A cross-cultural study of the development of face expertise in autism

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Atypicalities with face processing have been suggested to underlie some of the social impairments in Autism. These atypicalities are characterised by a lack of expertise with face processing and may provide insight into the development of this neurodevelopmental disorder. One way to probe face expertise is by testing the Own-Race Effect (ORE). Evidence (or lack thereof) of the ORE between children with and without autism can reveal fundamental information about the development of face perception in autism. Children with autism and typically developing children from the UK and Japan completed a two-forced choice alternative face recognition task across which contained Asian and Caucasian faces, in four different conditions (identity change, easy eyes, hard eyes, hard mouth). Attention to faces was measured during the task using eye-tracking. In terms of accuracy, there were cultural group differences (Japanese children more accurate, different pattern across conditions) but no developmental group differences - children with and without autism showed a typical ORE. There were cultural differences in face scanning during encoding and recognition - both UK groups showed a bias to eyes and mouths of own-race compared to other-race faces, whereas the opposite was found for the Japanese groups. Although culture has an influence on how children attend to faces, children with autism in Japan and the UK show a typical ORE. This has implications for theory around social development and face processing in autism.

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List of Abbreviations:

1. ASD: Autism spectrum disorder – (8)
2. TD: Typically developing – (8)
3. ORE: Own-race effect – (9)
4. IC: Identity change – (15)
5. EE: Easy eyes – (15)
6. HE: Hard eyes – (15)
7. HM: Hard mouth – (15)
8. FNF: Face-non-features – (28)

Statement of Copyright:

Declaration:

This thesis is based on joint research. All Japanese data collection was carried out by Dr Masahiro Hirai and colleagues. Additionally some of the UK data collection was assisted by an MA student. The author was responsible for overseeing the reduction and analysis of the data collected by all parties.

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Dedication

Dedicated to the loving memory of my late mother, Fiona Derges. Your love and support was integral to me even starting to study psychology, let alone in getting this far. I wish you could be here to see this. This one's for you mum.

1: Introduction

1.1: Face Processing and Autism Spectrum Disorders

Autism spectrum disorders (ASD) refer to a group of neurodevelopmental disorders characterised by deficits in social communication and restricted or repetitive patterns of behaviour, interests or activities (DSM-V, American Psychiatric Association, 2013). Deficits in social communication are a defining feature of ASD (Rapin & Tuchman, 2008). Central to these socio-communicative deficits are difficulties with processing information from others' faces (Dawson, Webb & McPartland, 2005). Faces convey a range of information that is crucial for facilitating and mediating social interaction – from conveying our moods, intentions, desires, focus of attention and of course our identity (Doherty, Anderson & Howieson, 2009; Cohen-Pager & Brosgole, 1992; Mian & Mondloch, 2012). Therefore, face processing abilities are really important for social interaction. For individuals who are typically developing (TD), faces capture attention from early on in development and expertise develops for processing the range of information that faces convey (Lee, Anzures, Quinn, Slater & Pascalis, 2011).

For individuals with autism, research has shown that face expertise does not develop in a typical way. For example, children with autism take longer to detect faces in a scene, and when they are looking at a face, they make shorter fixations compared to typical children (Riby & Hancock, 2009). Related to this, when looking to faces they show unusual scanning behaviour compared to typical children, with the most pronounced difference being reduced fixations towards the eye region (Jones, Carr & Klin, 2008; Pelphrey et al., 2002). They also show difficulties in using complex social information in faces, such as when performing emotion recognition, and they have been shown to have difficulties distinguishing different emotional expressions (Celani, Battachi & Arcidiacono, 1999; Gross, 2004). Face recognition memory has also been found to be impaired in autism, which is perhaps not surprising given that they spend less time focusing on faces (Weigelt, Koldewyn & Kanwisher, 2013; Williams, Goldstein & Minshew, 2005).

It has been suggested that lack of face expertise in autism may be due to lack of experience with faces as a results of reduced attention to faces throughout development (Wilson, Palermo, Burton & Brock, 2011). Understanding the developmental origins of face processing difficulties is an important line of research for understanding autism. Therefore, the aim of this research is to understand how experience shapes face perception in ASD. In order to understand this, a paradigm to test the ‘own-race effect’ (ORE) will be used with children with autism compared to typically developing children. The ORE is a robust effect in the typical face perception literature which shows better recognition for faces that we have more experience with (i.e. own-race faces). A paradigm to test the ORE will be used to compare performance between children with autism and typically developing children.

Reduced attention to faces throughout development is hypothesised to lead to reduced face expertise in autism. While measuring face recognition accuracy for own and other races faces, a second aim of this research will be to understand the role of attention when during face recognition. Attention will be measured using eye-tracking to probe whether attentional differences in autism contribute to face perception accuracy. It will also be possible to explore where experience shapes attention to own and other races faces differently.

Finally, and most importantly, we aim to test these effects cross-culturally with children with and without autism in the UK and Japan. This is a particularly key element of this research given that one of the major aims is to understand how experience shapes face perception in autism. As will be covered in greater detail further in this review, culture also impacts face perception. By examining cross-cultural face perception both in TD and ASD groups, we can look for similarities and differences between these groups to understand which elements of face processing are shaped by culture.

This review will firstly focus on evidence on the ORE in typical development, focussing on why experience has been seen to be an important factor. Following this, studies on the ORE in autism will be reviewed. Finally, studies linking attention to face perception and the ORE in autism will be discussed, before outlining the specific aims and questions for the current research.

1.2: The ORE in Typical Development

The ORE refers to a phenomenon in the face perception literature where people are generally more proficient at distinguishing own-race compared to other-race faces (Meissner & Brigham, 2001). This research has grown out of work in the US focussing on eyewitness testimony, initially centring on Caucasian and African-American participants, reporting a strong own-race bias in both populations (Bothwell, Brigham & Malpass, 1989). Such work has expanded to involve other racial groups and similar findings have been reported. In a study of Caucasian and Asian participants, O'Toole, Deffenbacher, Valentin and Abdi (1994) report superior own-race performance for the Caucasian and Asian participants. In addition to such work in adults, this has been further expanded to look at the effect in children. Pezdek, Blandon-Gitlin and Moore (2003) report better own-race face recognition in a sample of kindergarten and third grade African-American and Caucasian children. Similarly, de Heering, de Liedekerke, Deboni and Rossion (2010) report that Asian children between six and 14 years living in their native country show better own-race recognition, as did Caucasian children in their native country. Being present in early childhood would suggest early developmental origins of this effect.

Indeed, the roots of this effect can be seen very early on in the typical literature. At three months old, Caucasian infants are able to discriminate individual faces within the categories of Caucasian, African and Chinese faces using a novelty preference paradigm (Fantz, 1958), whilst at six months they can only discriminate individuals for Caucasian and Chinese faces, and at nine months only for Caucasian faces (Kelly et al., 2007a). The same pattern is mirrored for Caucasian and Chinese faces in Chinese infants as well (Kelly et al., 2009). Early attention to faces seems to play a role in this. At three months, although infants can tell apart own and other-race faces, they prefer to look at own-race faces, whilst newborns do not (Kelly et al., 2005). This pattern is also seen in African (Bar-Haim, Ziv, Lamy and Hodes, 2006) and Chinese infants (Kelly et al., 2007b). Thus it seems that from very early on in development, infants prefer to attend to own-race faces and subsequently develop an ORE.

Further evidence in support of the how experience shapes ORE comes from studies involving training and also from the adoption literature. Firstly we can consider work undertaken to train infants with other-race faces. Sangrigoli and de Schonen (2004) habituated three month old Caucasian infants to a single Caucasian (own-race) and single Asian (other-race) face. Subsequently they demonstrated better performance when discriminating novel Caucasian faces compared to Asian faces. However, when shown three exemplars of each race as opposed to one, they could distinguish both Caucasian and Asian novel faces. This has also been reported in older samples, at 6 to 9 months (Heron-Delaney et al., 2011), and 8 to 10 months (Anzures et al., 2012), although in these cases more experience was required than with the three-month-old infants (at three months the training blocks were six twenty second presentations; at six months, 70 minutes of training over months was required; and at nine months 16 minutes of video exposure a day for three weeks was required). This would suggest as experience of own-race faces increases, a greater degree of other-race face experience is needed to reduce the ORE.

Further evidence comes from the adoption literature. Asian children adopted between the ages of two to 26 months to Caucasian families exhibited comparable own and other-race face recognition at ages six to fourteen (de Heering et al., 2010). Likewise, Korean children adopted to Caucasian families between three and nine years old showed a reversed ORE when tested as adults. In contrast, Korean controls showed a typical ORE, being better at Asian faces (Sangrigoli, Pallier, Argenti, Ventureyra & de Schonen 2005). The research of Kelly et al., (2005, 2007, 2009) and Bar-Haim et al., (2006) demonstrate the importance of early experience in the development of the own-race effect, showing that with a relatively small amount of experience might be sufficient for the emergence of the ORE. However, it is also clear that there is a degree of plasticity invovled, as there is evidence to show that the ORE can be shaped in important ways by later experience as seen in the studies of de Heering et al., (2010) and Sangrigoli et al., (2005). Thus both early experience and later development are important for understanding the ORE.

Considering this collective evidence, it seems that between three and nine months, there is a period in which experience of own-race faces results in the development of the ORE. During this period, experience with other-race faces can mitigate this, but as age increases more experience is required. This suggests experience with and attention to faces early in development is important for shaping face perception and the development of the ORE. However, the adoption literature also makes it clear that experience with other-race faces continues to be important outside of this period, and can still have an impact later in life.

1.3: The ORE and ASD

Evidence of the ORE from the typically developing literature indicates that it is a well-documented effect that is found in adults, children and infants, and also found cross-culturally. This evidence strongly points to the role of experience in shaping this effect. For children functioning on the autism spectrum, experience with faces is atypical (Sasson, 2006). Adults, children and now young toddlers with autism have been found to show reduced and atypical attention to faces (Hanley et al., 2014; Jones et al., 2008; Klin, Jones, Schultz, Volkmar & Cohen, 2002). Therefore, it is possible that reduced experience with faces in autism shapes reduced face expertise. In the case of the ORE, given reduced experience we may expect children with autism to not to show this effect and not to show an advantage for recognition of own over other-race faces. A small number of studies have begun to explore this.

Four studies have been conducted looking into this phenomenon in ASD. The first of these was Wilson et al., (2011). This study of mostly Caucasian children (some were East Asian but had lived in Australia since birth) involved three different sequential two forced-choice tasks with own (Caucasian) and other-race (Egyptian) face conditions. In the first task children were shown a target face, followed by a target and a foil. In the test phase the target was an identical image to the one they had just seen. In the second task the target in the test phase was the same person, however it was a different picture of them. Finally in the third phase, they were shown a target face cropped to remove external features (although some did remain), and again they had to identify the target (different image of the same target alongside foil). Overall they reported that performance was better for the own-race faces compared to other-race, for both the ASD and TD groups. However, it emerged that after calculating age-standardised scores for performance, the ASD group showed high variability in performance. The authors therefore looked further within groups at those with age-appropriate face recognition scores, and those with age-inappropriate scores. In the ASD group, the age appropriate sub-group showed a typical ORE, whilst the age inappropriate sub-group did not. In contrast, the ORE remained in the typical group with age inappropriate performance. Thus there is some degree of support for a diminished ORE in ASD in this study, but only in a sub-group of ASD children.

Yi et al., (2015) carried out a study with three groups of Chinese participants – ASD, TD and those with intellectual difficulties who were matched to the ASD group based on non-verbal ability. In contrast to the Wilson et al., (2011), they used greyscale faces cropped to have all external features removed. Own and other-race faces were also matched for contrast and luminance. They were first given a set of 14 faces balanced for race and gender and told to remember them. In the test phase they were then shown target and foil faces and asked whether or not they had seen the face before. The ASD and ID groups scored significantly better on the own-race faces compared to other-race faces. The TD group however showed comparable own and other-race face performance. This appears to be evidence for the existence of an ORE in ASD. That said, the group difference in performance between the TD group and ASD group was particularly marked – the ASD group scored 52.5% on the own-race faces and 49.9% on the other-race faces, whilst the TD scored 81.1% and 83.0% respectively. The TD group then were operating at, or at least very close to, ceiling (the authors did not check with a statistical test). The authors did check for chance performance, with the all groups performing above chance on the own-race faces, and the TD and ID groups doing the same on the other-race faces. However even with this, the ASD performance for own-race faces was still only 52.5% with chance performance being 50%. This may have been a statistically significant difference however it still looks like a very poor performance for the ASD group on the task. The ID group also struggled on this task scoring 55.3% for own-race faces and 52.6% for other-race faces. Again these were above chance, but are still very poor scores. Thus the TD group are performing at an incredibly high level and not showing an ORE, whilst the ASD and ID groups are barely above chance. Therefore, the demands of this task and resulting performance make it difficult to draw firm conclusions about atypicality of an ORE in ASD.

The authors also conducted follow up work to this study. Yi et al., (2016) compared children with ASD to age matched TD and ability matched TD Chinese children, using the same method and stimuli as their 2015 study. In contrast, they report no difference in performance for the ASD children on own and other-race faces. Both TD groups meanwhile also showed comparable own and other-race faces. As with their previous study however it is important to examine the groups more carefully. Both TD groups scored significantly above chance, with the age-matched group scoring 82% for own-race and 81% for other-race, whilst the ability-matched scored 70% and 73% respectively. In contrast the ASD group did not score above chance for either face race, scoring 54% for each. Again, the TD groups are scoring well, with the age-matched group possibly at ceiling again, whereas the ASD group are scoring at chance. Considering the two Yi studies, it is difficult to draw firm conclusions – the TD group(s) seem to find them easy whilst the ASD groups are struggling with them considerably, only scoring above chance in one of the four tasks (2015, own-race faces) and even then scoring very poorly. This seems to suggest issues on some level with the task that make interpretation of the results relative to the Wilson paper difficult.

Finally, and of most relevance to the current study is Chien, Wang, Chen, Chen and Chen (2014). They involved a sample of Chinese ASD and TD children and a two alternative forced-choice paradigm. Children were presented with a target face, followed by the target and a foil face which was manipulated in one of four ways: identity change (IC; different face); easy eyes (EE; same target face but with different eyes photoshopped in); hard eyes (HE; same target face but with eye spacing increased); and hard mouth (HM; same target face but with spacing between the mouth and nose decreased). They were shown the target face for three seconds, then a blank screen, and then the target and foil. In their initial analysis they found no effects or interaction of face race. They did find a group/condition interaction, in that the TD group were better at the IC, EE and HE conditions, whilst the ASD group were better at the HM condition. This suggests that the ASD group struggled more with the easier condition when dealing with two completely different faces, and the two tasks where the critical information was located in the eye region. In terms of probing the ORE, the authors reasoned however that the effect may be subtle and so carried out independent sample t-tests separately for each condition. This revealed the TD group scored 100% on the own-race IC condition, whilst the ASD group scored significantly lower at 88%. In contrast when they compared performance for the TD and ASD groups on the other-race face identity change condition, the groups performed similarly (the TD group scored 94%, whilst the ASD group scored 96%). They suggest this difference on the own-race identity change condition is indicative of a lack of experience with their native faces that does not extend to other-race faces. They further explored this by examining differential percent scores (own-race score minus other-race score). Thus a positive score indicates an own-race advantage, and a negative an other-race advantage. On the easiest condition, the TD had a significant positive score, whilst the ASD group a negative score, but it was not significantly different from zero. This further suggests that on this IC condition the TD group demonstrated a significant own-race advantage, whilst the ASD group did not show any difference, in fact even trending towards an other-race advantage.

In summary, the literature on the ORE in ASD so far presents a mixed picture. Wilson et al., (2011) reported a reduced ORE in a sub-group of ASD children with age inappropriate face recognition scores; Yi et al., (2015) report a reduced ORE in ASD, and so do Chien et al., (2014). Yi et al., (2016) however report a typical ORE, as do Wilson et al., (2011) in the subgroup of children age appropriate face recognition. Thus there is some tentative evidence for a reduced ORE in ASD, but presently the picture is still unclear, particularly given the difficulty in making sense of the results presented by Yi et al. Some of these inconsistencies may be due to methodological differences between studies. Some use two alternative forced-choice paradigms while others test face recognition memory. Of the two studies that use face recognition memory tasks, either the control group was at ceiling (Yi et al., 2015) or the ASD group was at chance level (Yi et al., 2016). It is not clear why different paradigms would lead to different performance but further investigation is warranted. Most importantly, all studies to date have looked at the ORE in ASD in single cultures.

It should also be noted that this argument does not stipulate a complete lack of an ORE in ASD is expected, but rather a reduced ORE compared to TD children. As already discussed, early experience is important in the development of the ORE, but laterexperience still clearly plays a role. Given this, children with ASD are likely to receive some degree of experience of own and other-race faces, but less in comparison to TD children. This is why a reduced ORE is.

1.4: Face Recognition & The Current Study

In order to probe the ORE through recognition accuracy of own and other-race faces, the current study used the paradigm from Chien et al., (2014). Chien et al., used African and Asian faces as they only tested Chinese participants. As our sample consisted of Caucasian and Asian children, we used Caucasian and Asian faces so all children would see the same stimuli. Compared to the previous studies this is a very large cross-cultural study (68 Asian children, 56 Caucasian) collected in the UK and Japan simultaneously.

The cross-cultural aspects of this study is highly novel in this literature, and is also quite important within ORE literature as although the ORE has been reported across a number of cultures, there is also evidence it varies in strength across cultures. If we consider the previous ASD literature, the Caucasian study (Wilson et al., 2011) reported an ORE in both their ASD and TD samples (bar the age inappropriate ASD group). In contrast the studies that involved Chinese samples found a range of results, with both the TD and ASD groups showing an ORE in some studies, both not others. Other studies with typical populations using composite faces have also found that Caucasian participants show better own-race face recognition, whilst Asian participants showed comparable own and other-race performance (Hayward, Crookes & Rhodes, 2013; Michel, Rossion, Han, Chung, & Caldara, 2006). Cross-cultural work is therefore important to understand this variability in the ORE. For example if it differs between cultures it may suggest that there is an interplay of experience and culture on the development of face perception.

Based on the previous studies in this area, along with the argument put forth for reduced perceptual experience in ASD, we predicted that there would be a diminished ORE in both our ASD samples (the UK and Japanese sample) relative to their respective TD groups. If reduced experience leads to reduced expertise, then an interaction between group and race of face should be observed. Within the conditions of the paradigm, the easy and hard eyes conditions were of particular interest given the research that has shown children with ASD particularly focus less on these regions. Thus it was expected that children with autism would show the most noticeable difficulties on these trials compared to the TD groups. In addition to this behavioural analysis, eye tracking was also carried out to examine how attention is allocated during own and other-race face processing.

1.5: Attention during own/other-race recognition

Eye tracking research has shown that children with ASD show various atypicalities of social attention, most notably reduced fixations to the eye region (Jones et al., 2008;

Pelphrey et al., 2002). More generally they have been shown to take longer to fixate on faces, and when they do so making less and shorter fixations than TD children (Riby & Hancock, 2009). These attention atypicalities extend to using gaze information from the face of another person, such as detecting a target that another person is directing their gaze towards (Riby, Hancock, Jones & Hanley, 2013). Children with autism have been found to be both slower in responding, and less accurate not only naming the target an actor is looking at, but more broadly the area in which the target is located (Riby & Doherty, 2009). Thus a range of deficits in gaze behaviour in autism have been reported relative to the typical population, both in terms of how they direct their own gaze, and how they respond to the gaze of another. Such atypicalities may suggest a mechanism for any underlying differences in the development of face expertise.

Interestingly, gaze behaviour to own and other-race faces is subject to cultural influence. For example participants from the UK and Italy report looking someone in the eye during a conversation as more important than did participants in Japan and Hong Kong (Argyle, Henderson, Bond, Iizuka & Contarello, 1986). Likewise, in a sample of Trinidadians, Canadians and Japanese individuals, the Japanese group maintained the least eye contact, whilst the Canadians maintained the most (McCarthy, Lee, Itakura & Muir, 2006). Such differences seem reflective of the fact that avoidance of eye contact is considered a sign of respect in Eastern cultures, but not within Western cultures (Sue & Sue, 1977). Related to this, Eastern participants have reported that when a face makes eye contact with them, they subsequently judge it to be angrier, less approachable and more unpleasant compared to Western participants (Akechi et al., 2013). These attitudes towards eye-contact are borne out in eye-tracking research as would be expected. Blais et al., (2008) report during both learning and recognition that West Caucasian adults showed a strong prioritisation of the eyes, with some additional focus on the mouth region, whilst East Asian adults showed a strong focus on the nose. Kelly et al., (2011) report similar findings in a sample of British and Chinese children between seven and 12 years of age. As with the adults, the British children showed a strong preference for attending to the eye-region, whilst the Chinese children showed a central preference, attending to the nose. Thus we would expect differences in the scanning patterns to own and other-race faces for typically developing children in the UK and Japan, indicating the influence of culture on attention to faces. Studying gaze behaviour to own and other-race faces in autism can reveal whether gaze behaviour in this group is shaped by cultural experience as seems to be the case in the typical population.

1.6 Attention to Own and Other-Race Faces and the Current Study

To date, only two papers have looked at the links between attention in autism and recognition of own and other-race faces (Yi et al., 2015, 2016). Yi et al., (2015) report that ASD children looked longer at non-face areas (N.B. the authors do not specifically define to what these areas refer) than TD children generally, and less at the right eye than the TD group. However, there were also race effects involved, with the ASD and TD groups looking longer at the right eye of other-race (Caucasian) faces, than own-race faces.

Likewise, both groups spent longer looking at the left eye of other-race faces than own-race. They also report longer nose region fixations for the ASD and TD groups of own-race faces compared to other-race faces, and again for the mouth region. Their 2016 paper reported similar results.

Considering these two papers alongside previous eye tracking done in typical participants across cultures we can make a number of hypotheses about attention in the current study. The work of Blais et al., (2008) and Kelly et al., (2011) would indicate a cultural difference between our UK and Japanese samples. It would be expected for the UK sample to show a preference for attending to the eye region, whilst the Japanese sample would be expected to show a preference for attending to the nose region. However the work by Yi et al., would suggest this difference might be somewhat more nuanced, with this difference also being modulated by race of face. This would mean greater levels of attention being directed towards the eye region of other-race faces for the Japanese sample compared to own-race faces, and vice-versa for the nose region. Additionally this difference should be present in both the ASD and TD groups of the Japanese sample. It is more difficult to say whether a similar effect may be present in the UK ASD and TD groups (a difference in how they scan the own vs. other faces) based on the Yi papers given they only tested a Chinese sample. The cross-cultural nature of this work will allow us to compare this effect across two different cultures going beyond what is reported by the Yi papers.

The final element of the eye tracking will be looking at the within group differences i.e. comparing the ASD groups of the UK and Japanese samples with their respective TD groups. As covered a large body of work in Western samples studies have reported reduced eye fixations from participants with ASD relative to typically developing counterparts. In addition to this, it has also been reported that they show increased fixations to the mouth region relative to typical counterparts (Hanley et al., 2015). The work by Yi et al (2015, 2016) suggests a similar pattern should be expected in the Japanese group with respect to the eye region, also reporting that their ASD group showed reduced fixations to the eye region relative to their typically developing counterparts.

1.7 Hypotheses of the Study

The aim of the current study is explore the role of experience in face perception by comparing children with and without autism in terms of recognition accuracy and attention to own and other-races faces. Crucially, this study also provides a simultaneous cross-cultural comparison of the UK and Japan. Data will be considered separately for recognition accuracy and attention and two sets of hypotheses are made. It is expected that typically developing children in the UK and Japan show an ORE highlighting the role of experience in face perception. Based on the findings of Chien et al., (2014) it is expected that this will be seen most clearly in the identity change condition. Based on theories of reduced perceptual experience, it is expected that the ASD groups in the UK and Japan will showed a reduced ORE, and show particular difficulties on the conditions where manipulations are made to the eye regions of own and other-race faces, compared to TD children.

In terms of attention there are a number of expectations. Firstly, it is expected that the ASD groups in the both the UK and Japanese samples will exhibit reduced fixations to the eye region relative to their respective typical counterparts. Furthermore it is expected that there will be cultural differences between the UK and Japanese samples in how attention is allocated to own and other-race faces. In the Japanese groups a greater level of attention towards the eyes of other-race faces relative to own-race is expected, with the opposite pattern for the nose region. It is harder to predict whether a similar effect may be present in the UK sample, although given the pattern seen in typical work such an effect may be expected showing greater levels of fixations on the eyes of own-race faces compared to other-race.

By being able to investigate the ORE both behaviourally and through eye tracking this will allow a comprehensive examination of the phenomena within ASD, which will reveal key information in how face expertise develops in those with ASD compared to TD individuals, along with how differences in face perception may develop between cultures.

2: Methods

Participants

A total of 124 children participated in the study. Of these, 56 were from the UK, and 68 were from Japan. Table 1 provides information on participant characteristics for both samples.

In the UK sample, all children were recruited through local schools and advertisements on the Durham Developmental group Facebook page. The ASD group consisted of 21 children (4 female, 17 male), with a mean age of 9.1 years. The TD group consisted of 35 children (14 female, 21 male), with a mean age of 9.06 years. Verbal ability was assessed using the British Picture Vocabulary Scale III (BPVS) (Dunn and Dunn, 2009), and non-verbal ability was assessed with Ravens Colour Progressive Matrices (Raven, Raven & Court, 1998). The ASD group had a mean standardised BPVS score of 100.48 and a mean Ravens of 28.14. The TD group had a mean standardised BPVS score of 104.5, and a mean ravens of 28.57. There were no significant differences between ASD and TD groups for age, $t(54) = .071$, $p = .943$, standardised BPVS scores, $t(54) = -1.13$, $p = .265$, or Ravens score, $t(54) = -.30$, $p = .768$.

In the Japanese sample, individuals with ASD were recruited from the Jichi Medical University (Shimotsuke, Tochigi, Japan) and International University of Health and Welfare (Otawara, Tochigi, Japan). For the control group, healthy TD children participated in the study. Control children were recruited from the elementary, junior high, and high schools near the Jichi Medical University and the International University of Health and Welfare and had a negative history of psychiatric and neurological problems. The ASD group consisted of 29 children (eight female, 21 male), with a mean age of 9.90 years. The TD group was made up of 39 children (17 female, 22 male), with a mean age of 9.92 years. Verbal ability was assessed using the Japanese version of the Peabody Vocabulary Test (Ueno, Utsuo & Iinaga, 1991), and non-verbal ability was assessed using Ravens Coloured Progressive Matrices (Raven et al., 1998). The ASD group had a mean Peabody scaled score of 10.83, and a mean Ravens of 30.72. The TD group had a mean Peabody score of 10.65, and a mean Ravens of 30.21. There were no significant differences between the TD and ASD groups for age, t(66) = -.059, p = .953, Peabody scores, $t(66)$ = .465, p = .643, or Ravens, $t(66)$ = .509, p = .612.

		ASD	TD
Gender (M/F)	**UK**	17/4	21/14
	Japan	21/8	21/17
Age (Years) M (SD)	**UK**	9.10 (2.19)	9.06 (1.77)
	Japan	9.90 (1.52)	9.92 (2.03)
Peabody M (SD)	**UK**	N/A	N/A
	Japan	10.83 (1.38)	10.65 (1.64)
Ravens M (SD)	**UK**	28.14 (6.13)	28.57 (4.63)
	Japan	30.72 (3.73)	30.21 (4.44)
BPVS M (SD)	**UK**	100.48 (13.34)	104.51 (12.78)
	Japan	N/A	N/A

Table 1: A comparison of the descriptive statistics of the ASD and TD groups of the UK and Japanese samples

Comparison of the participants from both samples (Japan vs. UK) showed that the Japanese sample were significantly older than the UK sample (on average 9.91 years vs. 9.07), $t(122)$ = -2.5, p = .014, and they also had a significantly higher average Ravens score (30.43 vs. 28.43), $t(104.14)$ = -2.36, p = .020. It was not possible to compare verbal ability given the different measures used.

Given the differences between the samples[1], analyses were carried out separately for the UK and Japanese groups.

Eye-Tracking Participants

Of this total sample of 124 participants, 94 participants were included in the eye tracking analysis. 30 were excluded due to either due it not being possible to complete the eye tracking process with them, or due to poor capture from a completed eye track. The Japanese sample was as follows: ASD (M/F): 20/7 (27 of 29); TD (M/F): 16/13 (29 of 38). The UK sample was as follows: ASD (M/F): 12/2 (14 of 21); TD (M/F): 13/10 (23 of 35). After removing participants, within the UK sample, there were no significant differences between the ASD and TD groups for age $t(44) = .885$, $p = .381$, standardised BPVS $t(44) = -1.20$, p .235, and RPCM $t(44) = -.059$, $p = .953$. Within the Japanese sample there were no significant differences between the ASD and TD groups for age $t(51.847) = .316$, $p = 754$, PVS $t(55) = .665$, $p = .509$, or RCPM $t(55) = .401$, $p = .690$.

Cognitive and Behavioural Measures

As indicated, children in the British sample completed the BPVS III (Dunn & Dunn, 2009) as a standardised measure of their receptive vocabulary. Children in both the Japanese and British samples completed the Ravens Coloured Progressive Matrices (Raven et al., 1998). Children in the Japanese sample completed the Japanese version of the Peabody Picture Vocabulary Test IV as a standardised measure of their receptive vocabulary (Ueno et al., 1991).

Stimuli

The stimuli were colour images of Caucasian and Asian male and female adult faces, cropped and framed in an oval-shape window to remove the background and

[1] Age and Ravens were found to correlate with accuracy in both samples, UK age, r(52) = .254, p = .03, Ravens, r(52) = .187, p = .09; Japan, Age, r(68) = .329, p = .003, Ravens, r(68) = .275, p = .01.

external cues, and mounted on a black background (Chien et al., 2014). There were four target stimuli: male Caucasian, female Caucasian, male Asian and female Asian. In the recognition trial, target faces were presented alongside a foil face from one of four difficulty conditions. These were: identity change (different face to target), easy eyes (same target face, different eyes photoshopped in), hard eyes (same target face, eye spacing increased by 14 pixels, seven for each eye), and hard mouth (same target face, nose-mouth spacing increased by 10 pixels). The locations of the target and foil were counterbalanced. An example of the Caucasian and Asian female faces is detailed in figure one, with the same principles being applied to the male faces. The pair of stimuli presented would always be the target face + one of the foil faces. Faces presented had a height of 13.6cm, a width of 11.4cm and a visual angle of 9.72 by 8.15 degrees. During the encoding phase the face was in the centre of the screen whilst during the recognition phase one was placed on the left hand side, and one on the right, with a distance of 11.1cm in between.

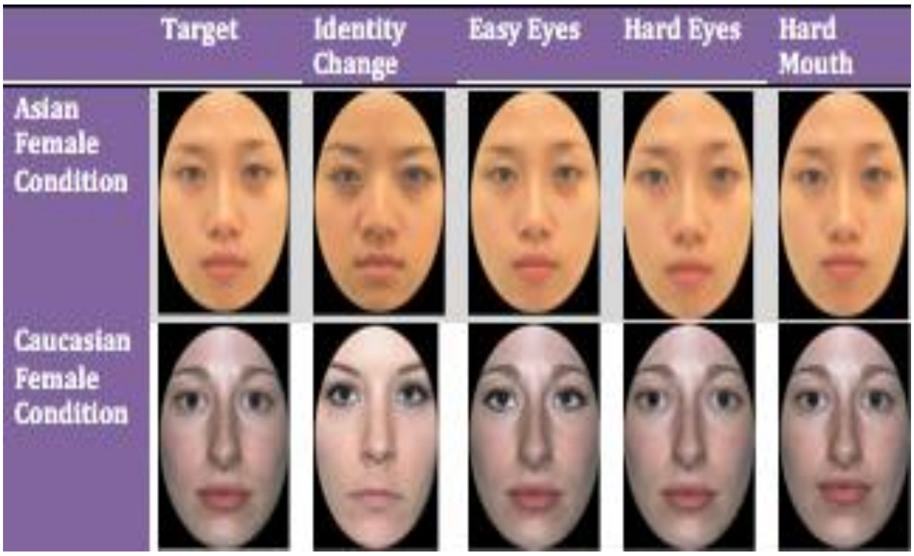

Figure 1: Caucasian and Asian female faces showing the target, and the foil shown in each difficulty condition.

Face Recognition Task

The experimental program was compiled with E-Prime and run on 15.6-inch laptop computer (Lenovo, need to get exact specs), which was connected to a 22-inch computer monitor with mounted eye-tracker. Children performed the task at a distance of 80cm from the monitor. There were 64 trials in total, [4 identities (2 Asian, 2 Caucasian) X 4 conditions (IC, EE, HE, HM) X 2 locations for the correct answer (left, right) X 2 repetitions]. 32 faces were presented, followed by a short break period during which the participant was required to stay seated during, followed by the final 32 faces. Prior to testing each child completed a practice session with two different Asian, and two African faces, one male and one female for each. These mirrored the identity change condition, but were not included in the formal test stimulus set.

Faces were presented using a sequential two-alternative-forced-choice discrimination trial. Each child was positioned in front the monitor. The trial began with a fixation cross, which (assuming the child was being eye-tracked) would cause the trial to begin by presenting the target face for duration of three seconds. If the child was not being eye-tracked the cross would disappear automatically after a few seconds. The target face would then disappear and be replaced by two faces, one to the left and one to the right of the location of the target face. Children were instructed to indicate which face they had just seen by pressing either the left or right key on a controller given to them. The two faces remained on screen until a response was made, and no time limit enforced. Feedback was not given throughout the trial, although the children were encouraged during the task. If the child asked whether they were correct, positive but non-specific responses were given, such as “you’re doing great”. Figure two demonstrates the flow of the trial.

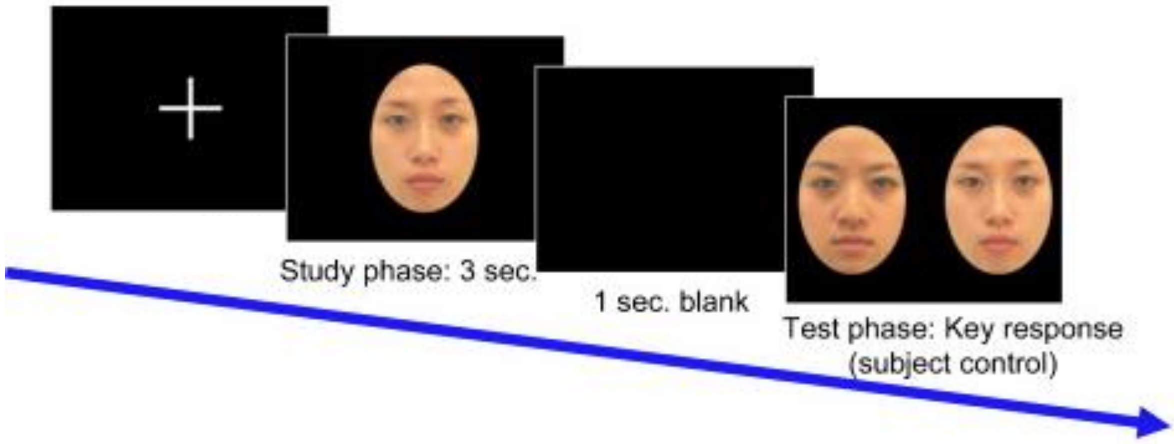

Figure 2: The flow of the trial, here demonstrated by the IC Asian female condition. In other trials the foil face (here on the left) would be replaced by that of a different difficulty. Image adapted from Chien et al., (2014).

Eye Tracking

An SMI Remote Eye Tracking Device (RED) 250 (SMI Germany) was used to record participants eye movements. This was a portable system using a 22-inch computer monitor that connected to the E-prime laptop, with the infrared eye-tracker connected below the monitor. This was completely non-invasive. The eye-tracker sampled at 250Hz with an accuracy of less than 0.5 degrees visual angle. At the start of each block of trials (i.e. before the 64 test trials) there was a calibration procedure in which participants were asked to look at a moving dot for nine points, followed by four point validation procedure. Recording of eye tracking data proceeded if the validation indicated an accurate track (validation scores of less than .5 for the X and Y axis). Eye tracking was attempted three times with each participant and if it was not successful after this, the experiment proceeded without eye tracking. The faces had defined regions of interest which were: eyes, nose, mouth, face non-features i.e. looking at the face area, but not any of the eyes, nose or mouth (FNF), screen, and out of bounds. The eye-tracking data was analysed with a bespoke program which was calculated the number of fixations to each of these regions, along with the amount of fixation time spent on each region.

Procedure

Once recruited, children were brought to the testing area (typically a room within the school unless testing was done within the department). The procedure for behavioural/eye tracking task was completed first. If children were unable to complete this phase of the experiment, they did not complete the second phase, in which the cognitive and behavioural measures were carried out. When testing was carried out within the schools, testing was split into two sessions to minimise disruption to each school day, with the first testing session consisting of the behavioural/eye tracking task, and the second sessions the cognitive behavioural measures. When testing was done within the department the tasks were completed in one session, in the same order as in the schools.

Ethical approval was obtained from the Durham University Faculty of Science Sub-Committee and conducted within the bounds of this approval. Informed, written consent was obtained from the parents of the children involved.

Analysis

Two major analyses of the data were conducted – one for the behavioural element of the study focusing on recognition accuracy and the ORE, and one focusing on attention and scanning during own and other-race face processing. The results for the behavioural element of the study, along with a brief discussion are presented in chapters nine and ten. The results for the eye-tracking element of the study, along with a brief discussion are presented in chapters 11 and 12, before the final general discussion in chapter 13.

3: Behavioural Recognition of Own and Other-Race Faces

3.1: Results (I), Does experience shape own and other-race face recognition accuracy?

Aim

The aim of this analysis was to compare the ASD and TD children from the UK and Japan for recognition accuracy of own and other-race faces.

Overall Accuracy

UK sample

In terms of overall accuracy on the face recognition task, the ASD group scored on average 70.39%, whilst the TD group scored on average 73.17%. There was no significant difference between the ASD and TD groups for overall performance (see Figure 1), $t(54) = -1.02$, $p = .314$.

Japanese sample

The Japanese ASD group scored on average 80.28%, whilst the TD group scored 81.77% for overall accuracy on the task. There was no significant difference between the ASD and TD groups in overall performance for face recognition in the Japanese sample (see Figure 1), $t(66) = -.73$, $p = .469$.

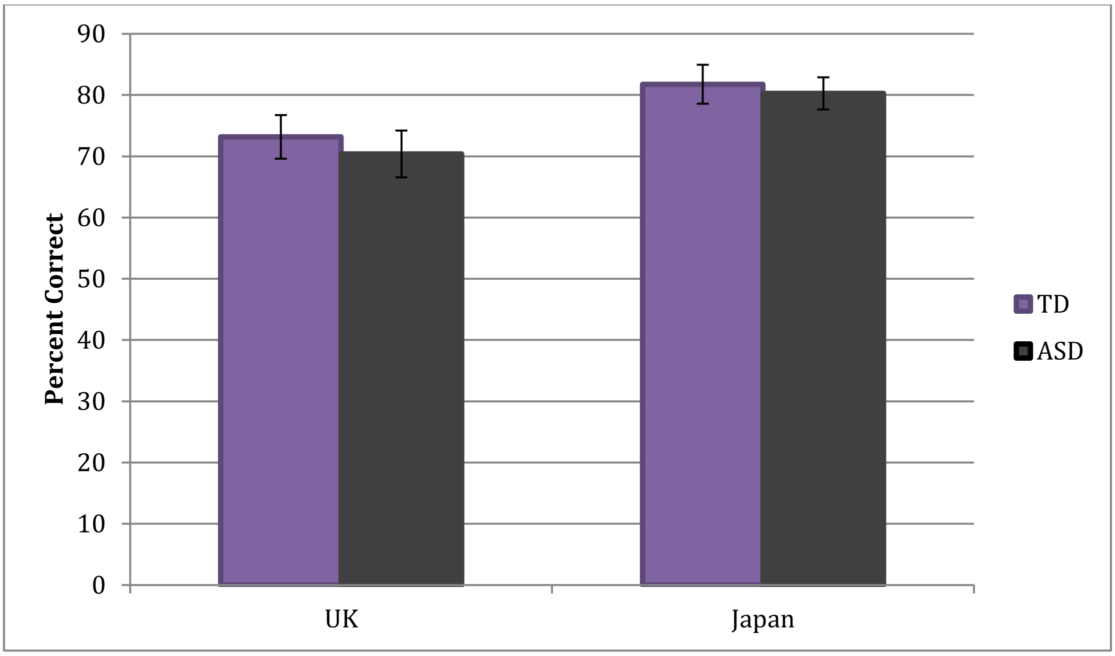

Figure 3: Overall accuracy for the ASD and TD groups of both samples. Error bars represent +/- 2 SE of the mean.

Overall, within each cultural sample there was no evidence of impairment for children with autism in terms of face recognition compared to the TD group. However the Japanese sample (81.13%) scored around 10% higher on average compared to the UK sample (72.13%), $t(122) = -5.50$, $p < .001$. This difference was not surprising given that the Japanese sample was older and had higher non-verbal ability. For this reason, further analyses were completed separately for the Japanese and UK samples in the following sections.

Chance and Ceiling Analysis

One sample t-tests were carried out for both the ASD and TD groups in the UK and Japanese samples to check performance against chance (50%) and ceiling (90%) levels.

UK Sample

The ASD group performed significantly above chance on the identity change (97%), $t(20) = 19.27$, $p < .001$; easy eyes (89%), $t(20) = 15.53$, $p < .001$; hard eyes (72%), $t(20) = 6.03$, $p < .001$; and hard mouth (62%) conditions, $t(20) = 5.46$, $p < .001$.

The ASD group performed significantly above or at ceiling on the identity change (97%), $t(20) = 2.77$, $p = .012$; and easy eyes condition (89%), $t(20) = -.403$, $p = .691$. They performed significantly below ceiling on the hard eyes (72%), $t(20) = -4.93$, $p < .001$; and hard mouth (62%) conditions, $t(20) = -13.36$, $p < .001$.

The TD group performed significantly above chance on the identity change (92%) $t(34) = 15.71$, $p < .001$; easy eyes (83%), $t(34) = 11.32$, $p < .001$; hard eyes (64%), $t(34) = 4.29$, $p < .001$, and hard mouth (60%) conditions, $t(34) = 4.10$, $p < .001$.

The TD group performed significantly above or at ceiling on the identity change (92%), $t(34) = .67$, $p = .507$; and easy eyes conditions (83%), $t(34) = -2.46$, $p = .019$. They performed significantly below ceiling on the hard eyes (64%), $t(34) = -8.35$, $p < .001$; and hard mouth (60%) conditions, $t(34) = -12.00$, $p < .001$.

Japanese Sample

The ASD group performed significantly above chance on the identity change condition (97%) $t(28) = 58.60$, $p < .001$; easy eyes (90%), $t(28) = 13.38$, $p < .001$; hard eyes (75%), $t(28) = 6.72$, $p < .001$, and hard mouth (60%) conditions, $t(28) = 4.20$, $p < .001$.

The ASD group performed significantly above or at ceiling for the identity change (97%), $t(28) = 8.48$, $p < .001$; and easy eyes (90%) conditions, $t(28) = -.116$, $p = .908$.

They performed significantly below ceiling on the hard eyes (75%), $t(28) = -4.22$, $p < .001$; and hard mouth (60%) conditions, $t(28) = -12.39$, $p < .001$.

The TD group performed significantly above chance on the identity change (95%) $t(38) = 28.00$, $p < .001$; easy eyes (83%), $t(28) = 14.14$, $p < .001$; hard eyes (65%), $t(38) = 5.44$, $p < .001$, and hard mouth (55%) conditions, $t(38) = 5.01$, $p = .004$.

The TD group performed significantly above or at ceiling for the identity change (95%), $t(38) = 2.86$, $p = .007$. They performed significantly below ceiling on the easy eyes (83%), $t(38) = -2.75$, $p = .009$; hard eyes (65%), $t(38) = -9.00$, $p < .001$; and hard mouth (55%) conditions, $t(38) = -19.40$, $p < .001$.

Summary

Children in all groups scored significantly above chance for all conditions. All groups found the identity change condition very easy, as they all scored at or above ceiling for this condition. Additionally the two ASD groups performed at ceiling for the easy eyes task, whilst the TD groups did not. However both samples scored below ceiling for the hard eyes and hard mouth conditions. Therefore, the task seemed to be at a suitable level for the children, as the conditions progressed from being relatively easy to relatively difficult in a similar pattern for all groups and no task was so difficult that they were operating at chance level.

Were children with autism less sensitive to information from the eyes?

UK group

Figure 4 illustrates the performance of the UK groups for accuracy across the conditions. To examine the effect of condition, a three-way mixed ANOVA was carried out with within subject factors face race (own and other) and difficulty (identity change, easy eyes, hard eyes, and hard mouth), and a between subjects factor of group (ASD and TD). There were main effects of face race; $F(1, 54) = 6.53$, $p = .013$, $\eta^2_p = .11$, difficulty; $F(2.56, 138.20) = 106.74$, $p < .001$, $\eta^2_p = .66$, and an interaction between face race and difficulty; $F(3, 162) = 5.77$, $p = .001$, $\eta^2_p = .10$. There was no main effect of group, $F(1, 54) = .912$, $p = .344$, $\eta^2_p = .017$, and no interactions of group and face race, $F(1, 54) = .018$, $p = .018$, $\eta^2_p = .001$, group and difficulty, $F(2.56, 138.20) = .438$, $p = .695$, $\eta^2_p = .008$, or group, face race, and difficulty, $F(3, 162) = .1.55$, $p = .208$, $\eta^2_p = .028$.

For the main effect of face race, the means indicated that the UK sample was significantly better at own race faces (M = 73.41) than other race faces (M = 70.58). For the main effect of difficulty, pairwise comparisons showed there was a significant difference in accuracy between all conditions (all *p's* < .001) apart from between the hard eye and hard mouth conditions ($p = 1.00$) (IC M = 92.02%, EE M = 79.88%, HE M = 58.72%, HM M = 57.35%).

To examine the interaction of face race and difficulty paired samples t-tests were carried out. This revealed the interaction was driven by the identity change and easy eyes condition. In the identity change condition, the UK sample were significantly better at own-race faces (95.09%) than other-race faces (88.84%), $t(55) = 2.99$, $p = .004$. They were also significantly better at own-race faces (84.38%) than other-race (76.34%) in the easy eyes condition, $t(55) = 4.02$, $p < .001$ (see Figure 3). There was no significant difference on the hard eyes condition between performance for own-race (59.60%) compared to other-race faces (58.93%), $t(55) = -.234$, $p = .816$. This was also the case when comparing own-race faces for the hard mouth condition (55.80%) and other-race faces (59.60%), $t(55) = 1.53$, $p = .133$.

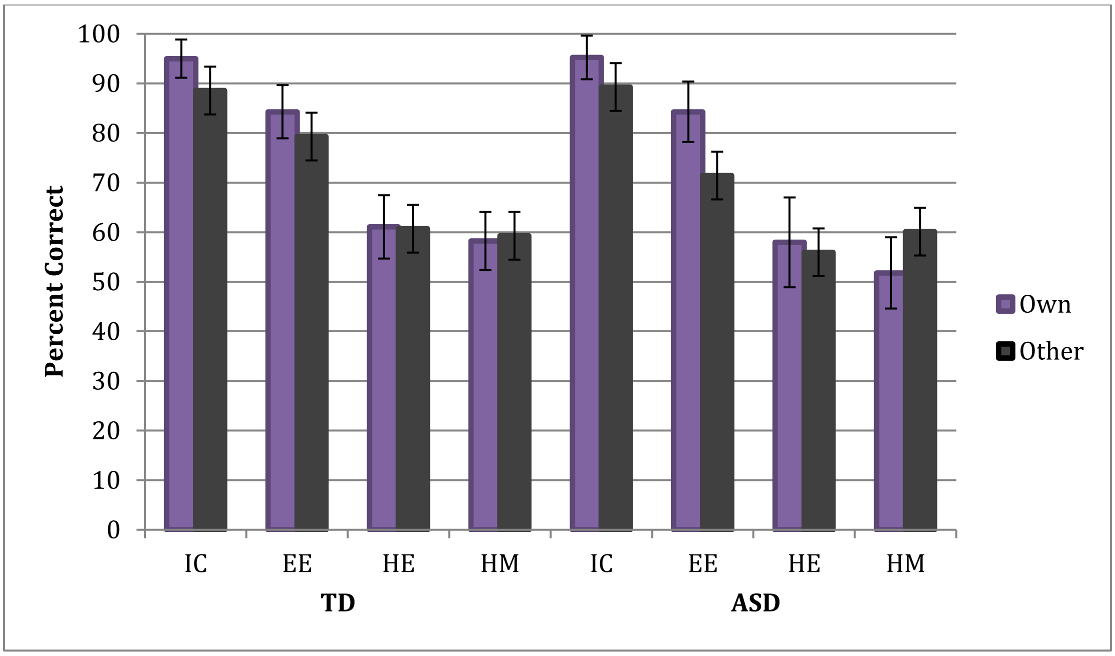

Figure 4: UK own and other-race performance for each difficulty condition for the ASD and TD groups. Error bars represent +/- two standard errors.

These results show that although face-race did impact performance (own-race easier than other-race particularly for the IC and EE conditions), this was the same for the ASD and TD groups. This is further evidenced by analysis of the differential scores. Differential scores can represent an ORE as they are made by subtracting total other-race performance for each condition from total own-race performance. Thus, a positive score indicates an ORE for that condition, whilst a negative score indicates an other-race advantage for that condition. Figure 5 shows the differential scores for the UK sample. One samples t-tests were carried out to compare the differential scores to a value of 0. In the UK ASD group, there was a significant ORE for the easy-eyes condition, $t(20) = 3.74$, $p = .001$. There was no significant ORE in the identity change condition, $t(20) = 1.56$, $p = .135$, hard eyes, $t(20) = .208$, $p = .837$, or hard mouth, $t(20) = -2.00$, $p = .059$. For the TD group, there was a significant ORE for the identity change condition; $t(34) = 2.60$, $p = .014$, and the easy-eyes condition; $t(34) = 2.17$, $p = .037$, but not the hard-eyes, $t(34) = .115$, $p = .909$, and hard-mouth, $t(34) = -.352$, $p = .727$.

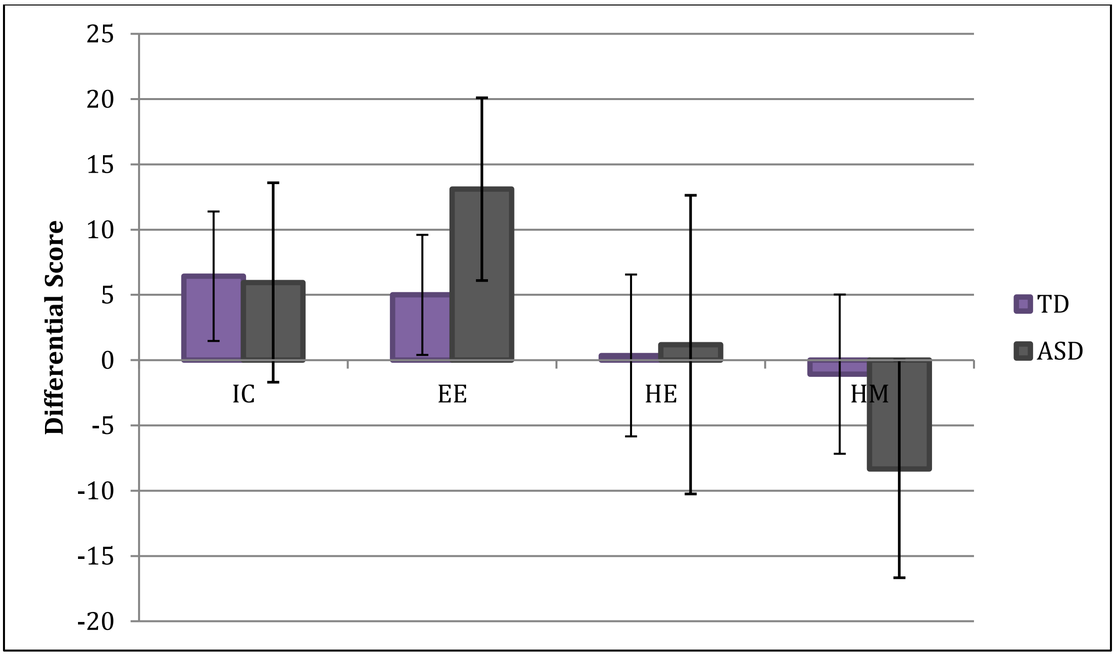

Figure 5: UK differential percent scores for the ASD and TD groups. Error bars represent +/- two standard errors.

By examining the interaction of face-race and difficulty and the differential scores, the own-race effect for the UK group seems to be present in the easier conditions for both ASD and TD children (identity change and easy eyes) as opposed to the two more difficult conditions (hard eye and hard mouth).

Japanese Group

Figure 6 illustrates the performance of the Japanese groups for accuracy across the conditions. There was a main effect of difficulty; $F(2.37, 156.65) = 147.96$, $p < .001$, $\eta^2_p = .69$, and an interaction of face race and difficulty; $F(2.01, 137.10) = 4.08$, $p = .018$, $\eta^2_p = .06$. However there was no main effect of face race ($F(1, 66) = 3.03$, $p = .086$, $\eta^2_p = .044$) or group ($F(1, 66) = .422$, $p = .518$, $\eta^2_p = .006$), no two-way interactions between group and difficulty ($F(2.37, 156.65) = .284$, $p = .790$, $\eta^2_p = .004$), face race and group ($F(1, 66) = 3.41$, $p = .069$, $\eta^2_p = .049$), and no three-way interaction between group, difficulty and face race ($F(2.08, 137.10) = .129$, $p = .886$, $\eta^2_p = .002$).

For the main effect of difficulty, pairwise comparisons showed that each of the conditions was significantly more difficult than the previous one (all p's < .001) (IC M = 97.58%, EE M = 90.80%, HE = 75.80%, HM = 60.25%). Paired samples t-test to unpick the interaction of face race and difficulty revealed this was driven by the hard eyes condition, where the Japanese sample were on average significantly better at own-race faces (80.15%) than other-race faces (71.88%), $t(67) = 3.54$, $p = .001$. There was no significant difference between own-race (97.79%) and other-race (97.61%) performance on the identity change condition, $t(67) = -.199$, $p = .843$; easy eyes condition (own-race = 90.07%, other-race = 91.73%), $t(67) = 1.10$, $p = .275$; and hard mouth condition (own-race = 60.85%, other-race = 59.56%), $t(67) = -.431$, $p = .668$.

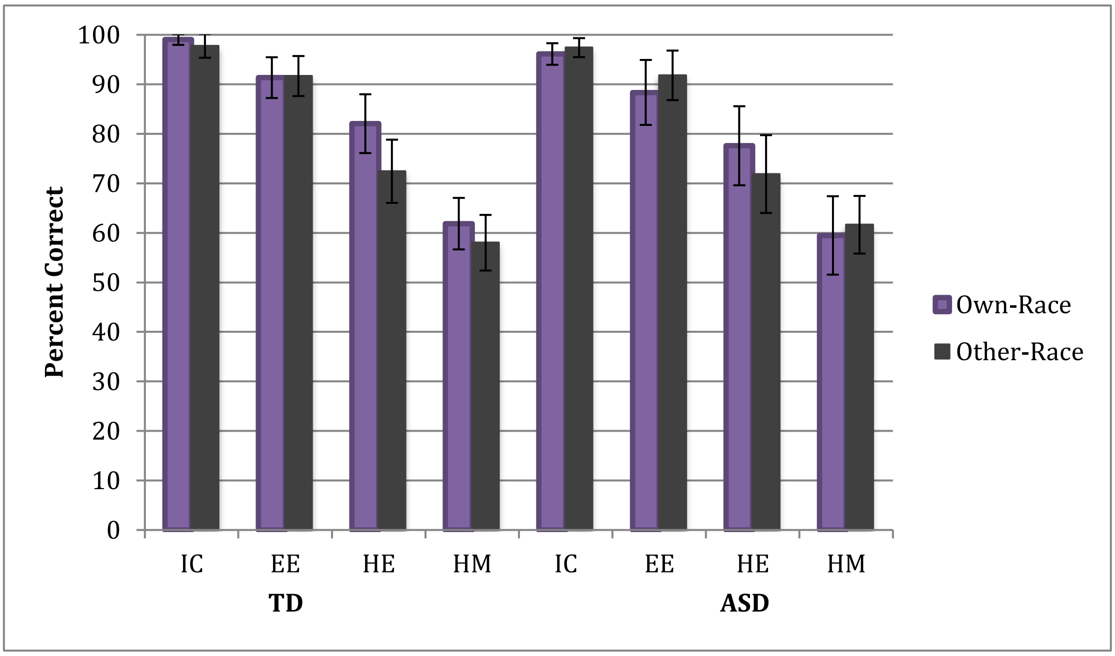

Figure 6: Japan own and other-race performance for each difficulty condition for the ASD and TD groups. Error bars represent +/- two standard errors.

These results show that although there was an overall effect of race of face, own-race faces were better recognised in the more difficult hard eyes condition. This pattern was the same for both the ASD ad TD groups.

To further explore the ORE, analysis of differential scores were conducted. Figure 7 shows the data for differential scores. One sample t-tests revealed that in ASD group, there was a significant ORE for the hard-eyes condition; $t(28) = 2.19$, $p = .037$. However there no significant ORE for the identity change, $t(28) = -1.00$, p = ,326; easy eyes, $t(28) = -1.61$, $p = .118$, and hard mouth conditions, $t(28) = -.434$, $p = .668$,. The TD group likewise showed a significant ORE on the hard eyes condition, $t(38) = 2.79$, $p = .008$, but no significant ORE for the identity change, $t(38) = 1.00$, $p = .324$; easy eyes, $t(38) = -.154$, $p = .878$; and hard mouth conditions, $t(38) = 1.05$, $p = .302$. Therefore although there was no main effect of race, it did still matter for the Japanese sample, specifically in the hard eyes condition, for both the ASD and TD groups.

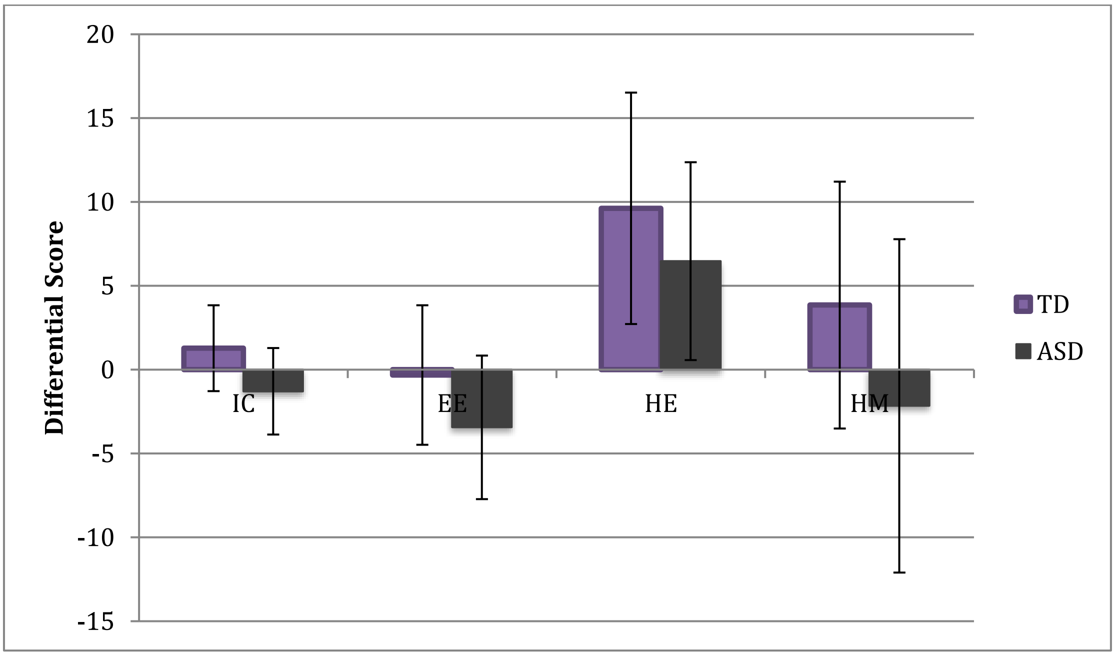

Figure 7: Japanese sample differential percent scores for the ASD and TD groups. Error bars represent +/- two standard errors.

3.2: Discussion of Results (I)

The aim of this study was to compare the recognition of own and other-race faces by children with ASD in the UK and Japan to their typical counterparts. As first mentioned in the methods section on page 26, it was decided the analyses would be conducted separately. The reasoning for this was firstly age; although the mean age of the groups may look similar, there is in fact nearly a full year in the difference between the groups (the UK sample's mean is 9.1 compared to 9.9 in the Japanese sample,or alternative nine years approx. 35 days, and nine years approx. 320 days respectively) and this difference was statistically significant. Likewise although the Raven's scores were similar they were still two points apart, and again statistically significant. Further considering the age component, one year in the context of face processing can be crucial. For example, Taylor, Batty, and Itier., (2004) report improvements in an upright face-processing task being most noticeable between eight to nine year olds, and 10 to 11 year olds. Given the extent to which face processing can develop over a year, this demonstrates the issue of comparability between the samples. It should also be noted that age and Raven's score were the only two demographic factors found to be relevant for task performance – they were not tangential factors. Given the differences in these scores between the samples as has been detailed, it seemed important to analyse the two samples separately. This seems a likely explanation for why the Japanese sample performed better overall than the UK sample (around 10%)

There was no difference between the ASD and TD groups in either cultural group indicating there was no evidence for general impairment of face processing in the children with autism. Additionally neither the UK or Japanese ASD groups seemed to show an insensitivity to the eye region for the two conditions with eye region manipulations.

Looking more specifically at the ORE, there was also no evidence for a reduced ORE in ASD, as both the UK and Japanese ASD groups showed the same pattern as their respective TD groups. There were however cultural differences between the samples. The UK sample showed significantly better overall performance for own-race faces than other-race faces. They performed well on the identity change and easy eyes conditions, but less well on the hard eyes and hard mouth conditions. These two factors interacted to reveal a behavioural ORE on the identity change and easy eyes conditions, whilst the hard eye and hard mouth conditions were equally difficult regardless of face race.

In contrast, the Japanese group did not show an overall difference in performance between own and other-race faces. However, there was an interaction – children in the Japanese sample showed equal own and other-race face performance on the identity change, easy eyes and hard mouth conditions, but better own-race face performance on the hard eyes condition.

Overall then, although experience with faces influences recognition accuracy, there was no clear evidence of atypicality for children with ASD in the UK or in Japan. The Japanese sample were better at the task overall however, and the ORE emerged in different conditions for the two samples (IC and EE for the UK, HE for Japan).

Considering this element of the results there are two possible explanations. Firstly there is evidence that the ORE is not as strong in Asian cultures compared to Caucasian ones. For example, Hayward et al. (2013) and Michel et al. (2006) report that Caucasian participants show better own-race face recognition for composite faces, whilst Asian participants show comparable performance. Similarly the work of Chien et al. (2014) and Yi et al. (2015, 2016) presents varied results in the strength of the ORE for their Chinese participants. It may be the case that due to cultural differences in the magnitude of the ORE explains why the ORE was observed differently between the UK and Japanese groups. However, it may also simply be the case that due to the Japanese sample being older and more able on the Ravens, they found the easiest tasks much easier than UK sample did leading ceiling performance to obscure the effect of face race on recognition.

In addition to this cultural aspect, the key finding was that the ASD groups in both samples showed an ORE that matched their respective typical population, contrary to the main hypothesis. This is in keeping with the results of Wilson et al., (2011) who report that children with ASD (with age appropriate face-recognition skills) demonstrate typical like performance when processing own and other-race faces. It does differ to findings from Chien et al. (2014) and Yi et al, (2015, 2016), although there are some key issues to bear in mind here.

In the case of Chien et al., (2014) it is very important to note the difference in sample sizes. The relevance of this becomes particularly clear when comparing the differential percent scores analyses between the two studies. In two of their tasks (easy and hard eye) they actually report very positive high scores for their ASD groups (between 10 and 15%) but the results were not significant. This is unsurprising given that their sample included 13 ASD children, and the variability was considerable. Given such a positive trend in their group, it may well be the case that were they able to test a larger sample, this trend would reach significance, instead indicating an own-race advantage in ASD, as opposed to a lack thereof.

With the papers by Yi et al. (2015, 2016), it is important to consider their pattern of results. Yi et al (2015) report very high performance for both own-race (81%) and other-race faces (83%). In contrast their ASD group score 52% for own-race faces, and 50% for other-race. Similarly, Yi et al (2016) again report high performance from their TD group for own (82%) and other-race faces (81%), whilst performance for the ASD group is again much lower (54% for both own and other-race faces). Additionally in this paper the ASD group failed to score above chance on either condition (they were above chance for own-race faces in Yi et al, 2015). This extreme disparity in performance for the ASD groups relative to their typical counterparts, coupled with them scoring at chance in three out of four tasks over the two papers seems to suggest the ASD group simply found the task too difficult. Thus direct comparisons with their results are difficult as it is not certain whether the behavioural results they report are truly reflective of the ASD groups performance.

At the outset, a clear argument was made for the role of perceptual experience in the development of the ORE, and why this would lead to a diminished ORE in ASD. The current results do indicate experience is important, as both children in the UK and in Japan show an advantage for recognising own versus other faces. However in the context of our results it is important to consider an alternative argument for a typical ORE within ASD. There are a number of factors to consider here.

Firstly, it is important to consider the task used to measure the ORE. The task used in this study required children to match one of the images in front of them to one they had just seen. Therefore, it may have captured image-matching processes as opposed to the processes involved in face learning in everyday life. Indeed, Andrews, Burton, Schweinberger and Wiese (2017) report that learning instances of a single face (as has been done in this study) is insufficient to recognise other instances of the same face. In other words, the face itself has not been learned, but one image of the face. Future research should therefore investigate whether this pattern of results is repeated with a task that more accurately measures face learning, such as that in Andrews et al. (2017). This would capture an important aspect of face learning in the real world – learning variability from the same face, which has by and large been missed in the ORE ASD literature.

Secondly, it is important to consider the extent to which experience influences the development of the ORE. It has been shown that training infants with other-race faces does improve their other-race face perception, which provides evidence that experience plays a role in face perception (Ge et al., 2008; Heron-Delaney et al., 2011). However, it may be that although experience is important, the effect it has is relatively small. Meissner and Brigham (2001) report in their meta-analysis that interracial contact (i.e. more interracial contact = more experience with other race faces) does account for a statistically significant amount of variance in the ORE. However, the amount of variance it accounts for is only 2%, meaning the magnitude of the effect is significant but small. Therefore it is important to consider other factors that may account for a greater proportion of the variance in the ORE (Young, Hugenberg, Bernstein & Sacco, 2012), particularly for children with ASD.

The argument proposed here and elsewhere was that reduced perceptual experience in ASD due to the inattention to faces impacts the development of face perception (McKone, Crookes & Kanwisher, 2009; Wilson et al., 2011). However, not all elements of face perception may require the same degree of expertise. For example, whilst they struggle with complex social information in faces such as emotion recognition (Celani et al., 1999; Gross, 2004; Walsh, Creighton & Rutherford, 2016), they may not struggle as much with face identity recognition. Arguably the skill of emotion recognition is more complex than face recognition, as it requires taking information from throughout the face and interpreting it – a more socio-cognitive skill. In contrast face recognition arguably involves more visual perceptual skills. Walsh et al. (2016) suggest this to be the case, reporting ASD participants scored poorly on measures of emotion recognition, but were able to complete an identification task similarly to typical controls. Therefore, although reduced perceptual experience may still be important in the shaping of face perception in ASD, particularly complex, socio-cognitive elements, it may be the case that it is not enough to impact the more basic, visual perceptual skills needed for face recognition.

Linked to this point, is important to think about early development and what is known about how and when social attention atypicalities emerge in ASD. Webb Neuhaus and Faja (2017) report that when considering metrics for measuring attention to faces, face perception and face learning memory, ASD and TD infants seem to diverge in development somewhere in the second half of the first year of life based on performance on such measures. Related to this is work by Jones and Klin (2013) who report that in terms of eye fixations, children who later go on to be diagnosed with ASD show typical patterns of attention to the eyes at birth. This typical attention pattern is sustained until around two months before starting to diverge, with infants showing the codifying patterns of attention in ASD at about two years. The important consideration here is the suggestion that attention in ASD appears typical at and shortly after birth, and then declines over time.

This evidence is important when considering the developmental timeline of the ORE. Kelly et al. (2007a) report that Caucasian infants can distinguish Caucasian, African and Chinese faces at three months using a novelty preference paradigm (Fantz, 1958). By six months, they can only tell apart the Caucasian and Chinese faces, and by nine months, only the Caucasian. Kelly et al. (2009) report the same pattern, with Chinese and Caucasian faces mirrored for Chinese infants. These two papers suggest that by six months, there has been at least partial development of the ORE. Furthermore Bar-Haim et al. (2006) report that at three months, although infants can distinguish faces of other-races, they show a preference to attended to own-race faces. This would indicate that even prior to the development of the ORE behaviourally, there is an attentional bias for own-race faces. Given the previously discussed developmental timeline, it would seem likely that infants with ASD would show this same attentional bias.

Therefore it seems like that those with ASD may have at least a period of experience with own-race faces during this early window that may be important for the development of the ORE, before their attention towards faces begins to diverge from the typical population. Whilst a full ORE may not develop by the time the divergence occurs, it may at least lay the foundations. Webb et al. (2017), along with Dawson (2008) have also argued for consideration of brain plasticity in ASD which allows for some catch up development of more basic elements of face processing, although not to an extent to completely make up for the atypical social development. Thus if early foundations for the ORE are laid prior to the divergence of the ASD and TD populations, this period of catch-up growth may be sufficient to ‘top up’ the more basic face recognition skills need for the ORE compared to more complex face perception e.g. processing of emotional faces (Walsh et al., 2016), resulting in a typical like ORE by childhood.

To conclude, evidence was not found in support of the hypothesis for a reduced ORE in ASD, either in the UK or Japan. The cross-cultural nature of this study provides strong support against the idea that reduced perceptual expertise in ASD leads to differences in face recognition ability. Although it is possible that the task used may tap skills not completely reliant on face processing (image matching) it is also possible that there are other explanations. There are inconsistencies in the literature with regards to reduced ORE in ASD, and it may be that the timing of divergence in social attention and later experience means that there is sufficient perceptual expertise with own-race faces to result in a typical ORE. This part of the research focussed on accuracy as a measure of ORE. The next part will look at the role of attention allocation during the same task.

4: Scanning of Own and Other-Race Faces

4.1: Results (II): Attention during Face Recognition

Aim

Measures of accuracy indicate how well children can perform a given task. Although informative, they cannot speak to what processes or strategies children use when completing a task. The behavioural accuracy data from this study did not indicate atypicalities in performance for children with autism in the UK or in Japan. However, it is possible that although children with autism are capable of differentiating own and other-race faces in a typical manner, there may be differences in *how* children encode and recognise own and other-race faces. In order to understand this, attention was measured during task completion with an eye-tracking device.

Eye-tracking data was only available for a sub-group of the participants. For the UK group, 14/21 ASD children and 32/35 TD children had eye-tracking data. For the Japanese group, 27/29 ASD children and 30/39 TD children had eye-tracking data. For this analysis, eye-tracking data from correct trials were analysed.

Encoding phase – how do children allocate attention when learning own and other race faces?

To examine the differences between the groups during the encoding phase, a three-way mixed model ANOVA was run, with within subject factors of face race (own vs. other), and region (FNF, eyes, nose, mouth), and a between subject factor of group (ASD vs. TD). Numbers refer to the percentage of total encoding time spent looking at each region. This was calculated by taking the amount of time spent looking at a given region during the correct trials for that face race, and dividing it by the total amount of time spent looking at all features for the correct trials for that face race, and then multiplying the result by 100 to give a percentage. Also it should be noted that the background region was not included in the ANOVA, and thus the percentages do not add up to 100%. This allows us to see where the children were directing their attention relative to each of the features.

UK Sample

Figure 8 illustrates the percentage of fixations to regions of interest for both the ASD and TD groups from the UK. There was a main effect of region; $F(2.07, 90.9) = 42.5$, $p < .001$, $\eta^2_p = .491$, but no main effect of face race; $F(1, 44) = .435$, $p = .435$, $\eta^2_p = .014$, and no main effect of group; $F(1, 44) = 3.35$, $p = .074$, $\eta^2_p = .071$. Additionally, there were two-way interactions between region and group; $F(2.07, 90.9) = 6.32$, $p = .002$, $\eta^2_p = .126$, and face race and region; $F(2.09, 91.8) = 20.3$, $p < .001$, $\eta^2_p = .316$, but no two-way interaction between group and face race; $F(1, 44) = 1.17$, $p = .285$, $\eta^2_p = .026$. Finally, there was no three-way interaction between face race, region and group; $F(2.09, 91.8) = 2.78$, $p = .065$, $\eta^2_p = .059$.

Examining the main effect of region, pairwise comparisons showed that there was no significant difference between time spent looking at the FNF regions (19.13%) and the eyes (25.27%) ($p = .771$). However, there was a significant difference between the percentage of time looking at all other regions ($p < .001$), with the greatest proportion being spent looking at the nose (47.15%), and the least being spent on the mouth (6.07%).

To examine the interaction of region and group, independent samples t-tests were carried out. This revealed the interaction was driven by the nose region with the TD group (56.54%) spending significantly longer looking at the nose region than the ASD group (37.10%), $t(44) = -3.51$, $p = .001$. There was no difference in the amount of time spent looking at the FNF region (ASD – 20.77%, TD – 17.53%), $t(44) = .787$, $p = .435$; the eye region (ASD - 30.61%, TD – 20.17%), $t(16.32) = 1.54$, $p = .143$; or the mouth region (ASD – 7.40%, TD – 4.68%), $t(15.62) = 1.03$, $p = .319$.

The interaction of region and face race was examined using paired sample t-tests, which revealed it was driven by the FNF, eyes, and nose regions. Significantly more time was spent looking at the eyes of own-race faces (28.65%) than other-race eyes (17.82%), $t(45) = 6.81$, $p < .001$. Significantly longer was spent looking at the other-race nose region (56.71%) than the own-race nose region (45.42%), $t(45) = -5.28$, $p < .001$. Significantly longer was also spent looking at the other-race FNF region (19.85%) compared to own-race FNF (17.11%), $t(45) = -2.24$, $p = .030$. There were no differences in the proportion of time directed to the own-race mouth region (6.13%) and other-race (4.91%), $t(45) = 1.98$, $p = .054$.

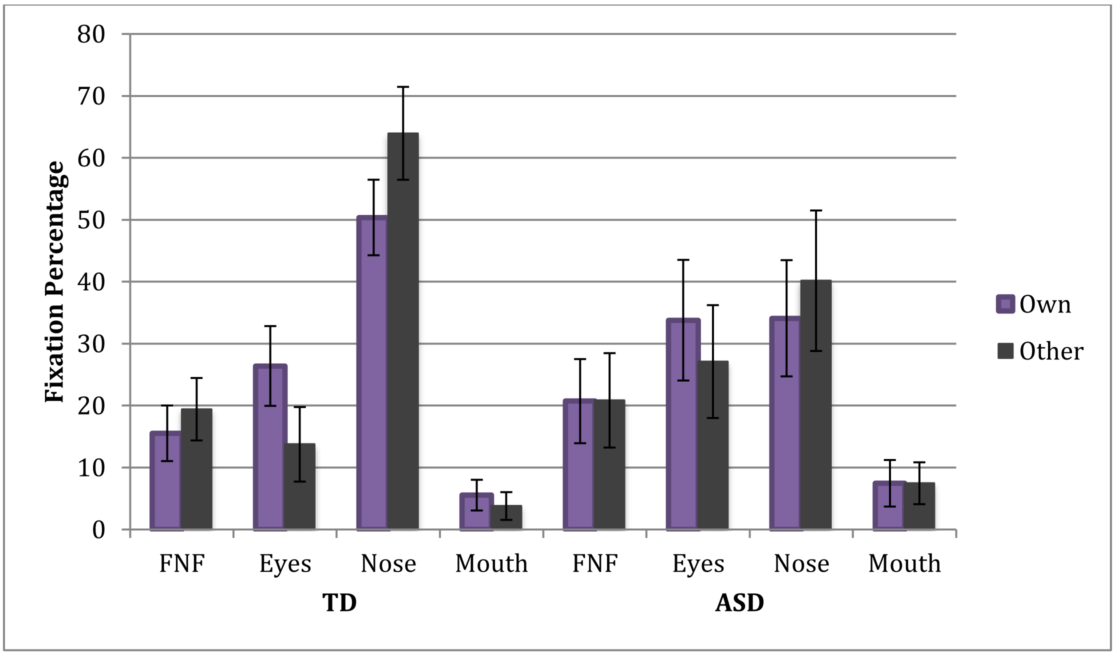

Figure 8: Comparison of percentage fixations to measured region of own and other-race faces in the UK TD and ASD groups. Error bars represent +/- two standard errors.

Japanese group

Figure 9 shows the percentage of time spent looking at the face regions for the Japanese ASD and TD groups. The same mixed model was run on the eye-tracking data from the Japanese group. There was a main effect of region; $F(1.73, 94.91) = 74.10$, $p < .001$, $\eta^2_p = .574$, and an interaction of face race and region; $F(2.19, 120.23) = 14.20$, $p < .001$, $\eta^2_p = .205$. However there were no main effects of face race; $F(1, 55) = .520$, $p = .474$, $\eta^2_p = .009$, or group; $F(1, 55) = .314$, $p = .577$, $\eta^2_p = .006$. Additionally there were no two-way interactions between face race and group; $F(1, 55) = .894$, $p = .348$, $\eta^2_p = .016$, or region and group; $F(1.73, 94.91) = 1.05$, $p = .345$, $\eta^2_p = .019$, and no three-way interaction between face race, region and group; $F(2.19, 120.23) = 2.46$, $p = .085$, $\eta^2_p = .043$.

Examining the main effect of region, pairwise comparisons showed that there was no significant difference in the amount of time spent looking at FNF (20.98%) and the nose (25.96%), $p = .110$. However, all other differences were significant (all *p*'s < .001). The most time was spent looking at the eyes (43.56%), whilst the least was spent looking at the mouth (7.41%).

A paired samples t-test was used to examine the interaction of face race and region. The interaction was driven by the eye and nose regions. Significantly more time was spent looking at the other-race eyes (48.07%) than the own-race eyes (38.81%); $t(56) = -4.61$, $p < .001$.In contrast, significantly more time was spent looking at the nose region of own-race faces (30.06%) compared to other-race faces (21.86%); $t(56) = 4.63$, $p < .001$. There was no significant difference in the amount of time spent looking at the own-race FNF region (21.68%) and other-race (20.50%), $t(57) = .680$, $p = .499$. There was also no significant difference between the amount of time looking at the own-race mouth (7.54%) and other-race mouth (7.32%) regions, $t(57) = .306$, $p = .761$.

In the Japanese sample, there was no evidence for a difference in attention allocation between ASD and TD children for own or other-race faces. Both groups show great levels of attention towards the eyes of other-race compared to own-race. In contrast, they show greater levels of attention towards the nose of own-race faces compared to other race. Even so, the eyes are still the most prioritised region for own-race faces.

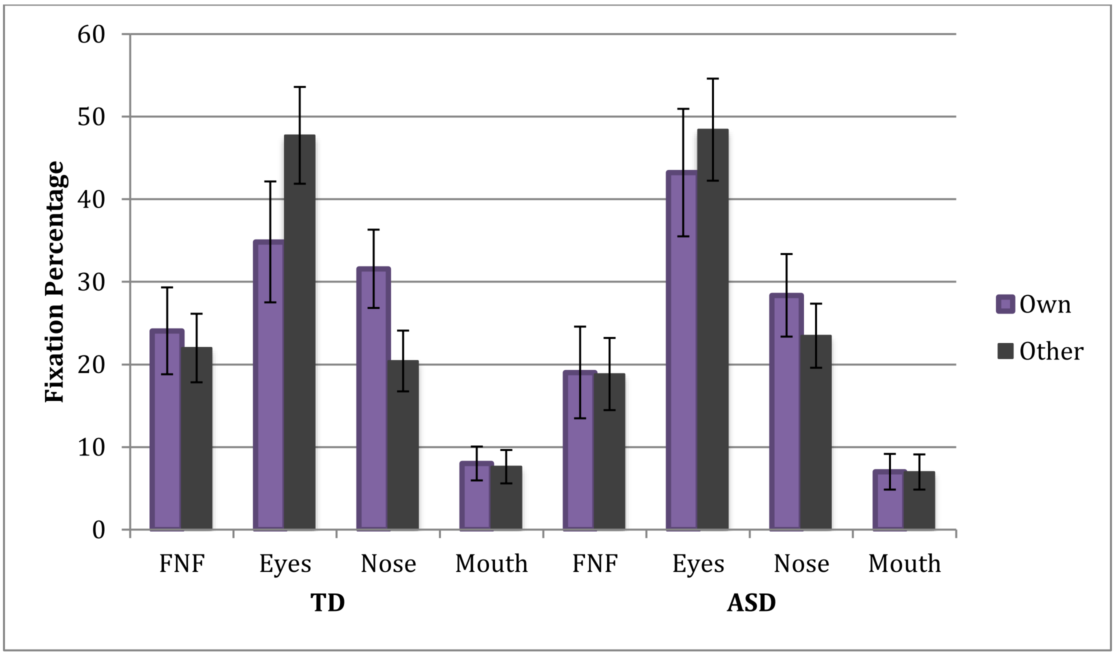

Figure 9: Comparison of proportional fixations to measured region of own and other-race faces in the Japanese TD and ASD groups. Error bars represent +/- two standard errors.

Summary – Attention during Encoding

UK

Overall, the ASD group spent less time looking at nose regions compared to the TD group, the attention pattern to faces during encoding was largely similar between the groups. Both groups looked at regions of faces differently depending on whether they were own or other race faces. More attention was given to the eyes when they were own race faces, and more attention was given to the nose when they were other race faces.

Japan

Unlike the UK sample, differences did not emerge between the ASD and TD groups. There was an impact of face race on region, with attention being more drawn to the eyes of other-race faces than own-race, whilst the opposite was true for the nose region. However overall the eyes were still the most prioritised region, regardless of face race

Recognition: How do children allocate attention when trying to recognise previously seen faces?

In this phase, the eyes and mouth were examined for the recognition phase because these were the important regions for successfully making a correct judgement. Additionally, given the high level of attention directed to the nose region during the encoding phase, attention to this region was examined as well. As with the encoding phase, the ANOVA was run using the percentages of time spent looking at the target regions in the correct trials. This is particularly important for this phase of analysis given that different children will have completed the task at different speeds, and so percentage data is needed to make the data comparable. To the examine the differences between the own and other-race faces in the recognition phase, a mixed model ANOVA was run with within factors of region (eyes vs. mouth), and face race (own vs. other), and a between subjects factor of group (ASD vs. TD).

UK group

Figure 10 shows the percentage of time spent looking at the eyes, mouth and nose for the UK groups during recognition. There was a main effect of region; $F(2, 88) = 29.36$, $p <.001$, $\eta^2_p = .400$, and face race; $F(1, 44) = 5.70$, $p = .021$, $\eta^2_p = .115$, however there was no main effect of group; $F(1, 44) = .001$, $p = .975$, $\eta^2_p < .001$. There was a two-way interaction between face race and region; $F(2, 88) = 30.60$, $p < .001$ $\eta^2_p = .410$. There were no two-way interactions between face race and group; $F(1, 44) = .234$, $p = .631$, $\eta^2_p = .005$, and region and group; $F(1, 44) = 2.81$, $p = .066$, $\eta^2_p = .060$. Additionally there was no three-way interaction between face race, region, and group; $F(2, 88) = 1.18$, $p = .312$, $\eta^2_p = .026$.

Examining the main effect of face race revealed that the percentage of time the UK group spent fixating on the eyes, mouth and nose was significantly larger for the own-race face (20.40%) than the other-race face (18.34%).

Pairwise comparisons of region reveal that significantly more time was spent looking at the eyes (M = 26.30, $p < .001$) and the nose (M = 26.93, $p < .001$) compared to the mouth during recognition. However there was no difference in the amount of time spent fixating on the eyes compared to the nose ($p = 1.00$).

The interaction of face race and region was examined using a paired samples t-test. This was driven by all three regions, where a significantly larger proportion of time was spent fixating on the own-race eyes (31.41%) compared to the other-race eyes (18.92%); $t(45) = 5.94$, $p < .001$. Likewise a significantly larger proportion of time was spent looking at the own-race mouth region (5.02%) compared to the other-race mouths (3.51%); $t(45) = 2.22$, $p = .032$. In contrast, significantly longer was spent looking at the nose region of other-race faces (32.80%) compared to own-race faces (24.50%), $t(45) = -5.61$, $p < .001$.

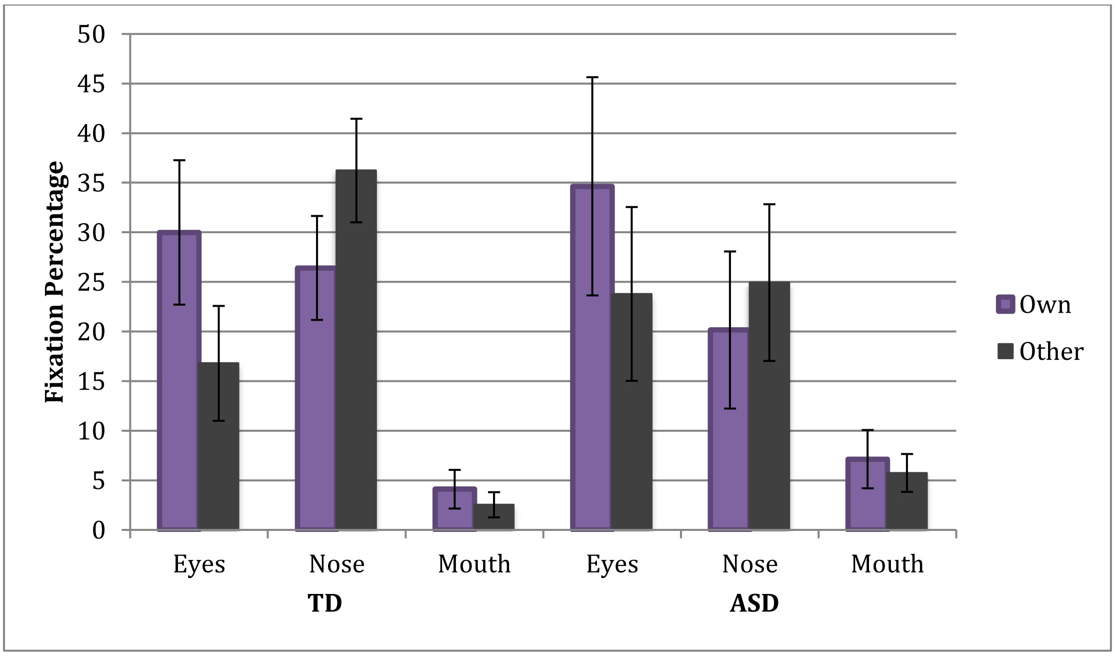

Figure 10: Percentage fixations on the eye and mouth regions of own and other-race faces during the recognition phase for UK TD and ASD groups. Error bars represent +/- two standard errors.

Japanese group

Figure 11 illustrates the percentage fixations for the Japanese groups on the eyes, mouth and nose during recognition. There was a main effect of region; $F(2, 110) = 115.55$, $p < .001$, $\eta^2_p = .678$, but no main effect of group; $F(1, 55) = .013$, $p = .911$, $\eta^2_p < .001$., or face-race; $F(1, 55) = .060$, $p = .808$, $\eta^2_p = .001$. Additionally there was a two-way interaction of face race and region; $F(2, 110) = 19.06$, $p < .001$, $\eta^2_p = .257$, but no two-way interactions between face-race and group; $F(1, 55) = 2.97$, $p = .090$, $\eta^2_p = .051$, or region and group; $F(1, 55) = 2.18$, $p = .118$, $\eta^2_p = .038$. Additionally, there was no three-way interaction between face-race, region, and group; $F(2, 110) = 1.49$, $p = .231$, $\eta^2_p = .026$.

Pairwise comparisons for the main effect of region showed that the most attention was directed to the eyes region (M = 40.82%). This was significantly more than the attention directed to the nose (M = 26.23%, $p < .001$) and mouth (M = 3.66%, $p < .001$). Significantly more attention was also directed to the nose compared to the mouth ($p < .001$).

Paired samples t-tests were used to examine the interaction of face race and region, which showed that this was driven by the eye and nose regions. Significantly more time was spent looking at the eyes of other-race faces (44.37%) compared to own-race faces (36.99%); $t(56) = -3.43$, $p = .001$. In contrast, significantly more attention was directed to the nose region of own-race faces (30.28%) than of other-race faces (22.44%); $t(56) = 6.04$, $p < .001$. However there was no significant difference in time spent looking at the own-race mouth region (3.54%) compared to other-race (3.80%); $t(56) = -.566$, $p = .574$.

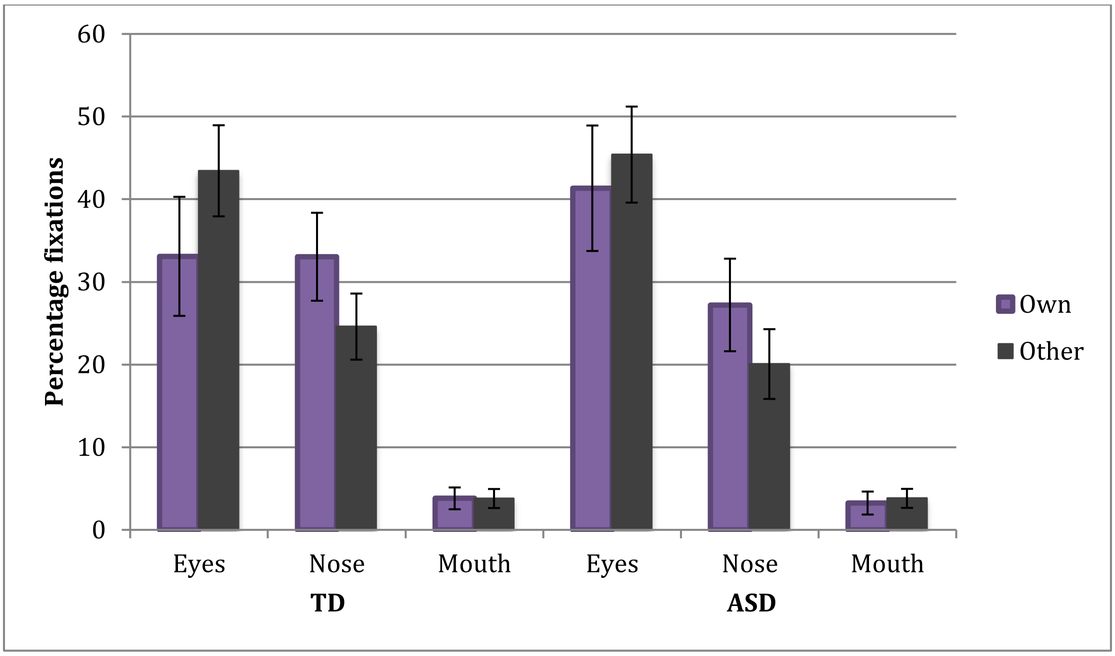

Figure 11: Percentage fixations for the eye and mouth regions of own and other-race faces during the recognition phase for the Japanese TD and ASD groups. Error bars represent +/- two standard errors.

Summary: Attention during recognition

UK

No group differences emerged in the UK during recognition of the eye, mouth and nose regions. Regardless of face race, the eyes and nose were prioritised over the mouth during recognition. There was also an impact of face race and region, with both the eyes and mouth of own-race faces being attended to more than these regions of an other-race face. In contrast, the nose region of other-race faces was prioritised over those of own-race. The attention to the eyes and nose mirrors the pattern of attention the UK sample shown to own and other-race faces in the encoding phase, but differs for the mouth.

Japan

As with the UK sample, no group difference emerged in the Japanese sample during recognition. The eyes were prioritised over the nose and mouth, and nose over the mouth regardless of face race. There was also an impact of face race on region; with the eyes of other-race face faces being attended to more than those of own-race. In contrast the nose region of own-race faces was attended to more than other-race noses. However face race had no impact on attention to the mouth region. This attention pattern mirrors what was found in the encoding phase for the Japanese sample for these regions.

4.2 Discussion of Results (II)

Group Differences

Analysis of the eye-tracking data did not reveal any significant differences between the ASD and TD groups in either the UK or Japanese samples regarding the eye region, during encoding or recognition. Previous work with Caucasian samples reports reduced eye fixations in children with ASD (Jones et al., 2008; Pelphrey et al., 2002), and increased mouth fixations (Hanley et al., 2015) compared to their typical counterparts. Work with Asian samples also report reduced fixations towards the eye region compared to typical children (Yi et al., 2015, 2016). Thus the current results differ from some the literature on this topic.

However some studies have reported no differences in terms of fixations to the eye region between ASD and TD groups (Kirchner, Hatri, Heekeren & Dziobek, 2011; Rutherford & Towns, 2008). Rutherford and Towns (2008) have suggested atypical scanning in autism may particularly evidence when viewing more complex emotional stimuli. Given that the current task was an identification task using cropped, neutral faces, this may have resulted in the ASD groups employing a more typical scanning pattern. This would also fit with the behavioural findings of Walsh et al. (2016), who report typical performance for simple identification tasks, but atypical performance for emotional recognition tasks.

Rutherford and Towns (2008) have also suggested that atypical scanning patterns in ASD may vary with severity of symptomology. It was not possible in the current study to obtain measures of autism symptomatology, and therefore this is something that should be considered in future work.

Cultural Differences

Although we did not find group differences between the TD and ASD groups in either the UK or Japanese samples, there were cultural differences in how the UK and Japanese samples attended to faces during encoding and recognition.

When encoding, the UK sample directed significantly more attention towards the eyes of own-race faces compared to other-race faces. In contrast, significantly more attention was directed towards the nose and FNF regions of other-race faces compared to own-race. Regardless of face race however, the nose was the most attended to region, suggesting an overall central bias during face recognition for the UK sample. Attention was also modulated by face race in the Japanese sample, with eye of other-race faces being attended to more than own-race, whilst the opposite was true for the nose. The eyes were overall the most attended to region regardless of face race however.

Cultural differences were also present during recognition. When focusing on the eyes, nose and mouth, the UK sample attended to the eye and mouth regions more for own-race faces compared to other-race, whilst the nose was attended to more for other-race faces. The opposite pattern was seen in the Japanese sample for the eyes and nose, directing more attention to the eyes of other-race faces, but more to the noses of own-race faces. There were no differences in attention to the own and other-race mouth region. Interestingly the Japanese sample allocated the most attention to the eye region, followed by the nose and then the mouth. In contrast the UK sample allocated attention equally to the eye and nose regions, with the least attention being given to the mouth.

Considering group differences, Yi et al. (2015, 2016) report that TD and ASD children showed different attention allocation for own and other-race faces. Like Yi et al. (2015, 2016) we also found that TD and ASD children allocated attention different for own and other-race faces in both the UK and Japanese samples, an advance on the Yi et al. (2015, 2016) studies that only tested a Chinese sample.

Previous literature has also reported differences between cultural samples in attention to own and other-race faces. It has been reported that Western samples show a preference for the eyes, whilst Eastern samples show one for the nose (Blais et al., 2008, Kelly et al., 2011). Furthermore Yi et al., (2015, 2016) report that these preferences are modulated by whether the face is own or other-race (although they only tested an Asian sample). We did not find an outright preference for the eyes in the western sample, with the nose receiving more or equal amounts of attention to the eyes depending on the phase of the experience (more in the encoding phase, equal during recognition). Likewise the Japanese sample did not show the outright preference for the nose region, and instead showed a preference for the eyes in both phases of the experiment. However there was clear evidence that attention to faces was modulated by face-race. The UK sample allocated more attention to the eyes of own-race faces, and more to the nose of other-race faces than own-race. This pattern was reversed in the Japanese sample. Thus although we did not find the outright preference for certain regions, we replicated and expanded the results of Yi et al., (2015, 2016), finding that attention is modulated by face-race cross culturally. In the UK sample, they preferred the eyes of own-race faces compared to other-race, and the noses of other-race faces compared to own-race. In contrast the Japanese sample preferred the eyes of other-race faces than own-race, and the noses of own-race faces than other-race.

This element of the research suggests that children ASD are able to demonstrate typical attention patterns during facial recognition, although it is possible that this is to some extent a result of the stimuli used. Additionally and perhaps more importantly, it suggests a typical like role for experience in the development face perception in ASD. This is evident from the fact that the ASD children demonstrated differential attention patterns for the own-race faces compared to the other-race faces. This was also the case across cultures, with both the UK and Japanese groups. This would suggest that the ability for experience to shape face perception is inherent to ASD, much the same as in the typical population. Additionally, this pattern differed between the two ASD groups, reflecting the pattern seen in their respective typical populations. This would also suggest that children with ASD are receptive to cultural norms in a manner similar to the typical population, which seems particularly interesting given the social dysfunction seem in ASD.

5: General Discussion

This research set out with two keys aims. Firstly, to examine the development of face expertise in children with and without autism across two cultural groups. The second aim was to investigate differences in how faces are attended to in children with and without autism across two cultural groups. This was investigated through the lens of the own-race effect, as there is strong evidence to indicate that experience with faces plays an important role in its development. Given that children with ASD tend to exhibit reduced to attention to faces, it was hypothesised that this would play an important role in diminished perceptual experience, leading to a diminished ORE. It was also expected there would be differences in the way children with ASD scanned the own and other-race faces compared to the TD children in both samples as revealed by eye tracking. Therefore the overall aim was to further understanding about the role of experience in the development of face perception in ASD.

Considering the first aim, it was found that children with ASD in the UK and Japan displayed the same ORE pattern as their respective TD groups. This differs to findings reported by Chien et al. (2014) and Yi et al. (2015, 2016), however each of these studies have some issues as previously discussed. It does fit however with the findings of Wilson et al. (2011), which is arguably a stronger study, particularly in terms of their task choice, due to using a task where different examples of the same face had to be recognised, as opposed to just one image of the face. Taking these results and those of Wilson et al. (2011), it was important to consider an argument as to why the ORE may develop typically in children with ASD. This argument was made in more detail during the discussion of chapter X so will be summarised here. Firstly it seems to be the case that facial attention in ASD is typical at birth, before beginning to diverge later on in infancy (Jones & Klin, 2013; Webb et al., 2016). However it seems to be the case that the ORE develops, at least partially, prior to this developmental divergence (Kelly et al., 2007a; Kelly et al., 2009), suggesting infants with ASD are likely to at least partially develop an ORE during this stage. Additionally, it has been argued that there is a degree of brain plasticity in ASD (Dawson, 2008; Webb et al., 2016), which allows for the catch-up of more basic elements of face perception, although not to an extent that it can completely overcome the atypical social development seen in ASD. The combination of these factors results in a typical appearing ORE by the time of testing during childhood (although it is entirely possible that they may be arriving at the same destination via a different route).

Considering the attention results, it was expected that there would be differences in how the ASD groups in both the UK and Japan scanned faces compared to the TD groups. Work with Eastern and Western ASD children has suggested reduced fixations to the eyes relative to their typical counterparts (Hanley et al., 2014; Jones et al., 2008; Yi et al., 2015, 2016), although inconsistencies in this literature had been noted (Kirchner et al., 2011), particularly when dealing with more simple faces i.e. neutral expressions, less socially complex faces (Rutherford & Towns, 2008). It was found here that contrary to expectations, the ASD groups also showed similar scan patterns to their respective TD groups. Interestingly, differences in scanning found were between the cultural groups. The Japanese sample showed preferences for the eyes of other-race faces compared to own-race, whilst the opposite was the case for the UK sample. This is in keeping with what previous eye tracking work with Eastern and Western samples (Blais et al., 2008, Kelly et al., 2011). A different pattern of attention was also detected in attention towards the nose region. In the UK sample, more attention was directed towards the noses of other-race faces compared to own-race, whilst in the Japanese sample the reverse was true.

With regards to the eye contact, this has been reported in previous samples (Blais et al., 2008, Kelly et al., 2011), and the suggestion is that this is governed by cultural norms surrounding eye contact (Sue and Sue, 1977, Akechi et al., 2013). This does not explain however, why they do not apply this across cultures e.g. why do the Japanese sample only consider eye contact to own-race faces rude? Additionally, it does not cover the results seen regarding the nose region, where the nose of the Chinese faces was prioritised by both samples. One possible explanation for this is that the features of the face differ in saliency between face-races and that this governs the attention of both the UK and Japanese samples. Xiao, Quinn, Pascalis and Lee, (2014) do report that the eyes of Caucasian faces are more salient than the eyes of Chinese faces, which would provide an explanation for why both groups paid more attention to the eyes of the Caucasian faces compared to the Chinese faces. Again though, this does not cover the nose region. Furthermore, the finding of saliency is in the minority here, with Fu, Hu, Wang, Quinn and Lee (2012); Hu, Wang, Fu, Quinn and Lee, (2014); and Liu et al., (2015) all reporting no differences in the saliency of facial features between Asian and Caucasian faces. Additionally Kato and Konishi (2013) carried out a study using schematic face stimuli where the salience for the regions other than the eyes were increased. Assuming the salience explanation was correct, this should mean that the sample would look more to the non-eye regions. Despite this, the eyes were still attended to more than other regions. This would seem to suggest that salience of features is not the reason for this result.

Our findings do replicate the results of two adult studies regarding attention to regions of own and other-race faces. In a Western sample, Brielmann, Bülthoff and Armann (2014) report that the eyes of the Caucasian faces were attended to more than the Chinese faces, and vice-versa for the nose. Likewise Wang et al., (2015) report this same pattern in a sample of Chinese adults. Wang et al., (2015) propose that the reason for this is a result of facial physiognomy, with the diagnostic features for distinguishing between Chinese faces differing from Caucasian faces. These diagnostic features do not differ depending on whether the observer is Caucasian or Asian, and thus would explain why both groups look more to the eyes of the Caucasian faces, and more to the nose of the

Asian faces. This can perhaps be seen as a more nuanced version of the saliency idea, and indeed Fu et al., (2012) suggest that although they found no differences in the saliency of the different regions, physiognomic differences may exist that could not be detected by the method used to establish saliency. This then seems a more likely explanation for the differences seen in how both groups attended to the Caucasian and Asian faces. A crucial point to takeaway from all of this however is that in both samples, the ASD groups demonstrated the same pattern as the typical group. In summary then our results suggest that children with ASD across cultures gain experience with faces, which shapes typical face recognition accuracy and typical scanning of own and other races faces.

Whilst there are some caveats to these conclusions that will be discussed shortly, these are nonetheless important findings. Behaviourally it suggests that the face recognition deficits seen as central to ASD may not be as pervasive throughout the population as some research suggests (Klin et al., 1999). In terms of attention, it likewise suggests that children with ASD may be able to demonstrate typical attentional patterns during facial recognition. Perhaps the most important element of this research however is that in both the face recognition task and the eye-tracking, children with ASD across cultures demonstrated an ORE that reflected that of their typical counterparts. This would seem to indicate that experience with faces can shape both face recognition skills and how attention is directed to faces in ASD. Furthermore, given that this pattern differs between the two cultures it also suggests that children with ASD are sensitive to cultural influences with regards to face perception as well. From a theoretical perspective, given that we know the ORE develops early in infancy, this would suggest that at least in early infancy in those with ASD, there is a period of typical-like face perception development.

There are some limitations of this research to be considered when discussing these findings and these are mainly centred on the task. Firstly, work within the face processing literature has suggested that presentations of a single example of a face are insufficient for face learning. If presented with just one example of a face, when asked to recognise the same face in different images, participants are generally very bad at this (Andrews et al., 2017). So the task employed here may not necessarily have tested face learning, and instead tested image matching. Future research focusing on the behavioural element of this study should take this into account by continue to explore this with task more reflective of real world face learning, such as the card sort task employed by Andrews et al. (2017). It should be noted that as mentioned previously, only the Wilson et al. (2011) study has employed such a task in this area of research, and our results report the same findings as theirs.

When considering the eye-tracking element, some authors have suggested that scanning patterns for children with ASD vary with stimuli complexity (Hanley, McPhillips, Mulhern & Riby, 2012; Rutherford & Towns, 2008). So when stimuli are less complex (isolated faces and less intense (faces with neutral expressions), scanning patterns may appear typical. However, when more complex stimuli are used, such as faces in every day social situations, or displaying emotions, ASD individuals display the atypical scanning patterns more regularly associated with the disorder (Pelphrey et al., 2002). Future research focusing on the eye-tracking element of the study should account for this by using faces across a range of social and emotional states. Both of these changes would result in a task more reflective of face processing and scanning in the real world and so would be a worthwhile addition to this body of literature. It may be the case that with a more life like task a different pattern of results for one or both aspects of this study could be found, or alternatively would provide even clearer evidence in favour of a typical ORE in ASD.

It could be argued that the previous level of explanation is unnecessary as the task used here has been used in the other TD/ASD literature cited. Whilst it is indeed possible that what has been shown here is simply the ORE, it may also only be something on the surface. Because it has been shown that ASD scanning varies with stimuli complexity (Hanley et al., 2012; Rutherford and Towns, 2008; Pelphrey et al., 2002), we cannot rule out the nature of the stimuli impacting our results. Furthermore, as pointed out by Andrews et al. (2017) the trend in TD face processing literature has been away from these kinds of tasks because they introduce image matching as a confound on the results. They report that when a task reflective of real world face learning has been used, the results have differed from those seen using the image matching tasks. Given this trend in the TD literature and the issues with image matching tasks reported by Andrews et al. (2017) combined with the results on scanning patterns in ASD, updating this task to match the TD literature would provide a clearer, more complete picture and add more depth to these findings.

Conclusions

Both Japanese and UK children with autism demonstrated the same ORE pattern as their respective typical counterparts. Likewise the scanning patterns employed for own and other-race faces in both ASD groups matched their typical counterparts. This would suggest that some elements of face perception are able to develop to a typical degree (although it may not be the case they develop in the same manner), and that at least in some situations, children with ASD scan faces in a typical manner. Future research should focus on refining the tasks used here to investigate this to further solidify these conclusions.

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