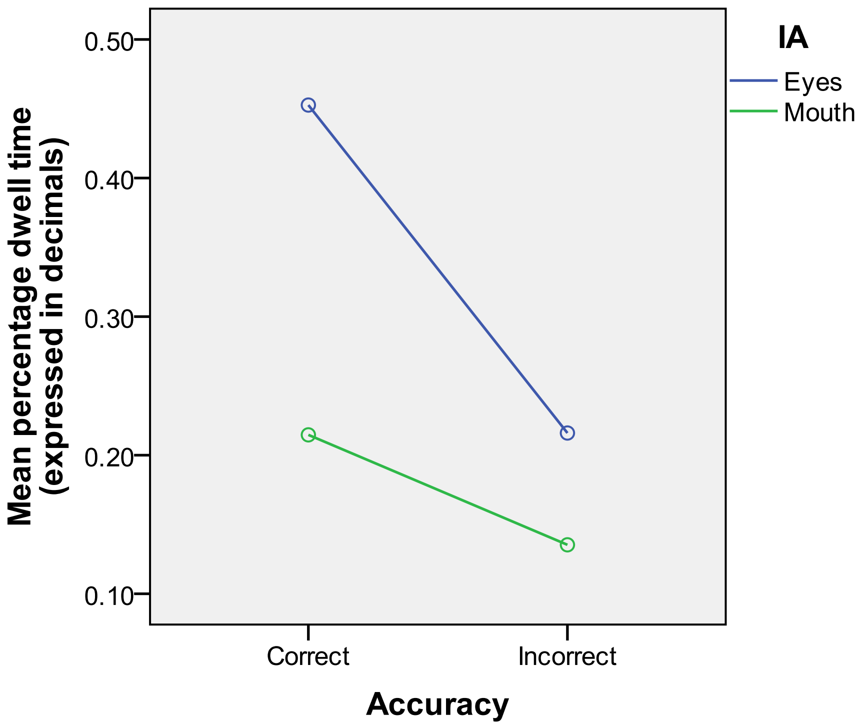

Figure 2.7 Graph illustrating the mean dwell time on each interest area between correct and incorrect recognition of sad.

Fear.

The interaction (see **Figure 2.8**) indicates that correct and incorrect recognition of 'fear' was dependent on dwell time on each area of interest. Related-test revealed that there was no significant difference in dwell time on the eyes between correct (M=49) and incorrect (M= 30) response to 'fear' (t (14)= 1.90), p= 0.070), or for dwell time on the mouth (t (14)= -0.252, p= 0.804) between correct and incorrect recognition. The results suggest that a combination of information from both the eyes and the mouth affected participant's ability to correctly identify fear.

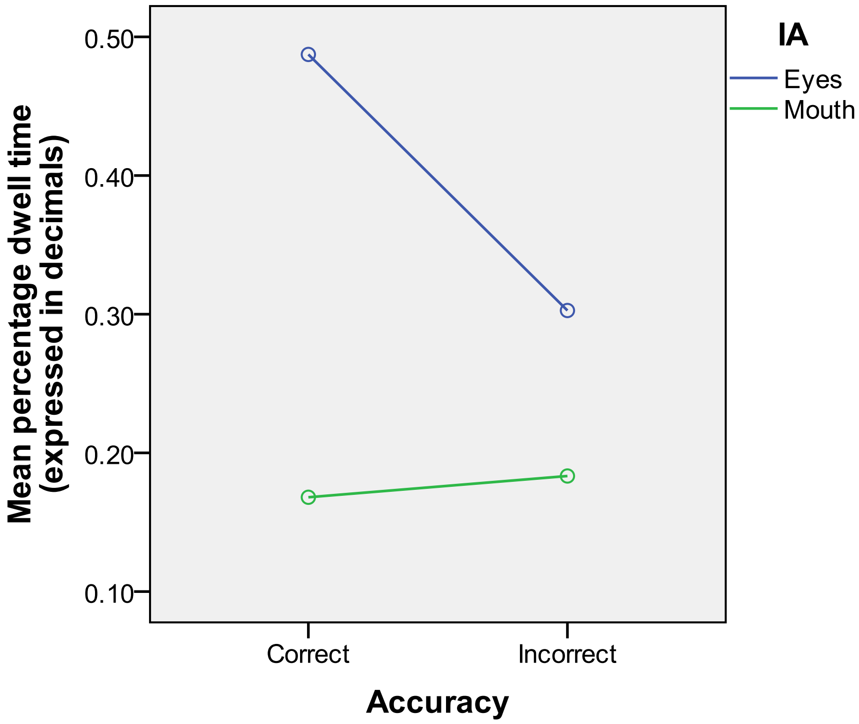

Figure 2.8. Graph illustrating the mean dwell time on each interest area for correct and incorrect recognition of fear.

Discussion.

The main aim of the study was to determine whether holistic processing or the ability to recognise emotional cues from the eye region were most vital for competent emotion recognition in the normal population. In doing so, the study sought to investigate whether the Theory of Mind (ToM) theory (Baron-Cohen, 1994) or the Weak Central Coherence (WCC) theory (Happe & Frith, 2006) could best account for impairments in emotion recognition in autistic groups.

The main finding in terms of overall accuracy was that typically developing adults are generally superior at recognising emotions when they are not able to process the expressions holistically than when they are not able to extract information from the eye region (see **Figure 2.1**). This seems to support the ToM theory which claims that poor emotion recognition stems from a failure to extract salient social information from the eyes. Further, the greater dwell time on the eye region than the mouth in the WCC experiment (see Figure 6.4) supports the notion that such gaze-behaviour, ubiquitous in non-clinical populations, is the foundation for adaptive emotion recognition- and thus competent theory of mind (Slessor, Phillips & Bull, 2008). The finding that, despite the eye-region being masked in **condition 1**, participants still spent 15% of their viewing time on this region lends further weight to the importance of the eye region for typical adults (Figure 6.4). Taken on their own, these general findings suggest that, rather than a local-bias in processing facial expressions of emotion affecting recognition, as the WCC theory hypothesises (Lahaie et al., 2006), a focus on individual features appears to suffice.

However, these findings do not permit a strong conclusion that holistic processing does not play a crucial role in recognising emotion expressions. Previous research employing the same facial stimuli as the current study has shown that recognition of basic emotion expressions is around 80% for normal participants (Ekman & Friesen, 1976). Participants did not reach this level in either experiment, with only 59% accuracy in the ToM condition and 69% in the WCC condition. Thus, the disablement of holistic processing in the WCC experiment clearly did affect participants' ability to perform at the optimal level in recognising facial expressions of emotion. Further, the occlusion of the eye region in the Theory of Mind (ToM) condition only permitted 'near-holistic' processing, a procedure defined as the elimination of individual features while the rest of the face is available for useful information (Tarres & Rama, 2005). Yet, the finding that each emotion was differentially affected by experimental manipulation (se Figure 6.2) suggests that merely having less information in the ToM condition is not a sufficient explanation for the results. If task difficulty alone were producing the results, recognition of all emotions should have been impaired in the ToM condition compared to the WCC condition.

Are different processes required for different emotions?

While the study found that accuracy was generally poorer in the ToM condition than the WCC condition, it also found that emotion expressions differed in the extent to which recognition was affected, and the condition in which it was most impaired. It thus appears that for a particular emotion, successful recognition may differentially support either the ToM theory or the WCC theory.

The non-significant difference between conditions in the recognition of happiness and surprise is consistent with findings that the mouth alone is sufficient to recognise these emotions (Smith, Cottrell, Gosselin & Schyns, 2005). Autistic individuals have been found to perform equal to that of matched controls in recognising happiness and surprise (Humphreys, Minshew, Leonard & Bermann, 2007; Ashwin, Chapman, Colle & Baron-Cohen, 2006). This is compatible with the ToM hypothesis as a failure to recognise emotional cues from the eyes would not impede this ability. However, a focus on local detail- the mouth in this instance, can also account for these findings.

Significantly better recognition of fear and anger in the WCC condition than the ToM condition supports the ToM hypothesis as previous research has found that these emotions require perception of the eye region (Ashwin et al., 2006). The study by Ashwin et al. (2006) also found no significant difference between a control group and an autistic group in recognising facial expressions of surprise and happiness, but a comparatively significant impairment in the recognition of fear for the autistic group. Additionally, recognition of fear in the ToM condition when the eye region was masked was poorer than that of all other emotions (see Table 6.1) and research by

Humphreys et al. (2007) found autistic individuals to be significantly more impaired in recognising fear than any other basic emotion. Taken together, the results strongly support the ToM hypothesis that a decrease in time spent viewing the eyes accounts for autistics difficulty in recognising fear. Interestingly, the current study did not find a significant difference in dwell time on the eyes between correct and incorrect recognition of fear in the WCC condition (see Appendix 11), but this may be accounted for by the designated interest area for the eyes being too large an area to detect subtle differences in dwell time on the eyes in particular rather than the region surrounding it.

Thus, the results of the current study appear to support the ToM hypothesis that a failure to attend to the eye region and detect the salient social information they express prevents adept emotion expression recognition (Baron-Cohen, 1994). This may be considered in the light of the ToM theory as an account of the social deficits common to autism. Reduced attention to faces and decreased eye contact with others are early diagnostic criteria of autistic spectrum disorders (APA, 1994, cited in Ashwin et al., 2006). Accordingly, if the autistic child does not attend to social gaze, the adult will fail to recognise the emotional information it communicates and the inner mental states such expressions signify.

The ability of autistic individuals to recognise positive emotions but not negative emotions also supports the existence of a domain-specific ToM brain mechanism involving the amygdala, responsible for detecting the eyes (Baron-Cohen, 2005). Bilateral damage to the amygdala has been found to cause abnormal viewing patterns of a face through decreased dwell time on the eyes and increased time viewing the mouth (Adolphs, Gosselin, Buhanan, Tranel, Schyns, & Damasio, 2005) and to also affect recognition of negative basic emotions including fear, anger and disgust (Adolphs, 2002). Thus, a lack of eye contact appears to directly reduce perception of negative emotions, as the present study has shown. The perception of the eyes and emotional expression is fundamental to the adaptive development and functioning of theory of mind. A deficit in recognising basic negative emotions would clearly interfere with social interaction through rendering the individual unaware of the feelings of others (Ashwin et al., 2006).

Is ‘disgust’ different?

However, recognition of facial expressions of disgust was significantly poorer when the face was not able to be processed holistically than when the eye region was not available for scrutiny ($p < .001$). Further, there was no significant interaction between dwell time on the eye or mouth region and accuracy for disgust (see Table 6.3). This suggests that holistic processing of facial cues is far more conducive to recognising disgust than any independent contribution from the eyes or mouth. This cannot be accounted for by the expression of disgust simply being a more difficult emotion to perceive as it was recognised more frequently than fear, anger and sad in the ToM condition (see Table 6.1). In the WCC condition, incorrect recognition of disgust was labelled as anger 73% of the time and sad 15% of the time. This pattern is comparable to those of an autistic group who took part in a study by Ashwin et al. (2006) which found that the autistic group labelled disgust as anger 63% of the time and sad 24% of the time. The typically developing adults only labelled disgust as anger 50% of the time and sad 46% of the time. The authors consider that this may reflect the importance of the eye region in recognising disgust, due to the tendency of autistic individuals to ignore this region. However, the study did not employ eye-tracking technology to confirm that this is the case. The findings of the present study, that disabling holistic processing causes normal adults to adopt a pattern of errors reflective of those from an autistic group, suggests that an impairment in holistic processing may be the more plausible explanation.

This conclusion is supported by research conducted by McKelvie (1995) using typically developing participants. Participants were presented with facial expressions of emotion in both upright and inverted orientations. An inversion effect has been found for the recognition of face identity, with inverted faces more difficult to recognise, and this is attributed to inversion disrupting holistic processing. Inversion reduced accuracy for sad, fear, anger and disgust, but not happiness. Of most relevance to the current study is that recognition of an inverted expression of disgust was significantly poorer than all other emotions. McKelvie (1995) interpreted the findings as indicating that recognition of disgust is most reliant on configural information. This requires holistic representation of all features in order to form meaning from its constituent parts. A focus on local detail, processing each feature separately, would therefore cause difficulty in recognising disgust (Humphreys et al. 2007). This suggests that normal adults need proficient central coherence in order to process and recognise disgust. Conversely, it should therefore be the case that a deficit in recognising disgust in the autistic population can be accounted for by a Weak Central Coherence (WCC).

Research by Rutherford and McIntosh (2007) supports this conclusion. They presented a group of individuals with autistic spectrum disorder (ASD) with faces expressing basic emotions with varying degrees of exaggeration from 'average' to 'double exaggeration'. They tested the hypothesis that the ASD group would use a 'rule-based strategy' to recognise emotions. A rule-based strategy involves using individual features of an expression as rules for classifying it as a particular emotion, such as a turned down mouth representing sadness. This strategy would therefore manifest itself if a grossly exaggerated version of an emotion, such as an excessively turned down mouth for sadness, is still considered to fit that rule. This strategy would indicate weak central coherence as it is reflective of a bias towards feature based processing (Rutherford & McIntosh, 2007). The most interesting result in terms of the present research is that recognition of disgust showed a greater effect of exaggeration than all other emotions. The most exaggerated version of disgust was chosen almost 80% of the time as best representing the expression a person would display in real life. The findings suggest that, due to a local processing bias, autistic individuals use a rule-based strategy for recognising emotions. Consequently, as disgust, more than all other emotions, requires a holistic strategy, it is the most severely affected by this bias.

Limitations and future directions.

A central aim of the current study was to determine whether information from the eye region or holistic processing of facial expressions were most vital for typically developing adults to recognise emotions. The secondary aim was to investigate whether the findings would shed light on which of these abilities must be impaired in a clinical population who has difficulties in emotion recognition, namely, individuals with autism.

The Theory of Mind theory of autism claims that a failure to attend to the eye region, and consequently detect the social information they communicate, causes the emotion recognition deficits in autism, consequently stifling adaptive social cognition (Baron-Cohen, 2005). The findings of the current study that overall emotion recognition was significantly poorer when the eye region was masked than when holistic processing was disrupted supports this theory. Specifically, anger and fear were significantly better recognised when holistic processing was disabled compared to when the eye region was masked.

Possible interventions for improving emotion recognition may involve instructing the individual to focus on the eye region. The amygdala patient in the study of Adolphs et al. (2005) improved recognition of fear by being explicitly told to focus on the eyes, supporting both the hypothesis that it is abnormal gaze which impedes performance, and that such interventions can improve it.

However, Speizo et al. (2007) have conceded that normalising the face gaze of individuals with autism may not be sufficient to overcome the numerous social and emotional deficits which accompany the disorder. In the present study, anger alone required a significantly greater dwell on the eye region for correct than incorrect recognition (see Figure 6.6). The further finding that recognition of disgust was significantly poorer in the WCC condition than the ToM condition may shed light on the reasons behind this.

The Weak Central Coherence (WCC) theory claims that the local processing bias found in autism causes the concurrent poor emotion recognition (Iarocci et al, 2006). The finding that recognition of disgust was greatly impaired when participants were forced to process the expression in a part-based manner lends support to this theory. A piecemeal strategy of analysing individual features would impede the ability to integrate information to make emotion judgements and may also result in an excess of irrelevant information from parts of the face that are not conducive to the task (Lahaie, et al., 2006). This seems a plausible explanation for the difficulty participants had in recognising disgust. The finding that emotion recognition in the WCC condition was poorer than the typical 80% accuracy for non-clinical participants (Ekman & Friesen, 1976) further supports a role for coherent processing in emotion recognition.

Non-clinical participants were recruited for the current study in the hope that it would enable a clear delineation of the individual effects of processing and gaze abnormalities on emotion recognition. Yet it appears that the effects were no easier to delineate in the normal population than they have been found to be in the autistic population (Happe, Ronald and Plomin, 2006). Decades of research into the causes of facial expression recognition deficits in autism have left little consensus regarding whether all emotions are affected or only a select few (Humphreys, et al., 2007). The current findings supports the conclusion of Happe, Ronald and Plomin (2006) that it may be time to give up on a single explanation of these deficits in autism.

Of course, this study cannot directly extrapolate its findings to the autistic population as it did not involve participants with the disorder. Instead, it has studied the interaction between the two processes believed to play a role in emotion recognition in non-clinical participants. There is therefore a need for caution in generalising what has been learnt to autistic groups. However, it has been shown that, for the non-clinical population, recognition of happy and surprise require little input from the eyes or holistic processing, yet fear and anger and sadness do appear to depend upon the eyes as a window to the inner thoughts and feelings they convey. Disgust, it seems, can only be appreciated through an ability to draw the subtle cues elicited into a coherent whole. Thus, as autistic persons have been shown to be impaired in both processes (Happe et al., 2006) it is no surprise that they find great difficulty processing emotion expressions, and this may underlie the concurrent social difficulties through a poor understanding of how others are feeling (Lahaie et al., 2006). It would appear that explicit instructions to attend to the eye region would be the most beneficial strategy to help such individuals overcome emotion recognition deficits, yet the present findings suggest that this would still render them without a full appreciation of a face expressing disgust.

The results of the current study are consistent with the hypothesis that normal adults may use both a part-based strategy- mainly involving a focus on the eye region, and a holistic strategy to recognise facial expressions of emotion (Rutherford & McIntosh, 2007) and previous research has found a link between weak central coherence and deficits in recognising emotion expressions from the eye region in autistic groups (Jarrold, Butler, Cottington,& Jimenez, 2000). Future studies should examine the nature of this link, that is, whether weak central coherence causally contributes to emotion recognition deficits in autism. This could be achieved using the gaze contingent window used in the current study and a gaze contingent mask in which the central feature fixated on is masked, removing local detail but allowing a holistic representation. As Van Belle et al. (2010) acknowledge, the use of these techniques could help investigate emotion recognition in autism. If autistics process emotion expressions holistically then they should be most impaired in the window condition where only local detail is available. If the deficit is mainly due to weak central coherence then we should find emotion recognition most impaired in the masked condition where local detail is not available and a holistic strategy would be most conducive.

With the ability to recognise emotional cues from facial expressions being integral to adaptive social cognition (Adolphs, 2003) a clearer understanding of the processing styles necessary to succeed in this task can benefit not only clinical populations, but all individuals wishing to partake in the social world.

References.

Adolphs, R. (2003). Cognitive Neuroscience of Human Social Behaviour. *Nature Reviews Neuroscience, Vol. 4,* 165-178.

Adolphs, R. (2002). Recognizing emotion from facial expressions: Psychological and neurological mechanisms. *Behavioural and Cognitive Neuroscience Reviews, Vol. 1*(1), 21-61.

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Nature, Vol. 433(7021),* 68-72.

Ashwin, C., Chapman, E., Colle, L., & Baron-Cohen, S. (2006) Impaired recognition of negative basic emotions in autism: A test of the amygdala theory. *Social Neuroscience, Vol 1* (3-4), 349-363.

Baron-Cohen, S. (1994). Mindblindness: An Essay on Autism and Theory of Mind. MIT Press, Cambridge.

Baron-Cohen, S. (2005). The empathizing system: A revision of the 1994 model of the mindreading system. In B. Ellis & D. Bjorklund (Eds.), *Origins of the social mind*. London: Guilford Publication.

Baron-Cohen, S., Jolliffe, T., Mortimore, C., Robertson, M. (1997). Another advanced test of theory of mind: evidence from very high functioning adults with autism or Asperger Syndrome *Journal of Child Psychology and Psychiatry*, 1997, 38, pp. 813-822.

Baron-Cohen, S., Wheelwright, S., Skinner, R., Martin, J., & Clubley, E. (2001). The autism-spectrum quotient (AQ): Evidence from Asperger syndrome/high functioning autism, males and females, scientists and mathematicians. *Journal of Autism and Developmental Disorders, 31*, 5–17

Bentin, S., Golland, Y., Flevaris, A., Robertson, L., C., & Moscovitch, M. (2006) Processing the trees and the forest during initial stages of face perception: electrophysiological evidence. *Journal of Cognitive Neuroscience, Vol. 18 (8*), 1406-1421.

Boraston, Z., & Blakemore, S. J. (2007) The application of eye-tacking technology in the study of autism. *The Journal of Philosophy, Vol. 581*, 893-898.

Durand, K., Gallay, M., Seigneuric, A., Robichon, F., & Baudouin, Y., J. (2007). The development of facial emotion recognition: The role of configural information. *Journal of Experimental Child Psychology, Vol. 97,* 14-27.

Ekman, P., & Friesen, W. V., (1976). Pictures of facial affect. Paulo Alto, CA: Consulting Psychologist Press.

Frischen, A., Bayless, A., P., & Tipper, S., P. (2007). Gaze cuing of attention: visual attention, social cognition, and individual differences. *Psychology Bulletin, Vo. 133 (4),* 694-724

Frith, U., (1989). Autism: Explaining the Enigma. Blackwell, Oxford.

Frith, U., & Happe, F. (1994). Autism: beyond “theory of mind”. *Cognition, Vol. 50*, 115-132.

Frith, U. & Happe, F. (2005) Autism spectrum disorder. Current Biology, Vol. 15 (9), 786-790.

Happe, F., & Frith, U. (2006) The Weak Coherence Account: Detail-Foucused Cognitive Style in Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders. Vol. 36 (1),* 5-23.

Happe, F., Ronald, A., & Plomin, R. (2006) Time to give up on a single explanation for autism. *Nature Neuroscience* **9**, 1218 - 1220 (2006) Published online: 26 September 2006 | doi:10.1038/nn1770

Humphreys, K., Minshew, N., Leonard, L., G., & Behrmann, M. (2007). A fine-grained analysis of facial expression processing in high-functioning adults with autism. Neuropsychologica, Vol. 45, 685-695, doi: 10.10.16.

Iarocci, G., Burack, A, J., Shore, I, D., Mottron, L., Enns, T, J. (2006) *Journal of Autism and Developmental Disorders*, Vol. 36, No. 1, January 2006.

Itier, J., R., & Batty, M. (2009) Neural bases of eye and gaze processing: The core of social cognition. *Neuroscience and Biobehavioural Reviews, Vol. 33,* 843-863.

Jarrold, C. Butler, W., D., Cottington, M., E., & Jimenez, F. (2000) Linking Theory of Mind and Central Coherence bias in Autism and in the Gneneral Population. Developmental Psychology, Vol. 38 (1), 126-138.

Kinderman, P., Dunbar, R., Bentall, P. (1998). Theory-of-mind deficits and causal attributions. British Journal of Psychology, Vol. 89 (2), May, 1998. pp. 191-204.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen D. (2002) Visual Fixation Patterns During Viewing of Natural Situations as Predictors of Social Competence in Individuals with Autism. Archives of General Psychiatry, Vol. 59, 809-816.

Kuhn, G., Kourkoulou, A., Leekam, R, S. (2010) How Magic Changes our Expectations about Autism. *Psychological Science* 21(10) 1487-1493.

Lahaie,A., Mottron, L., Arguin, M., Berthiaume, C., Jemel, B.N & Saumier, D. (2006). Face perception in high-functioning autistic adults: Evidence for superior processing of face parts, not configural face-processing deficit. *Neuropsychology, Vol. 20 (1),* 30-42.

Lipp, V., O., Price, M., S., & Tellegen, L., C. (2009). No Effect of Inversion on Attentional and Affective Processing of Facial Expressions. *Emotion, Vol. 9 (2),* 248-259.

McKelvie, S J. (1995). Emotional expression in upside-down faces: evidence for configurational and componential processing. *British Journal of Social Psychology, 34*, 325-334.

Neumann, D., Speizo, L, M., Piven, J., Adolphs, R. (2006). Looking you in the mouth: abnormal gaze in autism resulting from impaired top-down modulation of visual attention. *Social Cognitive and Affective Neuroscience, Vol. 1, (3),* pp. 194-202.

Pellicano, E. (2010) Individual differences in executive function and central coherence predict developmental changes in theory of mind in autism. Developmental Psychology, VOL. 46 (2), Mar, 2010, pp. 530-544.

Russell, J., & Fernandez-Dolls, J. (Eds.), (1997). *The psychology of facial expression.* Cambridge: Cambridge University Press.

Rutherford, D., M., & McIntosh, N., D. (2007). Rules versus Prototype Matching: Strategies of Perception of Emotional Facial Expressions in the Autism Spectrum. *Journal of Autism and Developmental Disorders, Vol. 37*, 187-196.

Slessor, G., Phillips, H, L., Bull, R. (2008) Age-Related Declines in Basic Social Perception: Evidence From Tasks Assessing Eye-Gaze Processing. *Psychology and Aging*. 2008, Vol. 23. No. 4, 812-822.

Speizo, L.M., Adolphs, R., Hurley, E., S., H., & Piven. J. (2007). Abnormal Use of Facial Information in High-Functioning Autism. *Journal of Autism and Developmental Disorders, Vol. 37*, 929-939.

Tarres, F., & Rama, A. (2005). A Novel Method for Face Recognition under partial occlusion of facial expression variations. *Proc. 47th International Symposium, ELMAR*. Multimedia Systems and Applications, June 2005.

Van Belle, G., De Graef, P., Verfaillie, K., Rossion, B & Lefevre, P (2010). Face inversion impairs holistic perception: Evidence from gaze-contingent stimulation. *Journal of Vision* Vol. 11, 1.