Face processing in Williams syndrome and Autism

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Abstract

Individuals with Williams syndrome (WS) have been characterised as hyper-sociable, showing an extreme compulsion to engage in communication with other people, whilst the opposite has been cited regarding autism. The most important social cue in our environment is the human face, which must be successfully recognised and interpreted for communicative signals. Although clear differences are apparent in social skills, individuals with WS and autism have been described as showing similarly atypical face processing styles. The present research addressed issues of face perception in Williams syndrome and autism to gain further insights into social abilities of individuals with these developmental disorders. Importantly, the research was grounded in typical face perception methods.

The investigation began with a large-scale exploration of face skills, probing identity, eye gaze, expressions of emotion and lip reading to ask how these two disorders uniquely impact upon performance. Participants with WS and autism could be dissociated from those with general developmental delay and from each other primarily on the basis of eye gaze ability. Participants with WS showed strong eye gaze abilities whilst participants with autism had extreme difficulties. Although interpretation of expressions of emotion also showed a difference between groups, autism and WS did not uniquely impact upon the processing of identity or lip reading. The exploration also allowed the consideration of models of face perception; characterised by a typical modular structure in WS but a lack of modularity in autism.

The second line of inquiry considered identity processing and firstly asked whether participants were more accurate at matching faces from internal or external features. Participants with WS showed an atypical use of internal features for matching unfamiliar faces, which may be linked to an atypical interaction style and exaggerated interest in unfamiliar people. Participants with autism used the same strategy to match faces of familiar and unfamiliar people and hence familiarity did not impact upon processing style.

Subsequent chapters probed feature salience (eyes .v. mouth) and structural encoding. Across paradigms typically developing participants and those with WS showed greater accuracy using the eye than mouth region, a pattern not evident in autism. Regarding structural encoding, individuals with WS showed use of configural cues under the task demands implemented in this thesis, where individuals with autism were only able to interpret featural cues. Previous evidence of similar face processing styles in WS and autism were not supported.

Taken together the findings provide further insights into face perception and social functioning in WS and autism. The research used the same participants across paradigms, considered level of functioning on the autistic spectrum and included investigations of WS and autism in the same research programme. Additional to the main experimental studies, pilot data is provided to open a new line of investigation into physiological arousal associated with holding eye contact in WS. Therefore, on the basis of the experiments conducted here, a number of suggestions are made to carry the research forward in future investigations. Throughout the thesis as a whole, comparisons are made between individuals with WS and autism that further our understanding of the links between face processing and social expertise.

Acknowledgements

I would like to thank my supervisors Dr. Gwyneth Doherty-Sneddon and Professor Vicki Bruce for their support during the course of my PhD. Their expertise has provided me with a valuable insight into face perception and aspects of typical development.

I am also particularly grateful to the Williams syndrome foundation for all their support helping me contact participants and publicise my research. Of course without the individuals with autism and WS who have helped with the research, these investigations would not have been possible. I therefore extend my gratitude to all the participants and their families who have taken part in my studies.

During turbulent times of my PhD I could not have continued without the full support of my husband Leigh and my parents, who have continually encouraged me to further my career and been interested in my work. Of course no acknowledgement would be complete without thanks to our beautiful daughter Jessica.

Author's Declaration

I declare that the work carried out for this thesis was done so in accordance with the Regulations of Stirling University. The work is original and no part of the thesis has been submitted for another degree. Any views expressed in the thesis are those of the author and in no way represent those of Stirling University.

Signed: ………………………………………………

Date: …………………………………………………

Experiments 1a and 1b of Chapter 3 have been submitted for publication: Riby, D. M., Doherty-Sneddon, G., & Bruce, V. Exploring Face processing in Williams syndrome and Autism. *Journal of Autism and Developmental Disorders*.

Experiments 5-7 have been submitted for publication: Riby, D. M., Doherty-Sneddon, G., & Bruce, V. The eyes or the mouth? Feature salience and unfamiliar face processing in Williams syndrome and autism. *Quarterly Journal of Experimental Psychology*.

An overview of selected aspects of chapters 3, 5 and 7 will appear in Brock, J., Einav, S. & Riby, D. M. (in press). The other end of the spectrum? Social cognition in Williams syndrome. In V. Reid, & T. Striano (Eds.). *Social cognition: Development, Neuroscience and Autism*. Oxford: Blackwell.

The data collection for Appendix B was carried out by Miss Leanne Ainsworth under supervision and testing arrangements made by Deborah Riby. All data analysis for Appendix B was carried out by Deborah Riby.

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Chapter One

General Introduction

1.1 Interpreting the human face

"The differences in human features must be reckoned great, inasmuch as they enable us to distinguish a single known face among those of thousands of strangers, though they are mostly too minute for measurement."

(Galton, 1907; 3)

The human ability to recognise faces is remarkable (Galton, 1907). Faces form a unique class of visual stimuli, extraordinarily rich in socially important cues and from which a diversity of information can be extracted (Kanwisher & Moscovitch, 2000). Not only are we able to recognise friends and family on a daily basis, across differences in lighting, clothing and posture, we are able to interpret indicators of feeling and thoughts. However, some individuals have difficulty interpreting these important cues that subsequently renders the ability to recognise people or identify communicative face signals particularly difficult. Where difficulties occur in interpreting face stimuli, social functioning as a whole may be affected. This thesis explores the ability to interpret faces by individuals with two developmental disorders characterised by unique social interaction styles; namely Williams syndrome and autism.

The introductory chapter provides an overview of research exploring the ability to retrieve signals from the human face. This is an essential everyday skill and research has probed the ability not only to identify people we know, but to interpret cues to feelings, attitudes, desires and even a cognitive state from the face. Beginning with an overview of the developmental disorders central to the thesis the introductory chapter then considers how research has used face processing methods to explore typical social functioning. Finally, the chapter brings together these two streams of thought to consider how face processing methods have been applied to WS and autism to delve into the social world of individuals with these developmental disorders.

1.2 Williams syndrome

The rare genetic disorder Williams syndrome was first identified by Williams, Barratt-Boyes and Lowe in 1961 who reported four patients sharing specific medical and behavioural characteristics that had not previously been described. The four patients had low IQ, suffered supravalvular aortic stenosis (narrowing of the aortic artery), medical heart conditions and had a distinctive and similar facial resemblance. All patients had gained little weight during infancy, with three of the four remaining below the average weight for their age. Williams et al. (1961) suggested that these characteristics constituted a newly identified disorder or syndrome. Since the initial inquiry by Williams and colleagues, this disorder has become known as Williams syndrome.

Williams syndrome (WS) affects approximately 1 in 20,000 live births (Morris, Demsey, Leonard, Dilts, & Blackburn, 1988) and is characterised by a unique dissociation of higher cortical functioning, presenting a distinct neuropsychological profile. The importance of this specific phenotype for studying the dissociation between language and cognition has become evident over the last decade, with many researchers using WS to study these two domains in isolation (for example Bellugi, Sabo, & Vaid, 1988). Research has shown a marked difference between functioning in verbal and nonverbal domains and has explored this dissociation in relation to spared and impaired modules.

1.2.1 Cognitive characteristics

Due to the dissociation between verbal and nonverbal abilities, original claims about the cognitive phenotype of WS were swamped with characterisations such as 'peaks and valleys of ability' and the 'juxtaposition of impaired and intact mental capacities' (Bellugi, Lichtenberger, Mills, Galaburda, & Korenberg, 1999b). Specifically, impaired non-verbal skills (visuo-spatial processing) appear alongside relatively more proficient verbal skills. This pattern of dissociation is particularly interesting in relation to the other developmental disorder to be considered in this thesis; individuals with autism often show the opposite pattern with more severe language deficits than visuo-spatial deficits (e.g. Rutter, 1984). The present review takes into consideration original findings of proficient language skills in WS, as well as identifying how recent research has emphasized possible atypicalities in areas that were originally labelled 'intact'.

Verbal Abilities

Although preliminary studies of WS emphasised strong language skills (e.g. Wang & Bellugi, 1994) and Pinker (1999), for example, argued that the genes of individuals with WS 'impair their cognition but spare their language', more recent in-depth research has emphasised that it is no longer appropriate to consider WS as an example of an intact language module (Levy & Herman, 2003). Recent explorations have identified subtle, yet important, deficits and delays to a variety of skills and language is thought to follow an atypical developmental pathway (Klein & Mervis, 1999). Karmiloff-Smith, Brown, Grice and Paterson (2003) make the strongest statement by claiming that the "myth of intact WS language needs to be dethroned and buried once and for all" (Karmiloff-Smith et al., 2003; 232).

Recent research shows that language not only follows an atypical developmental pathway, but contains deficits for certain linguistic abilities. Global semantic organization remains at a level of young children and never reaches a mature state, even in relatively high functioning adults (Johnson & Carey, 1998). Although children perform well in assessments of semantic fluency (Jarrold, Hartley, Phillips, & Baddeley, 2000) and their language is characterized by an over-flamboyant use of obscure words, their extensive vocabulary hides subtle deficits. In particular, atypicalities dominate grammar, pragmatics and the acquisition of morphology (Karmiloff-Smith, Klima, Bellugi, Grant, & Baron-Cohen, 1995; Paterson, Brown, Gsodl, Johnson, & Karmiloff-Smith, 1999).

When taking a holistic view of communication in WS, speech occurs before pointing, showing the opposite pattern to typical development (Mervis & Bertrand, 1995) and impairments occur in the development of triadic interactions (Laing et al., 2002). These examples show that speech and language as a whole is important as a social interaction tool. The use of language as a social communication skill (the pragmatics of language) has until recently been neglected in comparison to research concerning structural aspects. Early research suggested that pragmatic skills were particularly strong in WS (Karmiloff-Smith et al., 1995; von Armin & Engel, 1964). Recent studies have, however, suggested that there are deficits associated with WS, similar to those found in autism. Individuals with WS have been noted to display an over-familiar manner with an experimenter (Udwin & Yule, 1990) and show poor turn-taking and topic maintenance abilities (Meyerson & Frank, 1987). Laws and Bishop (2004) used the Children's Communication Checklist (Bishop, 1998), a parental questionnaire measure of linguistic and pragmatic competence, in research involving children with WS. Individuals with WS were rated as having significant difficulties or atypical ratings on all five of the pragmatic subscales; namely, coherence, over use of stereotyped conversation, a lack of appropriate initiation, conversational context, and a poor development of conversational rapport. In comparison with a group of younger typically developing children, those with WS were rated as having greater pragmatic difficulties despite equivalent syntactic abilities. Similarly, when compared with individuals with Down syndrome or specific language impairment, they showed significantly better syntax but significantly greater impairments on the stereotyped conversation and inappropriate initiation subscales. It appears, therefore, that language may be more problematic in WS than originally claimed, although there is little doubt that functioning in this domain is stronger than that found in the nonverbal domain.

Nonverbal Abilities

Nonverbal processing has traditionally been considered deficient in WS. A number of studies have found problems for participants with WS using the Wechsler Intelligence Scale for Children and the Wechsler Adult Intelligence Scale (WISC-R and WAIS-R respectively; Wechsler, 1981). Mathematics is a particular difficulty (Paterson, Girelli, Butterworth, & Karmiloff-Smith, 2006), alongside deficits on Block design or Coding tasks. For example, when assessing the abilities of 16 individuals with WS (ages 4 years to 15 years) Dall'Oglio and Milani (1995) found poor performance on block design, coding, and picture arrangement tests, alongside stronger performance for picture completion and object assembly. Further research has cited difficulties with visuo-spatial construction, an important element in a number of visuo-spatial tasks such as the block design (Farran, Jarrold, & Gathercole, 2001).

Within the nonverbal domain a great deal of research has been dedicated to the *way* items are processed. For example, Bellugi and colleagues (e.g. Bellugi, Sabo, & Vaid, 1988; Bellugi, Bihrle, Neville, Doherty, & Jernigan, 1992) have suggested that individuals with WS process information at a 'local' level. Attention is focused on the individual elements of an image at the expense of the whole representation. The basis for this claim is a characteristic pattern of errors on the block design task and on assessments of drawing ability. Individuals with WS may accurately select the individual parts of a puzzle or picture but fail to integrate these into one coherent representation. On an assessment of drawing ability, Bellugi et al. (1988) found that 3 individuals with WS (ages 11, 15 and 16 years) were able to draw parts of complex objects (e.g. cross, flower, house, and bicycle) without integrating them into whole pictures. In another study of drawing ability by 10 individuals (11 to 18 years of age), Wang et al. (1995) concluded that individuals with WS showed "an impairment in global coherence" (Wang et al., 1995; 58).

Another important skill within the nonverbal domain is face processing, which plays an important role in nonverbal communication and social functioning. This area will be addressed in detail later in this chapter as face perception is the main focus of the current thesis. In brief, face recognition ability has been regarded as an area of relative strength within the domain of visuo-spatial cognition alongside the deficits and atypicalities already discussed (Rossen et al., 1995).

1.2.2 Social characteristics

It is common for children with WS to be described as friendly, empathetic and sociable. Individuals are known to be socially dis-inhibited, spend time interacting with others and act empathetically towards other people (Gosch & Pankau, 1994). Consequently, compared to autism, WS is said to represent a 'polar opposite' group regarding social behaviour (Jones et al., 2000) and individuals with WS have recently been described as showing a strong "pro-social compulsion" (Frigerio et al., 2006; 254).

Due to reports of proficiency when interacting and functioning within their social environment, it had been suggested that WS was characterized by a relative sparing at understanding others' minds (Karmiloff-Smith et al., 1995). However, more recent work has suggested subtle deficits and abnormal functioning in socially important situations. Hyper-sociability and inappropriate social behaviour have been noted in a variety of recent studies (Jones et al., 2000; Laing, 2002). Jones et al. (2000) noted that the hyper-social drive of children with WS distinguished this developmental disorder from other learning difficulties (autism and Down syndrome) as well as from typical development. Hyper-sociability can manifest itself as attention seeking, over-affectionate and inappropriately elated behaviours and therefore, in contrast to being considered a spared ability in WS, social behaviour is considered atypical. These social characteristics may be responsible for a difficulty forming relationships with peers (Udwin & Yule, 1991). Hyper-sociability of this form is unique to WS and has been linked to amygdala dysfunction and the involvement of several limbic regions (Jones et al., 2000).

Bellugi, Adolphs, Cassady and Chiles (1999) noted that a tendency to interact with strangers was apparent from an early age. Mervis et al. (2003) noted extended looking behaviour towards strangers by young infants with WS (aged 8-34 months) compared to groups who developed typically and other developmental disorders. The authors commented that "infants and toddlers who have Williams syndrome manifest an extreme interest in looking at other people (whether novel or familiar)" (Mervis et al., 2003; 266). Involving older participants, Bellugi et al. (1999) asked participants with WS (mean age 23 years) to rate how approachable they considered 42 unfamiliar faces.

They found that faces were given abnormally positive ratings of approachability, irrespective of whether the faces had previously been rated as highly approachable or unapproachable by typically developing participants. Recently, Frigerio et al. (2006) found that individuals with WS were more likely to use extreme ratings on a scale of approachability than individuals who developed typically. Together, these studies reveal an extreme sociability and an interest in people. The specific characteristics of processing faces (the most salient social cue in our environment) will be considered later in this chapter but may link directly to this interest in people and the ‘social drive’ evident in WS.

One social cognition skill that will receive attention later in this chapter (section 1.3.2) is that of Theory of Mind (ToM). A fully detailed review of the importance of ToM in autism research is provided in this latter section, and individuals with WS will be described in section 1.3.2 with regards to this skill. It should be remembered however, that this is an ability that may have implications for the social functioning of individuals with WS.

1.2.3 Genetic characteristics

The genetic origin of WS was studied in detail throughout the 1990’s (Ewart et al., 1993; Frangiskakis et al., 1996; Nickerson, Greenberg, Keating, McCaskill, & Shaffer, 1995) and the identification of a micro-deletion on the long arm of chromosome 7 marked a breakthrough for the classification of the WS genotype. Originally it was thought that around 17-20 genes, spanning a 1.5 megabase chromosomal segment were deleted on chromosome 7q11.23 (Schultz et al., 2001; Osborne et al., 2001) helping create the distinctive WS profile. However, more genes are continually being investigated and the number of suspected deleted genes is now around 28 (Meyer-Lindenberg, Mervis, & Berman, 2006; Eckert, Galaburda, Mills, Bellugi, Korenberg, & Reiss, 2006).

The importance of the deleted 'elastin' gene was noted when Frangiskakis et al. (1996) found that 239 out of 240 individuals with WS were missing this gene. Indeed an elastin deletion is reported in 98% of individuals diagnosed with WS (Lowery et al. 1995). The absence of elastin is now assessed using Fluorescent in-situ Hybridisation (FISH) and represents the main route of genetic diagnosis of the disorder. The absence of the elastin gene can account for a number of the distinct features of WS, including cardiac abnormalities, hernias, a hoarse voice and premature skin ageing (Nickerson et al., 1995). Although the elastin deletion helps create the distinct medical abnormalities and represents an important WS marker, it does not contribute to all the characteristics of the WS phenotype. Elastin is not found in the brain and therefore cannot account for the distinctive WS cognitive profile (Frangiskakis et al., 1996).

Although the precise expression of the other genes deleted from chromosome 7 remains somewhat unclear, a number of different deletions combine to create the distinctive profile (Tassabehji et al., 1999; Tassabehji, 2003). The exact role of a number of genes deleted from chromosome 7 remains somewhat unclear, although advances have been made over the past decade. When evaluating the link between genotype and phenotype Tassabehji (2003) noted that although a deletion of syntaxin 1A (STX1A) may be important within the deleted region of chromosome 7, it is unlikely to be responsible for any of the main physical, mental and cognitive characteristics of the disorder. Tassabehji (2003) draws a similar conclusion regarding the deletion of the LimK1 gene, commenting that it is unlikely to create the distinct cognitive deficits linked to this disorder. In conclusion it has been noted that it is not easy to identify which genes are related to each aspect of the phenotype (Tassabehjji et al., 1999) and the exact impact of genetic deletions remains somewhat unclear in relation to the WS phenotype (Tassabehji, 2003).

1.3 Autism

This introductory chapter now moves on to consider a more well known neuro-developmental disorder. Since Leo Kanner's original article in 1943, autism has attracted a great deal of attention, particularly over the last two decades. Kanner, and a year later Hans Asperger, described patients whose abilities were characterised by social impairments, poor eye contact, limited empathy, impaired nonverbal communication, pedantic and monotonic speech and restricted or self-stimulating behaviour. Early classification of the disorder associated these behaviours with a subtype of childhood schizophrenia, however autism and schizophrenia have more recently been considered as separate disorders (though with some degree of co-morbidity, e.g. Konstantareas & Hewitt, 2001). The diagnosis of autism has gradually become more standardised and conceptualisation of the disorder has become broader.

In general however, the importance of limited verbal and communicative behaviours and abnormal social relationships are emphasised.

In 1976 Lorna Wing first described the pervasive developmental disorder (or autistic spectrum disorder) as characterized by a triad of impairments to areas of social relations, communication and imagination (DSM IV, American Psychiatric Association, 1994; ICD-10, World Health Organisation, 1992). The term 'spectrum' is used to refer to the wide range of severity that differentially affects individuals. The vast majority of individuals with a diagnosis of classic autism have some form of mental delay with about 80% having an IQ below 70 and of those with a higher IQ almost all fall within the 70-100 range (Peeters & Gillberg, 1999). Asperger syndrome (AS) shares the features of classic autism but without associated learning difficulties or language delay, therefore for the majority of individuals IQ is generally above 70. A few individuals with AS may even have exceptionally high levels of IQ (Safran, 2001). In all cases individuals with AS are considered high functioning on the autistic spectrum although they show social and emotional impairments (Peeters & Gillberg, 1999). The differentiation between AS and high-functioning autism (HFA) remains unclear and somewhat controversial (e.g. Klin, Pauls, Schultz, & Volkmar, 2005).

Autism presents itself with a distinct cognitive and social phenotype that is considered particularly debilitating in its most severe form. The spectral nature of the disorder emphasises extreme variability of functioning although core deficits are evident across the spectrum. For example, "autism is characterized by a chronic, severe impairment in social relations" (Baron-Cohen, 1988; pp.379) and one of the earliest symptoms is difficulty in joint visual attention behaviour (Loveland & Landry, 1986; Mundy, Sigman, Ungerer, & Sherman, 1986; Landry & Loveland, 1988; Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997; Leekam, Lopez, & Moore, 2000). Children with autism tend not to look at other people's faces to share attention and fail to engage in declarative pointing or gaze following (e.g. Cox et al., 1999; Leekam, Hunnisett, & Moore, 1998; Loveland & Laundry, 1986). It is difficult to tell whether the social and communicative problems evident in autism are two independent problems or whether they are integrated. These features present themselves across the autistic spectrum, whereas language ability and general IQ show extremes as overall functioning varies.

Research into the aetiology of this neuro-developmental disorder has recently acknowledged that the most likely risk factor is genetic liability (Rutter, 2005a). Although the evidence remains somewhat unclear, support for a link to chromosomes 2, 7 and 13 seems a promising avenue of investigation. It is suggested that the disorder is inherited through several 'autistic genes' at these different chromosomal sites (Maestrini, 1997). Indeed multiple genes in interaction probably account for the complexity underlying the disorder (Szatmari, 2003). It is believed that we are getting closer to the true origins of autism and that some headway will be made with new techniques over the next decade in elucidating the true aetiology (Rutter, 2005b; Szatmari, 2003). One general consensus is that autism is a multi-factorial disorder with its roots not only in genetic manifestations but also linked to non-genetic risk factors, for example prenatal viral infection (Piven et al., 1993). Shao et al. (2003) note that inheritance links are complex and familial transition is not accounted for by a single major gene, but a combination of several genetic and environmental factors. Much work is needed to gain a clearer understanding of the cause of autism.

1.3.1 Diagnosis and classification

The diagnostic criteria for autism are entirely behavioural. To fulfil the criteria for autistic disorder according to the DSM-IV of the American Psychiatric Association (APA, 1994), persons must have been symptomatic since infancy or childhood and manifest a specified number of deficits that are out of keeping with their developmental level in three aspects of behaviours. These include i) qualitative impairments of reciprocal interactions, ii) qualitative impairments of verbal and nonverbal communication, and iii) a markedly restricted repertoire of activities and interests (APA, 1994). Developmental atypicalities must be present in the first three years for a diagnosis to be made.

Due to the behavioural nature of diagnosing autism a number of different tools have been used by clinicians and this may account in part for variable prevalence rates. Chakrabarti and Fombonne (2001) proposed that approximately 16.8 per 10,000 preschool children have autistic disorder, while 45.8 per 10,000 have other autistic *spectrum* disorders including Asperger’s syndrome. The very nature of this spectrum disorder and the variability of severity and impairment make estimates of prevalence extremely difficult. Autism is usually reported to be at least three times more common in boys than girls (Peeters & Gillberg, 1999).

The whole spectrum of autistic-like conditions is sometimes referred to as autistic spectrum disorders, autistic continuum, or pervasive developmental disorders (PDD). For the purpose of this thesis, the variation in ability will be referred to as autistic spectrum disorders (ASD). The research presented in this thesis is conducted with participants previously diagnosed with autism (rather than other disorders on the autistic spectrum such as Asperger syndrome).

1.3.2 Theories and models of autism

Since the 1990s a small number of psychological models which aim to account for the typical autistic phenotype have dominated the field. These models are largely based on the constructs of ‘theory of mind’, ‘executive functions’ and ‘weak central coherence’. Any theory that tries to account for the triad of impairments must fulfil three criteria: First, the theory must specify a deficit universal to all individuals with autism, secondly the deficit and behaviour must be specific to autism (and not general learning difficulties), and finally a deficit must causally precede the onset of the behaviour and be present throughout development (Lewis, 2003).

Theory of Mind

“Having a theory of mind is to be able to reflect on the contents of ones’ own and others’ minds” (Baron-Cohen, 2001; 174). The concept of Theory of Mind (ToM) is derived from research probing similar abilities in non-human primates. For example, Premack and Woodruff (1978) probed whether chimpanzees exhibited ToM and a number of studies have considered that chimpanzees and possibly other apes, have a basic understanding (e.g. Byrne, 1994; Cheney & Seyfarth, 1990; Gallup, 1982). A specific deficit in intentionality and reasoning about other peoples' minds has been identified in autism (Baron-Cohen, Leslie, & Frith, 1985, 1986; Frith, 1989; Happé, 1993, Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1993). In a landmark paper, Baron-Cohen, Leslie and Frith (1985) found that three-quarters of children with autism had difficulty understanding the minds of others and recognising that other peoples' beliefs may be different from their own.

Since the original paper by Baron-Cohen et al. (1985), a number of studies have sought to prove or disprove the idea of ToM problems in autism using a range of methodologies and probing different skills. One of the main tasks used to assess ToM is the 'False Belief' (Wimmer & Perner, 1983). In a classic first-order false belief task the participant would be presented with the following scenario: Amy puts a chocolate in a basket and leaves the room to go and play. While she is away (and cannot see) her mother moves the chocolate from the basket to a cupboard. Amy returns. Where will she look for the chocolate? Four-year-olds tend to succeed at this task by correctly attributing a false belief to Amy, saying that she will look for the object in the basket, while younger children tend to fail (see Wellman, Cross, & Watson, 2001, for review). Individuals with autism fail this task at a much older age. For example, Happé (1995) concluded that children with autism required a far higher verbal mental age to pass false belief tasks than did typically developing individuals. While typically developing children had a 50% probability of passing with a verbal mental age of 4-years, participants with autism did not reach this level of success until they obtained a verbal mental age of over 9-years. Children who fail tasks designed to tap false belief reasoning are considered to lack insight into the nature of beliefs themselves and this is therefore clearly a problem for individuals with autism (Wellman et al., 2001).

So, from the abundance of research probing ToM skills, it is well established that individuals with autism, even with IQs within the normal range, have difficulty attributing mental states to others', where typically developing children as young as 3- or 4-years generally succeed (e.g. Baron-Cohen, 1989a, 1991; Baron-Cohen et al., 1985; Frith, 1989; Happé, 1993; Leslie & Frith, 1988; Perner, 1991; Wellman, 1990; Wimmer & Perner, 1983). Considering the problems evident on first-order false belief tasks, it is hardly surprising that individuals with autism also fail second-order false belief tasks. This type of task becomes more complex by asking, for example, what Mary thinks about John. Probing what the character will be thinking about is based on an imaginary dramatisation. Baron-Cohen (1989) found that even for the small number of participants with autism who could pass first-order false belief tasks, this type of mentalising was too difficult.

Hobson (1993) stated that ToM problems stem from early difficulties with affective aspects of interpersonal communication, whilst Tager-Flusberg, Boshart and Baron-Cohen (1998) suggested that ToM deficits emerge due to earlier difficulties regarding social perception, for example interpreting eye gaze signals. Individuals with autism have difficulties using eye gaze to make judgements about interest, intention or desire (e.g. Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1993). This 'mind blindness' has been described as one of the functional impairments of autism (see Baron-Cohen, 1989; Frith, 1989; Happé, 1994). Ruffman, Garnham and Rideout (2001) assessed ToM in children with autism (n=28, 5-13 years) using both eye gaze and verbal responses as indicators of functioning, with the aim of explaining whether difficulties on ToM tasks were a result of poor language abilities. Compared to children with general developmental delay, participants with autism showed fewer eye gaze shifts during a story telling task as well as providing less accurate verbal responses. Ruffman et al. (2001) concluded that there is an autism-specific deficit in using eye gaze for social understanding. There was also a correlation between level of functioning on the autistic spectrum and use of eye gaze shifts, as greater severity was associated with less looking. The authors concluded that severity of autism was linked to deficits in both ToM and the use of eye gaze. However, researchers remain uncertain as to how closely these skills are linked and indeed the direction of causality.

Theory of mind deficits have been linked to some extent to emotion or empathy difficulties. The understanding of complex emotions (e.g. surprise, jealousy) requires some knowledge of the causal effects of behaviour and subsequent interpretation of how another person might be feeling. Heerey, Keltner and Capps (2003) showed that self-conscious emotions (specifically embarrassment and shame) were problematic for 46 individuals with AS or high functioning autism (HFA) to label from photographs, more so than simple emotions (e.g. happy, sad). The groups with AS and HFA did not differ from typically developing individuals of comparable chronological age and verbal mental age for simple emotions but had clear problems with self-conscious emotions. The relationship between complex emotional understanding and ToM is therefore an important one and in autism both these skills may be deficient. The link between ToM and the processing of simple emotions (e.g. happy, sad) is less evident and indeed the ability to interpret these may be shown in participants who are high functioning on the autistic spectrum. Blair (2005) noted that individuals with autism show deficits in cognitive empathy referred to synonymously as ToM. The ability to represent the mental states of others is considered necessary for emotional, or cognitive, empathy to occur.

Blair (2005) commented that individuals with autism who are unable to interpret the mental states of others, thus lack ToM skills, are unable to respond empathetically to other people. A deficit in empathy has been noted extensively across the autistic spectrum. For example Baron-Cohen and Wheelwright (2004) report an empathy deficit in adults with AS and HFA using the Empathy Quotient questionnaire. The link between ToM and the interpretation of an important social and communicative face cues is therefore evident when considering emotional understanding in autism. However it is not possible to assume a direction or causal link here due to the co-occurrence of several deficits.

Considering how this skill may dissociate individuals with WS and autism is particularly important here. Initial studies by Karmiloff-Smith et al. (1995) suggested that, in contrast to those with autism, individuals with WS performed well on a series of standard false-belief tests. However, Tager-Flusberg and Sullivan (2000) note that Karmiloff-Smith and colleagues tested participants with WS ranging in age from 9- to 23-years and this is much older than the age at which children typically pass such tasks. Even considering the participants' mental age rather than their chronological age, their theory of mind success is unremarkable. Tager-Flusberg and Sullivan therefore conducted a series of studies looking at ToM performance in groups of younger individuals with WS. Their performance was compared with age-matched groups with developmental delay and children with Prader-Willi syndrome (PWS). Tager-Flusberg and Sullivan (2000) reported a pass rate of only 24-29% among 4- to 9-year old children with WS. This was significantly lower than the pass rate for age-matched children with PWS or unspecified developmental delay. A similar picture emerges for 'second-order' false belief tasks as Sullivan and Tager-Flusberg (1999) tested a sample of older children (8-17years) and reported broadly equivalent performance on second-order false belief tasks among children with WS and those with PWS. In a subsequent study with similar groups, Sullivan et al. (2003) presented stories in which a child protagonist made a false statement and participants were required to decide whether the child was lying or joking. Children with WS showed poor performance on second-order knowledge questions and made few references to mental states. Similar results were reported by Reilly et al. (2004) who used a similar story-based assessment and noted that children with Williams syndrome made fewer inferences of motivations and mental states than control participants. Together, the studies by Tager-Flusberg and colleagues suggest that although many individuals with WS eventually acquire sophisticated theory of mind and understanding of false belief (Karmiloff-Smith et al. 1995) and individuals with WS are certainly more adept that those with autism, the developmental process is delayed and appears no more advanced than general cognitive development.

Weak Central Coherence

In a different vein, autism has been described in terms of an atypical cognitive style known as 'weak central coherence' (WCC; Frith, 1989, Frith & Happe, 1994). The premise of this theory is that although individuals with autism are able to process information, they have difficulty linking parts together as a coherent whole. The child's perception and understanding of the 'whole' is weak relative to their perception of individual parts. In essence, an individual with autism is able to interpret the individual pieces of a puzzle but not put them together. As succinctly described by Volkmar, Lord, Bailey, Schultz and Klin (2004) this theory predicts "an internal social world that is piecemeal and disjointed, lacking the overall coherence that defines social context and meaning" (Volkmar et al., 2004; 142).

Frith (1989a) believes that typically developing individuals are compelled to integrate parts of information into coherent patterns, but in autism there is a fundamental deficit in constructing comprehensive interpretations into whole representations. This deficit and a deficient drive for central coherence accounts not only for behaviours and abilities missing in autism (e.g. joint attention or theory of mind) but also for visible symptoms (e.g. repetitive and stereotypical behaviours or fragmented sensations). For example, to achieve success in joint visual attention one may be required to link together cues of eye gaze (following the direction of another persons' eye direction) and communication to share the attention of another individual.

Evidence for WCC has been used to explain face processing in autism, as individuals may be able to recognise people familiar to them but may go about this in a different way. For example, participants with autism are more accurate matching faces from isolated face parts than in the context of a whole face (e.g. Teunisse & de Gelder, 2003; exp.2). They also do not show such a severe decrease in ability to process faces when they are upside down as typically developing individuals (e.g. Hobson, Ouston, & Lee, 1988; Miyashita, 1988; Tantam, Monaghan, Nicholson, & Stirling, 1989). Dramatic decreases in performance when faces are presented upside down are derived from the disruption of configural face processing, using the relationship between independent face features (see section 1.4.1). Further discussion of face processing in autism will be addressed in detail in section 1.4.4. Given the research evidence that individuals with WS may also utilise feature-based face processing styles (rather than considering the configuration of features), there is surprisingly little research exploring any link to central coherence abilities in WS. Importantly however, WCC theory has received support from autism research.

López, Donnelly, Hadwin and Leekam (2004) have shown that 'global' processing is possible under certain conditions in autism. López and colleagues conducted research with 17 adolescents with autism and 17 typically developing individuals, requiring them to match whole faces and individual face parts. When participants with autism were cued to a specific face feature (e.g. the eyes or mouth) they were more accurate matching whole faces than individual face parts. The authors imply that under conditions where individuals with autism are cued to face features, basic configural face processes are shown by the presence of a whole over part-face advantage. López and colleagues suggest (and support Plaistead et al., 1999) central coherence needs to be suitably and overtly primed in autism. In fact, going against evidence of featural processing, a number of studies have failed to find a local bias for faces in autism (e.g. Teunisse, 1996, exp. 2) and have found good use of the face configuration (e.g. Lahaie, Mottron, Arguin, Berthiaume, Jemel, & Saumier, 2006). Therefore evidence of weak central coherence may be used to account for some of the cognitive behaviours associated with autism, but may fail to take account for all the evidence.

Executive dysfunction

One further suggestion for the difficulties presented by individuals with autism, proposes that core cognitive deficits can be interpreted in terms of deviant cognitive processing; namely executive dysfunction (e.g. Ozonoff, Pennington, & Rogers, 1991; Russell, 1997). Executive functioning involves planning, inhibiting irrelevant information or identifying and switching strategies. It is proposed that individuals with autism are poor at planning their behaviour in order to achieve a particular goal. Part of the problem may be an inability to disengage from salient objects or inhibit responses that are inappropriate. Concerning the presence of repetitive behaviours in autism, Turner (1999a) proposes that children with autism cannot shift or disengage from a particular behaviour in which they are involved and as a result this behaviour is repeated over and over again. Interestingly, research has also indicated that individuals with WS may have some deficits related to executive functioning, though this is much less clear than the evidence regarding autism (e.g. Namihira, Hirayasu, & Koga, 2004; Tager-Flusberg, Sullivan, & Boshart, 1997).

The executive dysfunction hypothesis of autism gains support from research showing that adolescents with HFA show more severe and invariant deficits on executive function tasks than on tasks probing emotional understanding or ToM (Ozonoff, Pennington, & Rogers, 1991). However, unlike the other core cognitive theories of autism already mentioned, executive functioning deficits are widely reported in other clinical groups, such as Attention Deficit Hyperactivity Disorder, Tourette syndrome and schizophrenia. Therefore as a core cognitive theory of autism, this approach can not fulfil one of the key aims, that the behaviour is specific and unique to autism (e.g. Lewis, 2003).

As to whether any of these three cognitive models can account for the range of behaviour evident in autism, there appears to be benefits and downfalls in each. Contradictory evidence continues to be used to argue for and against these theories and the debate continues as to how autism can be described in terms of a core cognitive deficit. This is summarised succinctly by Tonn and Obrzut (2005) who note that although "central coherence, executive function, and theory of mind hypotheses are helpful in conceptualizing the disorder, it is unlikely that any of them represent 'mutually exclusive' abnormalities" (Tonn & Obrzut, 2005; 409). One theory that has received rather less attention focuses on the social rather than cognitive impairments evident in autistic spectrum disorders, as proposed in Wing's (1976) triad of social impairments.

Amygdala Theory

The amygdala theory of autism proposes that the hallmark symptoms of social impairment arise because of an inability to process the emotional relevance of social information (Baron-Cohen et al., 2000). The amygdala (part of the limbic system) has been implicated as one of the crucial brain regions for the interpretation of social stimuli and hence deficits in amygdala function have subsequently been linked to problems in social situations. Brothers (1990) proposed that the amygdala, orbitofrontal cortex and superior temporal sulcus work together to form the ‘social brain’ and the neural basis of social intelligence. Baron-Cohen et al. (2000) proposed that an amygdala theory of autism considers the role of amygdala dysfunction and abnormality in the core symptomology of autism. Having detailed core deficits related to autism in section 1.3 it is evident that social problems form one of the most striking deficits across the autistic spectrum. Therefore considering the role of the amygdala for the interpretation of social stimuli and affective responses, it is clear that an amygdala theory may account for the debilitating social deficits. However this does not explain all aspects of autistic characteristics (e.g. local processing styles, repetitive behaviours) and thus does not fulfil the requirements of a core theory of autism.

Considering the human face as one of the most important social stimuli in our environment, evidence for an amygdala theory has been sought from face perception research. Evidence from functional magnetic resonance imaging (*f*MRI) research by Baron-Cohen et al. (1999) found that individuals with autism and Asperger syndrome showed poor performance when reading emotions from the eye region, alongside a lack of amygdala activation during the task. In contrast typically developing participants showed activation of this region much more than the autism and Asperger syndrome groups. Therefore the role of the amygdala in face perception deficits found in the autistic spectrum are particularly important. We will returned to discussion of the amydgala in section 1.4.4. as the following sections of this introductory chapter consider face perception research in more detail.

1.4 Face Perception

The central theme of this thesis is the way faces are understood by individuals with WS and autism. Having introduced theories and relevant details for each of these developmental disorders, this chapter now considers face processing literature. Face perception will be used as a paradigm for investigating aspects of cognitive and social functioning. The thesis will involve paradigms already embedded in typical face perception literature whilst applying age-appropriate investigations and rigorous methods. It is necessary to introduce main theories and research themes evident in typical face perception literature before moving on to consider how this can reveal aspects of social and cognitive functioning in WS and autism.

1.4.1 Adult face perception

"There is no doubt that face processing is a human skill at which most adults are real experts" (Schwaninger, Carbon, & Leder, 2003; 81). Every day we interpret face signals for not only identity but a range of communicative cues (e.g. expression, eye gaze). These processes occur rapidly and must be successful to aid our interpersonal functioning within our social environment. Face perception has attracted a great deal of attention, partly due to our expertise and this section reviews the most relevant literature concerning adult face processing, relating directly to the aims and investigations of the current thesis. It would not be appropriate to review all the face perception literature due to the profusion of research exploring this phenomenon, but here we review the most relevant theories and studies.

Researchers have been interested in understanding how adults process faces due to their importance for successful social interactions and everyday functioning. Determining how faces are interpreted by adults allows consideration of the development of face skills and how face perception in developmental disorders may appear atypical. This section introduces the most relevant research concerning adult face perception, defines key concepts for subsequent experimental chapters and sets the scene for a discussion of possible atypicalities evident in WS and autism.

Are faces special and how does the brain process this important stimulus?

One of the main distinctions made in research with adults asks whether faces and non-face objects are processed in the same way. Research suggests that faces are processed in a different way to non-face objects, as well as being processed by specialised and distinct brain regions. Neuropsychological evidence has shown activation of the right fusiform gyrus (located in the occipito-temporal region) uniquely associated with faces and hence this region has become known as the 'fusiform face area' (FFA; Kanwisher, McDermot, & Chun, 1997, 1999; Kanwisher, 1998). Kanwisher, McDermot and Chun (1997) concluded that the FFA was selectively involved in the perception of faces, a finding supported by a number of research investigations using MRI and *f*MRI techniques (e.g. Gorno-Tempini & Price, 2001; Grill-Spector, Knouf, & Kanwisher, 2004). However, the notion that faces form a unique class of stimuli that require a dedicated and specialised brain region is controversial. The FFA has also been found to respond to other classes of information, such as animals (Chao, Martin, & Haxby, 1999) and has been activated by categorisation tasks (e.g. distinguishing types of birds, Gauthier, Tarr, Moylan, Anderson, Skudlarski, & Gore, 2000).

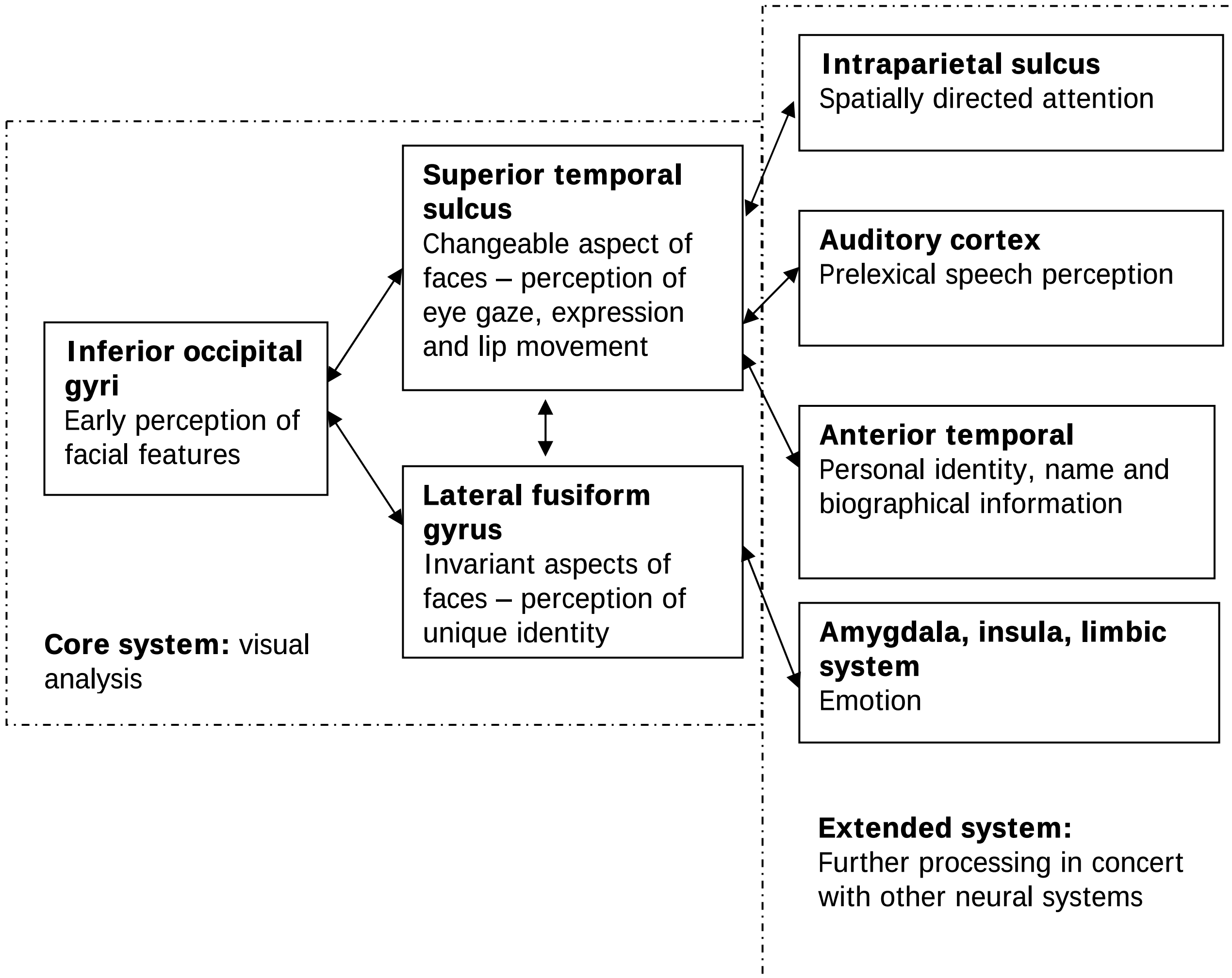
Gauthier et al. (2000) proposed that the FFA is activated by expertise and the need to distinguish a specific type of object from any general class of objects, not just faces. In research involving bird and car experts, participants were required to decide whether two birds were from the same species or whether cars were the same model but from different years. In another assessment, measured using *f*MRI techniques, the same participants indicated whether a bird or car was one they had previously seen or a new image. Car experts showed greater activation of the FFA when processing the car images whilst bird experts showed greater activation of this region for the bird images. Gauthier et al. (2000) therefore proposed that level of categorisation and expertise contributed to the specialisation of the FFA. We are all expert face processors and thus show activation of the FFA for this class of stimuli. There is still controversy surrounding the unique involvement of the FFA in face perception, but it is unlikely that this is the only brain region implicated in the processing of facial stimuli.

Rather than focusing solely on the role of the FFA, Haxby, Hoffman and Gobbini (2000) emphasised the role of multiple, bilateral regions of the brain for face perception. Particularly important here is the role of several brain regions in the interpretation of communicative face cues, such as expression of emotion, eye gaze or lip movement. They note the importance of the superior temporal sulcus in the perception of communicative and changeable face cues. This region plays an important role in the visual analysis of face cues and both receives and provides input from / to the extended brain system e.g. the amygdala and limbic system as a whole, plus anterior temporal regions. Figure 1.1 replicates Haxby et al.'s model of the neural system underlying face perception. The model emphasises the collaborative involvement of several areas of the brain in face perception, and how communicative face skills play an important role.

This returns us to the role of not only identity recognition but the use of communicative face signals in successful interpersonal communication. In further discussion of this model of the neural system underpinning face perception, Haxby, Hoffman and Gobbini (2002) emphasise the role of the amygdala when processing information of social importance, e.g. emotion. This brain region has already been emphasised in respect to autism (section 1.3.2) and the interpretation of social cues. Indeed the amygdala plays an important role in Brother's (1990) theory of a 'social brain'. The role of the amygdala in the interpretation of socially important cues is confirmed here by its relevance to face perception. As noted in Figure 1.1 the amygdala is an important feature of emotion processing.

This section emphasises that we must consider the interplay between different regions of the brain in typical, and possibly atypical, face perception skills. Not only does the fusiform gyrus play a role in face identification, but a complex interplay between other brain regions adds to the processing of communicative face cues. This extended system of face perception may involve brain regions implicated in the phenotypes of autism and WS, for example the amygdala and the superior temporal sulcus.

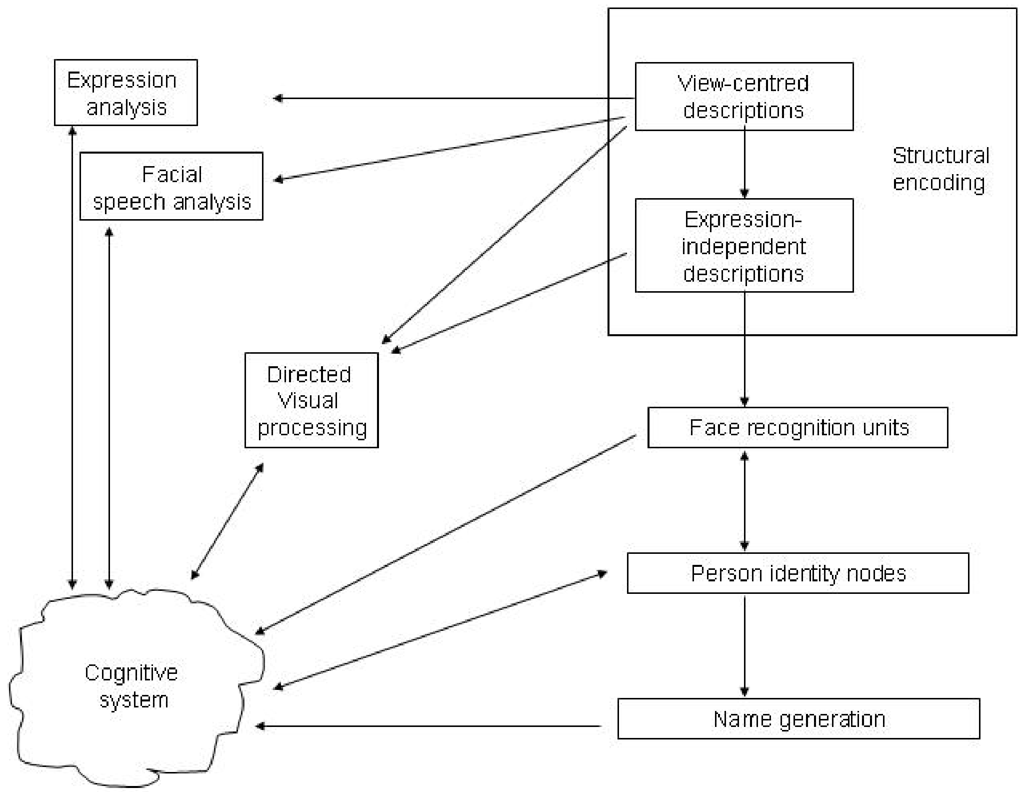
Figure 1.1 The interplay between several brain regions in the processing of facial cues, taken from Haxby et al. (2000).



A face recognition model

To account for adult skills at understanding faces and considering research involving individuals with 'prosopagnosia' (a disorder associated with an inability to perceive aspects of faces and identify familiar people), Bruce and Young (1986) proposed a functional model of face recognition. Rather than focusing on the neural system underlying face perception, this model concentrates on the *processes* by which faces are

Figure 1.2 The Bruce and Young (1986) functional model of face recognition



understood. The model distinguishes between a number of different and modularly independent codes for successful face recognition; including structural encoding, naming, expression and facial speech. Evidence for the independence of such codes is reflected in its modular structure (e.g. a lack of relationship between emotion processing and identification). This model has dominated our understanding of the way faces are understood by adults and has played a vital role in our understanding of both identification and communicative aspects of faces. Figure 1.2 illustrates the structure of the Bruce and Young (1986) model highlighting independent modules for each aspect of successful face processing. The separate nodes of processing may also be activated by different brain regions as emphasised by the Haxby et al. (2000) model. For example, face recognition units and person identity nodes may be implicated during the involvement of the visual analysis of faces (involving the inferior occipital gyri, superior temporal sulcus and lateral fusiform gyrus).

Both the Bruce and Young (1986) model and Haxby et al.'s (2000) neural system for face perception emphasise dissociated pathways for the processing of identity and social (communicative) face processing. This may become even more important where deficits are found for one of these skills but not the other. For example, some individuals with prosopagnosia are able to process emotion but not identity (Tranel et al., 1988), whilst the opposite may also be apparent (Kurucz & Feldmar, 1979). Thinking forward to the following experimental chapters and the review of face processing literature for WS and autism in this chapter, the dissociation may be particularly important. As so many brain regions and mechanisms are involved in the processing of face cues, disruption may occur at any of these points and in any of these brain regions, thus affecting face perception in many different ways.

For the current thesis, the most relevant component of the Bruce and Young (1986) model is the 'structural encoding' node, related to the *way* faces are processed. This will be particularly important for the latter experimental chapters (chapters 6 and 7) and will be returned to in detail. According to the Bruce and Young (1986) model, structural encoding produces a set of details or descriptions of a face, which includes the individual features and overall global configuration. This is particularly related to the perceptual aspect of face perception, the *way* faces are encoded in memory. The main distinction made here is between the use of featural and configural processing.

Structural encoding: features and configurations

Regarding processing style or the *way* faces are encoded, a distinction between face and non-face objects appears driven by the use of *configural* processing for faces but not objects. Conversely, object perception appears driven by *featural* (piecemeal, component) processing. For faces, feature information has been referred to as the separable local elements, which are perceived as distinct parts of the whole face such as the eyes, mouth, nose or chin (Carey & Diamond, 1977; Sergent, 1984; Leder & Bruce, 2000). Whereas, configural information refers to the spatial relationship between these features which is a result of spatial arrangements, for example eye-eye distance or nose-mouth distance (Bruce, 1988). Configural information has been defined further by Diamond and Carey (1986) who used the terms '*first-order relational information'* for the basic arrangement of the parts and '*second-order relational information'* to refer to specific distances and relations between features. Specifically, first-order relations define a face as a face, with the eyes above a nose which is in turn above a mouth. Conversely, second-order relations define the exact spatial relations of the face, for example the specific distance between the eyes or their distance above the nose. Second-order relational information is therefore much more fine grained than first-order relational information. Considering a template for a face, a number of researchers judge the specific distance between features to be less important and believe that we process a face as a *'holistic'* image (e.g. Tanaka & Farah, 1993; Farah, Tanaka, & Drain, 1995). This is considered an extreme alternative to face configuration, as the independent features of the face are not processed separately and therefore there is no focus on the relative distance between features. The holistic view considers that a face 'template' is used for recognition. In a series of experiments, Leder and Bruce (2000) found that relational information was used much more extensively than holistic information for a variety of face perception tasks. However Leder and Bruce (2000) note that the distinction between configural-relational and configural-holistic is not clear cut and may be difficult to distinguish both empirically and theoretically.

The use of configural relational face processing has been further supported by evidence from the face *'inversion effect'* (Yin, 1969). This refers to a reduction in the ability to interpret or recognise faces when they are inverted than when upright. For example, Yin (1969) required adult participants to recognise previously seen faces, airplanes and houses when upright or inverted (all images previously learned upright). Face recognition was affected more adversely by inversion that the recognition of non-face objects. Leder and Bruce (2000) explain this effect by the disruption of configural relational information for face but not object perception. The 'inversion effect' has been replicated a number of times with adult participants (e.g. Ellis, 1975; Goldstein & Chance, 1981; Leder & Bruce, 2000; Freire, Lee, & Symons, 2000; for a review see Valentine, 1988) and is considered a robust illustration of configural face processing.

Evidence for a holistic rather than relational mode of face processing is derived from evidence that we do not process independent features and this becomes explicit in composite techniques. Young, Hellawell and Hay (1987) divided faces into misaligned upper and lower sections and found adult participants were more accurate detecting famous people from upper features than when they were aligned with the bottom section of a different person. They referred to this as the '*composite effect'*, which was evident only when the two halves of the different faces were aligned to form a face of natural appearance and not when the upper and lower face sections were misaligned. The 'composite effect' interestingly disappears when the face is inverted as the relationship between the separate halves is harder to decipher. The authors claim that this pattern of performance is due to the whole configuration of the face only being fully available for upright faces. This is one of the strongest lines of evidence to suggest *'holistic'* face processing but does not rule out the importance of relations between features playing an important role in whole face representations.

Chapters 6 and 7 of this thesis will introduce and critique evidence for featural and configural processing in more detail using inverted faces in an illusion and face manipulation. This is directly relevant to evidence for typical or atypical properties of the structural encoding component of face processing in WS and autism. This component of the Bruce and Young (1986) model is the main interest of these subsequent experimental chapters.

Communicative face skills

As well as identifying people we know and those we do not know, it is crucial that we understand the communicative aspects of faces. We pay great attention to the facial signals we receive from other people. Knapp (1978) noted that "the face is rich in communicative potential" (p. 263). Indeed understanding communicative signals such as expressions or eye gaze is critical for successful interpersonal communication as they regulate conversation and indicate the direction of attention. Both the Bruce and Young (1986) model and Haxby et al.'s (2000) neural system for face perception emphasise the role of a distinct pathway for processing communicative face cues.

Darwin (1872) considered certain facial expressions as biologically determined and universally recognised, for the first time linking aspects of face perception to evolution (cited in Knapp, 1978). This was followed up by Ekman (1972) who found that throughout different cultures we have the ability to recognise a small number of basic emotions, including happiness, sadness, anger and disgust. Of course this does not demonstrate the huge diversity of expressions we are able to represent as well as interpret, but does show that there is a degree of universality in the recognition of certain expressions of emotion. The biological significance of facial expressions in social relationships is exemplified in species of non-human primates whose social structure is determined by their use of innate facial expressions (see Amaral, 2003). Izard and Walker (1974) found that severing the facial nerves of rhesus monkey mothers and infants led to a marked reduction in caring behaviour and an increase in aggression. This suggests that visual awareness of facial expressions and reactions to expressions play an important role in forming attachment bonds. This emphasises that understanding emotion is crucial to human interactions and everyday functioning.

Considering how expressions are produced, Ekman and Friesen (1976) proposed a 'Facial Action Coding System' whereby expressions of emotion are represented by the combination, or configuration, of facial movements and shapes. This has been supported by research concerning the identification of emotions. For example, Bruce and Young (1998) note that we use a configuration of face features to interpret feeling; the presentation of the eyes (wide open or narrow), the positioning of the eye brows (raised or lowered) and mouth (open or closed). All the features work together to represent a variety of basic and complex expressions of emotion, from happy or sad, to jealousy or disgust.

During interpersonal communication, gaze and eye contact serve a number of functions; regulating turn taking, expressing intimacy, directing attention or exercising social control (Kleinke, 1986). Baron-Cohen and colleagues (1995, 1997) have demonstrated that gaze direction can be used as an indicator of another person's mental state (ToM previously considered for autism). As adults we are particularly adept at using gaze cues to infer intentions, desires, feelings, competence and a number of other signals of mental state. Direct eye contact appears particularly important for interpersonal communication (see Chapter 8), and adults are extremely efficient at detecting this type of gaze (e.g. von Grunau & Aston, 1995; Langton, Watt, & Bruce, 2000). Direct eye gaze been shown to elevate physiological arousal (Gale et al., 1972), increase activity of the amygdala (Kawashima et al., 1999) and immediately draw our attention to a greater extent than averted gaze (e.g. von Grunau & Anston, 1995). This issue will become particularly important in Chapter 8 and Appendix B of the thesis as we consider the role of arousal in eye gaze perception. Shifting or averting eye gaze can be successful in directing a viewers' attention (e.g. Freisen & Kingstone, 1998; Langton & Bruce, 1999) and is important at many levels of social interactions (e.g. social referencing). Therefore eye gaze can be used as a critical social cue during interpersonal communication and as adults we are experts at interpreting such signals.

1.4.2 The Typical developmental of face perception skills

The central question posed by developmental researchers asks whether adults and children understand faces in the same *way*. Research considers whether children process faces in the same way as adults but at a lower level of ability, or whether qualitative differences exist. The basis of such research centres on the use of featural and configural processing styles (see section 1.4.1). It is proposed that young children up to the age of approximately 8-years interpret faces using a featural, piecemeal strategy, rather than focusing on the whole configuration (Carey, 1978, 1981). Researchers have specifically addressed the age at which an ‘adult-like’ style appears with a shift between featural and configural processing.

Structural encoding: qualitatively or quantitatively different?

Developmental research has predominantly focused on the recognition of unfamiliar faces and it is undoubtedly evident that children become more accurate at recognising faces as they increase in age (e.g. Carey & Diamond, 1977, Carey, Diamond, & Woods, 1980, for review see Chung & Thomson, 1995). A marked improvement in face processing ability is observed between 2- and 10-years (Schwarzer, 2002) with development continuing from infancy, through childhood and towards adult performance (Carey, 1981; Campbell, Walker, & Baron-Cohen, 1995; Campbell et al., 1999). Children also improve dramatically in their ability to remember unfamiliar faces between 5- and 13-years of age (e.g. Blaney & Winograd, 1978; Ellis & Flin, 1990). So it is recognised that children do not process faces with the same level of ability, or possibly even in the same *way*, as adults (Carey, 1981; Hay & Cox, 2000; Pascalis, Demont, de Haan, & Campbell, 2001). The important question arises as to whether increased exposure during childhood contributes to, and increases, our understanding of faces as an important class of social stimuli and hence are attended to more closely (e.g. Goldstein, 1975; Goldstein & Chance, 1980), or whether increased exposure leads to an *'encoding shift'* (Carey, 1978, 1981; Carey & Diamond 1977; Carey et al., 1980; Diamond & Carey, 1977). These two approaches may not necessarily be mutually exclusive.

The 'encoding shift' hypothesis revolves around the notion that a shift occurs in the way that faces are processed or understood as children increase in age. Carey and colleagues argue that children do not acquire sufficient knowledge to code faces configurally until the age of 10-years, up to which point faces are understood using the individual features in a piecemeal fashion. Support for this hypothesis is partly derived from evidence that young children, before the age of 10-years, are less affected by face inversion than adults. However the evidence may be contaminated by floor effects across conditions for particularly young participants (Carey et al., 1980; exp.1). Carey and colleagues propose that before 10-years of age children use featural processing for both upright and inverted faces and therefore show less disruption to performance when faces are inverted. However, Brace et al., (2001) measured children's reaction times to recognise faces and showed the classic inversion effect from 5-years. They attribute their finding of an inversion effect in such young children to having avoided floor effects on upright trials by using a child-friendly method. They tested children in the context of a story in which children were invited to rescue a boy from a 'wicked witch'. Children were asked to recognise only one child's face that was presented among a different set of foils on each trial; and there were very few test trials (three upright and three inverted); they measured reaction time in addition to accuracy. Their results provide indirect evidence of sensitivity to second-order relations by 6-year-old children, a conclusion that is consistent with other studies (e.g., Mondloch et al., 2002). Therefore there has been mixed support for the encoding shift hypothesis.

If children do not show a change in processing style with age, then we might expect them to show some ability to interpret the configuration or holistic aspects of a face. Regarding the holistic processing, Hay and Cox (2000) used a part-face paradigm with children. They found that when required to recognise features in isolation or in the context of a whole face, younger children (6- and 9–years) performed more accurately with isolated features. They proposed that individual feature processing was used by these young participants but older children and adults used the holistic face image and were more accurate when the feature was embedded in a whole face context. This provides support for a change in processing style with age. However, this evidence contrasts with other studies that have suggested holistic processing is possible at a young age, before other configural / relational skills. Holistic processing has been found to be mature by 4- to 6-years of age, whether measured by the composite face effect (Carey & Diamond, 1994) or the whole / part advantage (Pellicano & Rhodes, 2003; Pellicano, Rhodes & Peters, 2006; Tanaka, Kay, Grinnell, Stansfield, & Szechter, 1998). So what can we conclude about the way faces are interpreted by children? There is mixed support for an encoding shift hypothesis of face perception through childhood, although there does appear to be a clear difference in abilities between children and adults as we might predict. Unfamiliar face perception has attracted the most research interest with young children, and perhaps more attention is needed to investigate familiar face processing, at a stage when the most important figure in the child's life is the familiar face of their caregiver. Of course, children must not only identify people they know from those they do not know, but they must adequately interpret social communicative cues from the face to learn to interact appropriately in social situations.

Developing communicative face skills

It has been suggested that we may be born with some abilities to understand communicative signals from the face, such as eye gaze (e.g. Farroni, Csibra, Simion, & Johnson, 2002). For example, even newborns show a preference for looking at direct rather than averted eye gaze (Farroni et al., 2002) and eye-to-eye contact between mother and baby may occur as early as 4 weeks of age (Wolff, 1963). Certainly as young as 2-months infants show a preference for looking towards the eye region of faces (Maurer & Salapatek, 1976) and eye-like patterns portrayed by two dots (Spitz & Wolf, 1946). The visual interaction between infant and mother plays an important role in the development of attachment and the foundations of social development (Argyle & Cook, 1976; Knapp, 1978).

Even though a basic ability to detect or orientate to gaze direction may be apparent in the first few months, it is not until several years later that children begin to explicitly understand the underlying meaning or inferences of eye gaze as a social or cognitive skill (Doherty-Sneddon, 2003). By the age of 3- to 4-years children learn to detect attentional cues from eye gaze (Doherty & Anderson, 1999) or note a person's desires from where they are looking (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, &

Walker, 1995, Pellicano & Rhodes, 2003). Therefore the complex skills to not only follow but decipher mentalistic cues from eye gaze develops throughout infancy and childhood.

Regarding another important communicative cue, research has explored the development of understanding emotion. Although a number of theorists have considered the basic premise of emotion recognition as innate (see Russell, 1994) the empiricist argument considers that the recognition of emotion is learned through experience and is based on the gradual refinement with age of children's production and recognition of emotional signals (Fogel et al., 1992; Klinnert, Emde, Butterfield, & Campos, 1986). Ekman (1982) found that by 2-years of age infants were able to recognise 6 basic expressions of emotion (happiness, sadness, anger, fear, surprise, disgust) but it is not until much later in development that we are able to understand the meaning behind these recognisable depictions. Children learn to understand the consequences of feelings as they themselves experience a range of emotions. At approximately 3-years children can identify situations that might provoke certain emotions as well as individual expressions (Borke, 1971; Denham, 1986). At about this same age (3- or 4-years) children can identify happy or sad faces from an array, but it is not until a few years later that they can identify more complex emotions (Walden & Field, 1982). So a substantial body of research has examined children’s understanding of expressions of emotions and the developmental course of this skill. With this variety of communicative and identification skills at their disposal a developing child can successfully learn how to function in their social world. In cognitive development, even partial understanding and use of social signals plays an important role. For example, from the first year of life facial expressions of carers have an important impact on social referencing even though the explicit comprehension of social signals is still immature.

The final communicative face signal to be considered here is the ability to lip- or speech-read. Visual information from a speaker's mouth and face plays an important role in the perception of spoken language (e.g. for a review see Summerfield, 1987). Research has emphasised the developmental importance of this skill as the absence of lip-reading ability in young children can have consequences for speech processing (e.g. see Dodd & Campbell, 1987). Indeed infants must learn to combine both visual (interpreting mouth region) and auditory (listening to the sounds) analysis of speech together to aid the interpretation of sounds (Burnham, 1998). This is an important face perception skill that develops early in infancy. Research shows that infants as young as 10-20 weeks fixate on a speaker for longer when the lip movements and voice are in synchrony, rather than displaced (Dodd, 1979). Therefore, a developing infant or child must combine not only their perception of several face features, but their perception from different modalities. This is clearly an important face skill that develops in early infancy and can have subsequent impacts upon the understanding of language.

When face perception does not follow this precise course of development, subtle atypicalities may appear and subsequently impact upon everyday social skills. Two specific developmental disorders that have been shown to impact upon the ability to understand faces are WS and autism. The following sections provide an insight into why previous research has suggested that face processing in WS and autism may be atypical and dissociated from that seen in typical development.

1.4.3 Face processing in Williams syndrome

Children with WS are more interested in people than objects (Laing, 2002; Bertrand, Mervis, Rice, & Adamson, 1993), showing the opposite pattern to children with autism (e.g. Klin, Jones, Schultz, Volkmar, & Cohen, 2002). As discussed in section 1.2.1, WS is characterised by deficits in nonverbal processing, however within this domain, researchers have found an area of strength related to understanding faces. Early evidence of good face processing abilities predominantly focused on face recognition. In a behavioural study Bellugi, Lichtenberger, Mills, Galaburda and Korenberg (1999b) reported ‘near normal’ levels of performance for 10 individuals with WS using the Benton Test of Face Recognition and the Warrington Recognition Memory Test. However, some care is required when considering these results as more recent research has shown that both these tasks can be completed when all the face information is removed and only extraneous non-face information is used (Duchaine & Weidenfeld, 2003). Udwin and Yule (1991) stated that not only was face processing at chronological age level but children with WS (mean age 10 years 4 months) performed significantly more accurately than a control group of children matched on chronological age and verbal IQ (completing face recognition components of the Rivermead Behavioural Memory task). Claims of ‘intact’ or ‘spared’ face recognition monopolised early research (Bellugi, Wang, & Jernigan, 1994; Karmiloff-Smith, 1997) but may not have adequately detailed face perception in this developmental disorder.

Featural or configural processing

These early claims of 'intact' or 'spared' face processing skills did not contain sufficient detail regarding structural encoding to reveal group differences. Although performance may appear within a 'typical' range, this does not mean the task was being completed in the same *way* or using the same *strategy*. More recent research has purposefully probed the structural encoding of faces to reveal processing atypicalities. As previously emphasised, an abundance of research using different methods has indicated that typical adults process faces based on their configuration rather than independent features (e.g. Young et al., 1987; Leder & Bruce, 2000) and in children configural processing develops with age and expertise (e.g. Carey, 1977, 1981). In contrast, even adults with WS use feature-based processing to identify faces (e.g. Deruelle, Mancini, Livet, Cassé-Perrot, & de Schonen, 1999; Karmiloff-Smith et al., 2004).

Deruelle et al. (1999; exp.2) required participants with WS (n=12, 7-23 years, mean 11 years) to detect whether two simultaneously presented faces or houses were the same or different. Half the trials were upright whilst half were inverted. Typically developing participants (matched for chronological age; CA or mental age; MA) were more accurate for upright than inverted trials but the group with WS was not affected by inversion. However, the authors do not provide sufficient data to investigate error rates for each group and overall accuracy was deemed by the authors to be particularly high across conditions. The research also indicated that for typically developing participants performance decreased more dramatically for inverted than upright faces than houses, but there was no difference for inverting houses and faces for the group with WS.

Inspection of the results indicates that this was a very small difference for all groups, for example, the CA matched group showed a 0.83 increase in mean error rate (out of 12 trials) for inverted than upright faces. The lack of difference between upright and inverted trials for participants with WS may therefore be indicative of task difficulty. This may account, in part, for any difference in results when compared to Rose, Lincoln, Lai, Ene, Searcy and Bellugi (2006) who found that individuals with WS were affected by inversion, showing decreased accuracy for matching identity when faces were inverted.

In another experiment involving the same participants, Deruelle et al. (1999; exp.3) used schematic faces to discriminate between local and configural transformations. Using schematic shapes, participants with WS made more configural errors than typically developing participants in the CA or MA groups. The participants with WS also performed at a level indicative of their mental rather than chronological age (mean accuracy combining featural and configural trials WS 83%, MA 86%, CA 93%). Participants with WS did not make any more configural than featural errors but it was the difference between groups on configural errors that emerged. The difference between error rates was again very small (although significant on some factors) due to high accuracy. It is likely that together the level of distortion made to the schematic faces and unlimited presentation made the task too easy for many participants. Once again the authors provide minimal data and this does not allow a full insight into the results pattern across groups. The researchers combined evidence across their experiments to suggest poor configural processing in WS, indicating that faces are processed atypically and in a style more characteristic of younger typically developing children. These tasks gave the first indication that face processing in WS showed atypical structural encoding.

Deruelle, Rondon, Mancini and Livet (2003) followed up their earlier research with 12 individuals with WS (ages 5-17 years, mean 11 years). Each participant was matched to a typically developing child of comparable mental (MA) or chronological age (CA). The research involved low and high frequency images of faces to probe reliance upon featural or configural processing. One high or low frequency face appeared at the top of the screen and the participant matched identity to one of two faces at the bottom of the screen (unfiltered). The image at the top was an exact copy of the target image at the bottom but involved high or low frequency filtering (no change in orientation between images). These manipulations make either featural or configural information particularly difficult to utilise depending on whether high or low filtering is used. The authors do not report the overall mean error rates for the WS group but the typically developing participants show extremely strong performance (mean 0.6 errors, MA group mean 2.7 errors) and the WS group performed at a comparable level to the CA matches. A lack of detail in the results section, high mean accuracy for the typically developing participants and the same image used for target and correct answer hinder the interpretation. The researchers followed this up with different views of the faces to avoid pattern matching strategies (Deruelle et al., 2003, exp.2) and again found the same pattern for WS and CA groups. It is difficult to interpret these results without full data for each group but the authors suggest that participants (5-17 years) with WS and those who developed typically found it easier to match faces from low frequency images and hence using configural face processing. This might seem surprising for the group of typically developing individuals who would have been at an age where configural processing is used less reliably than featural processing (e.g. Carey, 1978, 1981; Carey & Diamond 1977). Clearer analysis of the results and investigation of the specific task design used here are warranted.

Deruelle et al. (2003) propose that their task manipulates access to featural or configural information. However, the configural (low frequency) condition could be seen as presenting '*holistic'* rather than manipulating configural information. Rather than investigating the spacing and relations between features, Deruelle and colleagues base their task on the overall holistic representation. So this study might indicate that individuals with WS are not impaired on holistic information processing but reveals little about configural processing. This may account for differences in results between their earlier investigation of configural processing (Deruelle et al., 1999; exp.3) and this study. This may also account for the evidence of so-called configural processing in their young typically developing participants. Holistic processing was assessed by Tager-Flusberg, Plesa-Skwerer, Faja and Joseph (2003) with research involving 47 adolescents and adults with WS (12-36 years, mean age 20 years 10 months) and a typically developing group matched for mean chronological age (n=39). Using a whole-part face paradigm, as previously described for typical children and adults, Tager-Flusberg and colleagues required participants to match individual face parts (e.g. eyes, nose, mouth) either in the context of a whole face or in isolation and the task involved the use of inverted and upright images. Overall participants with WS performed less accurately than a CA matched group in all conditions. The same results *pattern* was evident across groups as a decrease in accuracy was seen between upright and inverted faces and whole faces versus isolated parts. The authors note that a whole face advantage for upright but not inverted images is indicative of holistic face processing in both WS and typical development. The researchers conclude that holistic face processing appears typical in WS.

Taking a clear developmental approach, Karmiloff-Smith et al. (2004) began to trace the development of face skills (featural and configural processing). Karmiloff-Smith et al., (2004, exp.1) used real face images and implemented featural and configural face changes to investigate the ability to detect face manipulations and match identity. Twelve participants (16-51 years, mean age 30 years) carried out tasks taken from Mondloch et al. (2002). Full details and discussion of this paper will be considered in Chapter 7 where this task is central to the experimental evidence. Importantly, Karmiloff-Smith and colleagues provide evidence of not only a lack of configural face processing in WS but the atypical development of this skill. Applying a developmental trajectory approach this study has been the first tightly controlled exploration of the development of configural processing in WS.

To condense and interpret the evidence for face processing style in WS, the studies reported here show a gradual progression away from inappropriate claims of ‘intact’ face processing in this group. Early claims of strong face processing skills are now considered inadequate, and research has emphasised atypical face processing styles regarding a lack of configural processing. However, it does appear that individuals with WS are capable of interpreting the featural and holistic aspects of faces. This configural deficit may relate directly to evidence from section 1.2.1 emphasising the general style of processing nonverbal stimuli in WS.

Communicative face skills

Full details of communicative face skills in WS will be reviewed in Chapter 3 but central themes of the research are considered here. In section 1.2.2 it was noted that individuals with WS are characterised as particularly sociable and empathetic. It might therefore be expected that they would perform well on tasks probing emotional understanding. Indeed children with WS score well discriminating expressions from schematic faces (happy, sad) and perform at levels comparable to mental age matched typically developing children (Karmiloff-Smith et al., 1995, exp. 1). However, task demands appear particularly important as performance on an emotion sorting task (happy, sad, angry and scared emotions) showed less capable abilities for children with WS (n=22, 4-8 years, mean 7-years; Tager-Flusberg & Sullivan, 2000, exp. 3), as did a task involving moving facial expressions (n=26, 5-32 years, Gagliardi, Frigerio, Burt, Cazzaniga, Perrett, & Borgatti, 2003). Although motion aids the interpretation of expressions of emotion in typical development (Ambadar, Schooler, & Cohn, 2005) the same does not appear apparent in WS.

Adults with WS perform well when interpreting complex emotional states and this has been taken to suggest a sparing of socio-perceptual information processing (Tager-Flusberg, Boshart, & Baron-Cohen, 1998). Participants with WS (n=13, 17-37 years, mean 26 years 4 months) were matched to a group with Prader-Willi syndrome (PW) and a typically developing group. Prader-Willi syndrome is a rare genetic disorder associated with mild learning difficulties and emotional instability (Cassidy, 1997), but not specifically known to impact upon face processing. All participants were required to read a complex emotional state from the eye region using the 'Reading the Mind from the Eyes' task developed by Baron-Cohen et al. (1997). Expressions included 'concerned', 'flirtatious', sympathetic', and 'decisive'. Although the group of adults with WS did not perform as well as the typically developing group (WS 69%, TD 78%, PW 59%) Tager-Flusberg et al., (1998) concluded that "in Williams syndrome there is a selective sparing of the cognitive capacity referred to here as mentalising ability. Clearly adults with Williams syndrome are quite good at reading both simple and more complex mental state information from the eye region" (p.635). This has been supported by evidence that adolescents and adults with WS did not perform at a level predicted by CA but at the same level as a group with non-specific developmental delay when completing the Reading the Eyes task and emotion recognition tasks (n=43, 12-36 years, mean 20 years; Plesa-Skwerer, Verbalis, Schofield, Faja, & Tager-Flusberg, 2006).

It has previously been established that individuals with WS show an intense use of eye contact, relating to aspects of hyper-sociability. In experimental tasks probing eye gaze, Karmiloff-Smith et al. (1995; exp. 1) found 12 participants with WS (9-23 years) performed equivalent to typically developing individuals when using characters' directional gaze to infer intentions. In further research involving adults (n=10 mean 22 years), Karmiloff-Smith (1997) assessed various aspects of faces to investigate processing styles. The exploration included eye gaze matching and participants with WS performed less accurately than a comparison group of typical adults. Ceiling effects were evident in the typical sample and although performance was not at chronological age level, participants with WS showed accuracy over 80%. Further detail and critique of Karmiloff-Smith et al., (1997) will be provided in Chapter 3. Considering the interesting link between evidence of extreme and intense eye gaze in WS (e.g. Mervis et al., 2003), hyper-sociable behaviour (e.g. Jones et al., 2000) and processing eye gaze directions, this area of research has, to date, been relatively neglected (see Appendix B).

In research involving lip reading, a crucial communicative face skill, Böhning, Campbell and Karmiloff-Smith (2002) studied visual and audio-visual interpretation of speech by 13 adolescents and adults with WS (11-52 years, mean 19 years). Participants with WS repeated sounds they heard or saw being spoken on a video. In these conditions participants with WS did not perform as well as a control sample (matched for chronological age) using visual cues but performed at the same level as controls for auditory identification of speech. Visual speech identification was not merely delayed in the sample of individuals with WS, but showed an atypical pattern of performance. Investigating performance across different speech sounds, participants with WS found /th/ and /d/ sounds more difficult in comparison to other sounds (e.g. /b/, /v/, /g/), whereas younger typically developing participants did not show this pattern. Participants with WS were, however, able to integrate information from visual and auditory domains for audiovisual speech perception, and here performance showed delay but not a deviant pattern of performance. Therefore it appears that lip reading, or speech perception ability, may show some aspects of atypical development in WS. Although section 1.2.1 emphasised that language was a strength of the WS phenotype here evidence suggests that visually interpreting face cues to identify speech sounds may be atypical in this group.

Brain activity and face processing

In terms of neuropsychological evidence in WS, brain activity has been recorded using event related potentials (ERPs) during face recognition tasks and has shown little dissociation between human faces, monkey faces and cars (Grice et al., 2001). Typically face and non-face objects activate different brain regions (e.g. Kanwisher, McDermott & Chun, 1997). Additionally, brain activity associated with face perception has been found in both hemispheres, rather than localized to the right hemisphere as evident in typical development. Finally, individuals with WS showed atypical brain activity related to γ-bands. This colludes with evidence from ERP data that individuals with WS show atypical patterns of activation for upright and inverted faces (Mills, Alvarez, St. George, Appelbaum, Bellugi, & Neville, 2000). This may mirror evidence from behavioural tasks involving upright and inverted faces, whereby a lack of inversion effect is reported. Thus, evidence from brain activity studies suggests that face processing is neither as specialized nor localized in individuals with Williams syndrome, as it might be in typical adults (see section 1.3.1). Further evidence of whether individuals with WS show typical activation of the neural systems advocated by Haxby et al. (2000) is clearly warranted and may provide evidence of the underlying mechanisms involved in a variety of face skills (see Figure 1.1).

Relating directly to evidence from Haxby et al. (2000), it has been noted that activation and interactions of prefrontal regions linked to amygdala, (particularly the orbitofrontal cortex) may be associated with social functioning in WS (Meyer-Lindenberg et al., 2005). Individuals with WS have shown less activation of the amygdala in relation to threatening faces of strangers (Meyer-Lindenberg et al., 2005). Additionally, significant increases in activation have been observed in the right fusiform face area (FFA) and several frontal and temporal regions for individuals with WS when interpreting faces and eye gaze direction (Mobbs, Garrett, Menon, Rose, Bellugi, & Reiss, 2004). This may be linked to evidence that individuals with WS have increases in volume of grey matter in a number of brain regions associated with face perception, for example the amygdala and orbital and medial prefrontal cortices (Reiss et al., 2004). Therefore neuropsychological evidence is beginning to be merged with behavioural evidence to understand the underlying neural correlates of social and cognitive behaviours associated with WS.

Conclusions

Karmiloff-Smith et al. (2003) comment that "yet again we need to bury the myth of what at first blush seemed like an intact face processing module in adults with WS. Face processing follows a different developmental trajectory in this clinical population" (pg.238). Relatively good performance on face processing tasks has been shown to be associated with atypical cognitive and brain processes, counteracting original claims of an 'intact' face processing module in WS.

1.4.4 Face processing in Autism

Previously in this chapter, it has been emphasised that individuals with autism exhibit a lack of contact with their social world (Frith, 1999) and show signs of social inhibition (Rutter & Schopler, 1987). Regarding the most prevalent social cue in the environment, an inattention to human faces is apparent at an early age (Osterling, Dawson, & Munson, 2002) with one of the earliest detectable signs of autism being a lack of gaze following in infancy (Baron-Cohen et al., 1996). Research has explored face processing with a view to understanding some of the social impairments evident in autism (see Grelotti, Gauthier, & Schultz, 2002 for a review). It is clear to see how communication as a whole may fail as a result of misinterpreting vital facial cues. Indeed Boucher and Lewis (1992) noted that problems with unfamiliar face recognition could be implicated in some of the social deficits typical to autism.

Several studies have highlighted specific impairments in face processing by individuals with autism; for example problems with memory for faces (Boucher & Lewis, 1992), recognition of emotions (Teunisse & de Gelder, 1994), familiar face recognition (Langdell, 1978) and peculiarities interpreting eye gaze (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1993). Indeed in one study assessing aspects of face processing, Gepner, de Gelder and de Schonen (1996) concluded that children with autism exhibited a generalised deficit at understanding faces across a range of tasks, however the extent of impairment may vary depending on the task domain (see Chapter 3 for more detail of this study). As well as performing at a lower general level of performance on a variety of face skills, the *way* faces are processed in autism may also appear atypical.

Structural encoding: featural or configural processing

It is generally regarded that adults with autistic spectrum disorders encode and remember faces in an atypical manner (Joseph & Tanaka, 2003). It has been suggested that, as in WS, individuals may focus on individual features rather than a whole face configuration. This may link directly to theories of weak central coherence (WCC) in autism, where parts are not coherently integrated into a whole image (see section 1.3.2).

Evidence from the face 'inversion effect' (see section 1.4.1) with participants with autism suggests less of a disruption to performance than typical individuals when faces are inverted compared to upright, again suggesting a lack of configural processing (e.g. Hobson, Ouston, & Lee, 1988; Tantum, Monagham, Nicholson, & Stirling, 1989). However, contradictory evidence has suggested that high functioning adolescents with autism do show an effect of inversion (Teunisse & de Gelder, 2003; exp.1). In research involving 17 participants perceived as high functioning on the autistic spectrum (HFA) ranging 16-24 years, Teunisse and de Gelder (2003) found that the group with HFA showed the same pattern as their typical sample, and recognised upright faces more accurately and faster than inverted faces. The results from typically developing children also suggested that by 9-10 years an inversion effect was evident. This finding has recently been replicated with a different sample of participants with autism (Lahaie et al., 2006).

In research exploring the use of individual features from a holistic representation Teunisse and de Gelder (2003; exp.2) explored the 'composite effect' previously mentioned (section 1.4.1), with the same group of individuals with HFA. Participants showed no composite effect for reaction times or accuracy. This suggests that individuals with HFA make less use of holistic face images and rely more on independent features. Further support for feature-based face processing in autism is derived from the use of whole faces or face parts as previously introduced. Lopéz, Donnelly, Hadwin and Leekam (2004) required participants to match whole faces or face parts to a previously seen target. Seventeen adolescents with HFA (mean age 13 years) showed no difference between using whole faces or individual parts, but when cued to a specific feature they were more accurate with whole faces. Typically developing participants were more accurate for whole faces in all conditions. It therefore appears that when cued, holistic face processing can be achieved by individuals with autism and therefore task demands have a crucial impact on performance.

Lopéz et al. (2004) state that performance patterns for participants with ASD may be highly affected by different samples and tasks, accounting for divergent findings evident in the literature. Here the sample of individuals with autism was particularly high functioning and individuals functioning at a lower level on the autistic spectrum may have shown a different pattern of performance. In summarising this evidence for and against the featural processing of faces in autism, Jemel, Mottron and Dawson (2006) note that "there are conditions under which autistic individuals do not differ from typically developing persons … the versatility and abilities of face processing in persons with autism have been underestimated" (p. 1573). Consideration of level of functioning on the autistic spectrum is therefore particularly important (see Chapter 2).

Communicative face skills

It is unsurprising given typical autistic characteristics that individuals show a range of deficits on experimental tasks probing communicative face skills as well as in everyday situations. One clear area of deficit is that of eye gaze processing, probing the very core of autistic deficits. The ability to perceive gaze direction is an area of specific impairment for individuals with autism (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1993; Gepner, de Gelder, & de Schonen, 1996). However evidence from tasks involving higher functioning individuals has shown an ability to infer when a person is looking at them (Baron-Cohen et al., 1995), pick out a specific object that another person is looking at (Baron-Cohen, 1989) and report which object a person is looking at in a photograph (Leekam, Baron-Cohen , Perrett, Milders, & Brown, 1997). Once again, perhaps participants' characteristics play an important role in determining the pattern of performance for individuals on the autistic spectrum. Recently, Kylliäinen and Hietanen (2004) found that another person's static gaze triggered an automatic shift in visual attention in twelve children with HFA, supporting similar evidence using moving eyes and again involving high-functioning individuals (Swettenham, Condie, Campbell, Milne, & Coleman, 2003). It should be noted that a number of researchers have proposed that gross shifts in horizontal eye gaze direction are perhaps processed automatically and pre-attentively (e.g. Friesen & Kingstone, 1998; Langton & Bruce, 1999) and therefore it could be questioned whether evidence for gaze 'cueing' of this nature really shows that individuals with HFA are able to interpret and understand eye gaze cues. Additionally, it has been noted that although some children with autism are able to develop the ability to interpret eye gaze, this is predominantly restricted to individuals with an IQ of 70 or above (Swettenham et al., 2003). Leekam, Hunnisett and Moore (1998) emphasised that even when this ability does develop, it remains severely delayed compared to participants of equivalent mental age.

Kanner (1943) noted that one aspect of autism was an abnormality in affective contact with others thus implicating emotional understanding as a clear problem. Empirical evidence concerning the processing of emotional expressions in autism is somewhat confusing. For example previous evidence has shown that an individual's ability to interpret expressions is impaired or atypical (Hobson, 1986; Tantam, Monaghan, Nicholson, & Stirling, 1989; Grossman, Klin, Carter, & Volkmar, 2000). Dyck, Ferguson and Shochet (2001) comment that even taking out general level of intelligence, individuals with autism show a unique deficit in recognising emotional expressions. However some studies find emotion recognition at a level predicted by verbal ability (for example, Ozonoff, Pennington, & Rogers, 1990) whilst others suggest that recognition of basic expressions of emotion is unimpaired. For example in research involving 20 children with autism (mean 12-years), Castelli (2005) required participants to recognise expressions of anger, fear, disgust, happiness, sadness and surprise. Across all expressions participants with autism performed as accurately as typically developing children of the same chronological age. There was no evidence of deficits concerning more complex belief-based expressions as has previously been cited; such as 'surprise' (Baron-Cohen, Spitz, & Cross, 1993) or 'fear' (Howard et al., 2000). The emotion of ‘surprise’ has been noted to be particularly difficult for individuals with autism as it is considered a ‘belief-based’ emotion linked to an understanding of other people’s minds (see Chapter 3 more further details). There is therefore a lack of consensus from experimental tasks probing emotional understanding in autism. These contradictions are partly due to inherently different task demands (matching, recognising or sorting tasks) and participant characteristics (e.g. level of functioning on the autistic spectrum).

Looking at faces: evidence from autism

Researchers have applied eye tracking methods to investigate where individuals with autism look when viewing a face or social scene. Van der Geest, Kemner, Verbaten and van England (2002a) found that compared to typically developing participants, seventeen individuals with HFA showed the same pattern of fixation for upright faces. When participants were told to view photographs of faces displaying different emotional expressions (neutral, angry, happy, surprise) and eye movements were monitored, the eye and mouth regions were fixated on longer and more frequently than other areas (across emotions). The study does not dissociate fixations on eyes versus mouth and therefore it is not known whether the groups differed in their fixations towards these regions. Interestingly, when the researchers studied the direction of ‘first fixation’, both groups showed an initial shift towards the eyes. This may seem surprising given eye gaze and communication deficits cited in autism (e.g. Loveland & Landry, 1986). However, little detail is provided by van der Geest et al. (2002a) and it may have been that a shift towards the eye was manufactured by stimuli presentation (e.g. location on the computer screen, size of the image).

Van der Geest, Kemner, Camfferman, Verbaten and van England (2002b), in further research, found that compared to typically developing participants, 16 individuals with HFA showed no evidence of abnormality in gaze behaviour when viewing social scenes. When participants viewed colour cartoon-like images of scenes including one person (e.g. scenes of a house, playground, park) and the pattern of fixation was monitored, individuals with HFA showed the same number of fixations towards the human in the scene as did typically developing participants. Van der Geest et al. (2002b) also found that participants with autism inspected the picture for the same amount of time, had the same total scan path lengths and showed no evidence of a general processing deficit.

However, clear differences between individuals with autism and those who were developing typically were found when viewing clips taken from films. Klin, Jones, Schultz, Volkmar and Cohen (2002) recorded the fixation patterns of fifteen adolescent participants with autism when viewing film clips lasting 30-60 seconds (from Edward Albee's "Who's afraid of Virginia Woolf?") and categorized their gaze into the regions of eyes, mouth, body and objects. Each scene contained an interaction between 4 actors and participants with autism focused twice as long on their mouth region, half the time on the eye region and twice as long on the body region when compared to typically developing participants. They also spent twice as long fixating on the objects rather than the people compared to controls. Across five different clips the effect size between groups was greatest for the eye region. This research supports evidence that individuals with autism spend significantly less time focusing on the eye region of both familiar and unfamiliar faces (Dalton et al., 2005).

There could be a number of reasons why the results of the two previously detailed studies differ. For example, one task used static pictures whilst the other used moving dynamic interactions. Although both type of stimuli incorporate complex social scenes each picture in the study by van der Geest et al. (2002b) contained only one person and the pictures were cartoon-like images. In contrast Klin et al. (2002) took clips from old films and each scene showed the interaction between a number of people. All cartoon faces involved direct gaze whereas the video clips involved the natural interaction between people whilst talking. It may be apparent that the social nature of the stimuli was lessened and hence less demanding in the van der Geest et al. (2002b) task. In contrast Klin comments that "the demanding social complexity in the movie mirrors complicated social situations that individuals with autism may encounter in everyday settings" (Klin et al., 2002; 811). There will also have been clear differences in the size of faces, people and other objects between tasks. From studying the stimuli for each task it is clear that there are distinct differences, which may have impacted upon the results.

Regarding gaze fixation during face viewing, Dalton et al. (2005) found that 11 male participants with autism (mean 15-years) spent significantly less time than typically developing participants focused on the eyes. However, there was no difference between the group with autism and a typically developing group when viewing the mouth area. Interestingly, the group with autism spent the same amount of time looking at the face but spent proportionally less of their time focusing on the eye region. The difference between groups remained irrespective of whether the face was familiar or unfamiliar. Similar results have been cited by Pelphrey et al. (2002) who found that adults with

HFA viewed non-feature areas of the face more than the core feature areas (e.g. the eyes, mouth, nose) compared to a control sample of typical adults. It appears that individuals with autism do not only show deficits on behavioural assessments of face perception, but in general look at faces in a different way than is found in typical development. There may be a relationship between time spent looking at different face regions during development and typicality / atypicality of face perception skills, however the direction of this relationship is currently unclear.

Brain activity and face processing

Autistic spectrum disorders are considered neuro-developmental conditions that may be associated with abnormal connectivity between brain regions (Welchew et al., 2005) and therefore it is unsurprising that a number of neural atypicalities have been cited regarding face processing. Elgar and Campbell (2001) propose that face and emotion processing involves several cortical pathways linking brain structures including the right fusiform gyrus and the amygdala (already noted in section 1.3.2). As the link between brain regions is less developed and atypical in autism, it is understandable that cortical pathways would be affected for face perception. Haxby et al. (2000) emphasise the importance and involvement of several brain regions in the processing of different face cues (Figure 1.1 e.g. recognition of emotion or eye gaze). Elgar and Campbell (2001), alongside a profusion of research with typical adults, have noted the importance of the right fusiform gyrus (fusiform face area) and indeed in individuals with autism this region appears less activated by faces (Schultz et al., 2000). Schultz et al., (2000) showed participants with autism and typical individuals pictures of faces and objects, requiring them to make same / different judgements for two simultaneously presented stimuli. Typical controls showed activation of the fusiform gyrus for faces but not objects, whereas individuals with autism showed no activation of the fusiform gyrus for either type of stimuli. This atypical finding has been suggesteded by a number of researchers (e.g. Critchley et al., 2000; Grelotti et al., 2005 Pierce, Muller, Ambrose, Allen, & Courchesne, 2001).

Section 1.3.2 introduced the amygdala theory of autism, whereby deficits in affective functioning and social intelligence are associated with amygdala dysfunction (Baron-Cohen et al., 2000). Considering the neural basis of face perception a number of researchers have cited the important role played by the amygdala. For example, Grelotti, Gauthier and Schultz (2002) noted that the amygdala showed abnormalities in organisation and function in autism and Dalton et al. (2005) noted that activation of both the amygdala and fusiform gyrus regions was positively associated with time spent looking at the eye region of faces by individuals with autism. They suggest a heightened emotional response associated with gaze fixation in autism, which may in turn link to theories of atypical arousal and activation of the amygdala (section 1.3.2). Schultz (2005) proposed that these areas (amygdala and fusiform gyrus) play a crucial role in atypical development evident in autism, not only are these areas linked to face perception, but to social development as a whole. This again links directly to the amygdala theory previously introduced (Baron-Cohen et al., 2000).

Alongside atypical pathways between brain regions, the neural correlates of activity associated with viewing faces (measured using EEG techniques) is considered atypical in autism (e.g. Dawson et al., 2002; Grice et al., 2005; McPartland, Dawson, Webb, Panagiotides, & Carver, 2004). In fact the parents of children with autism also show atypical ERP responses to faces (Dawson et al., 2005). Evidence of atypical neural activity may also be associated with a different pattern of hemispheric processing of faces in AS compared to typical development (Ashwin, Wheelwright, & Baron-Cohen, 2005). Therefore an abundance of evidence suggests atypical brain functioning in autism, which may be particularly evident when viewing social stimuli and faces. Not only is the activation of different brain regions different in autism, but the connectivity between these regions may also be affected.

Conclusions

Evidence from the body of research exploring face perception in autism is marred by discrepancies in a large number of areas. There is lack of consensus regarding processing style; based on featural or configural information, and concerning communicative face skills. It is predominantly considered that individuals with autism show deficits in face processing linked to problems with social interactions and faces may be understood in an atypical manner in autism. Participant characteristics are clearly important as there is great variability in functioning along the autistic spectrum, which may be associated with differences in face processing skills. There is still much work to be done in this area, working with the same individuals across various tasks and manipulating task demands to find true facets of face processing in this population will ultimately tell us more about social functioning and possible ways of improving performance in social situations.

1.5 Thesis structure

This preliminary chapter has introduced relevant theoretical debates and experimental studies to set the scene for subsequent experimental work. It is important to note that the most relevant theories and references will be examined in greater detail in the appropriate chapters throughout the thesis. The use of inappropriate experimental paradigms, tasks and control groups and individual differences across samples have contributed to a mixed interpretation of face processing in WS and autism. Inadequate reporting of participant characteristics also hinders our interpretation of the results and whether the findings are applicable to all individuals with that specific developmental disorder. This is no more important than in the area of autism research where the spectral nature of the disorder has implications for general abilities and specific face perception skills. Similarly, tasks that result in floor or ceiling effects in the clinical and comparison groups tell us little about true levels of ability. This has been a feature of research involving individuals with both autism and WS (e.g. Deruelle et al., 1999; Karmiloff-Smith, 1997).

The research presented in this thesis aims to provide a more comprehensive investigation of face processing by individuals with WS and autism. The research uses the same group of participants across a number of tasks and paradigms, experimental designs applied to typical developmental face perception research and age-appropriate assessments. The overall aim is to explore skills that are required for identity recognition and the interpretation of communicative face cues. The first line of inquiry (chapter 3) applies tasks with similar cognitive demands across different aspects of face processing (identification, eye gaze, expressions, lip reading). This exploration specifically asks how WS and autism impact upon face processing in these domains, above and beyond level of developmental delay. Previous research with typically developing children by Bruce et al. (2000) applied a variety of tasks to probe these aspects of face perception, but the tasks have not previously been applied to appropriate groups of children with developmental disorders. As well as assessing a variety of skills this investigation allows the first insight into a possible model of face perception in these developmental disorders based on the foundations of Bruce and Young (1986). Theoretically this is important as evidence for or against a modular face perception system (as seen in Figure 1.2) may reveal more about the structure of general cognition in these groups. This approach has not previously been applied to the investigation of face perception in WS or autism.

The second line of enquiry considers the processing of unfamiliar faces, using a number of matching tasks and based on procedures evident in the typical face perception literature. Once again, task design is based on existing paradigms available from typical face perception literature to allow direct comparisons. Where available the same participants are recruited across tasks. Making subtle manipulations and revealing different features allows an insight into the relative salience of different parts of the face and how this may differ across the developmental disorders studied here. Atypical feature salience may be linked to the processing of communicative signals and thus impact upon social interaction styles.

Together these lines of enquiry will further our understanding of face perception skills in WS and autism and may reveal how individuals with these developmental disorders view their world. After all, the human face is probably the most prevalent social cue in our environment. Subsequently these investigations will tell us more about how face processing may be linked to social functioning as a whole. As noted, care is required when research involves special populations and it would not be appropriate to embark upon this investigation without first discussing the methodological considerations that inherently accompany the research. Therefore Chapter 2 considers the important role played by research methods in the interpretation of any subsequent findings and sets the scene for the following empirical investigations.

Chapter Two

General Methods

2.1 Introduction

This chapter considers the methodological issues of the current thesis; justification is provided for the methods employed in subsequent chapters, focusing on why such methodological decisions were taken prior to task implementation. There are always theoretical and methodological considerations when carrying out psychological research, no more so than when the research involves special populations.

2.2 Terminology

Over the last decade or so, the language and phrases used to refer to individuals with some form of developmental delay has varied and been modified; particularly to reduce prejudicial connotations and to maintain respect for the individual. Terms such as ‘mental retardation’ or ‘handicap’ are now used less frequently whilst phrases such as ‘intellectual disability’ are more frequent. Throughout the thesis a number of terms will consistently be used to refer to the participant groups.

Throughout the thesis autism and Williams syndrome (WS) will be referred to as ‘developmental disorders’ which may also be accompanied by co-morbid ‘learning difficulties’. Developmental disorders is a term used to describe severe, life-long disabilities attributable to mental and / or physical impairments, which are manifested before the age of 22 years. The term is used most commonly to refer to disabilities affecting daily functioning in several areas (such as learning, receptive or expressive language, daily independent living, self-care). Usually people with cerebral palsy, autism spectrum disorder (ASD), various genetic and chromosomal disorders such as Williams syndrome, Down syndrome and Fragile X syndrome are described as having developmental disabilities (DSM-IV, APA). As autism and WS provide the main focus for the current thesis, the term developmental disorder will feature recurrently.

Participants with autism will be referred to as such, as all participants adhere to the DSM-IV criteria for autism (DSM-IV category 299.00 Autistic Disorder) rather than the criteria for Asperger syndrome (DSM-IV category 299.80 Asperger's Disorder). However when referring to previously published research in this area including participants with classic autism as well as Asperger syndrome we will use the term Autistic Spectrum Disorder (ASD) referring to the continuum of performance and abilities related to autism.

The term 'learning difficulty' (previously referred to as learning disability) implies some form of delay in learning and functioning. When measured by standardised tests, a learning difficulty will be evident when a person shows an inability to achieve an expected level of proficiency within a particular learning field for their chronological age. This can occur co-morbidly with both autism and WS but may also occur in isolation when it is termed 'non-specific learning difficulty' synonymously with 'general developmental delay'. These individuals will suffer no known genetic syndrome or experience a known neurological injury. Participants with general developmental delay will play an important role in Chapter 3 when matched to individuals with WS and autism to investigate unique aspects of face skills related to the developmental disorders.

2.3 Matching participant groups

This section will consider the design and criteria used for group matching. The research applies a factorial matching design to compare performance on face processing tasks by individuals with autism and WS to groups of children who have developed typically. This section considers the implications of applying a factorial design, however, later in the chapter (section 2.3.2) an alternative approach will be introduced that might allow a developmental perspective to be applied to face processing skills; namely developmental trajectories.

2.3.1 Factorial designs

The factorial matching paradigm so frequently implemented in learning difficulty research is attributed to Hermelin and O’Connor (1970). Research concerning the development of individuals with learning difficulties and developmental disorders has applied a factorial design, whereby dissociations are sought between participant groups (Baddeley & Gathercole, 1999). Such designs are common in research involving individuals with autism and WS, and are intended to detect areas of functioning that are below or above a level predicted by chronological age or level of intellectual ability. Research concerning face processing in autism and WS has largely been based on contrasting performance to typically developing individuals of comparable levels of intellectual functioning or chronological age (e.g. Gepner, de Gelder & de Schonen , 1996; Hobson, Ouston, & Lee, 1988; Deruelle, Mancini, Livet, Cassé-Perrot, & de Schonen, 1999; Karmiloff-Smith, 1997).

To control for poor performance which may be a consequence of intellectual delay, typically developing groups matched on general level of ability are used (Jarrold & Brock, 2004). In the present thesis it is important that both verbal and nonverbal comparison groups are implemented as individuals with autism and WS show dissociations between verbal and nonverbal functioning. In autism it is common for individuals to show more competent nonverbal than verbal ability (e.g. Joseph, Tager-Flusberg, & Lord, 2002) whilst the opposite is apparent in WS (e.g. Klein & Mervis, 1999). To match groups on one of these abilities will by necessity mean they differ on the other. If researchers match participants with autism to a group of individuals who have developed typically on the basis of verbal ability, the participants with autism are likely to show superior nonverbal skills. Additionally, matching on one single measure of intellectual functioning may not reveal the true characteristics of performance; previous research investigating emotion perception in autism found impaired performance when individuals were matched to typical participants of comparable non-verbal ability (e.g. Ozonoff, Pennington, & Rogers, 1990; Bormann-Kirchkel, Vilsmeier, & Baude, 1995), but not when they were matched on verbal ability (e.g. Hobson, Ouston, & Lee, 1988, 1989). The inclusion of both verbal and nonverbal matched comparison groups is therefore important to the current research.

Jarrold and Brock (2004) note that matching participants on intellectual functioning inherently means they will differ in chronological age. The authors comment that increased age is accompanied by increased experience, which may influence task performance. Greater experience may help with, and compensate for, poor performance (Bishop, 1997; Evans, Hodapp, & Zigler, 1995). Therefore, when matching adolescents with autism to younger typically developing children of comparable intellectual ability, there will be differences in experience. For example, Gepner et al. (1996) matched participants with autism to typically developing children of comparable verbal and non-verbal abilities. The mean chronological age of the group with autism was 11 years 3 months, compared to 5 years 7 months and 5 years 11 months for verbal and nonverbal typically developing groups respectively. Six years of additional experience may have impacted upon performance for the group with autism. Gepner et al. (1996) did not include a typical group matched for chronological age. To accommodate this issue, the current thesis matches participants with learning difficulties to typically developing individuals on the basis of chronological age. Therefore, three comparison participants are individually matched to each participant with WS or autism: one on verbal ability (VMA), one for nonverbal skills (NVMA), and one for chronological age (CA). Of course when comparing groups it should be remembered that "findings of no group differences do not ensure that the processes and mechanisms used to compare the specific tasks function in the same way, with the same level of efficiency, or even that they are the same" (Burack, Iarocci, Bowler, & Mottron, 2002; 227).

The decision was made to use groups of typically developing children as the main comparison, meaning it will be possible to address questions of *typicality*. This will allow identification of deficient or superior levels of ability and atypical patterns of performance in the WS and autism groups. Matching typically developing participants on several measures (e.g. mental and chronological age) allows abilities to be compared to predicted chronological and mental age levels of performance. Some previous studies have matched participants with WS to those with Down syndrome (DS) as both groups show dissociations between domains of functioning (e.g. verbal and nonverbal) and patterns of processing (e.g. local and global). Rossen, Jones, Wang and Klima (1995a) compared face processing by individuals with WS and DS. The group with WS performed significantly more accurately than participants with DS when carrying out a number of face processing task (recognition memory and Mooney tasks). Matching groups with developmental disorders to each other, rather than to typical development, means it is less feasible to draw conclusions concerning the typicality of performance.

Additionally, comparing two groups with distinct developmental disorders "is limited because findings are unique to those specific populations and bear few, if any, implications beyond the specific groups" (Burack et al., 2002; 231). However, including children with other forms of learning difficulties as a comparison group may allow researchers to investigate issues of uniqueness (Burack et al., 2002), for example, are deficits in face processing specific to autism or a characteristic of general developmental delay? This directly addresses whether patterns of performance and abilities are 'syndrome-specific'. This may also allow the researcher the potential to control for life experiences, unique to individuals with learning difficulties in general and will be a feature of Chapter 3. In all chapters small groups of matched individuals with WS and autism (matched on chronological age and nonverbal ability) will be compared to infer differences between individuals with these two distinct disorders. As these groups show clear differences in social functioning but have been said to process faces with the same manner of atypicality, this comparison is central to the current thesis.

In Chapter 3, groups of children with non-specific learning difficulties (NSLD, also referred to as general developmental delay) were chosen as the comparison group. Participants in the NSLD group were classified as having general developmental delay by clinicians, based on IQ scores and adaptive behaviour. This decision was taken because the research that forms the basis of the exploration (Bruce et al., 2000) had already been applied to typical development. The study was therefore concerned with how WS and autism *uniquely* impacted upon face processing, above and beyond the fact that the groups were developmentally delayed. The focus was therefore on dissociating these *specific* disorders from general learning difficulties and from each other. In subsequent chapters (experiments 2-7) new tasks were designed and typically developing groups of children participated to compare performance levels and patterns. Therefore the focus for these chapters is less an assessment of *uniqueness* and more concerned with *typicality.*

2.3.2 Developmental trajectories

In a recent paper addressing the importance of matching groups, Jarrold and Brock (2004) concluded that it may be useful to apply regression techniques. This would allow the researcher to determine the specific factors that relate directly to task performance. Alternatively it may be possible to match groups using a carefully designed control task, but this requires the researcher to have a clear idea of the association between the control measure and the paradigm in use (Jarrold & Brock, 2004). In a similar vein, developmental trajectory research relates performance directly to chronological age for each participant, rather than basing performance on average group data. Questions of delay and deviance can therefore be addressed with this method. Developmental trajectory research can be used alongside group matching studies to reveal patterns of performance.

In a similar vein, Karmiloff-Smith et al. (2004) have discussed face processing in WS noting that task performance shows both delay and deviance. The authors note that it is desirable to build developmental trajectories for each specific task. This will provide a complete picture of the development of face processing skills in WS. Indeed “assessments at different ages and levels of functioning are central to creating a comprehensive picture of development across domains of behaviour” (Burack et al., 2002; 231). The tasks used in this thesis may be used in future research across different ages and applying a developmental trajectory approach. Once tasks have been used with groups in the present thesis, it will be possible to modify the procedures for use across ages. It would be necessary to avoid ceiling or floor effects across the developmental spectrum and therefore careful planning is needed, with factorial designs as a first point of reference. For example, across the age range studied by Karmiloff-Smith et al. (2004; exp. 3) accuracy was particularly high (proportional accuracy greater than 0.8) across groups and conditions. This may leave little possibility for improvement with age and is an important factor in research applying developmental trajectories. Factorial studies allow for the concise and reliable design of subsequent developmental trajectory investigations.

2.3.3 Group matching criteria

The previous section introduced the design to be used throughout the present thesis and the matching criteria are now considered. The method of matching groups based on general intellectual functioning has received a great deal of support and there are a number of standardised assessments available to gauge verbal and nonverbal abilities. As noted by Mottron (2004) in a meta-analysis of matching procedures used in autism research (1999-2002), intellectual functioning is the most frequently used matching variable. The most common measures of functioning were the Wechsler Intelligence Scales (46.9% of research), the British Picture Vocabulary Scale (BPVS; 22.3%) and the Ravens Matrices tasks (RPM; 16.9%). The matching measures used in the present thesis are two of the most common implemented in learning difficulty research; namely the BPVS II (Dunn, Dunn, Whetton, & Burley, 1997) and the Ravens Coloured Progressive Matrices (RCPM; Raven, Court, & Raven, 1990). The Wechsler Intelligence scales were not chosen as it would have been necessary to combine the child and pre-school versions of the task due to the abilities of the participants. Combining two versions of the task may have been troublesome and inappropriate.

The BPVS II (Dunn et al., 1997) assesses receptive vocabulary, providing standardised norms for equivalent mental ages. This task is particularly useful when working with participants of a large age range and varying abilities. Children are required to choose which picture, out of four, corresponds to a word spoken by the experimenter. The words become more complex as the task proceeds and the experimenter stops once the child fails to complete a pre-specified number of items. The Ravens Coloured Progressive Matrices (RCPM, Raven et al., 1990) is a child-version of the Ravens' Standard Progressive Matrices (Raven, Court, & Raven, 1992). While the latter is designed for adults as an assessment of general fluid intelligence, the former involves visually matching a target to a pattern, and is therefore less an assessment of general fluid intelligence and more one of visuo-spatial reasoning. Both tasks have been used extensively to match participants with learning difficulties to comparison groups. For example, Gepner et al. (1996) and Boucher and Lewis (1992) used the RCPM as the non-verbal matching criteria for participants with autism in research investigating face processing. Additionally, Hobson, Ouston and Lee (1988) used the BPVS and RCPM as matching measures when investigating face processing in autism.

2.3.4 Direct comparisons between WS and autism

The primary concern of the current thesis is to investigate possible atypicalities of face processing. Due to the limited availability of individuals with the two developmental disorders of interest and the importance of comparisons to typical development, direct relationships between autism and WS are limited. The primary focus is on investigating how each disorder may differ from typical development and therefore makes indirect comparisons between them. To allow some insight into the differences / similarities between WS and autism, small subgroups of each sample are formed in each chapter but these comparisons are based on small groups due to sample availability. Still, these comparisons are critical to understanding how face processing in WS and autism can be dissociated from each other. The divergent nature of abilities in WS and autism makes it particularly difficult to match groups on a number of issues (for example poor language abilities in autism alongside strength in this domain for WS). The primary focus of the analysis is therefore on deviations and similarities to typical development, answering questions of typicality or atypicality. This will become clear throughout each chapter.

2.4 Participant characteristics

Participant characteristics are particularly important when research involves groups with developmental disorders and this section considers relevant information regarding sample size and the diagnosis of autism. These details impact upon the interpretation of results and have relevance to understanding the phenotypes specific to autism and WS.

2.4.1 Sample size

Due to the rarity of WS and the size of the UK, research in this field often involves relatively small samples. The investigations carried out for the current thesis were conducted primarily with individuals in Scotland, though a small number of participants in experiment 1a were from the South East of England. Participants were recruited via the national Williams syndrome Foundation (WSF). All individuals identified by the WSF as being within the age range 6-20 years and residing in Scotland were approached to help with the research. A 74% return rate was achieved for recruitment, with 3 participants having to be excluded due to personal health reasons, additional diagnoses or task difficulty. The final sample size was fifteen individuals with WS for the majority of experiments in this thesis. This size of sample is representative of published research involving participants with WS; for example fourteen adult participants in the Karmiloff-Smith et al. (2004) investigation of face processing trajectories, and eleven participants in an investigation of internal and external feature processing by Deruelle, Rondon, Mancini and Livet (2003; exp. 3).

Individuals with autism were recruited via two schools; one mainstream school with a special education unit and one school for pupils with autistic spectrum disorders (ASD). The difficulty involved when working with participants with autism without additional diagnoses, who are willing and able to participate, and who understand the task demands, means that final sample sizes are often smaller than those originally recruited. Ten children were recruited from the special educational needs unit of a local mainstream primary school, however five of these did not subsequently participate due to difficulties with task compliance and health difficulties. A further twenty individuals were recruited from a special school for pupils with ASD and fifteen pupils subsequently participated. Again five were omitted for a number of reasons, including those previously mentioned.

In total twenty participants with autism took part and all had a confirmed diagnosis of autism. A sample size of twenty corresponds with previously published face processing research involving participants who have autism; for example fourteen individuals with ASD participated in research investigating internal and external feature processing for unfamiliar faces (Rondon, Gepner, & Deruelle, 2003), whilst seven participants were included in research involving various aspects of face processing (Gepner et al., 1996).

The sample size involved in the research means that consideration is required when deciding on appropriate statistical analyses. This is important in the current thesis when investigating the relationship between task performance and chronological age. Although for many individuals with these two developmental disorders, severity of the disorder is independent of chronological age, correlation analyses have been applied to reveal any age-specific effects. Care is needed to make firm conclusions from these correlation analyses due to relatively small samples sizes, however literature searches have revealed that previously published articles in this field of enquiry have used correlation methods with relatively small samples to investigate age-specific results. For example, Deruelle et al. (1999) used Spearman's correlation to investigate the relationship between chronological age and identity matching by 12 participants with WS ranging from 7 to 23 years of age and found a significant increase in accuracy with age. Deruelle repeated this procedure with colleagues in 2004 when investigating the relationship between age and face processing performance for 11 participants with autism spectrum disorder (aged 4 to 13 years). Deruelle et al. (2004) reported an increase in lip-reading ability with age in their sample. Therefore, although some care is needed for claims related to these correlation analyses, these procedures are evident in published articles of a similar nature (also see correlation evidence used by Deruelle et al., 2003 n=12; Karmiloff-Smith et al., 2004 exp.2 n=14; Gepner et al., 1996 n=7).

2.4.2 Confirmation of Diagnosis

All participants with WS were recruited via the WSF and therefore had previously been diagnosed with WS. Diagnosis is traditionally based on a clinical assessment of the distinct medical, behavioural, facial and cognitive characteristics associated with the disorder. Recent advances in genetic testing have allowed a number of individuals to obtain additional medical diagnoses using the fluorescence in situ hybridisation test (FISH). The FISH test detects the deletion of the elastin gene on chromosome 7 which is evident in 98% of individuals diagnosed with WS (e.g. see Morris et al., 1994). Eleven individuals who took part in the present research had previously had their diagnosis confirmed with a FISH test, whilst the remaining four participants had been diagnosed based on clinical assessments.

Due to the entirely behavioural nature of diagnosis for autism and the diverse methods available to clinicians, an additional confirmation of functioning was used to ensure all participants fell within the range for autism. For the purpose of confirming diagnoses, the Childhood Autism Rating Scale was completed by school teachers (CARS; Schopler, Reichler, & Rochen Renner, 1988). The CARS is a useful screening device for children, adolescents and adults with autism (Mesibov, Schopler, Schaffer, & Michal, 1989). Indeed, Eaves and Milner (1993) showed that the CARS correctly identified 98% of their participants with autism and the measure has subsequently been described as "one of the most psychometrically sound and well researched of the scales" for assessing the presence of autism (Browndyke, 2002; 8). Research has found agreement between the DSM-IV and CARS, concluding that it was more reliable than other measures including the Autism Behaviour Checklist, for diagnosing sixty-five children with autism (Rellini, Tortolani, Trillo, Carbone, & Montecchi, 2004). The scale relies upon rating an individuals' behaviour through direct observation with Likert-scale items assessing fifteen aspects of ability (e.g. scoring behaviour as 'age appropriate', 'mildly abnormal', 'moderately abnormal' or 'severely abnormal'). Areas of assessment include, among others, 'relating to people', 'imitation', 'object use', 'emotional response' and 'verbal communication'. The individual is given a total score for the fifteen areas of functioning and a score of less than thirty indicates 'non-autistic', a score or 30-36.5 indicates 'mild-moderate autism' and a total of greater than 37 indicates 'severe autism'.

Previous research has occasionally used mixed groups of individuals with autism and Asperger syndrome, referring to the sample as having autistic spectrum disorders (ASD) often to boost sample size. This may be problematic, especially when carrying out tasks involving social stimuli such as the face. Rondon et al. (2003) investigated internal and external face processing with fourteen individuals with ASD, 8 of whom scored in the autism range of the CARS and 6 classified as having Asperger syndrome (scoring less than 30 on the CARS). In total, scores on the CARS ranged from 20-38 showing extremes of ability. Verbal ability may play an important role when understanding task demands and mixing groups with clear differences in verbal skills may confuse results (verbal mental age ranged from 3 years 5 months to 12 years 3 months).

In autism, previous research has shown mixed findings, often based on sampling differences and individual abilities. The current thesis involves the same group of individuals with autism across chapters and therefore explores face processing with the same group across paradigms. Any discrepant findings across paradigms cannot be a result of participant characteristics. Individual CARS scores were above 30 for all participants and the studies do not mix participants with autism and Asperger syndrome. Using the same tasks with individuals with autism and WS also shows how performance differs across developmental disorders, with the same task demands in place.

2.4.3 Participant age

Across all studies, participants with autism and WS in the current thesis were between 6 and 18 years of age. Previous research investigating face processing in

WS has predominantly focused on adolescents and adults where face processing may be assumed to be ‘fully developed’. For example, Karmiloff-Smith et al. (2004, ages 16 – 51 years), Bohning, Campbell and Karmiloff-Smith (2002; ages 10 – 50 years) and Tager-Flusberg, Plesa-Skwerer, Faja and Joseph (2003; ages 12 – 36 years), only a small number have focused on face processing in children with WS (e.g. Deruelle et al., 2003; 6 –17 years). However, the aim of the present thesis was to explore abilities throughout childhood and adolescence. Paradigms are used that have been applied to developing skills in typical children and therefore in the current thesis we apply these same paradigms to face processing by children with WS and autism. Of course, inherent in designs involving participants of different ages, is the problem of task difficulty across the sample. It is important to avoid both ceiling and floor effects and therefore task design requires careful consideration (Burack et al., 2002).

2.5 Face processing tasks and research methods

One of the main features of the current thesis is that the paradigms employed originate directly from research investigating face processing with adults and typically developing children. Previous research concerning face processing in WS and autism has been characterised by tasks that may not be appropriately designed for the participants. Floor or ceiling effects are evident in a number of studies where tasks may have been too easy or too difficult for the participants with autism or WS and particularly easy for CA matched typical groups (e.g. Deruelle et al., 1999, 2003; Tager-Flusberg et al., 2003). Karmiloff-Smith (1997) conducted research with adults with WS (mean age 22 years) using tasks designed for use with children. Ceiling effects were apparent in a number of conditions for a matched sample of adults. Performance of the group with WS was also particularly high across tasks (over 80%) indicating that the task may have been too easy. After all, the tasks had been designed for use with typically developing children between ages 4-11 years (see Bruce et al., 2000). Additionally, Deruelle et al. (2003; exp. 3) studied internal and external processing for unfamiliar faces by eleven participants with WS. Participants with WS showed greater accuracy using external features, as did control groups of typically developing children, however ceiling effects in all conditions and for all groups hinder the interpretation (over 90% across groups and task conditions; see Chapter 4 for further critique of this research). Care is therefore required during task design to avoid such issues.

Early claims concerning ‘intact’ face processing in WS were primarily based on face recognition memory abilities and often used small samples (e.g. Bellugi, Sago, & Vaid, 1988). Accuracy on the Benton Test of Face Recognition (Benton, Van Allen, Hamsher, & Levin, 1978) was reported to be “well within the normal range” (Bellugi, Sago, & Vaid, 1988; 293) but research often failed to explore face processing in further detail. Only over the last decade has face processing in WS been shown to involve atypical processes (e.g. Karmiloff-Smith et al., 2004). The paradigms employed in the current thesis involve tasks already used to make subtle and sensitive assessments of various face processing abilities in typical development. Some small modification may be necessary for direct application to groups with developmental disorders, but in essence these are rigorous paradigms that have received support in the developmental face processing literature. The thesis expands on previous literature by involving comprehensive and extensive assessments of a variety of face processing skills, not only identity recognition (see chapter 3).

2.5.1 Face-matching and face-recognition paradigms

The majority of studies employ face-matching paradigms to investigate interesting facets of face processing in WS and autism. According to Donnelly and Hadwin (2003) matching tasks allow abilities to be assessed at "the point of face perception rather than at the interface of perception with memory" (Donnelly & Hadwin, 2003; 1016). This removes the reliance upon long term memory representations that are evident during face recognition memory tasks. Group differences are therefore not due to good or poor memory abilities. A number of the paradigms employed in this investigation have previously been used with recognition memory as well as matching paradigms (for example an investigation of upper and lower face processing by Langdell, 1978). Changing the type of task from recognition to matching changes the very nature of processing that takes place and is extremely important. The current thesis therefore also investigates whether patterns of performance are task specific, or whether they are reliable aspects of face processing across paradigms.

The majority of experiments presented in the current thesis involve the processing of unfamiliar faces. Unfamiliar faces were used as the stimuli as these allow the research to focus solely on face processing, rather than the interplay between memory and processing. The difficulty of obtaining familiar faces that are equally well known by all participants is particularly problematic in face processing research and would complicate any investigation of face processing for these groups (noted in chapter 4). Therefore, the current thesis focuses on addressing the way that unfamiliar faces are matched or recognised by individuals with autism and WS. The only experiment to incorporate familiar faces (experiment 3) was conducted solely for the reason of investigating differences between familiar and unfamiliar face processing.

2.6 Conclusions

Research involving participants with developmental disorders inherently involves a number of methodological decisions which have been addressed in this chapter. It is now possible to commence the experimental research conducted to investigate face processing in WS and autism. In directly applying research that has previously been used with typically developing children, chapter 3 explores a variety of face processing skills in autism and WS. Using the same group of individuals, across various domains of face processing the following chapter asks how these two specific developmental disorders impact upon face processing, above and beyond the fact that participants are developmentally delayed. Using tasks purposefully designed for children (Bruce et al., 2000) and matched groups based on the criteria set out in section 2.3.3, this research investigates the processing of identity, eye gaze, lip reading and expression.

Chapter Three

Exploring Face Processing Abilities

3.1 Introduction

The main theme of this thesis is to explore face processing by individuals with autism and Williams syndrome (WS) and this first experimental chapter explores a variety of such abilities. To fully understand faces in everyday situations various different aspects of face processing are required; it is not sufficient to merely recognise people, as cues of expression, eye gaze and lip reading all aid interpersonal communication. Chapter 1 provided a detailed overview of the development of face processing skills in both typical development and WS and autism. The current chapter emphasises the importance of using the same participants across various tasks to eliminate, or at least reduce, the impact of individual differences. Contradictory results plague a clear profile of face processing in both autism and WS and therefore it is particularly important that individual differences are at least controlled for, especially in two developmental disorders characterised by heterogeneity of ability. Chapter 3 probes the ability to process expressions of emotion, identity, eye gaze and lip reading using the same participants across domains of face skill.

3.1.1 Exploring face processing in typical development

Regarding the typical development of various face processing skills, Bruce et al. (2000) presented a comprehensive battery of tasks to a large number of children aged 4-11 years. The research not only assessed children's ability to match faces on identity but also the ability to process eye gaze, expressions and read sounds from the lips. Accuracy was assessed using both recognition and matching tasks to probe each area of face processing and thus manipulating task difficulty. For example, when recognising expressions of emotions, participants pointed to faces depicting 'happy', 'sad', 'angry' or 'surprise', whereas when matching expressions participants chose two faces depicting the same feeling. The overall aim was to produce developmentally sensitive assessments of various aspects of face processing. Specifically, Bruce et al. (2000) produced tasks that were appropriate for use with a wide range of ages.

For each domain of face processing Bruce et al. (2000) found a strong correlation between performance on different tests of the same face processing ability (recognition and matching). Replicating evidence from typical adults and patients with prosopagnosia, they also found evidence for the independence of identity and expression processing (Bruce & Young, 1986). This may suggest that the underlying modular structure and functionality of a face perception system is the same in children and adults, even though differences may occur within a 'structural encoding' node (configural or featural processing as noted in Chapter 1). The authors noted that the battery of face tasks may be useful for identifying children whose face processing ability was not in accordance with their chronological age and as the tasks could be presented on either paper or computer (producing the same pattern of results) this represents a flexible method of testing in different situations and with different groups of individuals. This would be especially useful for learning more about face processing in groups of individuals with WS and autism.

3.1.2 Exploring face processing in Williams syndrome

As noted in Chapter 1, the majority of research exploring face processing in WS has focused on identification. Although early research exploring face identification suggested strong performance and was typified by claims of 'intact' or 'spared' abilities (e.g. Bellugi et al., 1999b) more recent detailed investigations have shown not only a general delay in ability but processing atypicalities (e.g. Deruelle, Mancini, Livet, Cassé-Perrot, & de Schonen, 1999; Karmiloff-Smith et al., 2004).

The scarcity of research exploring communicative face skills has provided a muddled impression of face processing in WS. For example, adult participants have performed well identifying emotional expressions (e.g. Karmiloff-Smith, Klima, Bellugi, Grant, & Baron-Cohen, 1995, exp.1) but when tasks involve moving faces or sorting abilities, this has proved more difficult (e.g. Gagliardi, Frigerio, Burt, Cazzaniga, Perrett, & Borgatti, 2003; Tager-Flusberg & Sullivan, 2000, exp.3; Plesa-Skwerer Verbalis, Schofield, Faja, & Tager-Flusberg, 2006). The little research concerning eye gaze has suggested strong performance, for example using gaze cues to infer intentions (Karmiloff-Smith et al., 1995; exp.1), whilst lip reading ability has been characterised as atypical (Böhning, Campbell, & Karmiloff-Smith, 2002). Procedural manipulations as well as individual difference may contribute to variations found between studies.

As noted, it is important that research involves the same participants across tasks to reduce individual differences and two studies have adopted this approach. In research involving adults with WS (n=10 mean 22 years), Karmiloff-Smith (1997) assessed various aspects of face processing. Participants were required to match faces on either identity, eye gaze direction, expression or lip movements. The tasks were a small selection taken from the Bruce et al. (2000) research previously introduced in this chapter and were therefore designed for use with young children. Unsurprisingly given the original use of the tasks, the comparison group of chronological age matched typical adults performed at ceiling across tasks (over 90% accuracy). The group with WS also performed extremely well, scoring over 80% correct across all matching tasks, except when matching similar faces on identity (group mean approx. 50%). The high performance and ceiling effects in the typical sample suggest these tasks were unsuitable for use with this sample (especially typically developing adults) and therefore the results are rather inconclusive. On the whole however, participants with WS performed less accurately across all matching tasks probing communicative face skills and the study provides some suggestion of adult performance on various face processing tasks.

Deruelle, Mancini, Livet, Casse-Perrot and de Schonen (1999) investigated face processing skills with 12 WS individuals (7-23 years, mean 11 years) and groups of typical individuals matched for mental (MA) and chronological (CA) ages. Tasks required participants to match identity, expressions (disgust, surprise, happy), lip reading (‘a’, ‘o’ ‘i’), eye gaze, gender and age. Overall participants with WS performed at a level predictive of their mental rather than chronological age, even for identity matching which had previously been characterised as ‘intact’ (e.g.

Bellugi, Lichtenberger, Mills, Galaburda, & Korenberg, 1999b). The only task to show chronological age performance in WS was matching lip movements. This result appears somewhat confusing however as the MA group (mean age 5 years) performed better than the CA group (mean age 11 years). It should be noted that performance across the 6 tasks was particularly high with the CA group scoring over 90% for each task (combining tasks mean 95%) and the MA group scoring at around this same level for all tasks except matching on age (overall mean MA 89%). Finally, the group with WS scored above 80% on all tasks and across assessments had an average of 88%. It is possible that these assessments were too easy, at least for participants at the higher end of the age range. The spread of ages was rather uneven and may account for the lack of correlation between task performance and age in the WS group. Of the 12 participants in the WS group, 10 were 12 years and under whilst the remaining 2 were 16 and 23 years respectively. The authors suggest that this lack of correlation provides support for atypicality of face processing rather than mere delay, but this skewed spread of age may affect the correlation. Evidence from these tasks provides some insight into face matching by individuals with WS from 7-23 years however the tasks may not have been appropriate for the participants tested here.

The two studies outlined in this section have emphasised that although it is important to use a variety of tasks, these assessments must be at an appropriate level of difficulty for all participants and age may prove a crucial factor. Importantly, tasks designed for children have not been used to assess children with WS (but rather older participants). In fact, very few studies investigate the abilities of younger participants as the majority focus on older participants due to sample availability, or extend age ranges to boost sample size. Neither of the investigations in this section have incorporated recognition and matching tasks to probe the same face skill. Both Deruelle et al. (1999) and Karmiloff-Smith (1997) required participants to match rather than recognise faces on specific features. A full investigation using both recognition and matching tasks and age-appropriate assessments is clearly warranted.

3.1.3 Exploring face processing in autism

In contrast to WS research, a number of studies have probed face skills by participants with autism. As will become apparent, an increase in the number of studies does not necessarily lead to more consensus of opinion. In research involving a small number of individuals with autism, Gepner, de Gelder and de Schonen (1996) concluded that children with autism exhibit a generalised face processing deficit, however the extent of impairment varies depending on task domain. This large generalisation was based on the abilities of just 7 individuals with autism aged 6 to 17 years and little detail is provided to ascertain level of functioning. Each participant was matched to a typically developing child on verbal ability, one on nonverbal ability and a child with Down syndrome (DS; matched for nonverbal ability). Although combining comparison groups with typical development and learning difficulty groups allows some assessment of both atypicality and uniqueness regarding autism, the rationale for including individuals with DS appears unclear. Although individuals with DS may show no atypicality for face perception, they do have difficulties with expression processing (e.g. Wishart & Pitcairn, 2000; Williams, Wishart, Pitcairn, & Willis, 2005). Gepner et al. (1996) included tasks probing the ability to recognise and sort eye gaze, expression, identity and facial speech. Although there was evidence of a general problem with face processing across tasks, emotion and eye gaze processing were especially poor for individuals with autism. Detecting which (of two) faces showed direct rather than averted gaze, individuals with autism performed around chance (mean 54%). Performance was also particularly poor when sorting faces into expressions of ‘happy’, ‘surprise’, ‘dislike’ or ‘neutral’ (mean 32%).

In another study, Teunisse and de Gelder, (1994) applied a battery of face tests to study face processing in autism. Twenty individuals with autism (7-34 years, mean 16 years) were compared to groups of typically developing individuals aged 7-10 years, 12-17 and 19-34 years. Tasks assessed the ability to match identity across expressions or pose, categorise photos by gender or familiarity, and match individual features. The assessment showed ceiling effects in a number of conditions, however individuals with autism had specific problems when matching features presented in the context of a whole face and categorising faces by expression (happy, sad, neutral). The authors acknowledge that the ease with which many participants completed tasks may conceal subtle group differences.

Deruelle, Rondon, Gepner and Tardiff (2004) more recently studied face matching on the basis of identity, gaze, expressions (disgust, surprise, happy), gender and lip reading (‘a’ ‘o’ ‘i’). Twenty individuals with autism and Asperger syndrome (ASD; 4-13 years, mean 9 years) were matched to typically developing groups on the basis of chronological and verbal mental ages. Across tasks the ASD group performed less accurately than both comparison groups. However, both typically developing groups showed accuracy over 90% for 4 of the 5 tasks. The group with ASD had specific difficulty matching expression, gaze, gender and lip movements. For identity matching the participants with ASD did not differ from the two typically developing groups; however rather than showing stronger performance for this task the results reveal this was an effect of decreased performance by the typically developing groups. The participants with ASD showed great variability of functioning when assessed with the Childhood Autism Rating Scale (CARS) and mixing such a heterogeneous sample may mask subtle differences dependent upon general ability. Specifically, participants scored between 20-38 on the CARS and a score of less than 30 indicates ‘non-autistic’ (Schopler, Reichler, & Rochen Renner, 1980). Sample selection may therefore be questioned. Deruelle et al. (2004) found no relationship between performance and chronological age for the majority of face skills, but it may be more relevant to investigate the relationship between level of functioning on the CARS and task performance. After all, severity of autism and level of functioning is independent of chronological age.

Although tasks have been used that may not be most appropriate for all participants, these three published papers generally concede that individuals with autism and ASD have problems with a number of aspects of face processing. Specifically, communicative skills such as processing expressions or eye gaze are particularly deficient. Taking into consideration level of functioning of participants, appropriate comparison groups, a variety of different tasks and an appropriate range of ages, further research is required to succinctly profile face skills in autism and relate these for the first time to a model of face perception.

3.2 Experiments 1a & 1b Introduction

The aim here is to employ the full Bruce et al. (2000) battery of tasks described in section 3.1.1 to explore face processing by individuals with autism and Williams syndrome. Experiments 1a and 1b will address identification, eye gaze, expression and lip reading and show areas where Williams syndrome and autism can be dissociated from general developmental delay. This will specifically address the *uniqueness* of a face processing profile for WS and autism, rather than questions of *typicality,* which would be answered by comparisons to typical development.

First, experiment 1a applies the Bruce et al. (2000) assessments to participants with WS and then experiment 1b applies the same tasks to participants with autism. This battery has not previously been applied to children with these developmental disorders and the tasks were specifically designed by experts in the field of face perception for use with children. The inclusion of adult participants would create uninformative ceiling effects (see section 3.1.2). Research exploring a variety of face skills has not focused solely on children and young people with WS, but rather a wide age range has been included in previous research to boost sample size (e.g. Deruelle et al., 1999, ages 7-23 years, n=12). In autism previous research has included children and young people but confounded level of functioning (e.g. Deruelle et al., 2004). The tasks place similar cognitive demands upon participants and use similar matching and recognition procedures to assess different aspects of face processing. Based on the premise of Bruce et al. (2000), explorations will, for the first time, consider a model of face perception with these populations. The experiments in this chapter ultimately ask how WS and autism can be *uniquely* dissociated from general developmental delay in terms of eye gaze, expressions, lip reading and identity processing. The aim is to provide an exploration rather than a theoretically driven assessment, importantly with tasks designed specifically for the age group tested. The tasks are not explicitly aimed at exploring ‘structural encoding' or 'delay' or 'deviance' but rather at allowing insights into various face skills.

3.2.1 Experiment 1a

It has been noted that a scarcity of research has explored face processing skills with the same group of individuals with WS and therefore predicting the pattern of performance across domains for the same group of participants is rather complex. However, based on previous studies with a variety of participant groups it is possible to make some hypotheses regarding the predicted pattern of results. It is hypothesised that individuals with WS will perform well across the face skills tested here as evidence has suggested that this group are generally proficient at processing faces. More specifically we predict strong performance on identity matching tasks with performance showing greater accuracy than the comparison groups. Also in accordance with previous literature we would predict a good ability to process eye gaze and expressions of emotion at a level above individuals with general developmental delay. Less research is evident concerning lip reading ability but we might expect a level of performance comparable to verbal mental age.

Method

Participants

As illustrated in Table 3.1, fifteen individuals with WS with a mean age of 10 years 5 months (ranging 6 years 0 months to 15 years 10 months) were recruited through the Williams Syndrome Foundation (Scotland and Bucks, Berks & Oxon branches).

Eleven participants had previously received a positive FISH tests whilst 4 participants had been diagnosed by clinicians.

Table 3.1 Participant details for individuals with WS and their matched comparison groups

Group	N	Gender ratio (males:females)	CA[1]	VMA[1]	NV score[2]
Williams syndrome	15	9:6	10y 5m *(36)*	7y 2m *(21)*	15 *(6)*
VMA Match	15	11:4	9y 6m *(25)*	7y 1m *(20)*	18 *(5)*
NVMA Match	15	12:3	8y 1m *(15)*	6y 0m *(20)*	15 *(5)*

1 Chronological and verbal mental ages provided in years and full months. Standard deviation provided as full months in parenthesis.

2 Nonverbal mental age ability provided as mean score on the Ravens coloured progressive matrices task (max. score 36). Standard deviation in parenthesis

Verbal mental age (VMA) was assessed using the British Picture Vocabulary Scale II (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997), whilst nonverbal ability was assessed using the Raven's Coloured Progressive Matrices (RCPM; Raven, Court, & Raven, 1990; max score 36). Performance of the WS participants was compared with that of two groups of children with general developmental delay (also called non-specific learning difficulties, NSLD). Two NSLD participants were matched to each WS participant; one child matched on verbal mental age (VMA), and the other matched on nonverbal ability (NVMA). T-test statistics showed that each NSLD comparison group did not differ significantly from the WS group with which it was matched on that specific ability (WS-VMA matches p=.89; WS-NVMA matches p=.95). Table 3.1 provides full details of the verbal and nonverbal abilities of each group.

NSLD participants were classified as having global developmental delay by clinicians based on IQ scores and adaptive behaviour. Children were not included in this group if there was a family history of learning difficulty, if they suffered from a known genetic syndrome, or experienced a known neurological injury. Children were also excluded if they had attention deficit hyperactivity, severe sensory or physical impairment, severe behavioural difficulties or autistic spectrum disorder. Theoretically, the inclusion of children with general developmental delay is important as previous research has tended to compare performance with that seen in typical development, however, it must not be forgotten that these children have a specific learning difficulty that impacts upon numerous aspects of development. Although there is often no clear aetiology evident when a child exhibits non-specific learning impairments, we are able to gain important comparative information when studied alongside developmental disorders of known cause.

Ethical approval was granted by the Psychology Department at Stirling University as well as by the Professional Advisory Panel of the Williams Syndrome Foundation. Additionally approval was received from Stirling and Clackmannanshire councils prior to recruitment. Informed consent was received for all participants and parents additionally gave their approval for their child to take part. If parents felt their child would be able to understand the task requirements, the child also signed consent forms giving their approval to participate (particularly relevant to the older typically developing participants in the study). No participant chose to withdraw from the study once they had agreed to participate.

Materials

Tasks were taken directly from research conducted with typically developing children (Bruce et al., 2000) assessing a variety of perceptual and communicative face processing abilities. Figure 3.1 shows examples of matching tasks from each domain (recognition, eye gaze, emotions, lip reading). For all tasks the faces of children were used as stimuli.

<u>Expressions</u>

Tasks assessed the ability to interpret facial representations of four basic expressions of emotion 'happy', 'sad', 'angry' and 'surprise'.

(i) Expression-pair: Participants viewed 12 pairs of faces and were required to point to the person that was 'happy' for each trial, with following blocks assessing each expression in turn (sad, angry, surprise).

(ii) Expression-match: A target face was shown at the top of the page and participants were asked to point to the face of the person at the bottom who 'feels the same way as the person at the top'. There were 12 trials in total (3 for each expression) and an example is evident in Figure 3.1(i).

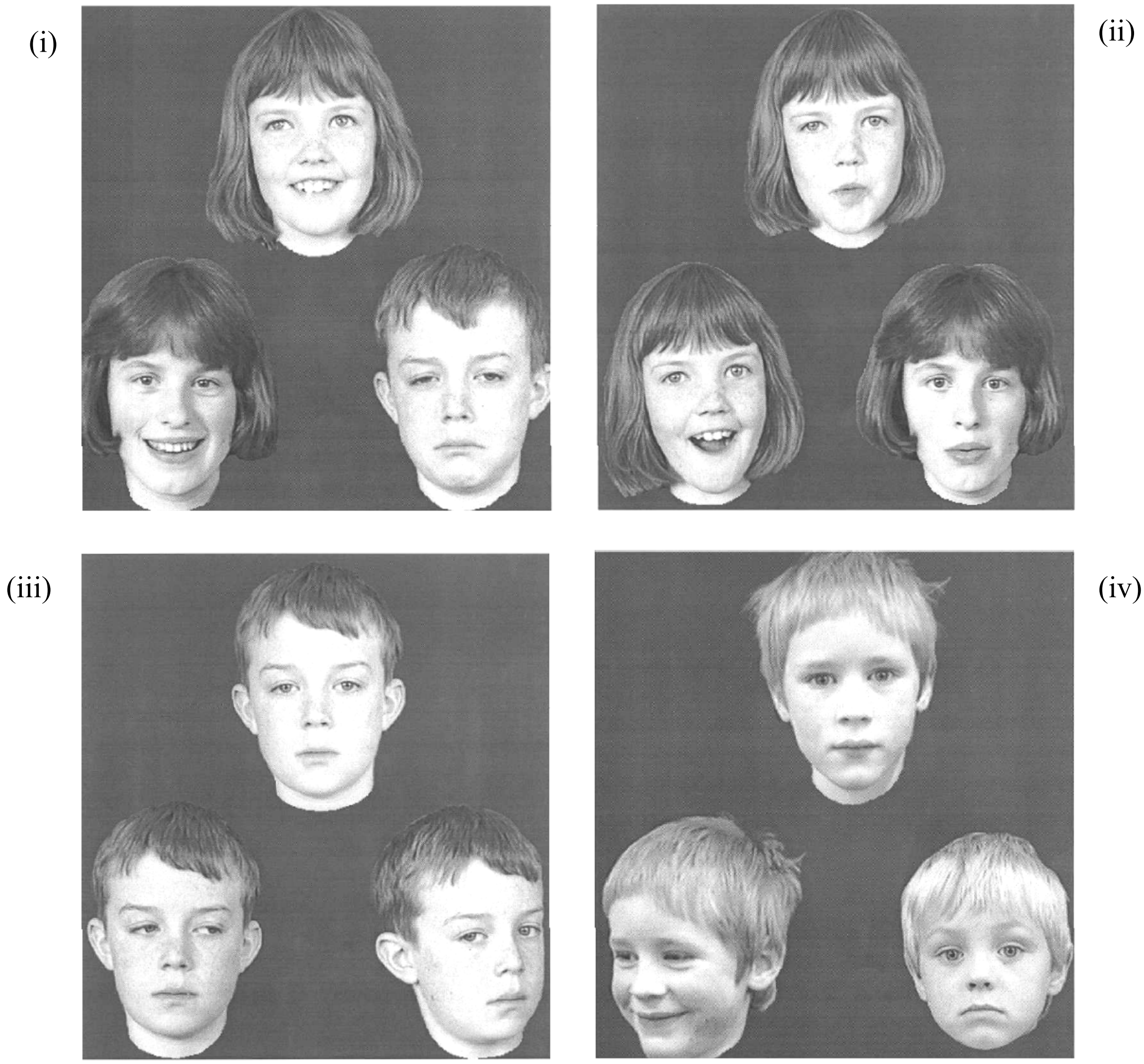
<u>Lip reading</u>

These tasks assessed whether participants could use the mouth region to make a simple judgement using the speech sounds /a/, /i/, /f-v/ and /u/.

(i) Sound-pair: Participants viewed 12 pairs of faces and pointed to the face in each pair that was saying 'ah', followed by blocks of 'ee', 'ff' trials and 'oo' in turn. The researcher spoke the desired sound but the participant was not able to see their mouth when the sound was produced (thus unable to use a visual match).

(ii) Sound-match: The participant was required to point to the child (out of two) that was saying the same as the target child at the top of the page for each of the 12 trials. See Figure 3.1(ii).

Figure 3.1 An example of the matching tasks; (i) expressions (happy) (ii) speech ('oo') (iii) eye gaze (iv) identity



Eye Gaze

Tasks assessed the participant's ability to match eye gaze independent of head direction.

(i) Gaze-pair: Participants viewed two faces presented side-by-side and pointed to the face that was looking at them for each of the 12 trials. Therefore participants detected direct rather than averted eye gaze, eye and head direction may not have been congruent.

(ii) Gaze-match: Participants viewed a target face at the top of the page and two faces underneath. For each trial they were required to point to the person who was looking in the same direction as the target face at the top of the page. There were 12 trials in total and again, head and eye direction may have been congruent or incongruent. See Figure 3.1(iii).

Identification

Participants completed trials by matching faces on identification. In each task the participant chose, from two faces, the picture of the same child as the target face and there were 16 trials for each assessment in this domain. Individuals of similar overall appearance were chosen as target and distracter faces.

(i) ID-matching whole faces: Whole face stimuli were used with target and distracter faces of similar appearance (same gender, similar age, overall appearance). Participants were required to find the two pictures of the same person as evident in Figure 3.1(iv).

(ii) ID-matching internal features: The faces from the ID-matching whole face task were used but the hair and ears (external features) were concealed to stop any effects of external face features.

Procedure

Participants were tested individually with two sessions lasting approximately 20 minutes. Tasks were randomly assigned to test sessions, with participants completing one task from each domain of face processing in each session. For each task participants had to point to the picture they felt corresponded to the correct answer with all tasks being self-paced and stimuli remaining in front of the participant until a response was provided. Bruce et al. (2000) conducted assessments using both computer and pen and paper style tasks finding no difference depending on procedure, therefore for ease of working with the participant groups in the present study, pen and paper presentation was chosen.

As well as assessing task accuracy, the analysis investigates the Fractional Success Rate (FSR) for each participant group. Bruce et al. (2000) set out an FSR to assess the difficulty of each face processing task for children of different ages. Here the FSR identifies group differences and shows where the mean accuracy for a group is representative of the number of participants ‘passing’ the task. Bruce and colleagues set the criterion as the number of participants reaching the 95% criterion on a binomial test with a guessing probability of 0.5. Therefore scores of 10 out of 12 (12 out of 16 for identity matching) constitute a successful pass. The number of participants reaching criterion, with the number of participants in the group as the denominator, is presented for each task. Chi-squared analyses reveal group differences in the number of participants successfully completing each task.

Results

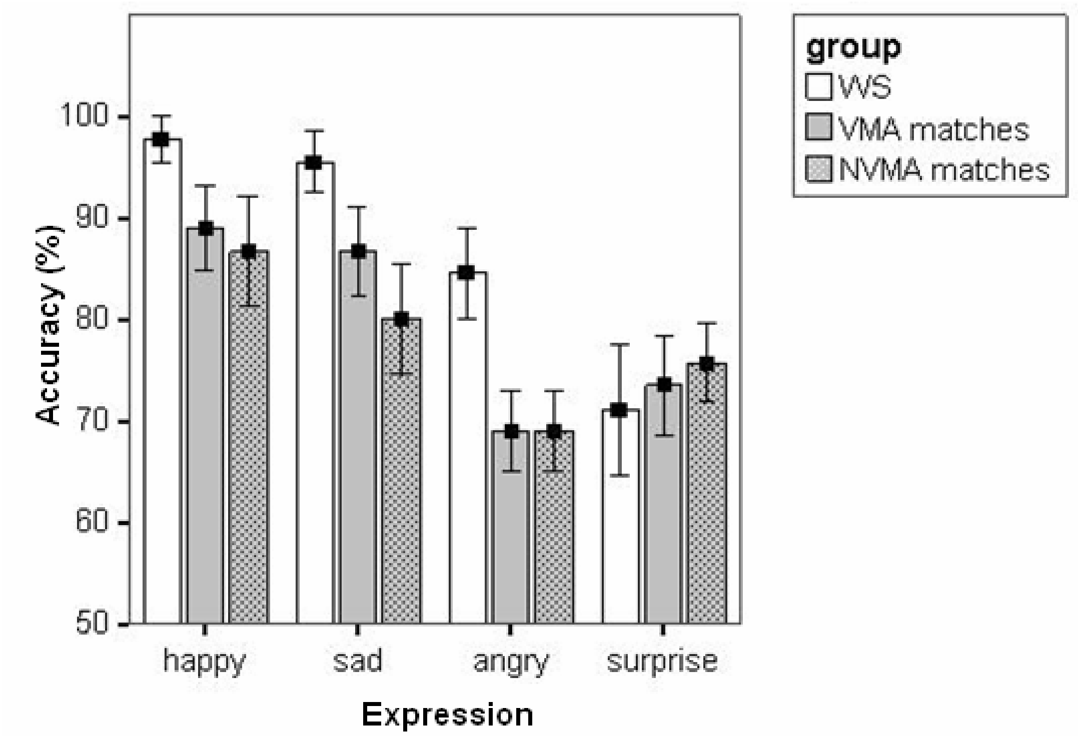
The performance of participants with WS is compared to groups with general developmental delay matched for verbal and nonverbal ability. This section considers each aspect of face processing and explores group similarities and differences in task performance (measured as accuracy level and fractional success rate seen in Table 3.2).

Expressions

Analysis of variance (ANOVA) with factors Task (Exp-pair, Exp-match) and Group (WS, VMA, NVMA) showed that on average participants found recognition easier than matching ($F(1,42)=26.81$, $p<.001$; recognition 81%, matching 75%). Participants with WS performed more accurately than the comparison groups ($F(2,42)=4.21$, $p<.05$; WS 84%, VMA 76%, NVMA 74% see Table 3.2) and the effect size $\eta^2=0.17$ implied that the difference between groups was particularly large (Clark-Carter, 1997). Clark-Carter (1997) notes that an η^2 of 0.138 represents a large effect size, whilst an η^2 of 0.059 is a medium effect size and an η^2 of 0.01 is a small effect size. Participants with WS performed significantly more accurately than those matched for VMA $t(14)=2.63$, $p<.05$ and participants matched for NVMA $t(14)=2.93$, $p<.05$. there was no difference in accuracy between the two groups with NSLD ($p=.51$).

The interaction between variables was not significant as greater accuracy for recognition than matching was evident across groups ($p=.94$). For expression recognition, several participants with WS reached the criterion for success compared to the comparison groups (see Table 3.2). In fact compared to the NVMA group, there was a trend for more participants with WS to pass the expression recognition task $\chi^2(1)=3.39$, $p=.07$.

Figure 3.2 The mean percentage correct for individuals with WS and their matched groups for each expression of emotion



When looking at the performance pattern across expression for which the same pattern was evident across tasks, it is clear that some were more difficult that others (evident in Figure 3.2). This analysis combines the results of the matching and recognition tasks for each emotion. An ANOVA with factors Expression (happy, sad, angry, surprised) and Group (WS, VMA, NVMA) revealed that performance differed across expressions $F(3,126)=14.37$, $p<.001$. T test analyses (using Bonferroni correction) showed that happy and sad did not differ in difficulty ($p=.30$), although happy was easier than both angry ($t(44)=6.22$, $p<.001$) and surprise (t(44)=4.70, $p<.001$). Sad was also easier to interpret than both angry (t(44)=4.09, $p<.001$) and surprise (t(44)=3.74, $p<.01$). Finally, overall there was no difference in the difficulty of angry and surprise ($p=.82$).

There was also a significant effect of Group $F(2,42)=3.51$, $p<.05$. Paired sample t-tests revealed that across expressions individuals with WS performed more accurately than the VMA and NVMA groups (WS-VMA t(14)=2.80, $p<.05$; WS-NVMA t(14)=3.68, $p<.01$) who did not differ (VMA-NVMA $p=.61$). the interaction between variables was not significant ($p=.24$).

<u>Eye Gaze</u>

An ANOVA with factors Task (Gaze-pair, Gaze-match) and Group (WS, VMA, NVMA) showed all participants were better recognising than matching gaze directions ($F(1,42)=25.75$, $p<.001$; recognition 77%, matching 67%). There was also a significant effect of Group $F(2,42)=5.62$, $p<.01$ as WS participants scored higher than both comparison groups (WS-VMA t(14)=3.55, $p<.01$, WS 80%, VMA 68%; WS-NVMA t(14)=3.53, $p<.01$, NVMA 68%), who did not differ (VMA-NVMA $p=.99$). An investigation of the effect size revealed that the difference between WS and the comparison groups was particularly large, $\eta^2=0.21$ (Clark-Carter, 1997). The performance of the WS group remained high for matching gaze directions (WS gaze pair 83%, gaze match 77%) showing competence across task difficulty. The interaction between Task and Group was not significant ($p=.23$).

The FSR (Table 3.2) showed that more participants with WS reached criterion than the comparison groups and this was particularly evident for gaze matching.

Table 3.2 Mean accuracy scores (% correct) and fractional success rates (FSR) for individuals with WS and each matched comparison group across tasks (SD in parenthesis)

	Group		
Task	WS	VMA	NVMA
Expressions			
Recognition	87 *(9)* 11/15	79 *(9)* 8/15	78 *(11)* 6/15
Matching	81 *(10)* 6/15	73 *(10)* 4/15	71 *(11)* 4/15
Overall Mean	84	76	71
Eye Gaze			
Recognition	83 *(9)* 8/15	72 *(13)* 3/15	75 *(15)* 6/15
Matching	77 *(11)* 6/15	64 *(11)* 1/15	61 *(14)* 1/15
Overall Mean	80	68	68
Identity			
Whole face	71 *(15)* 6/15	65 *(16)* 6/15	71 *(16)* 9/15
Internal features	55 *(8)* 1/15	44 *(12)* 0/15	40 *(13)* 0/15
Overall Mean	62	55	55
Lip Reading			
Recognition	84 *(12)* 9/15	73 *(13)* 5/15	73 *(16)* 6/15
Matching	76 *(11)* 7/15	69 *(17)* 4/15	61 *(20)* 3/15
Overall Mean	79	71	67

Compared to each comparison group more individuals with WS passed the gaze matching task $\chi^2(1)=7.58$, $p<.01$ (for each comparison group). Compared to the verbal matches (but not the nonverbal group) more participants with WS also passed gaze recognition $\chi^2(1)=3.89$, $p<.05$. Strong performance for eye gaze processing was therefore evident in the number of participants with WS passing the task as well as the mean accuracy.

Identity

For all groups participants were significantly better using the whole face than internal features. An ANOVA with factors Task (Identity whole, Identity internal) and Group (WS, VMA, NVMA) confirmed this preference ($F(1,42)=121.7$, $p<.001$; identity whole 69%, identity internal 47%). The WS group did not perform significantly better or worse than the developmental delay groups (overall $p=.15$). It is difficult to draw firm conclusions from the data concerning internal feature matching as all groups were poor when external features were masked, in fact performance was not significantly different from chance for any group when just using internal features (compared to chance levels WS group $t(14)=2.05$, $p=.07$; VMA group $t(14)=2.12$, $p=.07$; NVMA group $t(14)=-2.84$, $p=.06$). There was however a trend for a difference from chance level for all groups and the direction of this difference varied across groups (WS participants greater than chance, all typically developing groups lower than chance). There was also a significant interaction which can be explained by the performance of the WS group being affected less by covering the external features than the NSLD groups ($F(2,42)=5.63$, $p<.01$), however as stated, with performance close to chance level such claims should be interpreted with care. The FSR revealed no group differences in the number of participants passing the identity matching assessments.

Lip Reading

Participants found it easier to recognise speech sounds than match them, as confirmed with an ANOVA with factors Task (Lip Read recognition, Lip Read matching) and Group (WS, VMA, NVMA). Recognition performance was significantly higher than matching $F(1,42)=37.19$, $p<.001$ (mean recognition 76%, matching 69%). A significant interaction ($F(2,42)=4.05$, $p<.05$) showed that the only group for whom this pattern was not significant was the VMA group (for whom there was no difference between matching and recognition). Regarding overall accuracy, there was a trend for a difference between Groups ($F(2,42)=2.82$, $p=.07$) created by the difference between the WS and NVMA groups. Although there was a trend for a difference in accuracy for the VMA and WS groups ($t(14)=2.00$, $p=.07$); with greater accuracy for the WS group, the NVMA group performed significantly poorer than the WS group ($t(14)=2.79$, $p<.05$). Overall there was no difference in accuracy between the VMA and NVMA groups ($p=.45$). The FSR revealed no difference in the number of participants passing the tasks.

Age, performance and the relationship between face tasks

To investigate the effect of chronological age on task performance the above mentioned analyses were repeated with age in months as a covariate. Age was a significant covariate only for identity matching but did not impact on the results pattern. When age was considered, the difference between whole face and internal feature matching was lessened ($p=.06$), but the interaction of Group by Task was not affected. Spearman Rank correlation revealed that chronological age was only associated with identity processing ($p<.05$) as increased age was related to greater accuracy (see Table 3.3).

Although some care is needed due to sample size (n=15), Spearman Rank test revealed few significant correlations between tasks probing different aspects of faces, suggesting the independence of skills. Between domains, matching lip movements was correlated with recognising expressions; both tasks involve interpretation of the mouth region. There were also correlations between the two tests of identity processing and the two assessments of lip reading ability (*p*<.01)

Table 3.3 Correlation between each face processing task and chronological age for participants with Williams syndrome. R = recognition task, M = matching task, W = whole face, I = internal features

	Expressions		**Eye gaze**		**Lip reading**		**Identity**	
	R	*M*	*R*	*M*	*R*	*M*	*W*	*I*
chronological age	.27	.07	.42	.17	.434	.26	**.54***	**.54***
exp recognition		.39	.04	.30	**.52***	**.66****	.38	.33
exp matching			.15	.30	.25	.30	.41	.13
gaze recognition				.06	.09	.01	.17	.27
gaze matching					.04	.26	.13	.02
lip reading rec.						**.88****	.38	.32
lip reading match.							.46	.34
identity whole								**.70****

* *p<.05*

** p<.01

but all other relationships were non-significant. The lack of correlation between tasks probing the same face skill (recognition versus matching) for two face domains (emotions and eye gaze) suggests different mechanisms may be in play dependent upon task demands and suggests evidence of atypicality (based on evidence of typicality proposed by Bruce et al., 2000). Most importantly, the correlation between identity and expression processing was not significant, suggesting evidence of the independence of these skills cited in typical development (Bruce & Young, 1986). A typical model of face perception may be evident in 6-16 year olds with Williams syndrome.

Discussion

On a battery of face recognition and matching tasks, individuals with WS were able to process expressions of emotion and eye gaze with greater accuracy than individuals with general developmental delay. The specific behavioural phenotype for WS may relate to expertise in these areas of understanding people and faces. For example, strength using the eyes may support evidence that WS toddlers use social engagement devices like eye contact and focus on faces from an early age (Jones et al., 2000).

Rather than basing claims of proficient face processing in WS solely on identity, other aspects of faces must be explored as these are equally important and differentially impacted upon. In this study identity processing did not dissociate individuals with WS from general developmental delay and performance was not at a level predicted by chronological age (compared to Bruce et al., 2000). Using tasks that are age-appropriate and avoid ceiling effects reveals a deficit in identity processing for 6-16 year olds with WS. Typically developing children performed at the level approximate to these participants with WS by the age of 6-years and the WS individuals involved in the current research were much older than this. Therefore the current tasks suggest a severe delay regarding identity processing and no evidence of 'intact' or strong performance for this group.

Indeed using various face processing tasks children with WS do not show ubiquitous strong performance. Williams syndrome leaves relatively intact certain aspects but negatively influences others to a similar extent as the comparison groups. Taking the data shown here alongside research by Bruce et al. (2000), performance remains below that predicted by chronological age across *all* domains. Directly noting evidence from Bruce et al. (2000) the performance of their participants aged 5-6 years is approximately comparable to the evidence presented here for older individuals with WS. Once again, early claims of 'intact' face processing in WS should be interpreted with care and this investigation reveals a detailed profile including communicative skills as well as identification.

Across the ten years of age studied here (6-16 years) there was a significant correlation between chronological age and identity processing but not other face tasks. Deruelle et al. (1999) applied correlation analyses with their participants with WS as a large age range was evident (n=12, 7-23 years) but found no correlation between age and identity processing. This may, in part, be due to the dispersion of age in their sample and high accuracy leaving little scope for improvement. Additionally, as with the current study, some care should be taken due to small samples. Bruce et al. (2000) showed that children increased in face processing ability with age (4-10 years) across various face skills, but in WS this pattern appears restricted to identity processing. Of theoretical importance, supporting evidence from adults and patients with lesions, participants with WS between 6 and 16 years showed no relationship between expression and identity processing, supporting the independence of skills (e.g. Bruce & Young, 1986). The lack of correlation between a large majority of face tasks and domains suggests a modular approach. This is the first preliminary evidence for the modularity of face perception in WS, supporting a theoretical model found in typical development.

3.2.2 Experiment 1b

Extending the exploration to autism allows an investigation of face skills uniquely associated to this developmental disorder. On the basis of research reviewed earlier in this chapter, it is hypothesised that participants with autism will show deficits concerning expressions of emotion and eye gaze. Performance for these two domains will fall below that evident in general developmental delay. Overall a generalised deficit will be evident, though this may be no more than found in general developmental delay for areas of identity and lip reading

Method

Participants

Twenty participants ranging between 6 years 2 months and 16 years 0 months (mean age 12 years 0 months) with autism were recruited from local schools (group details seen in Table 3.4). Five participants attended the special educational needs unit of a mainstream primary school and the remaining fifteen children attended a special school for children with Autism. All participants had previously been diagnosed by clinicians and referred to their school / education unit through their local authority clinical psychologist. Children in the autism group satisfied the diagnostic criteria for autistic spectrum disorder according to the DSM-IV (1994) and the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Rocher Renner, 1988) classified 11 children as mild-moderately autistic, and 9 children as severely autistic. No participant scored out with the autistic range. Data analysis revealed no overall difference between these two subgroups of individuals with autism on accuracy and therefore participants are considered as one autism sample. Participants with autism were individually matched to two children with non-specific learning difficulties (NSLD); one matched on verbal and the other matched on non-verbal mental age as in experiment 1a. The autistic participant group had a mean verbal mental age of 5 years 11 months as assessed on the BPVS II and a mean nonverbal score on the RCPM of 15. Each of the matched groups did not differ significantly from the group with which it was matched on the matching task (autism and VMA matches *p*=.84; autism and NVMA matches *p*=.97). Full details of participant characteristics are available in Table 3.4.

Table 3.4 Participant details for individuals with Autism and their matched comparison groups

Group	N	Gender ratio (males:females)	CA[1]	VMA[1]	NV score[2]
Autism	20	16:4	12y 0m *(33)*	5y 11m *(14)*	15 *(7)*
VMA Match	20	12:8	7y 6m *(12)*	6y 0m *(15)*	13 *(5)*
NVMA Match	20	14:6	8y 10m *(30)*	6y 6m *(16)*	15 *(8)*

1 Chronological and verbal mental ages provided in years and full months. Standard deviation provided as full months in parenthesis.

2 Nonverbal mental age ability provided as mean score on the Ravens coloured progressive matrices task (max. score 36). Standard deviation in parenthesis

Results

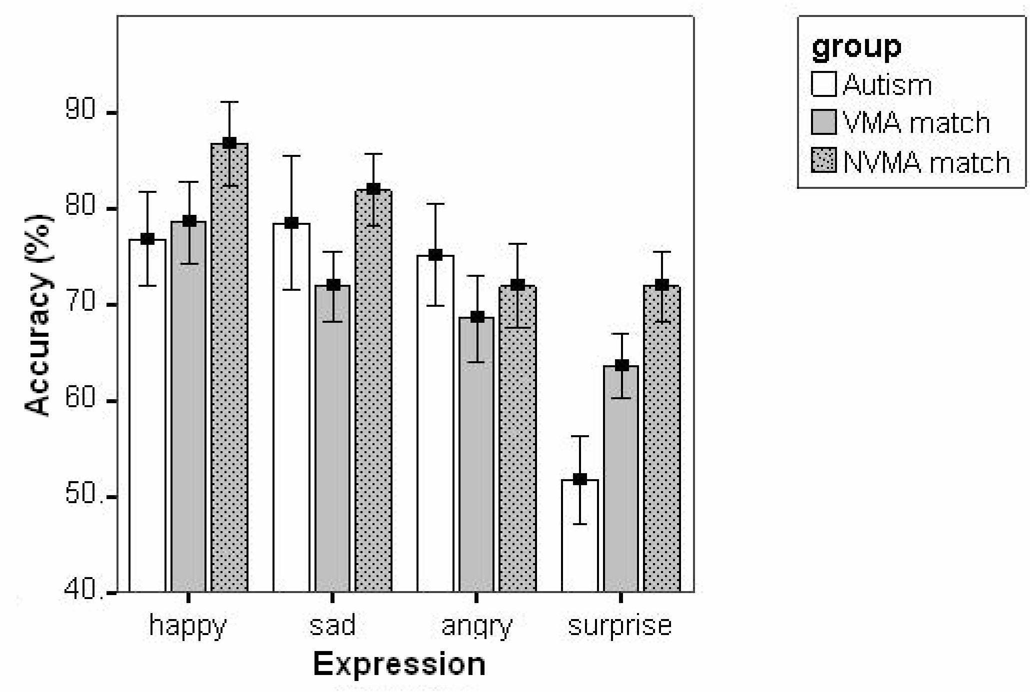
The performance of autistic participants is directly compared to that of the comparison groups matched on VMA and NVMA and each domain of face processing is addressed in turn (see table 3.5 for accuracy data for each domain).

Expressions

An ANOVA with factors Task (Exp-pair, Exp-match) and Group (Autism, VMA, NVMA) revealed that performance differed across Task $F(1,57)=5.62$, $p<.05$ with greater accuracy for recognition than matching (73% and 70% respectively). There was an effect of Group $F(2,57)=3.75$, $p<.05$ and the interaction between Task and Group was also significant $F(2,57)=3.25$, $p<.05$. For expression matching individuals with autism performed significantly less accurately than both comparison groups (matching task autism-VMA $t(19)3.37$, $p<.01$; autism-NVMA $t(19)=5.09$, $p<.001$) but for expression recognition the autism group only performed less accurately than the NVMA group (recognition task autism-VMA $p=.99$; autism-NVMA $t(19)=.78$, $p<.05$). The effects were supported by the number of participants passing each task as the FSR revealed fewer participants with autism passed the matching task compared to the NVMA group, but no other comparisons were significant $\chi^2(1)=6.14$, $p<.05$.

Taking the four emotions separately (seen in Figure 3.3) we apply an ANOVA with factors Group (autism, VMA, NVMA) and Expression (happy, sad, angry, surprise) to these data. There was no difference between Groups ($p=.17$) however there was an effect of the Expression ($F(3,171)=13.41$, $p<.001$). Overall comparing the four emotions, happy and sad were equal in difficulty ($p=.30$) but happy was easier than

Figure 3.3 The mean percentage correct for individuals with Autism and their matched groups for each expression of emotion



both angry (t(59)=3.13, *p*<.001) and surprise (t(59)=6.28, *p*<.001). Sad was easier than surprise (t(59)=4.67, *p*<.001) but not different from angry (*p*=.10). Finally, surprise was also more difficult than angry (t(59)=2.78, *p*<.01) making it the most difficult emotion to interpret. There was however a significant interaction between group and emotion (F(6,171)=2.14, *p*=.05) and along with Figure 3.3 it appears that this was created by the autistic group compared to the two learning difficulty groups for the expression of 'surprise' but not for the other expressions. The only expression to show a significant difference between groups was the 'surprise' expression where the autism group performed less accurately than either comparison group (autism-VMA t(19)=2.11, *p*<.05; autism-NVMA t(19)=2.86, *p*<.05).

Table 3.5 Mean accuracy scores (% correct) and fractional success rates (FSR) for individuals with Autism and each matched comparison group across tasks (SD in parenthesis)

		Group	
Task	Autism	VMA	NVMA
Expressions			
Recognition	70 *(15)* 8/20	70 *(12)* 6/20	78 *(13)* 10/20
Matching	63 *(12)* 1/20	71 *(11)* 5/20	75 *(8)* 7/20
Overall Mean	66	71	76
Eye Gaze			
Recognition	58 *(15)* 5/20	73 *(13)* 6/20	75 *(13)* 9/20
Matching	52 *(18)* 3/20	62 *(10)* 1/20	65 *(11)* 0/20
Overall Mean	55	68	70
Identity			
Whole face	63 *(14)* 8/20	68 *(12)* 8/20	69 *(11)* 7/20
Internal features	50 *(15)* 1/20	46 *(12)* 1/20	49 *(10)* 2/20
Overall Mean	57	57	59
Lip Reading			
Recognition	81 *(11)* 11/20	73 *(16)* 8/20	73 *(12)* 6/20
Matching	71 *(13)* 7/20	66 *(16)* 4/20	63 *(12)* 3/20
Overall Mean	79	71	67

Eye Gaze

An ANOVA with factors Task (Gaze-pair, Gaze-match) and Group (Autism, VMA, NVMA) revealed an effect of Group $F(2,57)=6.18$, $p<.01$. Participants with autism performed less accurately than both comparison groups (autism-VMA $t(19)= 2.57$, $p<.05$ autism 55%, VMA 67%; autism-NVMA $t(19)=3.77$, $p<.01$, NVMA 70%) who did not differ (VMA-NVMA $p=.46$). The effect size between groups was particularly large, $\eta^2=0.18$ (Clark-Carter, 1997). The autism group did not perform significantly different to chance level (chance =50%, $p=.27$), however the VMA group performed significantly above chance ($t(19)=7.14$, $p<.001$) as did the NVMA group ($t(19)=8.17$, $p<.001$).

Overall participants were more accurate recognising than matching eye gaze as shown by a significant effect of Task $F(1,57)=42.41$, $p<.001$ (recognition 69%, matching 59%). The interaction between Task and Group was not significant ($p=.41$). The performance of the autism group was at chance on both tasks demonstrating that the gaze deficit was autism specific (autism compared to chance gaze pair – $t(19)=1.65$, $p=.12$; gaze match $t(19)=.41$, $p=.69$). Fewer participants in the group with autism passed the gaze matching task than the nonverbal matched $\chi^2(1)=3.91$, $p<.05$ but no other pass rates differed across groups.

Identity

Both autistic participants and the matched comparison groups found it easier to match identity using the whole face than internal features. This was confirmed by an ANOVA with factors Task (identity whole, identity internal) and Group (Autism, VMA, NVMA) revealing a significant effect of Task $F(1,57)=103.11$, $p<.001$ (mean identity whole 67%, identity internal 49%). Indeed performance for all groups was not significantly above chance level when the external features were removed (autism $t(19)=.09$, $p=.93$; VMA $t(19)=1.4$, $p=.18$; NVMA $t(19)=.28$, $p=.79$). Additionally, there was no effect of Group ($p=.73$) as confirmed by the FSR and the interaction between the factors was not significant ($p=.36$).

Lip Reading

To investigate the ability to process lip movements an analysis of variance was conducted with factors Task (speech recognition, speech match) and Group (autism, VMA, NVMA). This revealed that the effect of Group was not significant ($p=.14$) as also evident from the FSR. There was a significant effect of Task $F(1,57)=50.79$, $p<.001$ as recognition was easier than matching (mean recognition 76%, matching 67%). The interaction between Group and Task was not significant ($p=.45$). All participants were able to complete the tasks with performance significantly greater than chance levels (overall mean autism 76%, VMA 70% and NVMA 68%). Therefore autism did not appear to uniquely impact on ability to read lip movements.

Age, performance and the relationship between face tasks

To consider the relationship between chronological age and task performance, the analyses were repeated with age in months as a covariate. The effect of age was not significant in any domain. This is clearly presented in Table 3.6 for the autism group and evident from Spearman Rank correlation tests. When level of functioning was considered using CARS score, there was a significant negative correlation between the CARS and expression, eye gaze and identity processing but not for lip reading. A significant negative correlation indicates that a high score of 'severity' of autism was associated with lower accuracy on face tasks.

Table 3.6 Correlation between each face task, chronological age and CARS score for participants with Autism. R = recognition task, M = matching task, W = whole face, I = internal features

	Expressions		**Eye gaze**		**Lip reading**		**Identity**	
	R	*M*	*R*	*M*	*R*	*M*	*W*	*I*
CARS score	**-.66****	**-.45***	**-.46***	**-.57****	-.19	-.09	**-.53***	**-.60****
chronological age	-.44	-.28	-.21	-.21	.28	.05	.08	.02
exp recognition		**.59***	.41	.35	**.43***	.07	**.45***	**.50***
exp matching			.24	.26	.29	.32	**.51***	.23
gaze recognition				**.79****	**.51***	.39	**.47***	.34
gaze matching					**.50***	.44	**.59****	**.52***
lip reading rec.						**.76****	**.45***	**.46***
lip reading match.							.32	.22
identity whole								**.69****

* *p<.05*

** *p<.01*

The correlation between face tasks revealed a number of significant relationships, particularly with whole face matching correlated with tasks in other domains. The correlation between matching and recognition tasks was significant for each domain (at least *p*<.05) indicating that the two tasks tapped the same face processing skill, replicating evidence from typically developing children (Bruce et al., 2000), and contrasting with evidence from WS in experiment 1a. Interesting here, the abundance of significant correlations between domains of face processing suggests an atypical relationship between face skills. Importantly, identity and emotion processing were significantly correlated for participants with autism. Evidence from this study with 6-16 year olds suggests a lack of modularity regarding face processing in autism and goes against a typical Bruce and Young (1986) model of face perception. In autism the correlation between tasks and poor performance across domains suggests a common generalised deficit. The current analysis suggests an atypical model of face perception in autism.

Discussion

In the present exploration participants with autism showed face processing ability that was impaired to differing degrees depending upon task domain, supporting previous research (e.g. Gepner et al., 1996). Although poor performance was evident for identity, speech sounds and particularly emotions, it was eye gaze that presented the most striking deficit. This relates to research concerning the core diagnostic features of autistic spectrum disorders. Along with problems seen to a lesser extent for expressions, these two domains of face processing relate directly to the key characteristics of autism. While face identity matching and lip reading were less problematic than other skills and remained at levels expected for general learning difficulties. Participants with autism did not perform with greater accuracy than children with general learning difficulties in any domain. Considering evidence from Bruce et al. (2000) participants with autism performed below their chronological age. In the areas where recognition and matching tasks were used, participants repeatedly found it easier to recognise than match aspects of faces. This may be a specific effect of task design rather than a firm conclusion regarding recognition and matching tasks as the same pattern was found across ages by Bruce et al. (2000).

In the current exploration, a specific ‘surprise’ deficit was found for participants with autism. Baron-Cohen, Spitz and Cross (1993) commented that this represents a ‘cognitive’ rather than ‘simple’ emotion as it is induced by belief rather than situation. This expression requires coding of both eyes and mouth so participants use various facial features. Baron-Cohen et al. (1993) found that participants with autism made more mistakes concerning surprise than comparison groups. The finding that surprise was particularly difficult for the participants with autism in the current study therefore replicates previous research. However, all participant groups found surprise the most difficult expression to recognise and match and the inherent difficulty of this emotion may play an important role in the observed deficit for participants with autism. The issue may be more an issue of ‘difficulty’ than a conceptual ‘surprise’ problem. The fact that participants with autism show a general lowering in ability may subsequently mean that when a more complex expression is considered performance falls to chance level. Further consideration of this issue is warranted.

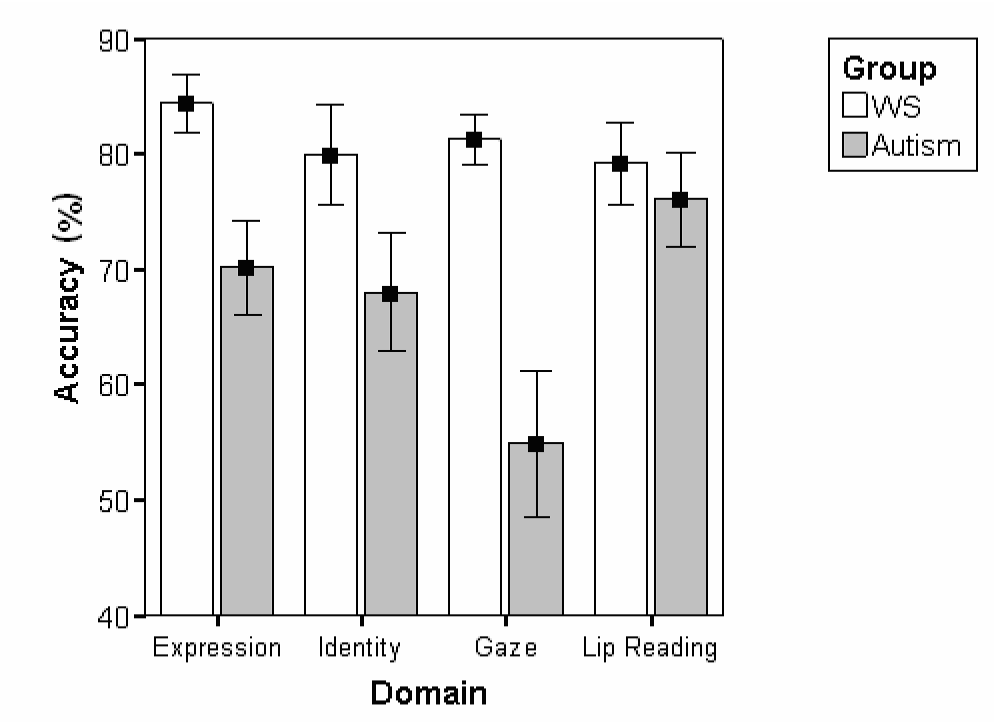
The correlation analyses indicated that chronological age was not related to performance, but level of ‘severity’ of autism was negatively associated with face processing. It should be remembered that these are correlation analyses and that the direction of this relationship can not be determined. Interestingly Deruelle et al. (2004) showed evidence from children with ASD of a significant correlation between age and lip reading ability, however level of functioning was not considered. In that previous research level of functioning may have been particularly important as the 11 participants included individuals ranging from 20 to 38 on the CARS. For the current tasks, apart from processing lip movements, poorer face processing skills were correlated with higher CARS scores. Regarding eye gaze and emotions, the domains that most clearly dissociated individuals with autism from general developmental delay, there were strong relationships between level of functioning and performance.

Providing a novel contribution to this area the current study showed evidence against a modular face perception system in autism. There was a significant relationship between numerous face tasks, and importantly between emotion and identity processing. Bruce and Young (1986) provide evidence for the independence of emotion and identity in their typical model of face perception that is not supported by these 6-16 year olds with autism. The correlation between domains suggests a more general deficit and a common skill affecting performance. A lack of modularity for face perception may be characteristic of autism.

3.3 Direct comparisons between Williams syndrome and autism

To allow a direct comparison between the abilities of individuals with autism and WS to interpret these four aspects of faces, the results from a small sample of participants for each group was analysed. To allow the autism and WS groups to be matched, the sample was trimmed to provide a direct match on the basis of chronological age and nonverbal ability. The resulting sample comprised 12 individuals with WS and 12 individuals with autism. The two groups were comparable in terms of chronological age (WS mean 11 years 8 months, autism mean 10 years 10 months $t(11)=.34$, $p=.74$). They were also comparable in terms of nonverbal ability as measured by the Ravens Coloured Progressive Matrices (WS mean 16, autism mean 16 $t(11)=.22$, $p=.83$). The groups varied in their verbal abilities due to the divergent nature of linguistic skills between these two populations.

Figure 3.4 Performance across face domains for a matched group of individuals with WS and autism



To investigate any difference in the profile of abilities across groups an ANOVA was conducted with factors Domain (expression, identity, gaze, lip reading) and Group (Williams syndrome, autism). The score for each domain was the combined accuracy for the recognition and matching tasks. The ANOVA revealed a significant effect of Domain $F(3,66)=4.79$, $p<.01$ when the groups were combined as performance varied dependent on the face skill that was required as evident in Figure 3.4 and this was noted as a particularly large effect ($\eta^2=.18$; Clark-Carter, 1997). There was also an expected large effect of Group $F(3,66)=5.63$, $p<.01$, $\eta^2=.28$ as individuals with WS performed more accurately than those with autism (mean WS 81%, mean autism 67%). Finally there was an interaction between

Domain and Group $F(1,22)=8.37$, $p<.01$ as the pattern of performance across domains varied depending on group membership (see Figure 3.4).

As expected from the previous analyses and inspection of Figure 3.4 the groups with WS and autism varied on two important domains of face skill, where individuals with WS performed more accurately than those with autism. The ability to processing expressions of emotion ($t(11)=3.18$, $p<.01$) and eye gaze directions ($t(11)=3.78$, $p<.01$) varied significantly between groups. Investigation of the effect size of the difference between groups on these two skills indicated particularly large effect sizes (expression d= 1.18, eye gaze d=1.54). Use of lip reading cues ($p=.55$) and identity matching ($p=.11$) were not significantly different between groups, as expected from the evidence of the separate groups already presented. Investigation of the effect size between groups indicated little difference in ability and a small effect size for lip reading ability (d=.28) and a medium effect size for identity processing (d=.71). Although WS and autism may not uniquely impact upon the processing of identity or lip reading skill, they vary differently and uniquely impact upon the processing of expressions of emotion and eye gaze cues. The clearest dissociation between groups involves the interpretation of eye cues for gaze processing.

3.4 General Discussion

Evidence from the current exploration emphasises that Williams syndrome and autism can be dissociated from general developmental delay, and from each other, primarily on eye gaze ability. In this domain participants with WS and autism exhibited contrasting profiles, those with WS performed more accurately than children with general developmental delay whilst participants with autism performed less accurately. The direct comparison between individuals with these disorders showed the greatest difference in ability regarding eye gaze. In WS this may relate to claims of exaggerated behaviour in social interactions (e.g. Jones et al., 2000) and intense eye contact (e.g. Mervis et al., 2003), whilst in autism this relates to core autistic deficits. Comparing the evidence from WS to previous research (Bruce et al., 2000) indicates that although performance was more accurate than individuals with general developmental delay, it remained below chronological age level. This contrasts with research suggesting intact abilities to infer intentions using directional gaze (Karmiloff-Smith et al., 1995) but supports evidence that adults with WS perform less accurately than age-matched comparisons when matching gaze directions (Karmiloff-Smith, 1997). Using age-appropriate tasks, the present study reveals that eye gaze detection is less affected in WS than general developmental delay, though performance remains below age-appropriate levels. The current evidence for gaze processing in autism confirms findings from previous research, such as evidence from Gepner et al. (1996) involving a smaller sample of individuals. Evidence of gaze recognition and matching performance with the same participants, using tasks which avoid floor and ceiling effects, emphasises the deficit. Correlation analyses provide preliminary support for previous research suggesting that gaze processing is linked with level of functioning rather than chronological age in autism (e.g. Swettenham et al., 2003). The correlation analyses also imply that gaze processing shares a common and atypical relationship with other face skills that differentiates models of face perception in autism and typical development. This contrasts with WS where the current evidence suggests a typical model of face perception.

Concerning the processing of expressions, participants with WS performed more accurately than those with general learning difficulties and also more accurately than individuals with autism. Strong performance processing expressions of emotion is surprising given evidence from previous research with WS participants using moving faces (e.g. Plesa-Skwerer et al., 2006, Gagliardi et al., 2003). However, the additional ingredient of movement in previous research may make the task more difficult for WS participants and relate directly to dorsal-stream deficits widely reported for this population (e.g. Reiss et al., 2004). Although the present task shows strong performance for the group with WS more ecological assessments using moving faces reveal subtle deficits. The current research confirms that when we compare the findings with other research explorations expression processing is not at an age appropriate level in WS, even though these individuals are characterised as sociable and empathetic. The independence of this skill is highlighted by the lack of correlation between processing facial expressions and identity processing, suggesting a typical face perception system and modularity. However, in autism there was a relationship between expression and identity processing. Individuals with autism performed relatively poorly regarding expressions, supporting research by Gepner et al. (1996). Deruelle et al. (2004) also found that children and adolescents with ASD were poor regarding expressions, more so than for identity (also supported here). Analysis of the four emotions revealed that participants with autism performed as well as learning difficulty matches for sad, happy and angry but showed a specific deficit regarding surprise (supporting Baron-Cohen et al., 1993).

Identity processing and lip reading ability did not dissociate WS or autism from general learning difficulties or indeed from each other. Previous research in WS has suggested that audio-visual speech perception develops atypically (Böhning et al., 2002), in the current tasks matching and recognition ability was predicted by mental age. Böhning and colleagues required participants to produce speech sounds, whilst the current task required recognition and matching of visual representations of sounds, therefore different task demands are apparent. The current task indicates that when 6-16 year olds with WS are required to visually 'lip read' sounds, performance is not dissociated from general developmental delay. The same could be said for participants with autism, who performed at a level predicted by their mental age. Evidence from the correlation analyses indicate that in autism the ability to lip read is not affected by level of functioning assessed by the CARS. Gepner et al. (1996) note that this was one ability that was less deficient than emotion or eye gaze processing, however Deruelle et al. (2004) found that lip reading was poor in autism when participants matched speech sounds. Here the use of recognition and matching tasks indicates that autism did not uniquely affect lip reading ability, any more or less than general developmental delay.

One of the most important findings of the current exploration is that participants with WS did not match faces at a level predicted by their chronological age. This contrasts with early claims of 'intact' identity processing (Bellugi et al., 1999b). Participants with WS performed as predicted by their mental age, and no different to individuals with general developmental delay. This supports claims that performance is below age appropriate levels (e.g. Deruelle et al., 1999). In addition to poorer performance than predicted by chronological age, the current exploration did not aim to identify processing *styles*, and therefore the task may be completed atypically (e.g. evidence from Deruelle et al., 1999; Karmiloff-Smith et al., 2004). Using age appropriate assessments and avoiding floor or ceiling effects, the current tasks of whole and internal face matching reveal a level of delay in WS. Early claims of 'preserved' identity processing continue to be questioned by more thorough investigations. The current investigation does however, support the independence of an identity system in a model of face perception (Bruce & Young, 1986) and implies a typical modular approach in WS.

Identity processing in autism was not dissociable from general developmental delay and thus autism was not uniquely related to a deficit in identity matching. Gepner and colleagues (1996) noted that identity matching was generally deficient in autism, but was not as poor as expression or eye gaze and this was replicated. The fractional success rate for identity matching tasks revealed that the performance of the group with autism mirrored the pattern of performance of the comparison groups, emphasising general task difficulty. The inclusion of the whole face and a condition where only the internal features were available may relate to evidence from research using face-parts by Teunisse and de Gelder (1994). In that study participants with autism found it easier to match face parts rather than whole faces, though removing the external features was particularly problematic in the current tasks. Recent research suggests that adults with high functioning autism show superior performance for face parts, but are able to interpret the overall configuration under specific task demands (Lahaie et al., 2006). Also studying higher functioning individuals Deruelle et al. (2004) found participants with ASD performed equivalently to typical children of a comparable chronological age. In that study participants scored much lower on the CARS than in the current research and we show that CARS rating is negatively correlated with identity processing.

Condensing the findings across face processing domains individuals with WS did not perform at a level predicted by chronological age. Contrasting early evidence from research by Bellugi and colleagues (1994) that adolescents with WS showed preserved and intact face processing, the current tasks reveal how this developmental disorder uniquely impacts upon face processing (not only identification but a variety of communicative skills). Considering level of developmental delay and applying age appropriate tasks, chronological age levels of performance are not present. The evidence supports a typical model of face perception with modularity of skills and the independence of emotion and identity processing. Further investigation may reveal subtle atypicalities within this system although this was not an aim of the current exploration and we do not explore the *source* of group differences. This research may lead to explorations of atypical performance, as well as applications to adult and younger participants. The findings of the current tasks appear typical of children and adolescents with autism and WS though extrapolation to adult abilities may be needed. The current tasks were designed for the age group studied here and it is important that age appropriate tasks are used; the inclusion of adult participants with these tasks is likely to create uninformative ceiling effects. Research to date has explored aspects of the structural encoding of faces in WS (regarding featural and configural processing, e.g. Karmiloff-Smith et al., 2004) but further research may explore other components of a model of face perception in more detail.

Across the four domains of face processing participants with autism showed general deficits for face skills and particular problems interpreting eye gaze and under some task conditions expressions of emotion. Gepner and colleagues (1996) emphasised that autism was characterised by a general deficit of varying degrees across domains. The present study supported this claim with a larger sample, recognition as well as matching tasks and taking into consideration level of severity of autism. Importantly, face processing in autism appears to be driven by severity of the disorder and is independent of chronological age. The inclusion of recognition as well as matching tasks allowed task difficulty to be moderated and shows deficits with different task demands. The general problems proposed by Gepner et al. (1996) may relate to a common deficit implied by the current investigation. A lack of modularity for face perception in autism appears characterised by a general atypical and deficient mechanism linked to both expression and identity processing. The relationship between many face domains and specifically emotion and identity processing emphasises an atypical face perception model.

It is important to note that the model of face perception that is used here is derived from adult data and is therefore viewed as a static model. The participants are not adults and are still developing face skills, whether this development is typical or atypical. Bishop (1997) emphasises that "it is dangerous to assume that a model of cognitive processing that is derived from the study of adults can be applied without modification to children: There is ample evidence that the nature of underlying representations may evolve in the course of development" (p.908). Therefore some care is required for this interpretation of face models in WS and autism. However, the fact that Bruce et al. (2000) cite the independence of skills tapping expressions of emotion and identity in typically developing children as young as 5-6 years and the group with autism in this chapter are much older than this, it is unlikely that a 'modular' system is likely to emerge and solely be delayed. The data presented here therefore provide an extremely useful first insight into how face perception systems in these disorder may be different from those seen in typical development. The inclusion of adult participants, or a developmental trajectory approach, may be valuable here for assessing any change in ability with age. However, as noted in the following section, chronological age may be less relevant than other measures when thinking about any developmental changes that occur.

Evidence from correlation analyses suggest that chronological age is not the best predictor of ability for participants with autism or WS. The investigation of age was not one of the primary aims of the investigation however analyses considering age were conducted (some caution is needed due to relatively small sample sizes). Further studies could involve age in more detail and investigate developmental trajectories. Correlation analyses also investigated the association between face processing domains. Research has previously emphasised independent cognitive mechanisms for identity and expression processing in individuals with general developmental delay (Singh et al., 2005). The model of face recognition by Bruce and Young (1986) established that different domains were processed as separate components of the cognitive system for faces. Correlation analyses in the current study revealed that participants with WS mirrored typical evidence of no relationship between expression and identity processing whilst these were significantly correlated in autism. This may provide preliminary evidence for an atypical model of face processing in autism but not WS.

In conclusion, the current study provides insights into the processing of identity, expressions, lip reading and eye gaze in WS and autism to ask how these two developmental disorders uniquely impact upon performance. In WS performance appears relatively strong, though not intact, across all aspects of face processing. Importantly, the lack of correlation between tasks probing the same ability (recognition and matching) suggests some processing differences compared to typical development. There is however evidence of the modularity of face processing in WS with the independence of expression and identity processing mirroring a typical model of face perception. In autism, eye gaze and processing certain emotions (e.g. surprise) are especially problematic but some skills (e.g. lip reading) are not uniquely impacted upon. A lack of evidence for the modularity of face perception provides new evidence of processing differences in autism. The results make a novel contribution to our understanding of face processing in autism and WS and specifically contribute to evidence for models of face perception in these two distinct developmental disorders.

3.5 Conclusions

The experiments reported in this chapter provide a profile of how Williams syndrome and autism can be dissociated from general developmental delay and from each other on the basis of various aspects of face processing. A profile of capabilities, emphasising how expression and eye gaze processing specifically impact upon expertise, is presented and discussed for each group of children and informs us of important aspects of face processing abilities in these developmental disorders. For the first time it is possible to use tasks to begin an investigation of possible models of face perception in autism and WS. The overall structure of any model may be apparent by the relationship between expression and identity processing, relating to typical developmental and patients with prosopagnosia (e.g. Bruce & Young, 1986). It must be remembered that care is needed to appropriately modifying adult models for use with children and those with developmental disorders. Subsequent chapters will consider components of a face perception model in more detail, for example assessing structural encoding properties.

Although the current chapter has focused on communicative skills, subsequent chapters will allow further exploration of identity processing, as it is crucial we recognise the important people in our social interactions. Inherent within this exploration we will learn more about how specific features of the face are processed and thus link directly back to this investigation of communicative face processing. All the face stimuli used in Chapter 3 were unfamiliar to participants and although they inform us of essential abilities concerning communicative face skills, they do not inform us about *familiar* face processing abilities. Chapter 4 investigates more directly how styles of face processing may relate to the familiarity. Once again investigations will be constructed on the premise of published research in the field of typical face perception.

Chapter Four

Familiar and Unfamiliar Faces

4.1 Introduction

This thesis investigates face processing by individuals with either Williams syndrome (WS) or autism. Chapter 3 explored various aspects of face processing in these developmental disorders, identifying domains of strength and weakness. The previous chapter also showed how WS and autism could be uniquely dissociated from general developmental delay and from each other on the basis of face processing performance (specifically eye gaze and to some extent expression) and began a discussion of possible models of face perception in these groups. The correlation analyses suggested that there may be fundamental difference in the *way* faces are processed in WS and autism. Chapter 4 now addresses one important domain of face processing in more detail; namely identification, and how familiarity may influence processing style. Identity matching ability did not differ across groups in Chapter 3 (even between WS and autism groups) and the issue of familiar and unfamiliar face processing allows the opportunity to delve deeper into this domain.

Face identification must be mastered successfully for an individual to function in their social world. It is essential that we are able to recognise friends and family for interactions to take place. As discussed in Chapter 1, there has been some suggestion that individuals with WS and autism do not identify faces in the same way as typically developing individuals (e.g. Mills, Alvarez, St. George, Appelbaum, Bellugi, & Neville, 2001, Deruelle, Rondon, Gepner, & Tardif, 2004). Chapter 4 explores these claims by investigating the use of internal and external features for familiar and unfamiliar face processing. We first explore the use of internal and external face areas for matching unfamiliar faces by individuals with WS (exp. 2a) and autism (exp.2b). As the participants with autism all attend the same residential special school this allows the additional opportunity to study the way personally familiar faces are processed (exp. 3).

4.1.1 Processing internal and external features

Internal features specifically refer to the eyes, nose and mouth whilst external features incorporate the hair, ears, and chin (see Figure 4.1 later in this chapter). Over the last two decades researchers have used methods of covering, cropping and blurring these areas to identify the type of face feature that is more or less useful for processing familiar and unfamiliar faces. Research has concluded that a different type of information is more or less useful depending on the familiarity of the face.

4.1.2 Review of the adult literature

Adults rely on internal and external face features to a different extent when processing familiar and unfamiliar faces (Ellis, Shepherd, & Davies, 1979; Phillips, 1979; Endo, Takahashi, & Maruyama, 1984; Young, Hay, McWeeny, Flude, & Ellis, 1985). Research has reliably shown that masking the internal features of familiar famous faces has a more detrimental effect on recognition than masking external features (Ellis et al., 1979; Young et al., 1985). This preference is not found for unfamiliar faces which are either recognised equally well from internal and external features (Endo et al., 1984; Hines, Jordan-Brown, & Juzwin, 1987; Phillips, 1979), or show an advantage for external features (de Haan & Hay, 1986; Nachson, Moscovitch, & Umilta, 1995; Young et al., 1985). Although different results have been cited in various studies using unfamiliar faces, this is likely to be due to differences between the size of the face area on view, as well as methodological issues such as blurring or cropping procedures. Importantly, no research has found that internal features are most useful for identifying unfamiliar faces.

As well as using recognition tasks, research has used matching paradigms to investigate this effect. For example, Young et al. (1985) asked participants to match individual face parts (either internal or external) to a whole face image and found that only for familiar faces were the internal features matched significantly faster. There was no difference in response times for the external features of familiar and unfamiliar faces. This difference between the relative use of features for familiar and unfamiliar faces drives the argument that familiarity effects face processing style. Taken together the evidence from recognition and matching tasks with adults indicates that the internal features of familiar faces are processed relatively more accurately than external features, an effect not found for unfamiliar faces.

Tracking the effect of familiarity on processing style, Bonner, Burton and Bruce (2003) used a familiarisation task with moving and static faces to explore the use of internal and external features. Participants repeatedly viewed videos of moving faces from a variety of positions over several days. Sixteen undergraduate participants completed face matching tasks on three consecutive days and it was found that as accuracy to match faces increased with familiarity, so did the ability to utilise the internal features (more so than external features). The ability to match internal features increased over the three days as faces increased in familiarity and by the end of the experiment internal accuracy had increased to the level of external performance. However, there was relatively little change in the ability to match external features across the three day study. Therefore, alongside matching and recognition tasks showing relatively higher accuracy for internal over external trials of familiar but not unfamiliar faces, Bonner et al. (2003) showed how this shift emerged with a change in familiarity.

4.1.3 Review of the developmental literature

Developmental researchers have been interested in the emergence of the internal feature advantage for familiar face processing. Campbell et al. (1995) studied qualitative differences in processing personally familiar and unfamiliar faces using internal and external features, with eighty children aged 3-11 years. The researchers cropped face stimuli to produce whole faces, internal feature and external feature trials and asked participants whether the person in the photograph attended their school. The research revealed children aged 3-7 years were more accurate using the external features of familiar faces, however this shifted towards an internal advantage by 10-11 years of age.

Campbell et al. (1999) carried out further research investigating famous face recognition with 5-15 year olds to clarify their previous findings using personally familiar faces. This time they used blurring to cover features in case the cropping procedure previously used appeared unnatural to young participants. Five to 11-year olds performed more accurately with external than internal features. Twelve and 13-year olds were equally accurate across conditions and the internal advantage did not appear until participants were aged 14-years. So in this study the researchers found evidence of a shift at a later age using a different type of familiar face stimuli (famous rather than personally familiar) and using a different procedure to manipulate images (blurring not cropping).

Both recognition studies by Campbell and colleagues found that children use external features more accurately for familiar faces before they develop the adult-like increase in internal feature accuracy. Thus research implies a qualitatively different strategy in use by young children compared to adults. However some caution should be taken as external feature accuracy may be exaggerated by the specific stimuli used. During their cropping procedures Campbell et al. (1995) did not remove all extraneous paraphernalia and clothes could be seen in some pictures of familiar people in the external condition. The relative size of the internal and external areas of the face is an inherent problem with this type of comparison and the addition of paraphernalia in the external condition may have added to this. Additionally it has already been stated that different results have been produced using different procedures (e.g. cropping, blurring) and different types of familiar faces (e.g. famous, personally familiar). In addition, recognition rates in the Campbell et al. (1999) study are very low for the youngest participants. Five and 6-year old boys only identified a mean of 4 out of 10 famous whole faces. This may indicate that the faces were not highly familiar to all participants, or indeed equally familiar. This is a major problem of using famous people as familiar face stimuli with children.

To try to replace the use of famous people as familiar stimuli Want, Pascalis, Coleman and Blades (2003) addressed the salience of internal and external features in the recognition of experimentally ‘familiarised’ faces with 5-, 7- and 9-year old children and adults. Their study used faces with which participants were briefly familiarised via a video recording. Participants were provided with internal or external features to identify faces they had previously seen and those that were new. All age groups showed faster reaction times and greater accuracy for external features for both types of face stimuli (‘familiarised’ and ‘new’). Recording reaction times can be problematic with young children who find computer tasks difficult and whose times vary dramatically. When providing an analysis of these reaction times, and studying overall accuracy, Want et al. (2003) did not explain whether there was evidence of a speed-accuracy trade off or whether they only analysed correct responses. This is important due to the low accuracy for the youngest group of participants, especially with the internal features (5-year olds mean internal accuracy 58%).

More recently research has investigated the processing of internal and external features of personally familiar *and* unfamiliar faces through matching *and* recognition tasks (Bonner & Burton, 2004). The researchers addressed face processing with both familiarity and task procedure manipulated with the same participants. Familiar faces were pictures of the participants’ classmates whilst unfamiliar faces were of children the same age from a different school. In the matching task participants were required to decide if two faces varying in view (either whole face, internal or external features) were the same person or different people. In the recognition task participants were required to identify the person from internal or external features. The same results were achieved through recognition and matching paradigms. Evidence of an internal feature advantage was found in children as young as 7-years of age for familiar but not for unfamiliar faces. The authors claim that by this age the pattern of processing for familiar faces appears 'stable' and adult-like. For unfamiliar faces internal feature matching was not significantly more accurate than external matching and therefore this internal advantage was only apparent for familiar face stimuli.

Together, studies with child participants build a rather unclear picture of the developmental timing of the emergence of an internal feature advantage for familiar faces. Importantly however, the relative increase in accuracy for internal than external features is reliably absent from unfamiliar face processing across the developmental spectrum.

4.1.4 Review of Williams syndrome and Autism literature

Within an internal / external face processing paradigm, Rondon, Gepner and Deruelle (2003) studied unfamiliar face processing by individuals with autism spectrum disorders (ASD mean 10 years, ranging 4-14 years). The fourteen participants with ASD were matched to groups of children of comparable chronological (CA) and verbal mental ages (VMA). Rated on the Childhood Autism Rating Scale (CARS) participants with ASD ranged from 20-38, thus showing Aspergers syndrome to severe autism. Participants matched face parts (internal or external) to whole face stimuli based on identity. However, pattern matching strategies may have been possible due to no change in view between stimuli pictures. There was a difference between groups as participants with autism performed equally well for internal and external features but typically developing groups were most accurate using external features. However, investigation of the data reveals extremely high accuracy across groups and conditions, indicative of the ease of the task and possibly related to the use of pattern matching strategies (overall mean CA 96%, VMA 87%, ASD 86%). Although some care is needed due to these factors, no group showed evidence of a relative increase in internal feature accuracy of these unfamiliar faces.

In a second experiment by Rondon and colleagues (2003, exp.2), chimeric faces consisting of the external features of one person and the internal features of another person were used. Again participants matched whole faces and face parts based on identity. For this task all groups were equally accurate when using internal and external features. The authors do not provide the overall mean error rates for the task and therefore it is not possible to investigate the overall ease or difficulty of the task. Across the two tasks Rondon et al. (2003) concluded that participants with autism utilised internal and external features equally for unfamiliar face processing. However, the age range of participants in the autism group was very wide (4- to 14-years) and previous research with typically developing children already reviewed in this chapter has shown variations in style dependent upon chronological age (Campbell et al., 1995, 1999; Bonner & Burton, 2004). This is particularly important when including very young children in the sample. Rondon et al. (2003) do not consider age variations in performance across their sample or indeed show if the average pattern of performance was representative of all cases. Additionally the authors include children ranging from Asperger syndrome to severe autism and mixing such a heterogeneous group may be problematic and thus care should be taken when interpreting the findings.

Deruelle, Rondon, Mancini and Livet (2003; exp. 3) studied internal and external processing for unfamiliar faces by eleven participants with WS. Individuals ranged

5-17 years for chronological age, thus showing a wide age range. Front views of faces were used and participants matched the appropriate face part to a whole face target. Internal trials consisted of oval shaped faces with external features cropped and external trials were whole faces with the internal features covered with a black oval. Examination of the available data reveals that the group with WS had a mean error rate of 1.2 (for 32 trials) in the external condition and therefore extremely high accuracy. Pattern matching strategies may have been used as the only difference between target and stimuli faces was a change in size (rather than view) and this may account in part for the high performance. Participants with WS showed greater accuracy using external features, as did control groups of typically developing children, however ceiling effects in all conditions and for all groups hinder the interpretation and may mask subtle group differences. Overall performance showed the group with WS were as accurate as chronological and mental age matched typically developing children. There was no effect of chronological age on the use of internal or external features, which is important with such a wide age range as previous studies find that performance patterns change with age (for example Campbell et al., 1995, 1999; Bonner & Burton, 2004). It is most likely that ceiling effects, as well as the small sample size, contribute to this lack of correlation. The authors conclude that individuals with WS show no atypicality in the use of internal and external face features.

4.2 Experiments 2a & 2b

The following experiments investigate unfamiliar face processing, using an internal and external face processing paradigm. Experiment 2a first applies this paradigm to unfamiliar face processing in WS and this is followed by a replication with participants with autism (exp. 2b). In each experiment the performance of participants with developmental disorders is compared to the performance of typically developing individuals matched on specific criteria; namely verbal mental age, nonverbal ability and chronological age. It will be possible to investigate whether accuracy levels and the pattern of performance for each groups shows evidence of typical or atypical face processing.

4.2.1 Experiment 2a

Given the high ‘exposure’ to the internal features of even unfamiliar faces in WS (evidence of hypersociability and intense eye contact) we predict strong performance when using the internal features of unfamiliar faces compared to participants who are typically developing.

Method

Participants

Thirteen individuals with WS participated, ranging from 10 years 2 months to 18 years 2 months (mean 13 years 6 months). All participants were recruited through the Williams Syndrome Foundation (Scotland branch) and consent was received prior to participation. Eleven participants had been diagnosed with the FISH test, whilst the remaining two participants had been diagnosed by clinicians. Verbal mental age was assessed using the BPVS II (Dunn, Dunn, Whetton, & Burley, 1997) and provided a mean verbal mental age for the group of 11y 1m (ranging 9y 3m to 13y 8m). Nonverbal ability was assessed using the RCPM (Raven, Court, & Raven, 1990) and provided a mean score of 15 (ranging 9 to 26, max. score 36). Of these thirteen participants 11 had previously taken part in the study reported in Chapter 3.

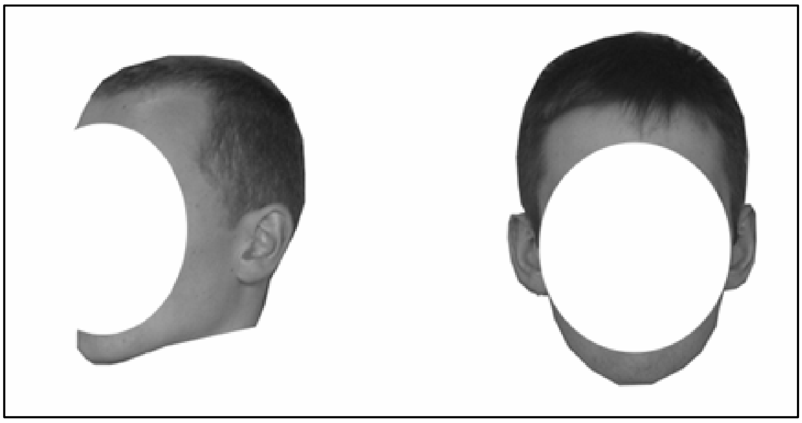
Each participant with WS was matched to a typically developing participant of comparable verbal mental age as assessed on the BPVS II. On the matching criteria, the typically developing participant group had a mean verbal mental age of 11 years 2 months (ranging 9 years 1 months to 13 years 11 months). There was no significant difference for verbal mental age for the two groups of participants ($t(12)=.84$, $p=.42$). Each participant with WS was also matched to a typically developing individual of comparable nonverbal ability as assessed by the RCPM and this group (NVMA) had a mean nonverbal score of 15 (range 9 to 26). There was no difference in nonverbal ability for the two groups ($t(12)=.37$, $p=.72$). Finally, each participant in the WS group was matched to a typically developing participant of the same chronological age and therefore the final group was aged between 10 years 0 months and 18 years 0 months (mean age 13 years 5 months). Again the group with WS did not differ significantly from this group on the basis of chronological age ($t(12)=.8$, $p=.40$).

Design and Procedure

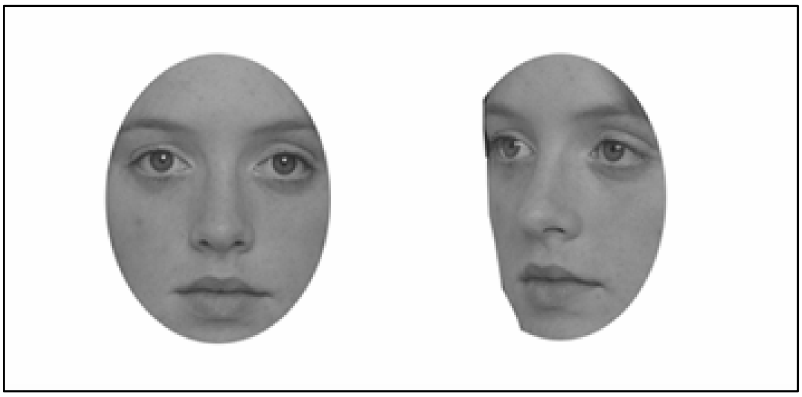
All faces were unfamiliar to participants and were of individuals who had previously given consent for their pictures to be used as part of an image database within the Department of Psychology at Stirling University. In total 8 different faces were used as stimuli. ‘Same’ trials constituted a full-view and a ¾-view of the same person. Different views were used so participants could not complete the task using pattern matching strategies alone. ‘Different’ trials were comprised of a full-view and ¾-view of different individuals of the same gender and ethnicity. The task comprised 24 trials, 8 in each condition (whole, internal, external) in randomized order and all participants completed all conditions. Participants never saw the same person in consecutive trials (across the whole, internal and external conditions).

Figure 4.1 An example of (i) an external feature different trial and (ii) an internal feature same trial.

(i)



(ii)



Removal of internal features from the whole face stimuli was standardised by taking an oval shape encompassing eyes, nose and mouth. External features comprised the hair, ears, chin and face contour. The stimuli replicate the exact parameters employed by Bonner and Burton (2004) and an example can be seen in Figure 4.1.

All participants were tested individually. As a practice trial, participants were shown pictures of the experimenter taken from two different angles and it was explained that they were both pictures of the same person but different views. For experimental trials, for each pair of faces the participant had to decide if the two images were of the same person or different people (providing the response ‘same’ or ‘different’). Trials were presented on A4 size paper and placed in front of the participant until a verbal response was provided, thus being self-paced.

Results

Overall, participants with WS did not perform at a level predicted by their chronological age. This was confirmed by a 3 x 4 ANOVA with factors Part (internal, external, whole) and Group (WS, VMA, NVMA, CA) as there was a significant effect of Group $F(3,48)=19.87$, $p<.001$. As evident in Table 4.1, participants with WS performed as accurately as those matched for verbal ability ($p=.93$) but there was a significant difference between the group with WS and the other typically developing groups. Participants with WS performed more accurately than those matched for nonverbal ability ($t(12)=3.08$, $p<.01$) and less accurately than those of comparable chronological age ($t(12)=4.10$, $p<.01$). In part this difference may be driven by the high accuracy of chronological-age matched participants, who performed significantly higher than all other groups and whose performance was close to ceiling on whole face and external trials.

There was also a significant effect of Part $F(2,96)=37.07$, $p<.001$. Whole face matching was significantly better than using both internal ($t(51)=8.65$, $p<.001$) and external features alone ($t(51)=5.04$, $p<.001$). Also participants were better with

Table 4.1 WS percentage correct for each face condition and each participant group (SD in parenthesis)

	Internal	External	Whole	Overall
Williams syndrome	80 *(12)*	73 *(16)*	87 *(13)*	81 *(12)*
VMA Matches	73 (*12)*	82 *(14)*	92 *(11)*	83 *(8)*
NVMA Matches	58 *(11)*	70 *(10)*	78 *(9)*	69 *(8)*
CA Matches	87 *(6)*	97 *(5)*	98 *(4)*	94 *(3)*
Overall	75 *(14)*	81 *(15)*	89 *(13)*	81 *(12)*

external than internal features (t(51)=2.82, p<.01). The significant interaction between variables showed that this was not the same for all groups F(6,96)=4.13, p<.01. Whilst all groups found it easier to use the whole face than face parts, performance on internal and external trials differed across groups. For the chronological age matches, participants were more accurate using external than internal features t(12)=5.42, p<.01. The same result was found for the NVMA group t(12)=3.86, p<.01. However the VMA group showed no difference between internal and external conditions. Participants with Williams syndrome were more accurate with internal than external features t(12)=3.57, p<.01.

To summarise, increased accuracy for internal over external features was only found for individuals with WS and not for any of the typically developing participants. Replicating previous research with both children and adults, all groups, including WS participants, found it easier to match faces using whole faces than individual face parts.

Discussion

The results indicate an atypical pattern of unfamiliar face processing in WS using an internal / external processing paradigm. Participants with WS were more accurate using internal features (e.g. eyes, nose, mouth) than external features (e.g. hair, chin). Relating directly to the main hypothesis of the study, participants exhibited a performance pattern comparable to that seen for familiar faces in typically developing children over 7-years of age (Bonner & Burton, 2004) and adults (Ellis et al., 1979; Young et al., 1985). Indeed, previous research has indicated that familiarity enhances the salience of internal features (Bonner et al. 2003), however, such results have never previously been found for unfamiliar faces. The present study may suggest that a shift to internal features for familiar faces is more likely in social than informational terms as individuals with WS are characterised by their over friendly social interaction style (Jones et al., 2000). This result demonstrates that it is not sufficient simply to look at overall accuracy levels for individuals with WS but it is necessary to delve deeper and study processing styles to investigate subtle but important group differences. It is the *way* the task is completed that is of interest and not overall accuracy. As noted in a discussion of the comparison between typical development and developmental disorders it should be remembered that an “individual’s capacity to compensate for his or her weakness by using some alternative strategy or skill” may affect performance styles (Burack, Iarocci, Bowler, & Mottron, 2002; 234).

The results of experiment 2a may also tell us about more general aspects of face processing, not solely related to WS. Perhaps there is an internal feature advantage for typical familiar face processing not only because people have ‘learned’ the internal features of people they know, but rather they ‘tend to’ or ‘are willing to’ attend to the internal features of familiar but not unfamiliar people. The performance of individuals with WS gives some indication of this argument. The participants with WS could not have ‘learned’ the specific internal features of these unfamiliar faces (due to repeat exposure etc) but they do cope well with such features. It could be argued that individuals with WS, due to their high levels of sociability and overfriendliness with strangers, are more ‘willing’ to attend to the internal parts of the face. This investigation not only contributes to our understanding of social aspects of WS but also contributes to our understanding of typical face processing styles.

The present findings may be linked to atypical socialisation patterns in WS; specifically the tendency towards overfriendliness with strangers. Indeed, an abundance of previous research has cited hypersociability and inappropriate socialisation in individuals with WS (Jones et al., 2000; Gosch & Pankau, 1994, 1997; Doyle et al., 2004). Researchers have observed that infants with WS appear “driven to engage strangers” (Doyle et al., 2004; 269). Bellugi et al. (1999a) noted an inner drive for social interactions with strangers above and beyond that seen in other clinical populations. Finally, Mervis et al. (2003) reported atypical looking behaviour towards a stranger in young infants with WS. Perhaps such findings are closely related to the present results of processing unfamiliar faces in a style usually reserved for familiar faces.

Although only typically developing participants matched for nonverbal and chronological ages showed an external feature advantage this relates to previous research using the internal / external paradigm (verbal matches showed no difference in accuracy across internal and external trials). Indeed unfamiliar face processing in adults and children has shown confounding evidence of both an external advantage and no difference in accuracy (Endo, Takahashi, & Maruyama, 1984, Young et al., 1985). However, the important comparison is between familiar and unfamiliar faces, or in the case of this experiment, between participant groups. It is the fact that different patterns of performance are found for the group with WS compared to the typically developing participants that is of importance to the present investigation. When comparing the use of internal and external features, and particularly across studies, there is a complication due to the size of the face areas on view and the amount of information contained in those areas. This may account for discrepancies concerning the use of internal and external across studies but importantly no previous research has cited increased accuracy for internal features for unfamiliar faces. The size of the internal and external regions could not account for the different pattern of results evident *across groups* in the current study as all participants saw the same stimuli.

It is possible to make some suggestions why the present results differ from those of Deruelle et al. (2003). In that study, participants matched face parts to whole face targets and only saw one view of the face. This may have contributed to the pattern of performance and the ceiling effects evident in the data, which may mask subtle group differences. Although the exact mean performance levels are not reported for the WS group in the internal and external conditions, across groups there was only a very small but significant difference in error rates for internal and external conditions (for 16 trials, mean 2.2 and 1.2 errors for internal and external respectively). The task reported in the current chapter was more difficult for participants with lower accuracy for both internal and external feature processing and may allow group differences to be more evident. Additionally the large age range of the Deruelle et al. (2003) study may also mask performance patterns; the inclusion of particularly young children may have affected results as we know the use of internal and external features changes with age. The present study uses older participants with WS to study more mature face processing styles. Therefore, the investigation reported here provides further evidence of face processing styles using an internal and external paradigm by individuals with WS.

Possible links can be made between the use of internal features in the current study and proficient abilities for other face processing paradigms using internal features. For example, individuals with WS are noted to be particularly empathetic and to perform as well as mental age matches on tasks of emotion processing (Karmiloff-Smith, 1995), thus using the eyes and mouth together. These are the main facial features implicated in emotional expressions, although the remaining internal features of eyebrows and forehead are all important and provide cues to feelings (Lundqvist & Ohman, 2005). Thus, it is clear that WS individuals are able to attend to, as well as understand, essential internal facial features with a variety of aims. Indeed experiment 1A showed evidence of proficient eye gaze and emotion processing in WS individuals and thus may be linked to a good use of the important social information gained from internal face features.

4.2.2 Experiment 2b

This experiment extends the investigation of internal and external feature use for unfamiliar face matching to participants with autism. Based on evidence from

Rondon et al. (2003) we predict that these participants will show equal use of internal and external features for matching unfamiliar faces.

Method

Participants

Seventeen individuals with autism were recruited from a small special school for individuals with autistic spectrum disorders. Participants ranged between ages 10 years 9 months and 18 years 3 months (mean age 16 years 1 month). Verbal mental age was assessed utilising the BPVS II and provided a mean verbal mental age (VMA) for the group of 10 years 10 months (ranging from 9 years 0 months to 12 years 0 months). Non-verbal ability was measured using the RCPM providing a mean score of 15 (ranging 9 to 21). Of the 17 participants with autism 9 had previously taken part in research contributing to Chapter 3 of this thesis.

Participants with autism were matched to three typically developing comparison individuals using distinct matching criteria. Verbal matches were made on the basis of verbal mental age using the BPVS II and the VMA group had a mean verbal mental age of 10 years 11 months ($t(16)=1.03$, $p=.34$). The group matched for nonverbal ability had a mean RCPM score of 15 ($t(16)=1.03$, $p=.32$) and the chronological age matched group had a mean age of 16 years 0 months ($t(16)=.45$ $p=.66$).

Childhood Autism Rating Scale (Schopler, Reichler, & Rocher Renner, 1988) scores for the 17 participants (completed by class teachers) revealed all children scored within the autistic range, with 10 classified as ‘mild-moderately autistic’ and

7 as ‘severely autistic’. Parental and individual consent was received for all participants prior to the study.

Design and Procedure

Task stimuli and the main procedure were the same as those used in experiment 2a and are therefore not detailed in this section (see section 4.3.1). Participants were tested individually within the school setting. In the week leading up to the study, class teachers worked with pupils ensuring they knew the terms ‘same’ and ‘different’ and confirmed with the researcher all participants understood these terms. To overcome the obstacle of verbal ability, the researcher placed two symbols under the experimental trial – one showing the word and symbol for ‘same’ and one for ‘different’. These symbols were those previously used by class teachers to aid learning with all participants.

Results

It was easier for all groups to match whole faces than individual face parts. This was confirmed by a 4 x 3 ANOVA with factors Group (autism, VMA, NVMA, CA) and Part (internal, external, whole). There was a significant effect of the Part as overall internal feature matching was most difficult ($F(2,128)=55.03$, $p<.001$). Whole face matching was significantly better than both internal ($t(67)=9.82$, $p<.001$) and external conditions ($t(67)=5.07$, $p<.001$). External accuracy was also significantly more accurate than internal accuracy ($t(67)=4.64$, $p<.001$). The results of the matching task may be affected by the near ceiling performance of the CA group in these analyses (see Table 4.2).

Participants with autism performed with less accuracy on the task as a whole compared to the typically developing groups as seen in Table 4.2. This was confirmed by the main effect for Group ($F(3,64)=54.14$, $p<.001$). Chronological age matched participants performed significantly better than the group with autism ($t(16)=10.72$, $p<.001$), as well as both the verbal ($t(16)=9.76$, $p<.001$) and nonverbal groups ($t(16)=16.84$, $p<.001$). The participants with autism also performed significantly less accurately than the verbal ($t(16)=2.98$, $p<.01$) and nonverbal matches ($t(16)=2.71$, $p<.05$) who did not differ ($p=.14$).

Table 4.2 Autism percentage correct for each face condition and each participant group (SD in parenthesis)

	Internal	External	Whole	Overall
Autism	60 *(11)*	64 *(13)*	78 *(13)*	65 *(10)*
VMA Matches	68 *(12)*	80 *(13)*	88 *(12)*	79 *(9)*
NVMA Matches	66 *(9)*	74 *(14)*	80 *(6)*	73 *(4)*
CA Matches	95 *(6)*	98 *(5)*	99 *(3)*	97 *(4)*
Overall	73 (*11)*	79 *(16)*	86 *(13)*	78 *(14)*

There was a significant interaction between Group and Part $F(6,128)=4.46$, $p<.001$ as although all groups found it easier to use whole faces, proficiency with internal and external features differed across groups. Participants with autism were equally accurate using internal and external features ($p=.25$) as were the chronological age matches ($p=.10$). However, the verbal matches were significantly better using external than internal features ($t(16)=2.98$, $p<.01$) as were the nonverbal matches (t(16)=3.76, *p*<.01). None of the groups were more accurate using internal than external features. To summarise, for trials using either internal or external features the autism and CA groups showed no difference in the results pattern. However it should be remembered that performance may be affected by ceiling effects in the CA group and if the task were harder the difference between internal and external conditions may have reached significance. In contrast both the VMA and NVMA groups showed greater accuracy using external than internal trials. No group found it easier to use internal than external features.

Discussion

Unfamiliar face processing in autism was investigated using an internal and external processing paradigm. The results replicate the findings of Rondon et al. (2003) as internal and external feature matching showed equivalent accuracy. Participants with autism showed the same pattern of performance as chronological age matched typically developing individuals, but at a lower overall level of accuracy. Importantly the group with autism showed lower accuracy compared to all other typically developing groups. As confirmed by previous research with both children and adults, there was no evidence of greater accuracy for the internal features of unfamiliar faces. The results therefore appear indicative of a general delay in ability rather than suggesting evidence of atypicality in autism.

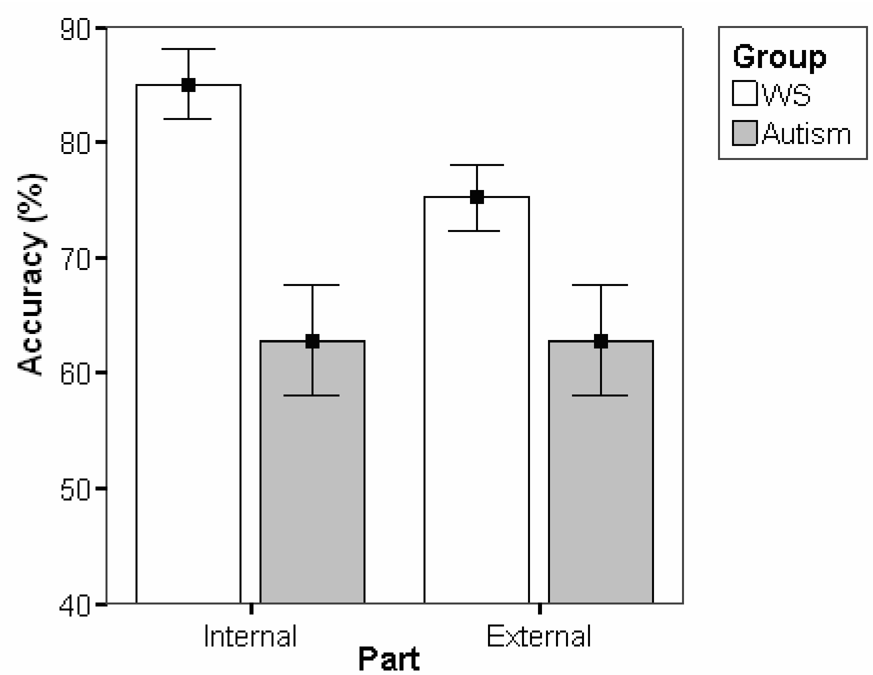
The difference between internal and external features for unfamiliar faces has been studied in detail in previous research and the fact that the four groups show some evidence of both equal reliance as well as an external advantage confirms the discrepancies previously found with children and adults. As mentioned previously in this chapter, some discrepancy between studies can be attributed to the different sizes of visible matching or recognition areas. However the same stimuli was used across groups and therefore cannot account for the difference found here. The important aspect of the current study is that the group with autism shows the same pattern of performance as the CA group and critically no group was more accurate with internal than external features for unfamiliar faces. It would be interesting to extend this investigation to personally familiar face processing.

4.3 Unfamiliar face processing comparing Williams syndrome and Autism

To provide some insight into the differing abilities of individuals with WS and autism, a small set of participants with each disorder were matched individually on the basis of chronological age and nonverbal ability. The groups were very small due to the availability of individuals of comparable chronological age and nonverbal ability who took part in the research. Therefore 8 individuals with WS were individually matched to 8 individuals with autism. The groups did not differ in terms of chronological age (WS mean 14 years 9 months, Autism 14 years 11 months; $t(7)=1.8$, $p=.12$) or nonverbal ability as assessed on the Ravens' Coloured Progressive Matrices task (WS mean 17, Autism mean 16, $t(7)=2.1$, $p=.31$).
To investigate the effect of group membership on task performance an ANOVA with factors Group (Williams syndrome, Autism) and Part (Internal, External) was carried out for the 8 individuals in each group. As we are primarily interested in the pattern of performance using internal and external features the whole face condition was not included in this analysis. As evident in Figure 4.2 the pattern of results for these small groups mirror that evident from the larger group analyses. When the groups of participants with WS and autism were combined there was no effect of

Part (p=.26) although participants with WS performed more accurately as evident by an effect of Group $F(1,14)=8.89$, $p<.05$ (WS mean 80%, autism mean 63%). There was no interaction between Group and Part (p=.27). Figure 4.2 clearly shows greater accuracy using the internal features for the groups with WS. As this finding was expected, post-hoc t tests were conducted on accuracy levels for internal feature matching and this confirmed that participants with WS were more accurate using internal face features than those with autism ($t(7)=3.48$, $p<.05$). However, there was also a trend for individuals with WS to perform more accurately than those with autism when using the external features ($t(7)=2.22$, $p=.06$). Figure 4.2 clearly emphasises that the difference between groups is at its most for the internal condition, as accuracy drops when external features are used the difference between groups is lessened.

Figure 4.2 Matched groups of participants with WS and autism processing unfamiliar faces from internal and external features



4.4 Experiment 3

Experiment 3 builds on the investigation of internal and external features by applying the paradigm to familiar face processing in autism. The participants with autism who took part in experiment 2b all attended a special residential school and this therefore allowed the opportunity to investigate personally familiar face processing styles. The use of famous faces may be especially problematic for participants with autism who often show less interest in television programmes, pop music or films, from which famous face stimuli are often obtained. This methodological concern is therefore overcome in experiment 3 by using personally familiar target faces. Familiar faces are created from images of the individuals at the school attended by all participants. It would have also been interesting to extend this to WS, however it was not possible to obtain personally familiar faces appropriate for all participants. A number of parents of individuals with WS involved in the study noted that their child lacked an interest in films or television and therefore even obtaining famous faces that all participants adequately recognized would have been problematic.

Experiment 3 uses matching and recognition tasks with personally familiar faces. If participants with autism show the same pattern of performance as non-autistic individuals, based on research with both children and adults, it is hypothesised that accuracy will be higher using internal than external features, differing from evidence for unfamiliar faces. This would therefore show evidence of an ‘internal feature advantage’ for familiar faces as the participants are above the age where this pattern has previously been cited using this methodology (Bonner & Burton, 2004).

Method

Participants

The seventeen autistic individuals who took part in experiment 2b also participated in this study. Therefore full details of this participant group may be found in section 4.3.2 and are not repeated here.

All participants had attended their school for more than 9 months and many had been pupils at the school for several years. The school has a maximum of 30 pupils and is therefore particularly small. Additionally, a number of pupils reside at the school and are in contact with each other for most of their time. This highlights that the participants are highly familiar with each other and hence with the faces used as familiar stimuli. Nine parents and pupils provided consent for use of the pupils' photographs as task stimuli and based on stimulus quality 8 faces were subsequently chosen.

Ideally, when working with groups of children with developmental disorders, it is useful to match participants with a comparison group of individuals of a similar developmental level (see discussion in Chapter 2). In the present study it would have been beneficial to match the participants with autism to typically developing children. Due to the nature of the present design, matching was not possible as obtaining face stimuli that were familiar to participants in both the autism and typically developing groups would have been problematic (especially given that the children with autism were in separate school provision). Some researchers overcome such difficulties by using famous familiar faces however the problems with this type of stimuli have already been discussed. Therefore only participants with autism participated in experiment 3.

Design and Materials

Matching Task

A within-participants design was used with the repeated factor Part (whole, internal features, external features). Half the trials were ‘same’ and half were ‘different’. ‘Same’ trials constituted a full-view and a ¾-view picture of the same person. Two views were used so that the pairs were not identical and participants could not complete the task using pattern matching strategies. ‘Different’ trials comprised a full-view and ¾-view of different individuals of the same gender and ethnicity. The task incorporated 24 experimental trials with 8 of each whole face, external and internal features with presentation randomized across condition and participants. Each trial was made up of two whole faces, two external feature images or two internal feature images presented alongside each other (see Figure 4.1). Familiar face stimuli were pictures of 8 participants attending the special school for autistic children (14-18 years; 4 male, 4 female).

Task stimuli were created by taking two photographs of each individual with any additional paraphernalia removed. One full-view image and one ¾-view were used and photographs were manipulated in Adobe PhotoShop 7.0 (Adobe Systems Inc, CA). One internal and one external feature trial was produced from each photograph. Removal of internal features from the whole face stimuli was standardised by taking an oval shape encompassing eyes, nose and mouth. External features comprised the hair, ears, chin and face contour. All images were converted to gray scale and chopped to remove background information.

Recognition Task

The recognition task comprised 8 familiar face trials and participants viewed full-view images in whole face, internal and external conditions. Block presentation was used with test order counterbalanced. Half the participants carried out the internal feature trials first and half the external feature trials. The whole face condition was completed last by all participants.

Procedure

For the matching task participants saw a pair of faces and were required to decide if the two images were of the same person or different people. Participants could either say the terms ‘same’ or ‘different’, or point to the relevant symbol. Only 4 participants chose to provide a solely nonverbal response, all other participants provided both a verbal and nonverbal response. The task was self-paced and the trial remained in front of the participants until they provided a response.

The participant completed the matching and recognition tasks in different testing sessions. For the recognition task, all images for each trial type were presented on one sheet of paper and participants named as many of the people in the pictures as possible (or provided some other identifying feature for later corroboration). Again the task was self-paced.

Results

Matching task

Participants with autism were equally accurate using internal and external features as confirmed by the analysis of variance. An ANOVA with the repeated factor Part (internal, external, whole) revealed a difference between conditions $F(2,32)=40.72$, $p<.001$. There was no difference between matching internal and external features ($t(16)=1.2$, $p=.25$, internal 60% external 61%) but whole face matching was significantly more accurate than using internal ($t(16)=7.94$, $p<.001$) or external features alone ($t(16)=6.54$, $p<.001$, mean whole face 78%). Performance in all conditions was greater than chance (compared to chance 50%; internal $t(16)=2.71$, $p<.05$, external $t(16)=3.23$, $p<.01$, whole $t(16)=10.32$, $p<.001$).

To summarise, in accordance with research from adults and typically developing children, performance accuracy was greater using whole faces than individual face parts. There was no evidence of a relative increase in accuracy for internal than external features of familiar faces.

Recognition Task

Participants with autism recognised more people from their school using the whole face than either internal or external features. An ANOVA with the repeated factor Part (internal, external, whole) revealed a significant effect $F(2,32)=12.40$, $p<.001$ (mean whole 70%, internal 53%, external 57%). A paired sample t-test investigating internal and external accuracy showed no significant difference ($p=.20$). The significant effect for part of the face was created by the whole face condition, which was significantly greater than using either internal ($t(16)=5.24$, $p<.001$) or external features alone ($t(16)=2.95$, $p<.01$). Importantly, there was no evidence of an internal feature advantage for recognising personally familiar faces. The results of the recognition task showed the same pattern of performance as the matching task.

Discussion

Regarding the main hypothesis there was no evidence of an internal feature advantage for familiar faces. Participants with autism did not show greater accuracy for internal than external features, even though chronological and verbal mental ages both exceeded the age where an internal feature advantage has been found in typical development using the same methodology (Bonner & Burton, 2004). Instead, there was no difference in accuracy for either type of feature.

Evidence of equal accuracy for internal and external features for familiar face processing has previously been found in young typically developing children aged 4- and 5-years (Newcombe & Lie, 1995). This result has not been found in older typically developing children, as by 7-years of age evidence indicates a shift in strategy towards the internal features (Bonner & Burton, 2004). Comparing performance with that previously found with typically developing children using the same methodology, evidence points to lower accuracy for children with autism (from Bonner & Burton, 2004). This may suggest an extreme delay in processing familiar faces, perhaps inherently linked to a lack of expertise with faces. This is the first time personally familiar face processing styles using both matching and recognition tasks have been reported with this population. However, as previously noted in the discussion sections for experiment 2 (a and b) it is difficult to conclude that task stimuli did not have an effect on the pattern of results obtained here. The presentation of stimuli replicated that used in the other experiments of this chapter, however it may have been that the relative shape or size of the internal or external sections created the pattern of results seen here. It may therefore be interesting to allow typically developing children to complete the task and check the pattern of results obtained. As no comparison group was used in this experiment the comparison of performance patterns is not possible for this experiment.

Internal features encompass the most important and informative communicative aspects of the face. For example, the eyes serve many functions in human communication as well as having an important role in emotional and social functioning (Doherty-Sneddon, 2003). Over numerous interactions these features are less likely to change than external parts of the face (for example by changing hair style). The social importance of the internal features should not be underestimated as successful interpretation of aspects of eye gaze, expressions and verbal cues represent just a few important abilities linked to these features. Of course the participants with autism in this study did not show the usual relative ‘advantage’ for internal features previously documented for familiar face processing. The link between internal features and social abilities may be of importance to this finding and may link to many of the essential social impairments associated with autism. The socially demanding nature of the internal face features may prevent autistic participants from favouring this area of the face, hence inhibiting an internal feature advantage. Indeed deficits associated with understanding social aspects of the face originating in the internal features have already been found in Chapter 3 with evidence of eye gaze and expression processing deficits. The General Discussion section of this chapter will return to the social nature of internal face features in detail when discussing both WS and autism and the processing of these important features (see section 4.5).

The present study does not indicate whether these participants with autism will *develop* the 'internal feature advantage' for familiar face processing at a later stage of development. It is possible that the results are evidence that the internal advantage for familiar faces develops at a later stage in autism. It would be interesting to study these issues with adults who have autism to see if the internal feature advantage is present and whether there is a different pattern of results for familiar and unfamiliar faces. Perhaps if we had chosen a higher cut-off for the age of participants this would have been overcome. Campbell et al. (1999) suggest that the internal feature advantage may be delayed in individuals with learning difficulties. We chose the specific cut-off age used in this study due to evidence using the same procedures in typical development by Bonner and Burton (2004). These possible age implications provide the impetus for future research using internal and external features with adults on the autistic spectrum. Indeed it is difficult to conclude whether these data are evidence of an atypical processing style, a delayed (or immature) way of processing familiar faces, or manifested by the specific stimuli presentation used. Finally, evidence from experiment 3 suggests that familiar faces may not be processed in a typical manner by young people with autism.

4.5 General Discussion

This section brings together evidence from the three experiments presented in Chapter 4 to learn more about familiar and unfamiliar face processing styles within an internal / external processing paradigm. Firstly, we consider evidence from the two experiments involving individuals with autism, before combining evidence from the two different developmental disorders regarding unfamiliar face processing.

4.5.1 Familiar and unfamiliar face processing in autism

Seventeen individuals with autism showed no evidence of an internal feature advantage for matching or recognising familiar faces. Studying the accuracy levels for experiments 2b and 3 together, unlike typically developing children and adults, participants with autism were no more accurate at matching personally familiar than unfamiliar faces. Additionally, the results for the two experiments highlight that familiar and unfamiliar faces were processed in the same *way* even when an additionally memory demand was present (both showing equal accuracy for internal and external features). In both experiments participants with autism replicated the findings of research with typically developing children and adults showing greater accuracy using whole faces than independent face parts. Additionally, the results of experiment 2b replicate previous research by Rondon et al. (2003) finding no difference between internal and external features for unfamiliar faces. The results may also relate to evidence from Chapter 3 of this thesis showing no specific strength interpreting cues from the internal face features (e.g. the eyes).

Numerous investigations have cited different processing styles for familiar and unfamiliar faces in both children (Campbell et al., 1995, 1999; Newcombe & Lie, 1995; Bonner & Burton, 2004) and adults (Ellis et al., 1979; Young et al., 1985). However, studied together, experiments 2b and 3 imply that individuals with autism do not exhibit this dissociation at the age tested here. This supports claims from

ERP investigations that have found no difference in brain activity for familiar versus unfamiliar faces, unlike typically developing comparison groups (Dawson et al., 2002). However, the present finding contrasts with functional MRI data, suggesting greater functional activity for personally familiar than unfamiliar faces (Pierce, Haist, Sedaghat, & Courchesne, 2004).

From the present investigation, the distinction between familiar and unfamiliar faces appears less clear for individuals with autism. It is not possible to imply whether this lack of distinction is due to the lack of social importance placed on social stimuli in autism or whether an alternative explanation is required (for example the chronological and mental ages of participants). Closely related to this, Charman (2004) claims that individuals with autism are less ‘expert’ in social interactions and expertise has previously been associated with differential processing patterns for familiar and unfamiliar faces and indeed increased salience of faces as a whole for older children and adults.

Experiments 2b and 3 can be linked to deficits in interpreting and appreciating appropriate social and interpersonal cues. Internal facial features are attended to in typical face-to-face communication and these features are harder to change over repeat exposure (Ellis et al., 1979). In typical development we look at a person’s mouth and eyes for socially important information rather than their hair or ears. Therefore internal features become more salient as we become experts and learn which represent the most valuable facial resources (e.g. Bonner et al., 2003). This preference may never be achieved by individuals with autism. Grelotti, Gauthier and Schultz (2002) suggest that a poor specialization for faces, resulting from inactivation of the fusiform face area and atypical styles of processing, can be linked to a lack of expertise with faces in autism. As well as the present study, previous research has shown that people with autism do not look at the same face features as typically developing comparisons. Langdell (1978) stated how autistic children favored lower face features (e.g. mouth) whilst typically developing individuals favored upper features (e.g. eyes) and this area will be returned to in detail later in the thesis. Also, evidence shows that children with autism have specific problems interpreting cues from some of the most important internal face features; for example eye gaze (Baron-Cohen et al., 1995; Gepner, de Gelder, & de Schonen, 1996) and an inability to recognize the significance of the eyes (Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Perhaps such difficulties are due partly to the features beings used, as well as the socially demanding nature of the face.

4.5.2 Unfamiliar face processing in Williams syndrome and autism

The results for unfamiliar face processing by individuals with WS and autism reveals that participants with WS show a specific atypicalilty. Unlike autistic and typically developing participants who showed no internal feature advantage, participants with WS were more accurate using internal than external features of unfamiliar faces. Notably, participants with autism did not show any difference from the typically developing groups for unfamiliar face processing style and thus no evidence of atypicality. Although evidence has previously suggested problems with both familiar and unfamiliar faces in autism, experiment 2b showed general delay rather than atypical deviance in performance. Perhaps the decrease in overall accuracy for participants with autism was related to a problem with faces per se, rather than specifically related to the demands of this task.

In contrast, individuals with WS performed at a level comparable to their verbal mental age but did not complete the task in the same *way*. This is the first evidence of an internal feature advantage for unfamiliar face processing and suggests that individuals with WS are not processing this type of face typically. Figure 4.2 emphasised that the difference between individuals with WS and autism was heightened when the internal features were used. This internal advantage may be related to a preference for the highly social nature of the internal features as previously suggested. The relationship between task performance and social abilities in WS cannot be determined here, as the direction of any effect is currently unclear. It is not known whether individuals with WS are more sociable and drawn to the eye region because they find the internal features useful or informative, or whether the effect is in fact in the opposite direction. Additionally, this result may explain the strong performance of this group when completing tasks using the internal features such as eye gaze and expressions (see chapter 3). Participants with WS in Chapter 3 were also less affected than children with general developmental delay when the external features were covered in the identity matching task. So the groups with WS and autism vary both in accuracy levels and processing styles when using the internal and external features for unfamiliar face processing. Although general delay appears characteristic of autism, deviance in processing style is evident from this paradigm in WS.

4.5.3 The internal versus external features paradigm

Claims have been made concerning the link between internal features and configural processing styles in typical development. Hay and Cox (2000) noted a decrease in featural encoding and an increase in configural processing with age in typically developing children as a shift towards internal features was seen for familiar faces. Thus the eyes and mouth become more salient and their relative position to each other increases in importance. Additionally, Campbell et al. (1995) stated that internal feature processing required a “finer grain of spatial resolution” (Campbell et al., 1995; 208) and the ability to work with this spatial resolution developed with age and expertise. However, experiment 2a with participants with WS shows evidence of this internal feature style for *unfamiliar* faces. If we take into account this suggested link between internal features and configural processing the data provide some suggestion of configural styles of face processing in WS for unfamiliar faces. However, the data thus far do not rule out the notion that individuals with WS are processing the independent features of internal features without encoding the configuration. Further work is needed here as the link between internal / external processing and reliance upon featural / configural processing requires more empirical support.

Relating this to autism, the present findings can be associated with processing styles and linked to the Weak Central Coherence theory of autism introduced in Chapter 1 (WCC; e.g. Frith, 1989; Frith & Happé, 1994). This approach emphasizes that individuals with autism process information without linking parts together centrally. Typically developing children have been found to show a featural rather than configural bias (Diamond & Carey, 1977; Schwarzer, 2000; Pascalis, Demont, de Haan, & Campbell, 2001) and process external features most accurately. Taking into account claims of a link between external features and featural processing strategies, it is possible that the lack of an internal feature advantage for familiar faces in the present study is partly due to the lack of configural processing. If children with autism possess WCC they are inhibited in processing the overall configuration of the stimuli and thus never achieve the internal bias seen in adult-like processing. Results from experiment 3 may provide some support for the WCC theory of autism.

4.5.4 Methodological considerations

The tasks employed in this chapter relied on the matching of face parts for unfamiliar or familiar faces. It may be interesting to extend this investigation to face memory tasks (e.g. recognition abilities) as previously conducted with adults, to recognise previously presented faces from internal or external features. To incorporate participants with WS, a learning paradigm (as employed by Bonner et al., 2003) could be employed to investigate the change in use of internal and external features as the face increases in familiarity. Additionally, chimeric faces combining the internal and external features of different individuals might overcome the use of unnaturally presented cropped face parts (as used by Rondon et al., 2003, exp.2). The lack of ecological validity in the present study may be overcome by this modification and the use of whole face stimuli. Additionally, reaction time data may reveal group differences and subtle patterns of performance missed by task accuracy. Including reaction times for conditions where accuracy is particularly more poor may, however, be problematic.

4.6 Conclusions

This chapter has explored how familiar and unfamiliar faces are processed using internal and external features in WS and autism. We have identified that atypical processing styles in WS may be hidden by accuracy level analyses. Importantly the results provide a significantly new contribution to our understanding of face processing and potentially social functioning in WS; that internal face features are of primary importance and high salience. Both familiar and unfamiliar face processing styles in autism are the same and conclusions have been made concerning why this may be the case. The thesis now moves on to apply a variety of face processing methodologies in order to systematically investigate the use of different face features. Rather than solely categorising features as ‘internal’ or ‘external’ the subsequent experiments focus directly on the important features of the eyes and mouth and their role in face processing for these groups of individuals.

Chapter Five

Processing the Upper and Lower Face

5.1 Introduction

The overarching aim of this thesis is to investigate the way faces are processed by individuals with autism and Williams syndrome (WS). The previous chapter investigated the use of internal and external features, splitting the face into different areas to explore processing styles for familiar and unfamiliar faces. The present chapter builds on this by probing the use of the upper and lower face regions for unfamiliar face matching; with this procedure we focus on the eye and mouth regions. The investigation presented in this chapter is important for extending our knowledge of how individuals with autism or WS use different parts of the face, whilst also applying a research paradigm grounded in typical face research.

Evidence from recognition tasks imply that facial features differ in their relative salience (Shepherd, Davies, & Ellis, 1981). For adults, attention is not evenly distributed across the face as there is a hierarchy of salience with more attention paid to the hair, then the eyes, mouth and nose in roughly that order for both familiar and unfamiliar faces. This chapter reviews the literature concerning feature salience and then describes an experiment to investigate which facial features are easy to interpret and which are more difficult for individuals with WS and autism. The performance of the participants with WS and autism is compared to that of typically developing individuals matched on verbal mental age (VMA), nonverbal ability (NVMA) or chronological age (CA). As the tasks being implemented in the current chapter are not standardized, have not previously been used with typically developing individuals, and have been designed specifically for the current research, these comparison groups will allow an insight into how the performance of the groups with developmental disorders varies, or is the same as, that seen in typical development. This will address the question of typicality for using upper and lower face regions. Importantly, the paradigm used here is derived from research with typical adults and children (Langdell, 1978).

5.1.1 Understanding the eyes and mouth

Typically developing children and adults show a preference for looking at the eyes and mouths of human faces (Yarbus, 1967; Walker-Smith, Gale, & Findlay, 1977; Mertens, Siegmund, & Grusser, 1993). Ellis (1975) noted that the eyes and mouth were especially important as they revealed essential information about what a person was trying to communicate; more so than other features. Research on gaze behaviour during adult face processing has shown that participants fixate first and foremost on the eyes then mouth when no instructions are given (Groner, Walder, & Groner 1984; Janik, Wellens, Goldberg, & Dell'Osso, 1978; Yarbus, 1967). It is clear that these areas are extremely important when understanding faces for a number of reasons.

Similarly, studies have shown that faces have regional variations in salience, with lower features less salient than upper features for adults (Shepherd et al., 1981). For example, Malcolm, Leung and Barton (2005) propose that this difference in salience is shown by regional differences in the inversion effect. Malcolm et al. (2005) found that seventeen adult participants (mean age 28 years) were less accurate when detecting mouth manipulations for inverted faces than when detecting eye manipulations. However some care should be taken when interpreting the findings of this unfamiliar face matching task as accuracy for inverted mouth trials was significantly below chance (approximately 25%) and rather than not being able to do the task, participants may have been using an alternative strategy (such as using the eyes when presented with mouth trials). Changes made to salient inverted eyes were detected above chance. The authors conclude that the hierarchy of features becomes more important during face inversion, as attention is drawn to areas of greatest salience.

Directly of relevance to the current chapter, the eye region probably contains the most important social information gained from the face and is therefore highly salient. This region is essential for interpreting eye gaze as well as holding joint attention between individuals. With links to the establishment of joint attention, it is clear to see how the interpretation of the eyes can impact at the core of social and cognitive development (Johnson, 2005). Research with children and adults has shown that the upper face is highly salient as processing using upper features is more accurate than using lower features (Langdell, 1978; McKelvie, 1976). For example, McKelvie (1976) showed a total of 115 adult participants 27 faces with eye or mouth regions masked and asked participants to remember the faces. At test, participants remembered significantly fewer faces with the eyes than the mouths masked. Therefore, McKelvie (1976) concluded that the eyes were more important than the mouth in the representation of faces in memory. Indeed the eyes were particularly important when compared to all other facial features.

In a similar line of research, Langdell (1978) assessed the ability to recognize personally familiar faces from isolated face parts and inverted pictures. Groups of 10 young autistic individuals (mean age 9 years 8 months), 10 older autistic participants (mean age 14 years 1 month), matched groups of typically developing children (one group for mental age and one for chronological age) and children labeled as 'subnormal' took part in the research. Participants viewed face areas, with the rest of the face covered, and were asked to name the person in the picture. For example, revealing only the eyes, mouth, upper features or lower features with ten trials in each condition. The faces were of the other children in their participant group and included a picture of the participant. All typically developing and 'subnormal' groups showed greater accuracy in naming individuals from their upper than lower features. In contrast, the younger group of individuals with autism was more accurate with the lower than upper features (mean percentage errors 21.97 and 29.42 respectively). The older group of participants with autism showed no difference in accuracy based on upper or lower features (mean percentage errors 8.28 and 11.06 respectively) and Langdell (1978) suggested this shows a "homogeneous knowledge of the entire face" (Langdell, 1978; 264). Importantly, an increased accuracy for upper face recognition was not found in either autism group. Langdell (1978) discusses these findings in terms of the relationship between face processing and social functioning, noting that participants with autism do not show a typical bias toward using the most social aspect of the face. However, investigating the accuracy levels for both conditions reveals that ceiling effects may have impacted upon the performance pattern of the older participants with autism. Research has also suggested that the eye region is remembered more than the mouth region in face memory tasks, with evidence of the same pattern for both typically developing adults and children (Pellicano, Rhodes, & Peters, 2006).

Compared to the eyes, the mouth region appears to be less salient for typically developing individuals, though possibly not for individuals with autism. Barton and colleagues (Barton, Keenan, & Bass, 2001; Barton, Deepak, & Malik, 2003) have found that large changes in mouth positioning are nearly undetectable when adults observe inverted faces, though eye region changes are detected more reliably. Again the researchers claim this is due to attention being directed to more salient features (supporting Malcolm et al., 2005). Similarly, comparing the processing of several face areas, Matthews (1978) used Identikit procedures to reveal that 40 adult participants gave processing priority to hairline and eyes, before considering the nose, and mouth when recognizing faces. The mouth is, however, an important source of information containing cues not only to how someone is feeling (expressions of emotion) but aiding verbal communication (facial speech, lip reading).

5.1.2 Processing the eye and mouth region in Williams syndrome and autism

Evidence from eye tracking and behavioural investigations provide some suggestion that the salience and use of the eye and mouth regions may differ in autism (e.g. Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Baron-Cohen, Wheelwright, & Jolliffe, 1997; Bormann-Kischkel et al., 1995; Celani, Battacchi, &

Arcidiacono, 1999). Gross (2004) found that when assessing emotions participants with autism were no better than chance using only the upper facial features, but were more accurate using lower features. Masking of features was used and pictures were of humans, dogs or orangutans; however only one presentation of each species and each face-part was used for each expression. Gross (2004) concluded that participants with autism attend to lower face features when making judgments about emotions. This supports claims from Langdell (1978) regarding the use of upper and lower features for familiar face identification. Therefore it seems that group differences remain even when the task demands differ.

However, recent research has suggested that attention may be drawn to the eyes in autism as well as typical development. In research conducted by Bar-Haim, Shulman, Lamy and Reuveni (2006) 12 boys with high-functioning autism (mean 10 years) attended more to the eye region than mouth regions of a face. A target probe was presented on a face just below the mouth or slightly above the eyes. Participants had to detect this probe as fast and as accurately as possible. Individuals with autism and those that developed typically were faster when detecting the probe above the eyes than below the mouth and therefore Bar-Haim et al. (2006) concluded that individuals with high-functioning autism were able to allocate attention to the eyes. However, allocation of attention does not necessarily infer that the participants with autism were actively interpreting the eye region or eye cues and this may be the critical difference between groups.

Although not directly assessing the use of the eye and mouth regions, Tager-Flusberg, Plesa-Skwerer, Faja and Joseph (2003) investigated the use of face parts in a whole-part recognition task with participants with WS. The research was specifically interested in whether participants were affected by face inversion, and whether individuals with WS were more or less accurate for processing isolated face parts than whole faces. A large sample of adolescents and adults with WS (n=47, ages 12-36 years, mean 20 years) matched parts of faces to a previously presented whole face target. Six trials used the isolated eye region, whilst six trials assessed use of the mouth region. For upright faces, participants with WS and individuals who developed typically showed greater accuracy for matching eyes to previously seen whole faces than matching the mouth region. However, in WS this difference failed to reach significance (mean eyes 67%, mouth 61%). The research replicates previous research suggesting that adults are more accurate at matching faces using the upper than lower features (Langdell, 1978). Although the pattern of performance for individuals with WS did not research significance the direction of any difference between the use of upper and lower features is mirrored in WS. It would make sense that the difference between eye and mouth regions is found in WS considering evidence of a good use of the eye region for eye gaze cues (e.g. chapter 3, alongside previous research from Karmiloff-Smith et al., 1995).

5.2 Experiments 4a & 4b

To investigate how individuals with autism and WS process different face features, the following section splits face stimuli into upper and lower parts. Experiments 4a and 4b use the upper versus lower face processing paradigm established in typical face processing research to assess feature use by participants with Williams syndrome (exp. 4a) and autism (exp. 4b). The experiments in this chapter aim to confirm the findings of Langdell (1978) using unfamiliar rather than familiar faces and face matching rather than identification. This is an important methodological dissociation between the present study and previous research, which influences the very nature of demands placed on participants. A matching task was chosen to lessen the verbal demands and reduce the possibility of floor effects for participants with autism. Also, recognition of familiar faces involves matching to long-term memory and group differences may emerge due to memory difficulties. It will be interesting to see if the upper versus lower face pattern evident in previous research using familiar face recognition can be extended to a different face processing paradigm.

5.2.1 Experiment 4a

Based on the previous research carried out for this thesis, it is predicted that children with WS will show the same pattern of performance as typically developing participants and will match faces more accurately using upper than lower features. Individuals with WS have already shown proficient use of upper features, for example the eye region for gaze cues (exp. 1a). Evidence from Tager-Flusberg et al. (2003) suggests that adults and adolescents with WS show a similar performance pattern as typically developing individuals when using the upper and lower features. A change of procedure used in the current study may confirm this pattern. Explicitly, it is hypothesized that participants with WS will match face parts more accurately from upper than lower features.

Method

Participants

Four groups took part in this study with each participant with WS matched to three typically developing individuals of comparable verbal (VMA), nonverbal (NVMA) and chronological age (CA). The fifteen participants with WS were recruited through the Williams syndrome Foundation (Scotland branch) and several participants had previously taken part in experiments that contribute to this thesis. Eleven participants had received FISH tests to confirm their diagnosis of WS. The testing session consisted of a number of face processing tasks contributing to this thesis.

The participants with WS ranged from 10 years 0 months to 18 years 8 months with a mean chronological age of 15 years 6 months (see Table 5.1). Verbal mental age (VMA) was assessed using the British Picture Vocabulary Scale II (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997) giving a mean verbal age of 10 years 10 months (ranging 9 years 1 month to 13 years 1 month). Nonverbal ability was assessed using the Ravens Coloured Progressive Matrices (RCPM; Raven, Court, & Raven, 1990) giving a mean score of 15 (ranging 9 to 28). Typically developing participants were recruited from mainstream primary and secondary schools. The typically developing groups did not differ from the group with WS on the ability for which they were matched (WS-VMA p=.73; WS-NVMA p=.69; WS-CA p=.36) and full details are seen in Table 5.1.

Table 5.1 WS and comparison group details for chronological ages as well as verbal and nonverbal mental age abilities (SD in parenthesis)

Group	N	Gender ratio (males:females)	CA[1]	VMA[1]	NV score[2]
Williams syndrome	15	10:5	15y 6m *(34)*	10y 10m *(20)*	15 *(6)*
VMA Match	15	7:8	11y 6m *(17)*	10y 11m *(24)*	26 *(5)*
NVMA Match	15	9:6	8y 4m *(16)*	8y 0m *(17)*	15 *(3)*
CA Match	15	10:5	15y 8m *(33)*	15y 0m *(19)*	31 *(6)*

1 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviations

2 Nonverbal mental age ability provided as mean score on the RCPM (max. score 36)

Informed consent was received for all participants prior to their involvement. Ethical approval was gained from the Psychology Department, the Williams syndrome Foundation and the local council prior to carrying out the study.

Materials

Participants viewed a target face part at the top of the page and had to match this with one of the face parts shown at the bottom. Only upper or lower features were available for matching. The target face shown at the top of the page differed from the correct answer and distracter on view (therefore performance solely due to pattern matching was not possible). For example Figure 5.1A and 5.1B show front view target faces but 45 degree faces for the distracter and correct answer. The 45 degree and front view faces appeared as the target equally often across trials. The correct answer appeared equally often on the left and the right with the distracter face on the opposite side. Participants completed 6 trials in each of the upper and lower face conditions with the order randomized across participants.

All images were of female faces due to the availability of photographs showing 45 degree and front view faces from the Stirling Faces Database. The face stimuli were of individuals between 18 and 21 years of age and were unfamiliar to participants. Stimuli were presented as black and white images and all pictures were standardized to 200x300 pixels. Photographs were trimmed and the upper or lower features removed using Adobe Photoshop 7.0 (Adobe Systems Inc, CA). Features were removed from a midpoint of the nose either above or below this point depending on the desired features (see Figure 5.1).

Procedure

Participants were tested individually either in their own home or in school. Stimulus presentation was self-paced and the trial remained in front of the participant until they made their choice. Participants were required to point to the face at the bottom that matched the identity of the face shown at the top of the page.

Figure 5.1 i) a lower feature matching trial ii) an upper feature matching trial

i ii

Results

The mean percent correct obtained on each type of trial and each group is displayed in Table 5.2. A 2 x 4 analysis of variance (ANOVA) was carried out on the percentage of correct answers with Part-of-Face (upper, lower) and Group (WS, VMA, NVMA, CA) as factors. This revealed a significant main effect of part of the face used for matching $F(1,56)=30.72$, $p<.001$ and participants were more accurate using the upper than lower features. There was also a significant effect of Group $F(3,56)=10.43$, $p<.00l$ predominantly created by the high performance of the CA matched group (see Table 5.2). Combining performance on upper and lower conditions, the CA group performed significantly higher than the WS group ($t(14)=4.43$, $p<.01$), as well as both the VMA ($t(14)=3.37$, $p<.01$) and the NVMA groups ($t(14)=4.83$, $p<.001$). Importantly, there was no difference in overall accuracy for the WS, VMA and NVMA groups (WS-VMA p=.13, WS-NVMA p=.34, VMA-NVMA p=.17).

There was no significant interaction between the factors (p=.22) and therefore the participants with WS showed the same pattern as the participants who developed typically. All groups were most accurate at matching the identity of unfamiliar faces from the upper face area and participants with WS performed at a level predicted by their mental age.

Table 5.2 The mean percentage of correct answers for each type of trial for participants with WS and their matched comparison groups (SD in parenthesis)

	Upper Features	Lower Features	Overall
Williams syndrome	88 *(13)*	67 *(19)*	77 *(12)*
VMA match	88 *(12)*	78 *(10)*	83 *(7)*
NVMA match	85 *(11)*	76 *(10)*	81 *(7)*
CA match	98 *(6)*	86 *(9)*	92 *(5)*
Overall	89 *(12)*	77 *(14)*	80 *(9)*

Age and performance

To investigate the effect of participant age on task performance, Spearman's Rho correlation test was applied to the data. Accuracy for typically developing participants was collated into one group (n=45) and the WS group performance was analysed separately. For typically developing participants between the ages of 8 years 0 months to 18 years 6 months there was a significant increase in overall task accuracy as they increased in age ($r=.77$ $p<.01$). For participants with WS there was also a significant increase in accuracy with an increase in chronological age ($r=.81$, $p<.01$).

Splitting accuracy by face part (upper or lower) typically developing participants showed a significant increase in performance with age for both face regions (upper $r=.55$, $p<.01$; lower $r=.61$ $p<.01$). Participants with WS showed a significant increase in lower face matching with age, but not upper face matching (upper $r=.29$, $p=.30$; lower $r=.70$ $p<.01$). Some care is required for interpreting correlation data for the WS group due to the relatively small sample size (WS n=15, TD n=45) and ceiling performance in the upper face condition.

Discussion

The upper face area was more useful for unfamiliar face matching than the lower region, for both individuals with WS and typically developing participants. The evidence corresponds with previous claims from familiar face recognition showing an upper face advantage in typical development (e.g. Langdell, 1978). No previous research has directly addressed upper and lower face processing in WS and therefore it is not possible to compare this finding with previous evidence. However, it is possible to discuss what this finding tells us about face processing by individuals with WS and specifically how this finding may relate to features of the WS phenotype and our own previous research. Referring back to chapter 3, individuals with WS were proficient at processing the eyes for gaze cues, an essential upper face feature. This ability dissociated the group with WS from individuals with general developmental delay. In contrast, when using the lower face for speech cues, chapter 3 showed no difference between individuals with WS and general developmental delay. Strength using the upper features of the face in the present chapter may relate to a proficiency at tasks using these upper features (evident throughout chapter 3).

The same performance *pattern* was evident across groups as the upper face features were matched most accurately. As with all tasks of this nature (including the internal versus external processing paradigm) some inherent difference may appear between task conditions, but importantly performance was not *differentially* impacted upon across groups. All groups found the upper rather than lower features easier to match for unfamiliar faces. Although participants with WS show some evidence of general delay (as performance was comparable to mental and not chronological age) there was no evidence of atypical deviant processing using this paradigm.

5.2.2 Experiment 4b

Based on the premise of Langdell (1978) it is hypothesized that participants with autism will not show greater accuracy for upper than lower features, although this relative advantage for upper features will be evident for typically developing groups. A different *pattern* of performance will therefore be evident between the typically developing and autism groups suggesting atypical performance in autism.

Method

Participants

Twenty individuals with autism with a mean age of 14 years 9 months (ranging from 9 years 11 months to 18 years 1 month) were recruited from a school for pupils with autism spectrum disorders. Each participant was matched to three typically developing participants on the basis of verbal mental age, nonverbal ability and chronological age.

Table 5.3 Participant details for individuals with Autism and their matched comparison groups

Group	N	Gender ratio (males:females)	CA[1]	VMA[1]	NV score[2]
Autism	20	16:4	14y 9m *(29)*	7y 2m *(23)*	15 *(6)*
VMA Match	20	15:5	6y 6m *(18)*	7y 3m (*21)*	12 *(7)*
NVMA Match	20	13:7	7y 11m *(15)*	8y 2m *(18)*	15 *(5)*
CA Match	20	12:8	14y 11m *(27)*	14y 8m *(20)*	31 *(5)*

1 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviations

2 Nonverbal mental age ability provided as mean score on the RCPM (max. score 36). Standard deviation in parenthesis

Verbal ability was assessed using the BPVS whilst nonverbal performance was assessed by the RCPM. T-test statistics showed that the group with autism did not differ significantly from the group with which it was matched on any of the matching criteria, as also evident from the mean scores in Table 5.3 (autism-VMA p=.78; autism-NVMA p=.69; autism-CA p=.41). Using the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Rocher Renner, 1988) 11 children were classified as mild-moderately autistic and 9 children as severely autistic.

Results

A 2 x 4 ANOVA with factors Part (upper, lower) and Group (autism, VMA, NVMA, CA) was used to analyse the percentage of correct responses for each type of trial. This revealed a significant effect of the part of the face used for matching $F(1,76)=27.63$, $p<.001$, with upper feature accuracy greater than lower feature accuracy. The ANOVA also revealed that when upper and lower conditions were considered together there was a significant effect of Group $F(3,76)=32.29$, $p<.001$. The participants with autism did not perform as accurately as the VMA group ($t(19)=2.96$, $p<.01$), the NVMA group ($t(19)=5.68$, $p<.001$) or the CA group ($t(19)=8.98$, $p<.001$). Additionally, the VMA group did not perform as well as the NVMA group ($t(19)=3.24$, $p<.01$) who in turn did not perform as accurately as the CA group ($t(19)=4.53$, $p<.001$). Ultimately on overall task performance the group with autism did not perform as well as any of the typically developing groups (evident in Table 5.4).

The ANOVA revealed a significant interaction between Group and Part $F(3,76)=6.93$, $p<.001$. T test analyses showed a significant difference between upper and lower face conditions for participants in the VMA group ($t(19)=5.66$, $p<.001$), the NVMA group (t(19)=3.94, *p*<.01), and the CA group (t(19)=3.68, *p*<.01) but not for participants in the autism group (*p*=.48).Specifically, all typically developing groups found it easier to match parts of the face using the upper than lower features as evident in Table 5.4. However participants with autism did not show a difference in accuracy for matching the upper or lower features of unfamiliar faces.

Table 5.4 Autism data for the mean percentage of correct answers obtained in each type of trial (SD in parenthesis)

	Upper Features	Lower Features	Overall
Autism	60 *(17)*	63 *(13)*	61 *(13)*
VMA match	79 *(10)*	65 *(12)*	72 *(10)*
NVMA match	84 *(8)*	77 *(6)*	80 *(6)*
CA match	94 *(10)*	86 *(12)*	89 *(7)*
Overall	79 *(16)*	72 *(14)*	74 *(14)*

Looking at the performance of the group with autism in each condition (evident in Table 5.4), for matching upper features participants with autism performed significantly less accurately than all other groups (autism-VMA t(19)=4.04, *p*<.01, autism-NVMA t(19)=6.11, *p*<.001, autism-CA t(19)=7.61, *p*<.001). For lower features there was no difference in accuracy for participants with autism and those matched for verbal mental age (*p*=.52), however performance was significantly lower than those matched for NVMA (t(19)=3.87, *p*<.01) and CA (t(19)=7.53, *p*<.001).

Age and performance

To investigate the relationship between chronological age and performance, Spearman's Rho correlation test was applied to each group (TD n=60, autism n=20). For typically developing participants, performance increased with age ($r=.42$, $p<.01$) but for participants with autism there was no significant relationship between age and performance ($r=.08$, $p=.74$). Interestingly, performance was also not correlated significantly with score on the CARS for participants with autism ($r=.06$, $p=.78$).

Splitting performance by face part, typically developing participants showed an increase in accuracy with age for both face regions (upper $r=.54$, $p<.01$; lower $r=.55$, $p<.01$). For participants with autism there was no significant correlation between age and performance for either upper or lower features (upper $p=.75$; lower, $p=.75$).

Discussion

Participants with autism did not show greater accuracy for matching upper than lower features of unfamiliar faces, dissociating their performance from the groups that developed typically. There was no difference in accuracy using the upper or lower face areas for the individuals with autism. This lack of difference is driven by poor performance in the upper condition. Overall performance level suggests a general deficit or delay on the current face processing task and no specific benefit, or indeed interference, caused by access to the eye region. The difference between groups when using the upper face region is the important aspect of the results section and replicated findings from eye tracking studies dissociating the use of eye and mouth regions (Dalton et al., 2005).

The mean age of the group with autism was 14 years 9 months, corresponding almost exactly to the average age of the older autism group from Langdell (1978; mean 14 years 1 month). The results of the present study replicate the findings of Langdell for this age group of individuals with autism as there was no difference using upper or lower face regions. Importantly, Langdell (1978) used a familiar face recognition task and the present study replicates the findings using unfamiliar face matching with a larger sample of individuals (20 compared to 10 participants). This confirms the suggestion that the upper face region is not relatively more useful for face processing than the lower region for individuals with autism, contrasting evidence from typically developing children and adults.

The socially relevant information retrieved from the upper face region, and specifically the eyes, does not increase the use of this region in autism. Langdell (1978) noted that equal use of the upper and lower features does not imply active gaze avoidance in autism, if this were the case then lower face accuracy would be *higher* than that for the upper face. That is not to say, however, that poor performance by participants with autism in the upper face condition is unrelated to the involvement of the eyes. Direct gaze was shown in the front view of faces in the present task and this may have hindered performance for the participants with autism.

In summary, the group with autism performed less accurately with both upper and lower features when matching unfamiliar faces, and thus show general delay as well as atypicality of identity matching compared to typically developing participants. Importantly, the relative increase in accuracy for upper over lower face matching seen in the typically developing groups was not mirrored by the group with autism.

5.3 Experiments 4a and 4b: Typical relationships between age and performance

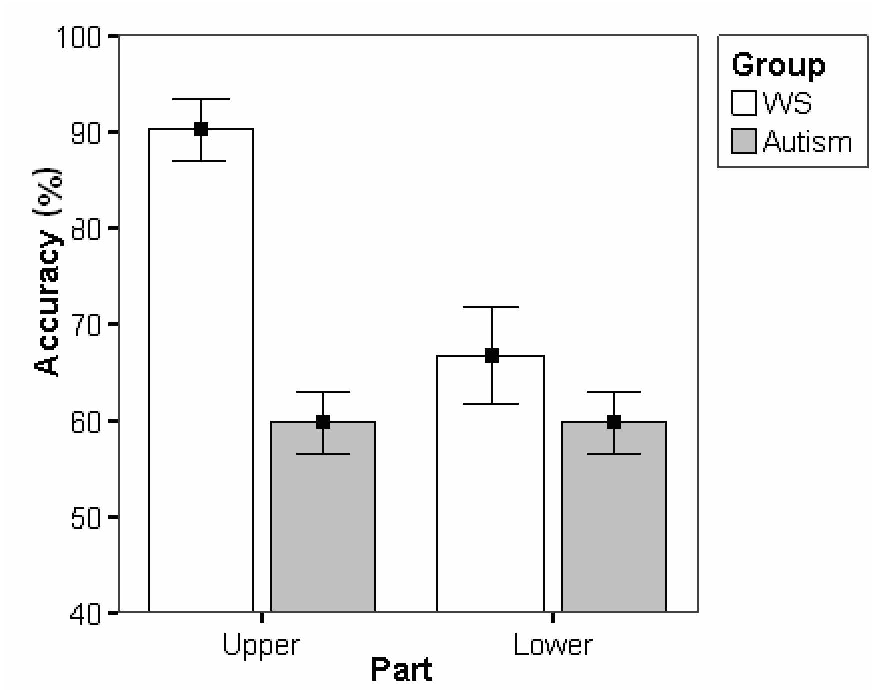
It is possible to combine the data for typically developing children who participated in experiments 4a and 4b to look at the overall relationship between age and performance. The total sample of typically developing children encompassed 81 children between the ages of 7 years 11 months and 18 years 6 months. This sample size takes into consideration that a small number of participants were included as a control participant for an individual in the WS group as well as a participant in the autism group and therefore were only included once in this investigation. The pattern of performance for this large sample of typically developing children can inform us of the processing pattern for upper and lower features that is typical through development and related to chronological age. Children who developed typically were more accurate matching upper than lower face features $t(80)=.2.97$, $p<.01$ (mean upper features 85% mean lower features 79%).

Correlation analyses revealed that performance increased significantly with age for the task as a whole $r=.56$ $p<.01$ and indeed this was evident for both upper and lower features separately (upper features r=.61, $p<.01$; lower features r=.55, $p<.01$). Therefore across all ages in typical development it is easier to match upper than lower face features; a pattern mirrored in WS but not autism.

5.4 Experiments 4a and 4b: Directly comparing WS and Autism

A sub-group of individuals with WS and autism were matched to each other on the basis of chronological age and nonverbal ability to allow comparisons between these two developmental disorders. Each matched group comprised 12 individuals and the groups did not differ on chronological age (WS mean 13 years 8 months, Autism mean 13 years 9 months; $t(11)=1.08$, $p=.31$) or nonverbal ability (WS mean 14, Autism mean 15; $t(11)=.34$, $p=.74$). A 2x2 ANOVA with factors Group (WS, Autism) and Part (Upper, Lower) was conducted and revealed not only a significant effect of Part $F(1,22)=12.35$, $p<.05$ and Group $F(1,22)=545.30$, $p<.001$ but an interaction between factors $F(1,22)=11.19$, $p<.01$. Investigation of partial eta squared revealed that all effects were particularly large (Group $\eta^2= .53$, Part $\eta^2=.31$). Figure 5.2 shows that although individuals with WS were affected by the part of the face they were using ($t(11)=3.5$, $p<.01$), this was not evident in autism ($p=.99$). The difference between individuals with WS and autism is greatest when the eye region is involved (upper WS-autism $t(11)=7.50$, $p<.001$; lower WS-autism $p=.27$). This is emphasized by the effect size between groups being greater for upper than lower features (upper face between groups d=2.32, lower face d=.45).

Figure 5.2 Matched groups of participants with WS and autism processing upper and lower face features



5.5 General Discussion

Experiments 4a and 4b investigated how individuals with autism and WS match unfamiliar faces using upper or lower features. Although participants with WS showed the same pattern of performance as the typically developing groups, participants with autism did not. This paradigm shows delayed and deviant performance in autism alongside delayed performance in WS. All typically developing participants and those with WS showed relatively greater accuracy for matching upper than lower features of unfamiliar faces. For the group with autism this relative benefit for upper features was not evident. The results from experiment 4b replicate previous research by Langdell

(1978) using a familiar face recognition task. Therefore, placing different demands on participants the pattern of performance remained the same.

Together experiments 4a and 4b provide an insight into how individuals with two specific developmental disorders use different face areas to match identity. The group with autism does not show a strong ability to match face parts and specifically does not show the relative proficiency using the upper compared to lower features that is seen in typical development or WS. It may be possible that individuals with autism have not developed the same expertise with these features. It is difficult to say whether the lack of an upper face advantage in autism is due to difficulties interpreting social stimuli or whether the effect appears in the opposite direction (social difficulties emerge due to atypical face processing). Relating this to autism in general, research has suggested that individuals may not be as sensitive to socially arousing information in their environment (such as faces and particularly people's eyes) or may show sensory abnormalities (e.g. hyper- or hypo-arousal) which may impact upon the type of information gathered from their environment (e.g. Rogers & Ozonoff, 2005). Learning that the eyes are a particularly informative face feature may therefore be one effect of these atypicalities in autism and affect face processing and experiences interacting with people as a whole.

Also taking the data for typical development from experiments 4a and 4b, it is possible to see that increased accuracy for matching upper than lower features is apparent across ages. Between 7- and 18-years of age children and adolescents who develop typically show that upper features were most accurately matched. This corresponds to evidence from typical development for identity recognition by Langdell (1978). The large sample of typical participants makes comparisons relatively easy to interpret though more care is needed in the individual experiments where smaller samples are apparent. The pattern of performance is mirrored by the small sample of individuals with WS, though the difference between upper and lower regions appears more exaggerated in this sample. Upper feature accuracy does not appear related to age in WS, however ceiling effects were evident for a number of participants, therefore this may be less representative of performance patterns as a whole. For the 20 individuals with autism, task performance was not significantly correlated with age and the difference between upper and lower face parts was much less evident.

Relating back to previous chapters, participants with autism had problems interpreting the eye region for gaze cues in chapter 3, requiring use of the upper features. In the same chapter, this group had difficulties with expressions, requiring use of both the eye and mouth regions. Therefore this difficulty using the upper face area is mirrored throughout this thesis across tasks with varying demands. In contrast, the group with WS exhibits the relative advantage for upper feature matching that is clearly found in children who develop typically. Linking back to previous experiments, individuals with WS have proven good at interpreting the eyes for gaze cues and expressions in chapter 3 and these tasks inherently require use of the upper features. Indeed the tendency towards internal features in chapter 4 may also relate in part to a strength at using the upper internal features. Therefore the results are also mirrored across chapters and across tasks of varying requirements.

5.5.1 Methodological considerations

The experiment presented in this chapter included 6 trials in each face condition and this is comparable to the number of trials used by Tager-Flusberg et al., (2003) in their investigation of whole .v. parts face processing in WS. One reason for this relatively small number of trials was to make the task quick for participants with short concentration spans (always a consideration for research with young children or individuals with developmental disorders). However, to increase the reliability of findings it may be useful to include more trials. Another reason for the small number trials was for using face stimuli already available on the Stirling Faces Database, however for future studies new images of faces could be made. This will also allow for the inclusion of male as well as female stimuli.

The present investigation involved unfamiliar face matching, replicating the results from familiar face recognition (Langdell, 1978). By changing the task demands the nature of the processing required by participants is also altered. Concerning autism, the present study has found no evidence of increased accuracy for upper than lower features across different paradigms and different face stimuli. It can therefore be deduced that this is a consistent finding in autism and the upper face and eye region does not demand attention. Additionally, and of equal importance, greatest accuracy using upper features by typically developing individuals has been replicated for unfamiliar face matching, confirming evidence from familiar face recognition. This chapter has therefore, not only informed us of feature use in autism and WS but extended the literature concerning typically developing participants.

As with other tasks presented in this thesis, accuracy data reveal an interesting difference between the typically developing and developmental disorder groups. The use of reaction times may also reveal subtle group differences or similarities, although low accuracy levels may make reaction times somewhat unreliable. If the eye region automatically captures attention and is processed more reliably than the lower face area, we might hypothesise that participants would be faster for upper than lower face matching (this may be linked to faster reaction times for configural than featural face processing, Donnelly & Hadwin, 2003). Decreased latency for upper features would not be predicted for participants with autism.

On another methodological note, it is difficult to ignore the unnatural nature of the face stimuli presented in this task, with upper or lower face areas missing. It would be interesting to investigate whether these results are replicated with whole faces, with unwanted face areas blurred or covered to inhibit their use. This would avoid the unnatural aspect of cropped faces, although blurred images may also appear somewhat unnatural. It may also be possible to incorporate whole faces with unwanted face areas covered by naturally occurring obstacles, such as a sunglasses covering the eye region, a hat covering part of the upper features and a bandana covering the lower face. However, it has been found that children are particularly affected by paraphernalia (e.g. Freire & Lee, 2000). There are a number of possible task manipulations that could be incorporated within this paradigm, though each have their own difficulties. Increasing ecological validity is important for mirroring naturalistic face processing.

5.6 Conclusions

This chapter has provided evidence for an atypical use of upper and lower face regions for unfamiliar face matching in autism, alongside typical but delayed use in WS. Typically developing children and individuals with WS were more accurate matching upper than lower features, whilst participants with autism showed no difference between regions. The evidence presented here notes that individuals with WS show a lower level of performance than predicted by chronological age but the same overall pattern of performance, however, that is not to say that the task is being conducted in the same way across groups. For example, participants with WS may be utilizing feature-based processing of the eye region and therefore are less accurate than the chronological age matched group who may be utilizing configural processing. The current chapter cannot explore these issues in detail. The following chapter builds on the foundations of the current exploration, using whole faces with manipulated features rather than cropped images and goes some way further in exploring processing styles. Although face distortions will affect the natural aspect of the face, using whole images may go some way in decreasing the obvious face manipulations evident in the upper versus lower paradigm. Experiment 5 requires participants to spot distortions to the eye or mouth region of unfamiliar faces using a classic face illusion, whilst also providing the opportunity to investigate aspects of configural processing. As well as extending the investigation of feature use with whole faces, the following chapter allows an exploration of processing styles (or structural encoding) within the same task. In addition it will therefore be possible to investigate claims of atypical processing strategies for the first time in this thesis.

Chapter Six

The Thatcher Illusion

6.1 Introduction

To investigate the way faces are understood by individuals with Williams syndrome (WS) and autism, chapter 6 employs a face illusion to probe use of the eye and mouth regions, as well as explore processing style. For the first time in this thesis we will probe the structural encoding of faces and examine the use of 'second-order relational' information (for a clear definition of 'second-order relational information' refer to Chapter 1 section 1.4.1). The chapter builds on the exploration of eye and mouth processing by using whole face images with manipulations made to face areas in accordance with the illusion. Applying a paradigm used in typical face perception research it will be possible to learn more about face perception in WS and autism.

6.1.1 The Thatcher Illusion

The Thatcher Illusion (Thompson, 1980) has previously been employed to investigate face processing style and is created by inverting the eye and mouth regions with respect to the rest of the face. The resulting face is subjectively perceived as grotesque, however this perception is reduced by inverting the image. Figure 6.1 provides an example of the classic illusion as produced by Thompson (1980) emphasizing how the manipulation appears removed, or at least lessened, by inversion.

Figure 6.1 The classic Thatcher illusion: The original image, the altered upright image and the altered inverted image (from left to right)

Taken from Thompson (1980)

Over the last two decades researchers have been interested in this illusion when interpreting how faces are processed and in particular the effect of face inversion. For example, Lewis and Johnston (1997) used the Thatcher illusion as a key to probing configural processing. One interpretation of the illusion is that the inverted face appears less grotesque as the features are not processed in configuration, but as independent face parts. This has proved informative for investigations of face processing style and the use of configural or featural information. Bartlett and Searcy (1993) suggested that configural information is disrupted by 'Thatcherising' the face whilst featural information remains unaffected. As part of the ongoing discussion of face processing in Williams syndrome and autism, the Thatcher illusion is particularly useful; not only may it inform us about processing the eye and mouth regions, it may contribute to our understanding of processing style.

6.1.2 The Thatcher illusion and adults

Over the last two decades this illusion has been treated as a rough benchmark for whether configural processing is taking place. For example, Sjoberg and Windes (1992) measured the time taken for adults to detect the Thatcher illusion and found a steady increase in reaction time as the angle of rotation increased. The greatest increase in reaction time occurred between 60 and 120 degrees as the face traversed the horizontal axis (participants took much longer to detect the illusion at 120 than 60 degrees). They concluded that based on the disruption caused by inversion, configural information was essential for detecting Thatcherised faces. This was also concluded when Murray et al. (2000) asked adult participants to rate how 'bizarre' a face appeared. It was found that between 90 and 120 degrees there was a dramatic effect on performance and passing the horizontal position was disruptive to configural processing. Based on several such studies, it has been concluded that an inverted Thatcherised face is particularly difficult for adults to detect.

6.1.3 The Thatcher illusion in children

Although an abundance of research has suggested that children do not begin to use configural face processing until late childhood (e.g. Carey & Diamond, 1994), studies have found that younger children are susceptible to the Thatcher illusion. Lewis (2003) proposed that if children base face judgments on isolated features more than adults (and thus less on the relationship between features) they will be able to spot a Thatcherised face at a greater degree of rotation. This claim is based on the premise that rotation disrupts configural but not featural processing.

Lewis (2003) conducted research involving 66 participants from 6- to 75-years of age who were required to rotate a picture of a Thatcherised famous face presented on a disc until the face appeared ‘funny’ or ‘strange’ (beginning in the inverted condition). The degree of rotation was noted for each participant and the average degree needed for the face to appear grotesque was around 75 degrees from inverted (108 degrees from upright). This corresponds to the 90-120 degrees proposed by Murray et al. (2000). Importantly the task involved only one experimental trial with a face that may have differed in familiarity across participants (a new English pop star). The face was also presented as a large 12-inch image possibly impacting upon processing style. Overall, Lewis found no difference in the degree of rotation when age was considered and concluded that children perceive the Thatcher illusion in much the same way as adults. Importantly, Lewis commented that “whatever configural encoding is required to see the Thatcher illusion, it is present from an early age and the degree of rotation at which it is available is unchanged by development” (Lewis, 2003; 1420). Evidence from the Thatcher illusion task therefore impacts upon, and challenges, claims that children are unable to utilize configural face cues and also emphasises that the Thatcher illusion may be rather uninformative as a tool for assessing development.

Donnelly and Hadwin (2003, exp. 1) asked participants which of two faces looked the most ‘unusual’, with one face showing the Thatcher illusion. Children (6-10 years) and adults took part in the study and trials were either upright or inverted grey scale images. Although all participants performed at ceiling level for upright trials, all groups were less accurate with inverted faces. When Donnelly and Hadwin (2003, exp. 2) replicated the procedure with Thatcherised Mooney faces they found that children aged 6-years were less susceptible to the illusion than older participants. Taking the results for the two experiments together, the authors conclude that there is evidence of weak configural processing in younger children that becomes more resilient with age. It certainly appears that when grey scale faces are presented simultaneously and participants are asked to detect the illusion, young participants show some use of configural face processing. This age range also corresponds with research by Mondloch, Dobson, Parsons and Maurer (2004; exp. 3) finding that 8-year olds rated inverted Thatcherised faces as less ‘bizarre’ than upright faces (on a seven-point scale).

Adding to the literature, Bertin and Bhatt (2004) studied the illusion in infancy. In an habituation study 32 six-month-old infants were familiarized with either unaltered or Thatcherised schematic faces. A novelty preference was used to assess whether infants could tell the difference between a habituated face (either Thatcherised or unaltered) and a new face drawing (the opposite condition). Increased looking at the new face would indicate successful discrimination. The study found that infants were able to successfully discriminate between faces in an upright condition but not when inverted. The evidence suggests that to some extent this illusion is not only present for adult face viewers but also for both children and infants and Bertin and Bhatt (2004) conclude that the results are consistent with the idea of infants being sensitive to aspects of second-order relations.

Based on this one paradigm it would seem unjust to challenge all previous research concerning featural and configural processing for children, however there is some suggestion that certain aspects of second-order relations (that are implicated in this illusion) appear to be used by infants, children and adults. Therefore, as well as revealing important aspects of eye and mouth processing, the Thatcher illusion may be able to reveal whether individuals with WS or autism are susceptible to these aspects of face processing.

6.1.4 Thatcher illusion and autism

One study has implemented the Thatcher illusion with participants with autism to understand how faces are processed by this group. Rouse,T Donnelly, Hadwin and Brown (2004) found that a sample of 11 males with autism (and additional moderate learning difficulties, mean verbal age 6 years 3 months, non-verbal ability 9 years 3 months, chronological age 9 years 7 months) were as susceptible to the illusion as control groups of typically developing children (n=15, matched for nonverbal ability) and children diagnosed with moderate learning difficulties without autism (n=15, matched for verbal ability). Participants viewed two blurred unfamiliar faces side by side (upright or inverted) with one face Thatcherised. The task stimuli were taken from Donnelly and Hadwin (2003) as previously detailed in this chapter. Participants indicated the face that appeared ‘funny’ or ‘strange’. Both accuracy and reaction time were measured and as a control condition the task was also conducted with pictures of houses (with the windows and door inverted). The data showed no difference in accuracy between the group with autism and either matched comparison group (however ceiling effects were evident for the typically developing group in the upright condition). All groups were more accurate for upright than inverted faces and houses and for all groups the difference between upright and inverted conditions was greater for faces than houses. The authors conclude that participants with autism are as susceptible to the Thatcher illusion as typically developing individuals and engage in some relatively face-specific processes that enable second-order relational processing.

The trials used by Rouse and colleagues (2004) involved an inversion of both mouth and eye regions as used in the traditional form of the illusion. It would be interesting to separate these areas and use partially Thatcherised faces with either mouth *or* eyes inverted. After all, it may be that the group with autism find judgments based on the eye region particularly difficult. This would make sense in the light of previous research separating the eyes and mouth and suggesting no upper face advantage for individuals with autism (e.g. Baron-Cohen et al., 1995, Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Langdell, 1978). This would also make sense in terms of the findings of previous chapters of the thesis, showing difficulties interpreting the eye region across various task demands.

To our knowledge the Thatcher illusion has never been used to study individuals with WS, although this may inform us of interesting performance patterns. Given evidence of a typical style for processing upper and lower features (exp, 4a) it would be interesting to see if individuals with WS mirror evidence from typically developing participants. Therefore, we would expect better performance for more salient features; explicitly, eye region accuracy greater than mouth region accuracy. It would also reveal whether participants with WS use aspects of second-order relations of the face, as previous research has suggested that performance is reliant upon featural processing (e.g. Rossen, Jones, Wang, & Klima, 1995).

6.2 Experiment 5a & 5b

For both autism and WS, it appears that a more detailed investigation of the Thatcher illusion and second-order relational information is warranted. Not only will this tell us about the processing style used by participants, but particularly relevant to this thesis, the investigation will tell us about susceptibility to the eye and mouth regions. It will be useful to make separate manipulations of the eye and mouth regions to include trials where one or the other is inverted. This will tell us whether susceptibility to the illusion is driven by a particular face area and whether this varies across groups. Experiment 5a will first apply the illusion with participants who have WS, followed by a replication in autism for experiment 5b.

6.2.1 Experiment 5a

When alterations are made to only the eye or mouth regions, it is predicted that all participants (WS and typically developing) will be more accurate for changes made to the eyes than mouth, supporting evidence from chapter 5. It is also hypothesized that individuals who develop typically, as well as participants with WS, will be more accurate for upright than inverted trials. Previous research has concluded that children are able to detect a Thatcherised face more accurately when upright than inverted (e.g. Donnelly & Hadwin, 2003). Importantly, based on evidence from chapter 5 we predict the same *pattern* for the WS and typically developing groups (greater accuracy for eyes than mouth and upright than inverted trials).

Method

Participants

Primarily the participants were the same as those who took part in experiment 4a, forming groups of WS individuals and matched groups of typically developing children based on verbal, nonverbal ability and chronological age. However two participants with WS did not complete this task due to one being unavailable and another being unable to conform to task demands. Participant details are shown in Table 6.1 and full details concerning group matching and recruitment are available in section 5.2.1 of chapter 5.

Table 6.1 Participant details for individuals with WS and their matched comparison groups

Group	N	Gender ratio (males:females)	CA[1]	VMA[1]	NV score[2]
Williams syndrome	13	10:3	13y 6m *(33)*	10y 8m *(21)*	15 *(7)*
VMA Match	13	7:6	11y 0m *(19)*	10y 11m *(20)*	27 *(4)*
NVMA Match	13	8:5	8y 0m *(14)*	8y 3m *(11)*	15 *(5)*
CA Match	13	8:5	13y 8m *(31)*	12y 10m *(19)*	30 *(8)*

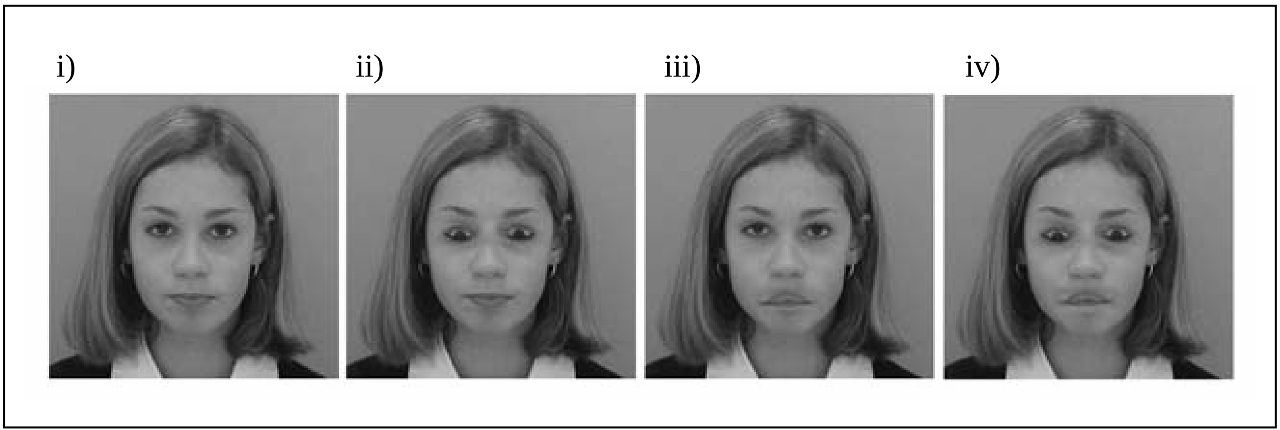
1 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviations

2 Nonverbal mental age ability provided as mean score on the RCPM (max. score 36) standard deviation in parenthesis

Materials

Digital photographs of 12 individuals were used to create the task stimuli (all faces would be unfamiliar to participants). Each photograph was converted into grey scale and cropped so only the head and shoulders were in view (as seen in Figure 6.2). Using Adobe Photoshop 7.0 (Adobe Systems Inc, CA) images were manipulated to make the desired feature change. For each face image three distinct changes were made; the mouth was rotated, the eyes were rotated or both eyes and mouth were rotated. An example of each of these manipulations is evident in Figure 6.2. All images were standardized to 300 x 200 pixels in size. Pairs of stimuli were made with the original image and one of the manipulated images side by side with a 1 cm gap between them. The position of the original image was counterbalanced and appeared on the left and right equally often. One third of the trials (12 in total) appeared in the upright condition, one third appeared rotated 90 degrees (6 trials 90 degrees left and 6 trials 90 degrees right) and one third appeared inverted.

Figure 6.2 An example of each type of face manipulation i) original image ii) inverted eyes iii) inverted mouth iv) inverted eyes and mouth



Procedure

Participants were tested individually in their own home or in the school setting. All participants had already completed tasks investigating face processing (as part of this thesis). As practice trials participants viewed upright pairs of images with manipulated features. The practice comprised houses (e.g. one house in the pair with the windows and door in incorrect places) and faces (e.g. with features incorrectly placed or missing). The manipulations in these practice trials were particularly large to help participants understand the task demands (see figure 6.3a). Participants were asked to point to the picture that looked ‘funny’ or ‘strange’. All participants successfully completed the practice trials.

Figure 6.3a An example of a practice trial using i) a scrambled face and ii) the original image

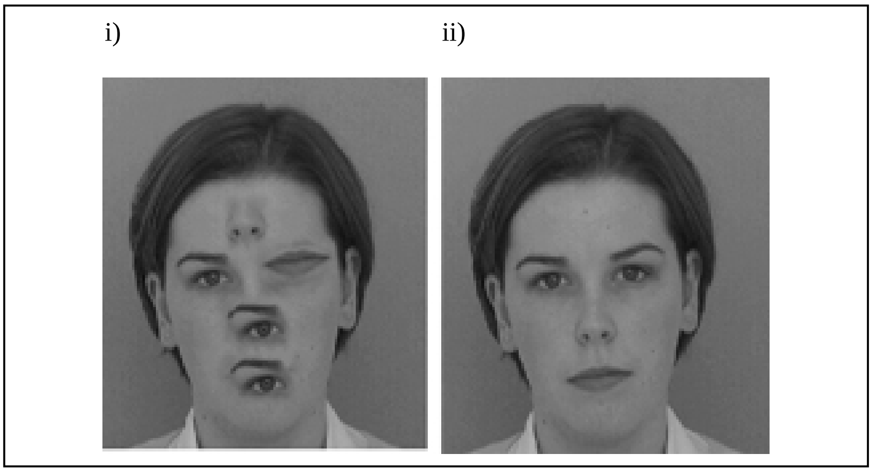
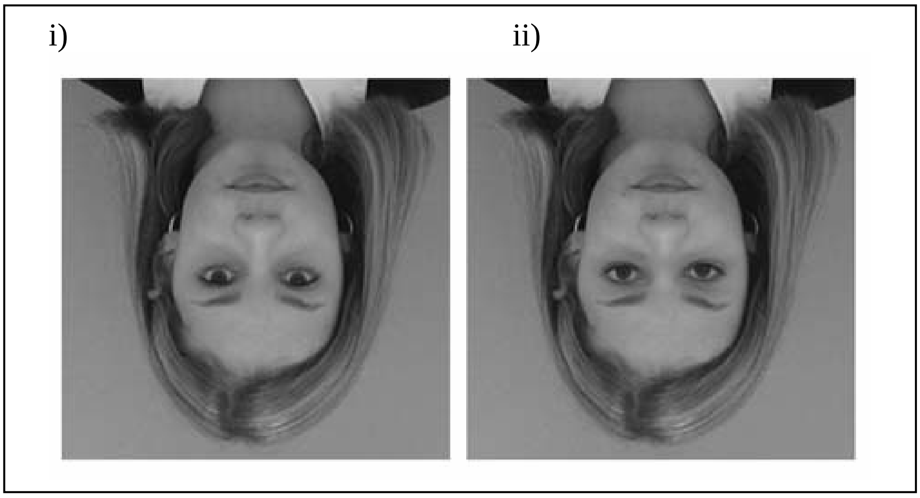


Figure 6.3b An example of an experimental trial in the inverted condition i) the original face and ii) image with eyes rotated



For experimental trials, participants viewed two black and white faces presented side by side on A4 paper and were asked to point to the face that looked funny or strange (replicating the instructions used by Rouse, Donnelly, Hadwin, & Brown, 2004). The images remained in front of the participant while they made a two-alternate forced choice and pointed to the correct face. Participants completed all 36 trials without a break. Figure 6.3b shows an example of an inverted trial with the eyes of image b) rotated and therefore being the correct answer

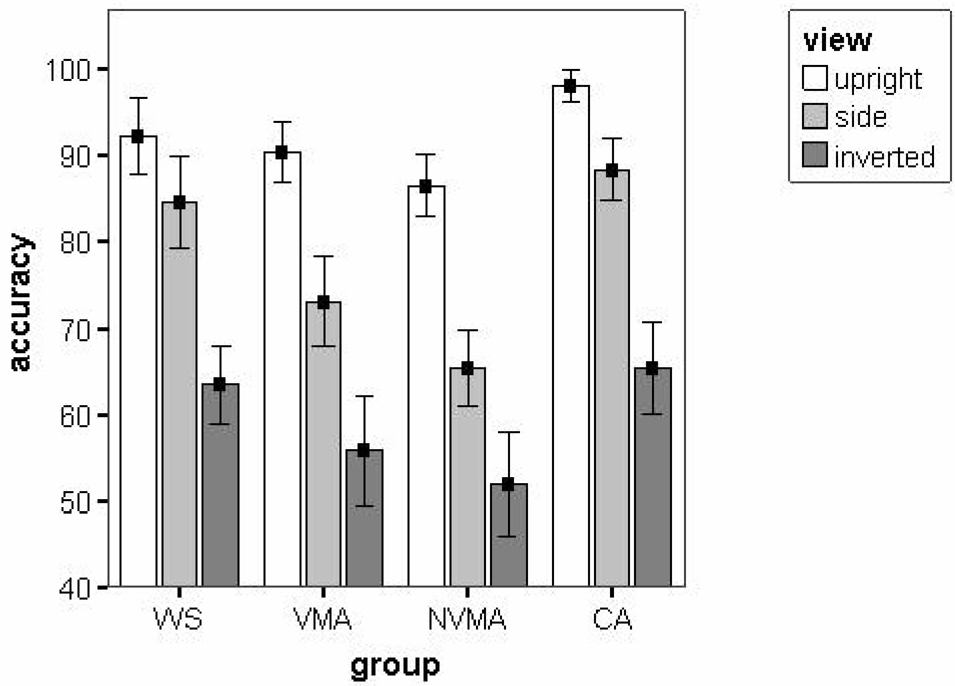
Results

The question of whether the groups were susceptible to the traditional Thatcher illusion (with both eyes and mouth rotated) is addressed before moving on to investigate the eye and mouth rotation trials.

The Thatcher illusion

As evident in Figure 6.4, participants in all groups were most accurate at detecting the manipulated face in the upright condition. A 4 x 3 ANOVA with factors Group (WS, VMA, NVMA, CA) and View (upright, 90 degree, inverted) was applied to the accuracy data for stimuli in which both eye and mouth were rotated. Participants were significantly affected by the View $F(2,96)=49.03$, $p<.001$. Upright Thatcherised faces were detected more accurately than 90 degree faces ($t(51)=4.87$, $p<.001$) which in turn were more accurate than inverted faces ($t(51)=10.51$, $p<.001$; mean upright 92%, 90 degree 78%, inverted 59%). There was also a significant effect of Group $F(3,48)=6.97$, $p<.01$, specifically the CA and WS groups performed with equal accuracy ($p=.75$, mean WS 80%, CA 84%) and the WS group also did not differ from the VMA matched group ($p=.27$, mean VMA 73%). However, it should be noted that the performance of the CA group is at ceiling for the upright condition, therefore conclusions that the WS group performed at CA level should be made with extreme care. Finally, the WS group performed significantly better than the NVMA group ($t(12)=4.16$, $p<.01$, mean NVMA 69%). Regarding the typically developing participants, the CA group performed more accurately than both other groups (CA-VMA $t(12)=8.64$, $p<.001$; CA-NVMA $t(12)=7.23$, $p<.001$) and the VMA group performed more accurately than the NVMA group ($t(12)=2.59$, $p<.05$).

Figure 6.4 Percentage correct for individuals with WS and their matched comparison groups. Trials include upright, 90 degree (side) and inverted Thatcherised faces



The interaction between variables was not significant ($p=.81$), all groups decreased in performance as the orientation of the face moved away from the upright position and showed susceptibility to the Thatcher illusion.

Investigating performance related to chronological age, Spearman's Rho correlation revealed that for this small group of participants with WS, there was an increase in overall task accuracy with age r=.92, $p<.01$. For typically developing participants (with groups combined n=39) again performance increased significantly with age (r=.83, $p<.01$). Therefore, for spotting Thatcherised faces, across conditions, participants who developed typically and those with WS became more accurate with age. Some care is needed in interpreting these correlation analyses due to ceiling effects in the upright condition.

Interestingly, when performance is split by orientation, participants with WS and those who developed typically showed an increase in accuracy with age for upright trials (TD r=.46, $p<.01$; WS r=.73, $p<.01$). This is particularly interesting in the inverted condition as it might be predicted that typical participants would find inverted faces more difficult to process as they increase in age and become more reliant upon configural processing, however there was no change in accuracy with age for these trials (r=.29, $p=.07$). Participants with WS were less accurate for inverted trials than the typical group and again performance did not change with age (r=.33, $p=.27$).

The cost of inversion

The cost of inversion is calculated as the percentage decrease in performance when the face is inverted compared to upright (as performed by Rouse et al., 2003). This was calculated for each group and revealed little difference in the overall cost of inversion. This is confirmed by a one-way ANOVA between the Groups (WS, VMA, NVMA, CA) which was found to be non-significant ($p=.91$; WS mean -29%, VMA mean -35%, NVMA mean -35%, CA mean -33%). Participants with WS were as affected by inversion as the typically developing groups.

It might be expected that typically developing participants would show an increase in inversion costs with an increase in age. Greater use of configural processing as the individual increases in age, may make the inversion effect more pronounced. However the relationship between age and inversion cost was not significant for typically developing participants (n=39, p=.85) or the group with WS (n=13, p=.79). This indicates that across the developmental spectrum children and adolescents are equally susceptible to the Thatcher illusion.

Eye and Mouth Rotation Analysis

As illustrated in Table 6.2, the mean accuracy for each group in each condition was calculated to investigate the pattern of accuracy across task conditions. Performance on trials involving *either* eye or mouth rotations were investigated with a 4 x 3 x 2 ANOVA with the independent factor Group (WS, VMA, NVMA, CA) and repeated factors View (upright, 90 degree, inverted) and Feature (eyes, mouth). Participants were more accurate for eye than mouth manipulations $F(1,48)=4.37$, $p<.05$ (mean eyes 74%, mouth 69%) supporting the idea that the eyes are a more salient feature.

Participants became less accurate at detecting the illusion as the orientation of the face moved away from the upright view $F(2,96)=88.13$, $p<.001$ (mean upright 87%, 90 degree 73%, inverted 53%). Post hoc t-tests showed that upright faces were more accurate than both 90 degree ($t(51)=5.06$, $p<.001$) and inverted faces ($t(51)=14.67$, $p<.001$) and in turn 90 degree faces were more accurate than inverted faces ($t(51)=7.71$, $p<.001$).

There was also a significant effect of Group $F(3,48)=12.04$, $p<.001$ as WS participants performed more accurately than those matched for nonverbal ability (mean WS 72%, NVMA 63%; $t(12)=3.78$, $p<.01$) and less accurately than those matched for CA (mean 80%; $t(12)=3.76$, $p<.01$). As evident in Table 6.2 there was no difference in ability for the WS group and those matched for verbal ability (mean 70%; $p=.34$). There was a trend towards significance between performance for the NVMA and VMA matched groups ($t(12)=2.24$, $p=.05$). Finally the CA group performed more accurately than both the verbal matches ($t(12)=4.19$, $p<.01$) and nonverbal matches ($t(12)=5.54$, $p<.001$).

As seen in Table 6.2, performance for spotting mouth changes in the inverted condition was particularly poor for all groups. Analysis of this performance against chance level (50%) for mouth trials showed no difference for any group (compared to chance: WS $p=.58$, VMA $p=1.00$, NVMA $p=.27$, CA $p=.34$). Only participants in the Williams syndrome and CA groups spotted changes to the eye region significantly better than chance for inverted faces (against chance WS $t(12)=3.21$, $p<.001$, CA $t(12)=3.74$, $p<.001$, VMA $p=.75$, NVMA $p=.44$).

There were no significant interactions indicating that all groups found it easier to spot eye than mouth changes and that all groups were significantly affected by inversion. All participants were susceptible to an altered version of the Thatcher illusion. As typically developing participants (n=38) increased in age they became more accurate at detecting both eye and mouth changes (eyes $r=.64$, $p<.001$; mouth $r=.38$, $p<.05$). For the WS group (n=13) there was a significant increase in the ability to detect eye changes with age ($r=.59$, $p<.05$) and a positive but non-significant correlation between age and mouth change detection ($r=.02$, $p=.95$).

Table 6.2 Percentage correct for all manipulations of feature and view for WS participants and their matched comparison groups (SD in parenthesis)

	Feature	Upright	90 degrees	Inverted	Overall
WS	*Eyes*	87 *(13)*	81 *(21)*	62 *(13)*	76 *(7)*
	Mouth	81 *(15)*	71 *(22)*	52 *(12)*	68 *(10)*
VMA matches	*Eyes*	87 *(12)*	71 *(21)*	52 *(22)*	70 *(10)*
	Mouth	86 *(19)*	69 *(21)*	52 *(21)*	69 *(10)*
NVMA matches	*Eyes*	83 *(16)*	62 *(19)*	47 *(17)*	63 *(13)*
	Mouth	78 *(17)*	63 *(24)*	44 *(18)*	62 *(13)*
CA matches	*Eyes*	98 *(7)*	87 *(17)*	63 *(12)*	83 *(8)*
	Mouth	96 *(6)*	83 *(12)*	54 *(14)*	78 *(7)*
Overall		87 *(12)*	73 *(17)*	53 *(13)*	

Eye and Mouth Inversion Cost

A two-way analysis of variance with factors Group (WS, VMA, NVMA, CA) and Feature (eyes, mouth) revealed no significant effects indicating that the cost of inverting eyes and mouth was equal (p=.54; mean eyes -33%,mean mouth -35%) and all groups were equally affected by inversion (p=.34; WS=-28%, VMA=-34%, NVMA=-36%, CA=-37%).

Discussion

The essential conclusions of this experiment are that the participants with WS show the same level of susceptibility to the Thatcher illusion as typically developing participants. Even when the eye and mouth manipulations are independent, the *pattern* appears the same across groups. The Thatcher illusion is driven by the same features for the typically developing and WS participants. Specifically, eye changes were easier to spot than mouth changes supporting the idea that this may be a more salient feature (e.g. Shepherd, Davies, & Ellis, 1981) and the proposed hypothesis. The fact that the inversion cost was the same for the eye and mouth changes when presented separately does not support the idea that least salient features are more difficult to process under inversion (e.g. Malcolm, Leung, & Barton, 2005). However, this inversion cost is affected by accuracy in both upright and inverted conditions and in both these cases accuracy was lower for mouth than eye changes. Importantly, supporting the idea that mouth changes are very hard to spot in inversion due to their low salience (Barton, Deepak, & Malik, 2003) no group showed performance above chance for mouth changes when inverted. However the WS and CA groups did show performance above chance for inverted eye trials. In fact comparing inverted trial performance for the WS and CA groups for the complete task and the separate eye trials, the addition of the mouth in the original illusion seems to have a limited additive effect (WS whole inverted 64%, eyes inverted 62%; CA whole inverted 65%, eyes inverted 63%). Perhaps therefore, performance on the inverted trials for the Thatcher illusion is driven by the use of the eyes. This would challenge the idea of configural processing being the essence of the Thatcher illusion and imply that performance can rely on individual features (this may also explain evidence for the illusion in infants and young children).

If the performance of the WS group depended solely on the feature-based processing (whereas the typically developing group utilised second-order relational processing) we might expect greater accuracy for this group on the inverted trials, as featural processing would not be disrupted to the extent of configural processing. However, the group with WS was not more accurate than the typically developing groups at spotting changes in the inverted condition and the same pattern was evident across groups. Based on the premise of this illusion, the present study does not provide evidence of feature-based face processing in Williams syndrome. For example, previous studies finding no inversion effect for faces in adults and adolescents with WS have been used to make claims of a local / featural face processing bias in this group (Rossen et al., 1995). The current results are consistent with large inversion effects for unaltered faces in recognition memory tasks by children with WS (Jones, Hickok, & Lai, 1998). Children with WS therefore appear to process faces in the same *way* as typically developing children matched on mental age when completing a Thatcher illusion task. If the premise of the Thatcher illusion rests on a reliance upon configural processing, then the current chapter implies that configural processing is possible in WS and is disrupted by inversion.

6.2.2 Experiment 5b

As noted in section 6.1.4, a recent study by Rouse et al. (2004) found that children with autism were susceptible to the Thatcher illusion and thus concluded that they were able to process second-order relational information. The present study begins with the aim of replicating this finding before extending the investigation to independent manipulations of the eyes and mouth. It is hypothesized that all participants will show less accuracy for inverted that upright trials. Importantly the pattern of performance for eye and mouth trials may differ between groups, as found for upper and lower face processing in the previous chapter (experiment 4b). Greater accuracy for eye than mouth trials will not be found for participants with autism, but will be evident for typically developing participants.

Method

The experiment replicates the methods used for experiment 5a with the same participants used in experiment 4b. Table 6.3 reproduces Table 5.3 emphasising the participant characteristics for this task. For further details see previous sections of this thesis.

Table 6.3 Participant details for individuals with Autism and their matched comparison groups

Group	N	Gender ratio (males:females)	CA[1]	VMA[1]	NV score[2]
Autism	20	16:4	14y 9m *(29)*	7y 2m *(23)*	15 *(6)*
VMA Match	20	15:5	6y 6m *(18)*	7y 3m (*21)*	12 *(7)*
NVMA Match	20	13:7	7y 11m *(15)*	8y 2m *(18)*	15 *(5)*
CA Match	20	12:8	14y 11m *(27)*	14y 8m *(20)*	31 *(5)*

1 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviations

2 Nonverbal mental age ability provided as mean score on the RCPM (max. score 36). Standard deviation in parenthesis

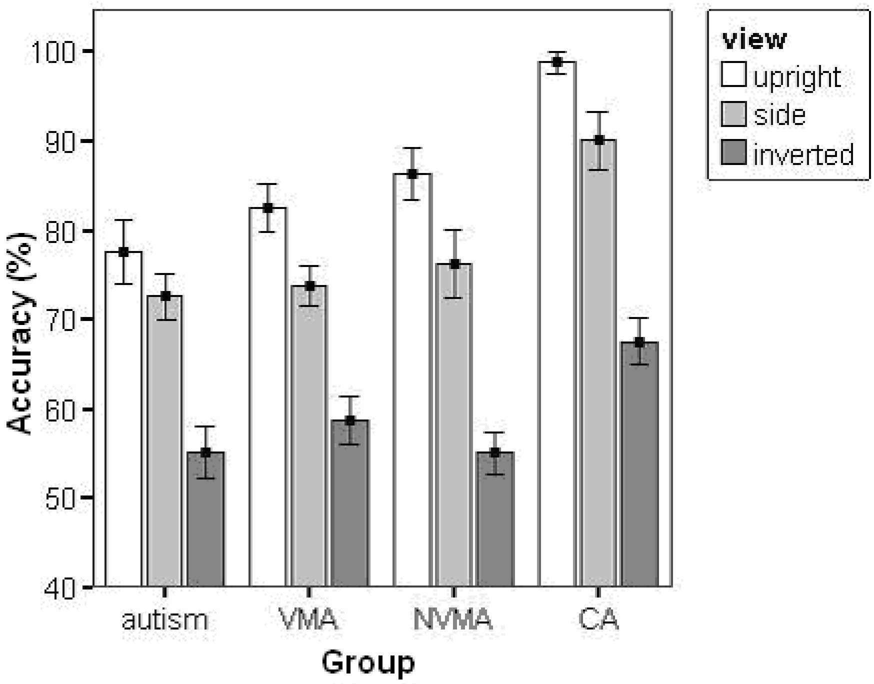
Results

The Thatcher illusion

Task accuracy was assessed with a 4 x 3 ANOVA with factors Group (Autism, VMA, NVMA, CA) and View (upright, 90 degree, inverted) and showed that participants were affected by View $F(12,152)=97.41$, $p<.001$ (see Figure 6.5). Accuracy for upright faces was greater than 90 degree (mean upright 86%, 90 degree 78%; $t(79)=4.00$, $p<.001$) as well as inverted faces (mean inverted 59%; $t(79)=13.60$, $p<.001$). Additionally, inverted faces were processed with greater difficulty than 90 degree faces ($t(79)=9.77$, $p<.001$).

There was an effect of Group $F(3,76)=22.06$, $p<.001$ created by the strong performance of the CA participants who differed significantly from all other groups and show evidence of ceiling effects in the upright condition (see Figure 6.5; CA-autism $t(19)=7.70$, $p<.001$; CA-VMA $t(19)=5.82$, $p<.001$; CA-NVMA $t(19)=5.62$, $p<.001$). The CA group performed significantly more accurately than all other groups in all conditions, even when the stimuli were inverted. Interestingly there was no difference in overall performance for the autism and VMA group ($p=.12$) and a trend for a difference between the autism and NVMA group (with higher accuracy for NVMA matches, $t(19)=2.03$, $p=.06$). The interaction between factors was not significant ($p=.24$) as all groups, including those with autism, showed greatest accuracy for upright than inverted trials.

Figure 6.5 Percentage correct for participants with Autism and their matched comparison groups for fully Thatcherised faces in three orientations



The correlation between age and performance revealed that typically developing participants (n=60) increased in overall accuracy with age (r=.50, *p*<.01) as well as independently for upright (r=.33, *p*<.01) and inverted trials (r=.47, *p*<.01). For the autism group (n=20) there was no significant correlation between age and overall performance (r=.24, *p*=.30), upright trials (r=.37, *p*=.11) or inverted trials (r=.05, p=.84). There was also no significant correlation between CARS score for the autism group and their performance (r=.18, *p*=.44). Task performance for the group with autism was therefore unrelated to age or level of severity as measured by the CARS.

The cost of inversion

A one-way ANOVA with factor Group (Autism, VMA, NVMA, CA) revealed no difference in inversion cost for the four groups *(p*=.25, autism M=-23%, VMA M=-

24%, NVMA M=-31%, CA M=-31%). Importantly, participants with autism were as affected by inversion as the typically developing groups.

Eye and Mouth Rotation Analysis

The accuracy for each group and condition was collated (Table 6.3) and analysed to investigate how eye and mouth manipulations were detected. Performance for trials involving either eye or mouth rotations was investigated with a 4 x 3 x 2 ANOVA with the independent factor Group (Autism, VMA, NVMA, CA) and repeated factors View (upright, 90 degrees, inverted) and Feature (eyes, mouth). This revealed a significant main effect of Feature with participants more accurate using eyes than mouth $F(1,76)=13.08$, $p<.01$ (mean eyes 71%, mouth 66%). There was also a main effect of View created by a decrease in performance as the orientation moved away from upright $F(2,152)=103.48$, $p<.001$ (mean upright 79%, 90 degrees 72%, inverted 55%). Post hoc t-tests showed that upright faces were more accurately assessed than 90 degree faces ($t(79)=5.24$, $p<.001$) which in turn were more accurate than inverted faces ($t(79)=8.41$, $p<.001$). As predicted, the greatest difference was between upright and inverted face stimuli ($t(79)=11.79$, $p<.001$).

There was a significant main effect of Group $F(3,76)=32.59$, $p<.001$ as accuracy for the group with autism differed significantly from all others (mean autism 60%, VMA 66%, NVMA 69%, CA 81%). Post hoc t-tests showed that participants with autism performed less accurately than those matched for VMA ($t(19)=4.14$, $p<.01$), NVMA ($t(19)=4.06$, $p<.01$) and CA ($t(19)= 8.60$, $p<.001$). In addition although the VMA and NVMA groups did not differ in accuracy ($p=.28$) the CA group was better at detecting the Thatcherised face than both the VMA and NVMA groups (CA-VMA $t(19)=6.27$, $p<.001$; CA-NVMA $t(19)=5.51$, $p<.001$). So on the task as a whole the group with autism did not perform as accurately as any of the typically developing groups.

Table 6.4 Percentage correct for all manipulations of feature and view for participants with Autism and their matched comparison groups (SD in parenthesis)

Group	Feature	Upright	90 degrees	Inverted	Overall
Autism	*Eyes*	61 *(15)*	61 *(15)*	50 *(16)*	58 *(10)*
	Mouth	69 *(11)*	63 *(15)*	55 *(15)*	62 *(8)*
VMA matches	*Eyes*	81 *(18)*	74 *(5)*	59 *(15)*	71 *(7)*
	Mouth	73 *(7)*	63 *(15)*	50 *(16)*	62 *(8)*
NV matches	*Eyes*	84 *(12)*	76 *(15)*	55 *(15)*	72 *(12)*
	Mouth	75 *(5)*	68 *(15)*	54 *(12)*	65 *(8)*
CA matches	*Eyes*	98 *(5)*	93 *(11)*	65 *(13)*	85 *(7)*
	Mouth	94 *(13)*	80 *(19)*	55 *(16)*	76 *(12)*
Overall		79 *(14)*	72 *(15)*	55 *(13)*	

The important interaction between Feature and Group was significant F(3,76)=5.55, *p*<.01. Post hoc t-test analyses revealed that VMA, NVMA and CA groups were all more accurate when detecting eye than mouth manipulations (VMA t(19)=3.81, *p*<.001, NVMA t(19)=2.16, *p*<.05, CA t(19)=2.87, *p*<.05). All typically developing groups showed greater accuracy for eye than mouth changes, however individuals with autism were equally accurate detecting eye and mouth manipulations (*p*=.09). In fact the trend was in the opposite direction to the typically developing groups, in that mouth manipulations tended to be detected more accurately than eyes. The interaction stems from the different performance pattern for the autism group compared to the typically developing groups and explicitly the lack of an eye over mouth advantage in autism.

The interaction between View and Group also reached significance $F(6,152)=4.41$, $p<.001$. The autism group performed much less accurately than all typically developing groups in the upright condition (autism-VMA $t(19)=3.87$, $p<.01$; autism-NVMA $t(19)=6.24$, $p<.001$; autism-CA $t(19)=14.69$, $p<.001$) but did not differ from the other groups for inverted trials (autism-VMA $p=.64$; autism-NVMA $p=.65$; autism-CA $p=.17$). This interaction may also be driven by the difference between upright and 90 degree accuracy as the group with autism appeared less affected by the faces being presented on their side than the typically developing groups. This is evident in Table 6.3 showing accuracy levels for all conditions and groups and emphasized by the eye condition showing no mean difference in accuracy for upright and 90 degree trials for participants with autism (61% for each for the autism group but a drop of 5% for the CA group). The three-way interaction between factors was not significant ($p=.86$).

The relationship between the ability to detect eye or mouth manipulations and age was investigated with Spearman's Rho correlation. Typically developing participants (n=60) increased in their ability to detect eye and mouth manipulations as they increased in age (eye $r=.59$, $p<.01$; mouth $r=.47$, $p<.01$). Participants with autism showed a non-significant correlation between age and the ability to detect either eye or mouth changes (eye $r=.08$, $p=.75$; mouth $r=.19$, $p=.42$). There was also a non-significant correlation between CARS score and both eye and mouth manipulation detection (CARS and eyes r=.12, *p*=.60; mouth r=.29, *p*=.22).

Eye and mouth inversion cost

A cost analysis was carried out to investigate whether the decrease in performance was equivalent for all groups. A two-way ANOVA with the between-subject factor Group (autism, VMA, NVMA, CA) and within-subject factor Feature (eye, mouth) showed that participants had an equivalent decrease in performance for trials where either the eyes or mouth were manipulated (*p*=.97). However there was a significant difference between Groups F(3,76)=7.29, *p*<.001. Post hoc t-tests revealed that although there was no difference in inversion costs for the autism and VMA groups (*p*=.09), the autism group were less affected by inversion than the NVMA and CA groups (autism-NVMA t(19)=2.7, *p*<.05; autism-CA t(19)=4.05, *p*<.01). Additionally, the CA group showed a larger inversion cost than both VMA (t(19)=2.77, *p*<.05) and NVMA (t(19)=2.54, *p*<.05) groups who did not differ (*p*=.54). This is likely to be accounted for by the high accuracy in the upright condition rather than poorer performance in the inverted condition for the CA group.

The autism group shows the same level of susceptibility to the Thatcher illusion as the typically developing groups when the traditional illusion is used however if eye and mouth rotations were independently manipulated the effect appeared driven by different features. Participants with autism showed no difference for detecting mouth or eye changes, however typically developing individuals were more susceptible to eye than mouth manipulations.

Discussion

Participants with autism were susceptible to the traditional Thatcher illusion, as accuracy for detecting Thatcherised faces decreased in the inverted condition. This decrease in accuracy was equivalent to that of children who developed typically. When the eyes or mouth were inverted, participants with autism were equally accurate with each type of alteration, however, typically developing groups were more accurate at detecting eye than mouth changes. The effect in the autism group appears driven by poorer performance for eye trials, rather than greater susceptibility to mouth changes. Although participants with autism use the mouth more accurately, this does not imply that the mouth region is more salient per se, rather that the eyes appear less salient. The eyes may not be especially capturing of attention in autism, as has previously been proposed (e.g. Ristic, Mottron, Friesen, Iarocci, Burack, & Kingstone, 2005).

The findings regarding autism support previous research using the Thatcher illusion by Rouse et al. (2004). Interestingly, the group with autism in the present study showed a comparable level of accuracy to the typically developing group matched for verbal and nonverbal ability (trend for nonverbal to be more accurate). This replicates the finding from Rouse et al. (2004) who found their group of 11 boys with autism performed at a comparable level of accuracy to groups of typically developing children matched for nonverbal ability and moderate learning difficulty participants matched for verbal ability. As well as showing similar inversion costs the groups also showed no difference for accuracy or reaction times in the previous research. The group of 20 participants with autism in the present study showed lower accuracy as a whole compared to the chronological age matched group, however performance of this group is characterized by ceiling effects. When interpreting the traditional Thatcher illusion, participants with autism are as susceptible as typically developing individuals of comparable mental ability, rather than level of maturation (chronological age).

The present study goes further by exploring the origin of the inversion effect, relating this to the use of the eye and mouth regions. When these features are manipulated separately it appears the Thatcher illusion is driven by different features in the autism and typically developing groups. Interestingly, all groups remained susceptible to the illusion when only the eyes or mouth were manipulated, showing lower accuracy for inverted than upright trials. It could be argued that these findings show that performance is not reliant upon the configuration of the whole face, but by the local relationships between features (for example the configuration of the eye region or the mouth region). Importantly, the eye region, a source of essential social information, did not draw the attention of participants with autism any more or less than the mouth region, this contrasts with the large effect the eye region has for typically developing individuals.

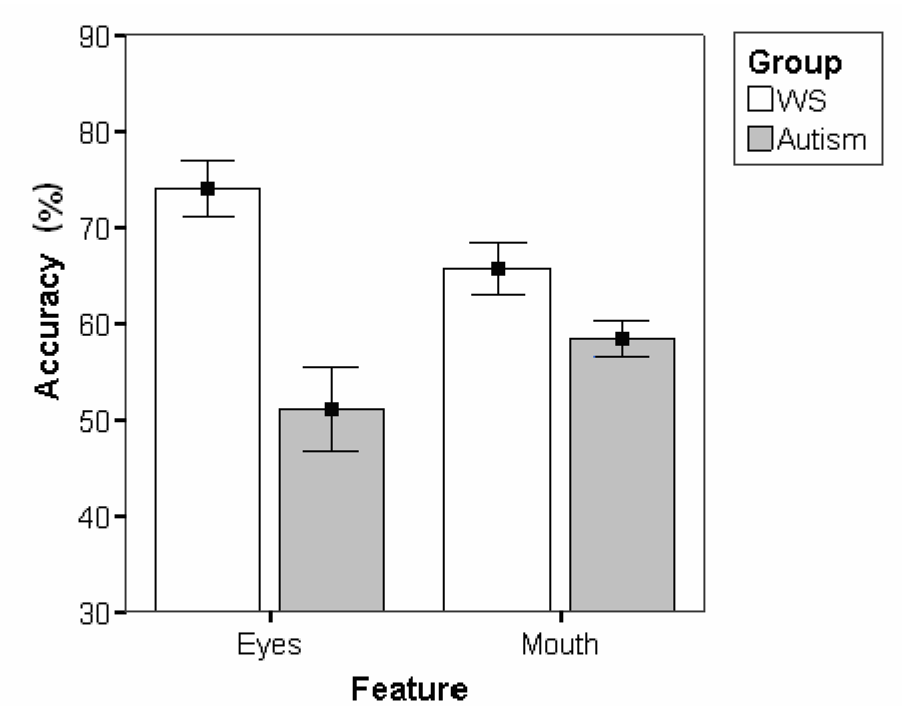
Relating this finding to evidence from experiment 4b using upper and lower face features, these two studies provide converging evidence. The upper face features, specifically the eyes, do not show the increased salience in autism that is shown in typical development. Across paradigms, typically developing individuals have been more accurate when the task requires use of the eye region, suggesting this feature may be more informative than others. However, this is not evident in autism as no difference is found for the upper and lower, eye and mouth, regions across paradigms. In autism the eyes appear to neither draw nor avert the participants' attention compared to the mouth.

6.3 Combining experiments 5a and 5b to compare WS and autism

To compare the performance of individuals with WS and autism two subgroups were created. Each matched group comprised 12 individuals and the groups did not differ on chronological age (WS mean 13 years 8 months, Autism mean 13 years 9 months; $t(11)=1.08$, $p=.31$) or nonverbal ability (WS mean 14, Autism mean 15; $t(11)=.34$, $p=.74$). For this investigation only upright and inverted conditions were included as the additional 90degree rotation failed to show any significant impqacts upon performance in the earlier sections oft his chapter. A 2x2 ANOVA with factors Group (WS, Autism) and Orientation (Upright, Inverted) was conducted to investigate susceptibility to the Thatcher illusion for each group. This revealed an effect of Orientation $F(1,22)=13.46$, $p<.01$ as both groups were more accurate for upright than inverted trials as expected (upright 78%, inverted 58%). There was also an effect of Group $F(1,22)=18.73$, $p<.001$ as individuals with WS performed more accurately than those with autism (WS 79%, autism 57%). As expected from the analyses for each group, there was no interaction between Orientation and Group as the same pattern of results was evident ($p=.10$).

To investigate use of the eye and mouth regions for each of the matched groups an ANOVA was conducted with factors Group (WS, Autism) and Feature (Eyes, Mouth), the data were combined for upright and inverted trials using these features. The analysis revealed that overall there was no effect of Feature ($p=.87$). However there was an effect of Group $F(1,22)=22.73$, $p<.001$ (WS 70%, autism 55%) and an interaction between Group and Feature F(1,22)=6.53, *p*<.05. This interaction was expected due to the analyses in previous sections of this thesis. Individuals with WS and autism, when matched, show different abilities to use face features. Participants with WS were more accurate detecting eye than mouth rotations (t(11)=2.35, *p*<.05, eyes 74%, mouth 66%) whereas participants with autism showed no difference using the eyes or mouth (*p*=.17, eyes 51%, mouth 58%). Figure 6.6 shows the difference between groups when detecting Thatcherised eyes and mouth.

Figure 6.6 Percentage correct for eye and mouth detection for matched groups with WS and autism (n=12)



Investigating each feature separately across groups, individuals with WS were more able to detect eye rotations than individuals with autism (t(11)=3.41, *p*<.01) and there was a trend towards the WS group also processing the mouth region more accurately (t(11)=2.03, *p*=.067). So, when smaller matched groups were included the results showed the same pattern as with the larger groups matched to typically developing individuals. Importantly, when individuals with WS and autism were matched on chronological age and nonverbal ability, individuals with WS are more accurate at the Thatcher illusion task as a whole and show much greater ability to detect rotations when they occur only in the eye region. The difference between individuals with WS and autism for processing the mouth region is much less clear.

6.4 General Discussion

All groups showed susceptibility to the traditional Thatcher illusion. It was more difficult to detect changes when the face was presented on its side (at 90 degrees) and even more difficult if the whole face was inverted. In addition, the use of separate eye and mouth manipulations showed that susceptibility to the illusion may not be driven by the same features for all participants. Both WS and typically developing participants were more accurate when the change occurred in the eye region, but this was not apparent for participants with autism. Individuals with autism were equally accurate when the change occurred to the mouth or eyes. Compared to the typically developing groups and individuals with WS it is clear that the ability to detect eye changes was particularly poor for the autism group (rather than relatively stronger mouth detection). Malcolm et al. (2004) conclude that eye changes are easier to detect as this is a more salient region of the face, and although this appears relevant when considering the Thatcher illusion in typical development and WS, it does not gain support from autism.

Linking to evidence from previous chapters, it was not unexpected that participants with autism would have difficulties with the eye manipulations. Chapter 3 showed poor performance using this feature (e.g. eye gaze), chapter 4 suggested that attention may not be drawn towards internal features and chapter 5 found no upper face advantage. Concerning WS, we have already shown strong performance with the eye region (chapter 3), a good use of internal features (chapter 4), and greater accuracy using upper than lower face parts (chapter 5), thus the present pattern of results is not surprising. Together experiments 4 and 5 present converging evidence regarding the use of different features in Williams syndrome and autism. In both these studies, the relative increase in accuracy shown when the task involves the eye region is not found for participants with autism, but is seen for groups of typically developing participants and those with WS.

The essence of the Thatcher illusion is believed to be the disruption of second-order relational processing, a type of processing interrupted by inversion (Thompson, 1980). It is alleged that detection of the illusion is particularly difficult under inversion when this type of configural information is distorted. Second-order relational information refers to the distance between individual features, or between features and the face contour. Regarding processing of the illusion in autism, Rouse et al. (2004) note their results show individuals with autism are able to interpret important configural aspects of the face. They go on to say this supports evidence from Joseph and Tanaka (2003) of no overall deficit in processing ‘holistic’ face information in autism. The unclear link between holistic and configural processing here is somewhat confusing. Under conditions of low demands, with simultaneous presentation of faces and unlimited time demands, it is evident that participants with autism are susceptible to the forces that drive the Thatcher illusion. Whether the illusion is entirely dependent upon configural processing, however, seems to remain unclear. Previous research in this area has not clearly dissociated between the different types of configural face information detailed in typical face perception literature. Here we see evidence that ‘second-order relational’ information can be deciphered under certain task conditions, but this does not imply ‘intact’ face processing, or indeed that all types of configural processing are possible in autism.

Evidence that infants, young children, individuals with autism and WS are susceptible to an illusion derived by the use of second-order relational processing suggests that under certain task conditions this form of configural processing is possible. That is not to say, however, that these individuals rely on configural processing to understand faces in everyday situations. Use of second-order relational information is just one sub-type of configural processing that may, under certain task demands, be possible. It does appear that the *relationship between* features is critical for susceptibility to the Thatcher illusion and therefore that these groups of participants are using aspects of relational information. Evidence has suggested that featural information is not adversely affected by inversion and therefore cannot entirely explain the Thatcher illusion. For example, Scearcy and Bartlett (1996) made normal faces grotesque by blackening teeth and participants were able to detect this with the same ease for upright and inverted trials. Independent features are still individually processed in inversion and it is the relationship between them that is the essence of the face inversion effect. Similarly Leder and Bruce (1998) darkened eyebrows and found this was not sensitive to inversion and in further research they used a comprehensive selection of tasks to illustrate that neither featural nor holistic face processing are disrupted by inversion, but it is the relations between single features that is essential (Leder & Bruce, 2000). In children it is this relational aspect of features that develops slowly up to about 6- to 7-years of age (e.g. Mondloch , Dobson, Parsons, & Maurer, 2004; Mondloch, Le Grand, & Maurer, 2002). Certainly for the current task, the relationship between the eyes and the other face features appears particularly important and drives performance (and susceptibility to the illusion) in typical development and WS, but not in autism. Mondloch, Leis and Maurer (2006) contend that “there may be different face-processing mechanisms that utilize second-order relations and that become sensitive to second-order relations at different rates during development” (p. 241). The current evidence suggests that if this is the case, then the type of information disrupted by the Thatcher illusion *can* be used by individuals with autism and WS.

Some of the evidence cited here may be explained by the simultaneous presentation of face pairs allowing a direct comparison between images in the current task. Donnelly and Hadwin (2003) noted that this style of presentation allowed their groups of young typically developing children to complete the Thatcher task. Presentation style may impact on the degree of configural / relational processing needed for susceptibility to be shown. It would be interesting to see if this pattern of performance for the groups with autism and WS remains with different task requirements, placing different demands on the participants. For example, Lewis (2003) asked participants to rotate an inverted face until it appeared grotesque and a similar procedure could be used to see if the degree of rotation needed to detect the illusion is the same across groups. This altered version of the task may reveal that the degree of configural processing being used by groups differs and the amount of inversion needed for detecting the illusion separates groups. Therefore, although the current chapter has added to our knowledge of eye and mouth processing in autism and WS, direct claims of processing *style* based on this illusion should be made with care. The configural relationship between features appears most important for the current task, certainly within the eye region. Further research is required to investigate whether the Thatcher illusion affect can reliably be achieved by processing just the eye region.

Relating the present findings to previous research with typically developing children (e.g. Lewis, 2003; Donnelly & Hadwin, 2003; Mondloch et al., 2004) the results are in accordance with young children showing susceptibility to the Thatcher illusion. The youngest group of participants (mean age 6 years 6 months – matched to autism group of verbal ability) showed susceptibility to the illusion to the same degree as the oldest group (mean age 15 years 8 months – matched to WS group on chronological age). The results confirm that children are susceptible to the mechanisms driving the Thatcher illusion (and therefore to some extent configural relational processing). Donnelly and Hadwin (2003, exp. 1) used a similar task procedure and found susceptibility to the illusion for participants aged 6 years. However when Mooney faces were Thatcherised the task showed that 6-years olds were not susceptible to the illusion (Donnelly & Hadwin, 2003, exp. 2). The specific task demands therefore have a large influence on performance patterns. The additional configural demands in place using Mooney images may probe a type of configural processing that is not accessible to children at this young age. Importantly the typically developing participants in the current study showed the same pattern of results as previous research, with greater task accuracy for upright than inverted faces.

6.4.1 Methodological considerations

The use of reaction time data may prove useful in this investigation. Alongside the evidence regarding accuracy, latency data may show if there is a speed accuracy trade-off. Although participants in the current task were not told to react as fast as possible, it may be that taking longer to complete the task allows a change in strategy when the task is difficult. Donnelly and Hadwin (2003) suggest that an increase in configural rather than featural processing should be accompanied by faster reaction times. It is not possible to interpret this aspect of performance from the present data.

Additionally, the simultaneous presentation of faces may have impacted upon the processing style adopted by participants. If faces were presented sequentially (e.g. each for 250 msec) a short time span may have forced a change in strategy and indeed prevented feature-by-feature comparisons. This may also have made the task too difficult for the lower functioning participants, creating floor effects across conditions and was one of the main reasons why simultaneous presentation was used. It should not be ignored however, that simultaneous presentation may enforce a perceptual strategy (rather than face-specific processing) in the current task.

The inclusion of 90 degree side views provide further evidence of the decrease in accuracy as the face moved away from the upright orientation. Lewis and Glenister (2003) state that this degree of rotation does not affect the use of configural encoding but does affect face recognition accuracy. They further state that little attention has been given to this degree of rotation with regards face processing and that it provides further insights into face processing strategies. Indeed concerning the normal rotation of faces Valentine and Bruce (1988) found a linear increase in reaction times for adults when both matching and recognising faces as they were rotated from 0 to 180 degrees in 45 degree units. This suggests that face processing difficulty increases as the face moves away from upright. In addition, Lewis (2001) found that the time taken to detect Thatcherised faces increased gradually as the face moved away from the upright position. This is supported by the accuracy data from the present experiment and the inclusion of 90 degree trials has allowed us to assess face processing as the orientation is manipulated. Additionally, the degree of rotation has never been studied with groups of individuals with WS and autism.

6.5 Conclusions

Experiment 6 has provided evidence that participants with WS and autism are susceptible to the Thatcher illusion. This chapter implemented a face illusion to study the use of the eye and mouth regions. Participants with WS resembled typically developing children by showing susceptibility to the illusion and more accurate detection of changes made to the eyes than mouth. Participants with autism again showed susceptibility to the illusion but did not show greater accuracy for eye than mouth trials. As to whether the Thatcher illusion is the best task for probing processing style, the current chapter has discussed evidence from infants, children and adults. The Thatcher illusion may not be the most robust tool for the assessment of configural relational processing and to build on this and further our knowledge of the structural encoding of faces in autism and WS, the following chapter applies a more rigorous methodology. Again the aim will be to look at the use of the eye and mouth regions, but this time making featural or configural changes to faces that will investigate the *way* the face is processed in a more reliable manner. The paradigm to be explored has been used in typical face processing research and will now be applied to autism and WS.

Chapter Seven

Moving or Changing Features

7.1 Introduction

To further our exploration of feature use in autism and WS, the current chapter applies distortions to the eye and mouth regions whilst rigorously assessing aspects of configural and featural processing. Several early studies assessing the salience of facial features used a procedure termed ‘face distortion’ whereby alterations were made to one or more features. If participants were able to detect the change, the amended feature was assumed to be salient. This is the basic premise of experiments 6a and 6b whereby changes to the eye and mouth region need to be identified for the participant to decide if two face images are the same or different.

Early experiments of this nature used Identikit or Photofit methods to change features, for example Matthews (1978) used Identikit to make different combinations of hair, eyes, nose, mouth and chin components. Participants made same or different judgments on simultaneously presented face pairs and reaction times for detecting changes to the eyes or hair were significantly faster than those for the nose or mouth. Conclusions were made concerning how salient each feature appeared, with eyes and hair appearing to be more salient than nose or mouth. It is now possible to use computer manipulations for creating task stimuli with feature changes in whole face images, as evident in previous experiments of the thesis.

7.1.1 Featural and configural change detection – evidence from adults

When studying differences in representations of familiar and unfamiliar people, O'Donnell and Bruce (2001) examined how well participants could detect configural or feature changes to internal and external features of newly familiarised and unfamiliar faces. The authors hypothesised that people would detect manipulations differently depending on their level of familiarity with the face. The 20 adult participants showed that as the familiarity increased so did sensitivity to the eye region and the ability to spot eye changes (manipulations of brightness and inter-pupillary distance). It was concluded that it may not be that the eyes are actually more salient, but that we selectively attend more to this region because of its social and communicative importance. It could however, be proposed that these results are due to increased salience for this face region.

In similar research using change detection methods, Mondloch, Le Grand and Maurer (2002) modified a single female face (called `Jane') to create eight new versions (called `sisters'), four that differed on their internal features (featural set) and four that differed on the spacing of features (spacing set). To make the spacing set, the eyes were moved up, down, in, or out from a central position by 4mm, whilst the mouth was moved up or down 2mm. Pairs of grey-scale faces were presented sequentially and participants indicated whether the two faces were the same or different. Thirty-six adult participants were more accurate than children (aged 6, 8 and 10 years). Completing trials involving feature manipulations, adults performed more accurately than 6- and 8-year olds but as accurately as 10-year olds, whereas for the configural spacing trials adults were more accurate than all groups of children. High accuracy across conditions indicated that adults could judge identity based solely on featural cues or on second-order relational cues, at least when faces were upright. Again the type of configural information assessed here refers to the second-order relationship between independent face parts.

7.1.2 Featural and configural change detection – evidence from children

Although 5-month olds can detect exaggerated changes in the spacing of schematic faces (Bhatt, Bertin, Hayden, & Reed, 2004) and 6-year-olds are above chance on the spacing set of the 'Jane' task, even 14-year-olds make more errors than adults (Mondloch et al., 2002; Mondloch, Le Grand, & Maurer, 2003). This is clearly an ability that changes with age and gives an insight into the developmental course of face processing 'style' (e.g. the predominance of featural or configural strategies). A number of studies have used a paradigm whereby changes to individual features or spacing have been implemented to assess featural or configural processing and this section will review the evidence from children.

Baenninger (1994) created faces that differed primarily on features or configuration and asked 8- year olds, 11-year olds and adults to detect which of two faces matched a previously seen target. Baenninger moved the eyes, nose or mouth by switching their location for configural trials (e.g. the mouth moved to above the eyes). For feature trials, white discs were placed to obscure features (for example placing two white discs over the eye region). For all groups recognition accuracy was more adversely affected for configural than featural changes and all groups found the task more difficult when none of the features were in their traditional position than when at least one feature was correctly located. Baenninger concluded that children were using the configuration of the face as much as adults and all groups were using the configuration more reliably than the feature information. However, the distorted nature of the configural changes cannot be ignored and this may have been particularly disorientating to all participants, more so than placing discs to obscure features.

In further research using more natural looking faces and investigating featural and configural changes, Gilchrist and McKone (2003) assessed face distinctiveness. Seven-year old children showed configural and featural enhancements of distinctiveness for upright faces and an effect of featural distinctiveness for inverted faces. Feature changes involved thicker eyebrows, or lips whilst configural distinctiveness was enhanced using closer eyes or lower mouths. The authors concluded that 7-year old children and adults showed the same pattern of sensitivity to these face manipulations. This relates to the youngest age group found to use configural processing in other face paradigms (e.g. Carey & Diamond, 1994) and a move towards the internal features of familiar and not unfamiliar faces (e.g. Bonner & Burton, 2004). Taken together with the various studies applying a configural and featural manipulation paradigm with child participants, research has found different results regarding the age when configural changes are detected, often dependent upon the task demands and methodology.

Mondloch, Dobson, Parsons and Maurer (2004) developed earlier work by Mondloch and colleagues (2002, 2003) and investigated face matching with configural and featural modifications. They implemented a matching task using the 'Jane' faces previously used by Mondloch et al. (2002) but blurred the external face contour and used a condition where the eyes were covered. This was included to restrict use of features that may be particularly salient to children (outer face parts or paraphernalia). They also presented face pairs for an unlimited time so that children had the opportunity to process second-order relational information (which may be difficult in the earlier study by Mondloch et al. due to the rapid presentation of faces). The research concluded that under some conditions 8-year olds demonstrated moderately good sensitivity to second-order relations, for example when viewing time was unlimited, faces were presented simultaneously and when distortions of spacing exceeded natural limits. The ability to detect configural spacing changes increased from 65% (in the 2002 paper) to 73% with a new presentation style (unlimited and simultaneous). Once again, task procedure appears to drive performance patterns found here.

Moving down the developmental spectrum to investigate configural processing by younger children, Freire and Lee (2001) used natural looking faces to test the ability of 95 children (aged 4-7 years) to learn and subsequently recognise faces that differed primarily on features or configuration. All features remained in their relative positions and were on view, but subtle shifts in positioning were used for configuration manipulations (in the same way as Mondloch et al., 2002 with adults). As well as moving the eyes closer or further apart from a central point, configural eye changes involved a move up or down relative to the rest of the face. The mouth was also moved up or down relative to the nose position. For featural trials the features were exchanged with another person. Having seen a target image of the original face (for 5 seconds), participants were asked which of four pictures looked most like the original person. Three distracter faces were described as brothers to aid the young participants. Freire and Lee (2001) found that all children were able to chose the original face from the three that differed on the basis of features or configuration. However the task was based on a very small number of trials (two in each condition) and floor effects were evident for 4-year olds in the configural condition (referred to in Pellicano, Rhodes, & Peters, 2006), therefore care should be taken to conclude that the findings are reliable. The authors comment that the results of the recognition task provide “the first direct evidence of above chance level configural encoding in face recognition by 4- and 5-year olds” (Freire & Lee, 2001; 358). This seems surprising given evidence from other face processing paradigms that show children do not use configural processing until approximately 6- to 8-years of age (e.g. Carey & Diamond, 1994).

Pellicano, Rhodes and Peters (2006) felt that further work was required with pre-school participants to overcome the floor effects found by Freire and Lee (2001). In an immediate recognition memory task involving manipulations to eye and mouth features and spacing, 4- and 5- year olds were assessed alongside adults. Children and adults performed more accurately when a target feature contained the same configuration as the original study face, than in a face with an altered configuration. Furthermore, children and adults recognized features better when presented in the old-configuration condition than in isolation, and the authors note that this replicates previous reports of holistic processing in 4- and 5-year-old children (Pellicano & Rhodes, 2003). The results suggest that like adults, children use the relational configural information between features to code faces. This goes against claims for a lack of configural processing in young children (e.g. Carey & Diamond, 1977; Mondloch et al., 2002, 2004).

Indeed contrasting these results, Mondloch, Leis and Maurer (2006) carried out a story book task with 4-year old participants (n=12) to assess their ability to recall the configuration of the faces for main characters. In a task neatly designed to be attractive to young participants, Mondloch and colleagues (2006) used a computerised story-book for participants to learn the faces of characters (three different faces) and later recognise these from foils involving different features and configurations. Although 4-year olds were able to accurately detect characters when viewing foils who differed on individual features, they did not perform above chance when face configuration was manipulated. Mondloch et al. (2006) take this as further evidence that young children, at 4-years of age, are not able to decipher configural face cues to the same extent as older children and adults. The use of configural face information appears to develop with age, whilst evidence from several tasks and differing paradigms shows divergent information concerning the precise age when aspects of configuration are detected.

7.1.3 Featural and configural change detection – evidence from developmental disorders

When trying to explore the structural encoding of faces by individuals with developmental disorders, researchers have suggested that subtle and important differences are evident compared to typical development. In research applying the 'Jane' faces, Karmiloff-Smith et al. (2004; exp. 1) explored featural and configural processing by a group of 12 adolescents and adults with WS (ages 16-51 years, mean age 30 years). The procedure replicated that used by Mondloch et al. (2002), borrowing the stimuli used in the previous research. In blocked trials differing on features (eyes or mouth) or configuration, Karmiloff-Smith and colleagues traced the developmental trajectory of face processing style in WS. When matching faces on identity, participants with WS were more accurate for featural than configural trials (86% and 51% respectively for upright faces). The study also incorporated inverted faces and found that participants were more accurate for upright than inverted stimuli (we replicate this finding with Thatcherised faces in chapter 6). Matching identity for inverted configural trials showed extremely poor performance (mean 31% WS group, mean 29% control group, the authors do not provide an explanation for why the accuracy in this condition is so low). Karmiloff-Smith and colleagues claim this provides evidence for a lack of configural face processing in WS compared to the control group, as performance in the upright configural condition was significantly lower for the WS group. They note the difference did not remain once faces were inverted, however extreme care should be taken when making judgments based on such low levels of accuracy. The authors note that the inversion effect was not typical of individuals with WS (however in chapter 6 of the current thesis we showed the same degree of inversion cost for the groups of typically developing and WS individuals). In total the group with WS showed the same level of accuracy as the control sample of chronologically age matched individuals, however Karmiloff-Smith et al. (2004) conclude that configural processing remains *qualitatively* different in WS as use of this type of processing does not change with age.

As an additional investigation of face processing in WS, Karmiloff-Smith et al. (2004; exp. 3) explored featural versus configural processing of schematic faces. Feature changes were made to the eyes by changing their shape (round eyes became diamonds or squares of a similar size) and configural changes were made by stretching or squashing features towards or away from the midpoint. Participants judged which of two faces differed most from a target. Developmental trajectories were built for each task according to chronological age for their twelve adolescent and adult participants (ages 15-52 years, mean age 27 years). The group with WS showed developmental delay in the ability to process the face configuration, which remained when their performance on the Benton face task was controlled. The authors conclude that face processing in WS shows not only evidence of developmental delay but also atypical configural processing. This supports earlier work by Karmiloff-Smith (1997) finding that 10 adults with WS did not differ from typically developing controls when required to match faces on their features, but were significantly less accurate using the configuration. These previous studies did not distinguish between using the eye and mouth regions.

Although no research has directly applied the ‘Jane’ faces with participants with autism, a number of studies have used face parts or whole faces to assess processing style. Researchers have concluded that both children and adults with autism process faces in terms of individual features rather than configurations (e.g. Tantam, Monaghan, Nicholson, & Stirling, 1989; Davies, Bishop, Manstead, & Tantam 1994; Teunisse & de Gelder, 1994). These studies have been discussed in detail in the introduction to this thesis (see section 1.4.4) but importantly they add to the notion that participants with autism are more accurate when processing featural than configural information. However, based on the premise of the Thatcher illusion, the previous chapter of this thesis suggested that at least some second-order relational information may be used by individuals with autism. A specific type of configural processing may at least be accessible to individuals with autism under specific task conditions.

7.2 Experiments 6a & 6b

The following experiments make manipulations to configural and featural aspects of faces and require participants to match identity. Eye and mouth regions are manipulated with configural changes made to the positioning of face parts and featural changes made by replacing existing face parts. Faces are presented simultaneously to eliminate memory effects which may make the task more difficult for children and groups with developmental disorders. The stimuli will remain in front of the participant until their response is provided to reduce effects of rapid presentation, as suggested by Mondloch et al. (2004). Finally, the external features of the face are not covered as in some previous studies (Mondloch & colleagues, 2002, 2004) to avoid making the task more difficult for the group of participants with autism. However, there is a possibility that the external features may contaminate performance due to their salience for unfamiliar faces. Importantly, the whole natural appearance of the face is always on view and the positioning of the features remains within natural limits. The investigation will add to the present thesis by revealing whether participants can spot featural or configural changes and also whether eye or mouth manipulations are more or less difficult to detect.

7.2.1 Pilot testing

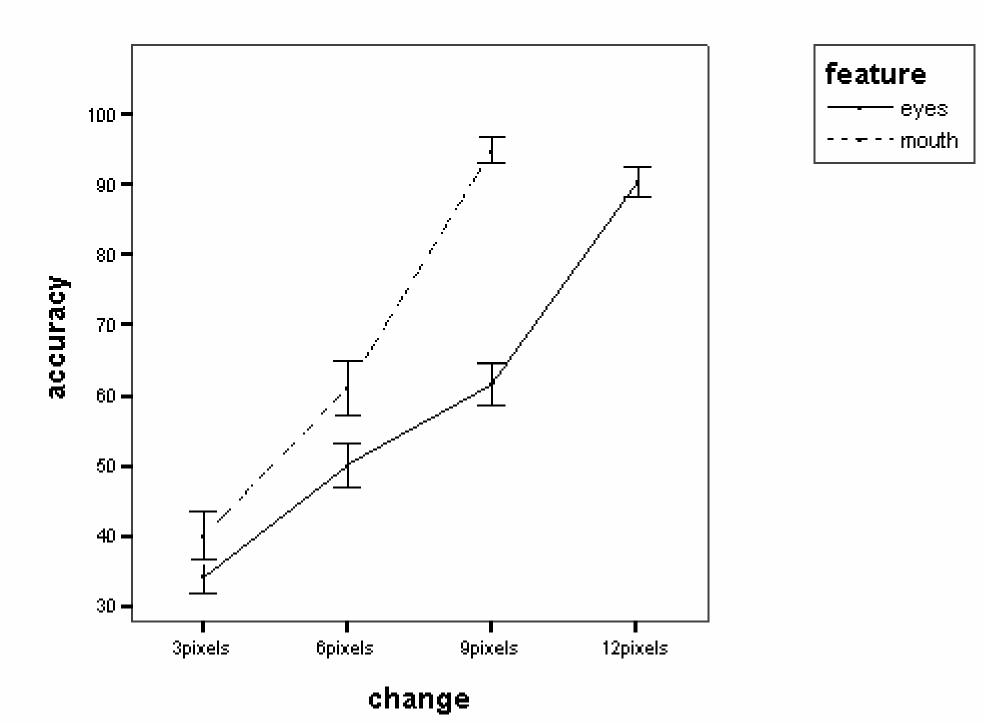
Pilot testing was used to assess the degree of manipulation to be used for configural trials. This was conducted to avoid ceiling or floor effects in this condition due to task difficulty. This phase of testing was based on the pilot testing regime used by O’Donnell and Bruce (2001). The pilot assessment was only used for the trials involving a configural ‘move’ rather than a ‘change’. Previous research has made particularly subtle shifts of features which may be too difficult for participants with autism and therefore lead to floor effects (as in Freire & Lee, 2001, for the youngest group of 4-year old participants). Conversely it would not be desirable for the feature manipulation to be so exaggerated that it appears unnatural and leads to ceiling effects.

Relatively large numbers of children were recruited to assess the degree of change needed to tell the difference between two faces. The main difference between this task and the experimental task was that participants were specifically told which feature to study (eyes or mouth) and the task was carried out in blocks separately assessing the eye and mouth regions.

Thirty-two 6-year old (mean age 6y 2m, SD 11months), 27 8-year old (mean 8y 4m; SD 8months) and 29 10-year old (mean 10y 1m; SD 11months) typically developing children from mainstream schools took part in the pilot study. Participants were asked to decide if two faces were the same or different. Half the participants completed the mouth trials first whilst half completed the eye trials first (all participants completed both conditions). For the mouth block participants were told ‘you are going to see some pairs of faces and I want you to tell me if the two faces are exactly the same or slightly different, if you look at the mouth you might be able to tell if there is a difference’. The same instruction was used for the eye trials with the appropriate word substituted in the sentence.

Faces were manipulated using Adobe Photoshop 7.0 (Adobe Systems Inc, CA) to make subtle changes in positioning to the eyes and mouth. For each manipulation the desired area was cropped from a face image, altered by the desired pixel change and pasted back into the image. The 'feathering' tool was used to avoid obvious cut sections from the original image. Eye trials comprised 8 conditions whereby the eye distance was made closer or further apart by 3, 6, 9, or 12 pixels. The interocular distance was manipulated from the midpoint of the bridge across the nose for each face. Mouth trials comprised 6 conditions whereby the mouth was made higher or lower by 3, 6 or 9 pixels. The 12 pixel shift in mouth direction was deemed unnecessary as this appeared extremely distorted and unnatural in appearance.

Figure 7.1 Percentage correct for detecting changes to the eyes and mouth (pilot data)



Participants completed 5 trials in each of the 'different' conditions plus an equal number of 'same' trials where no manipulation was used (in total 40 eye trials and 30 mouth trials). Overall 5 different faces were used across conditions. Accuracy for correctly detecting the change (different trials) was plotted against the degree of movement to determine task difficulty (Figure 7.1).

For eye changes the experimental trials will impose a 9 pixel shift in interocular distance. This degree of manipulation resulted in an accuracy of 62% from the pilot data. Smaller manipulations of 3 and 6 pixel changes were deemed too difficult for the experimental task, and for participants who may find the task as a whole more difficult (mean accuracy of 34% and 50% respectively). A shift of 12 pixels was deemed too easy for experimental trial (mean 91% for pilot study) and may lead to ceiling effects.

For mouth trials a 6 pixel shift in a vertical direction was chosen for experimental trials. In the pilot study this degree of movement resulted in a mean accuracy of 61%. The 3 pixel shift was deemed too difficult as this may produce floor effects (mean 40%) whilst the 9 pixel change appeared too easy resulting in a 95% accuracy level. Therefore for all experimental trials in experiments 6a and 6b a 6 pixel shift in position would be used for mouth trials whilst a 9 pixel move would be used for eye trials.

7.2.2 Experiment 6a

Experiment 6a uses faces containing featural or configural manipulations to the eye and mouth regions to investigate face processing in WS and typically developing children. It is difficult to predict the exact pattern of performance for typically developing children varying in age due to discrepancies in the existing literature. However it is predicted that the chronological age matched group (the oldest typically developing participants) would be proficient at detecting both featural and configural face manipulations (mean age 15 years). In contrast it is predicted that the group with WS will be more accurate when detecting featural than configural changes (based on work by Karmiloff-Smith et al., 2004, finding configural changes particularly difficult). However, previous research carried out for this thesis (using the Thatcher illusion) has suggested that some relational aspects of configural processing may be possible in WS. Importantly, it is predicted that there will be an interaction between face manipulation and participant group; caused by the different performance patterns evident in the CA and WS groups.

The salience of eye versus mouth changes will be assessed within and between groups to look at the use of these face regions. It is predicted that all participants will be more accurate for spotting eye than mouth changes based on the previous two chapters of this thesis.

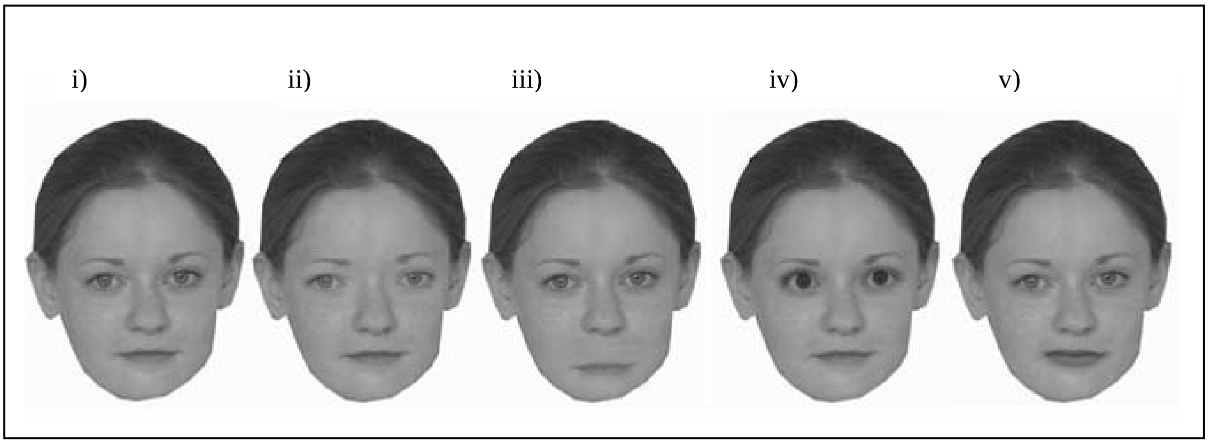
Participants

The individuals with WS taking part in this study were those who participated in experiments 4a and therefore full details of the Williams syndrome group and the typically developing participants to whom they were matched is available in section 5.2.1. The participant characteristics for each group are summarized in Table 7.1.

Materials

Stimuli were created by making featural or configural changes to one of two faces presented side-by-side. Figure 7.2 shows the types of manipulations with the original image on the left (a) and changes made to the eyes and mouth respectively. Manipulations were standardized across face stimuli (4 different unfamiliar faces used as stimuli from the Stirling University Psychology Department face image database). Eyes were made closer, reducing the interocular distance by 9 pixels from the mid-point (each eye moved by 4.5 pixels), or wider by the same distance.

Figure 7.2 An example of each type of each type of facial manipulation i) original face image ii) eyes moved - wider iii) mouth moved – lower iv) eyes changed v) mouth changed



The mouth was made higher or lower by 6 pixels. For feature changes the eyes or mouth were inter-changed with another person of similar appearance and features of the same size. Finally the whole face image was standardized to 300 pixels in width. Each participant viewed 32 trials (16 same and 16 different) seeing each different face 8 times. For ‘different’ trials the manipulated face appeared equally often on the left and right.

Table 7.1 Group details for individuals with WS and their matched comparison groups

Group	N	Gender ratio (male:female)	CA[1]	VMA[1]	NV score[2]
Williams syndrome	15	9:6	15y 6m *(34)*	10y 10m *(20)*	15 *(6)*
VMA Match	15	10:5	11y 6m *(17)*	10y 11m *(24)*	26 *(5)*
NVMA Match	15	9:6	8y 4m *(16)*	8y 0m *(17)*	15 *(3)*
CA Match	15	8:7	15y 8m *(33)*	15y 0m *(19)*	31 *(6)*

1 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviations

2 Nonverbal mental age ability provided as mean score on the RCPM (max. score 36). Standard deviation in parenthesis.

Procedure

Pairs of faces were presented side by side and the participant was required to indicate if they were exactly the same or different. The original face appeared at least once in each trial. Participants were not told to look at any specific face feature when carrying out this task. Explicitly the participant was told ‘you are going to see two faces and I would like you to tell me if the faces are exactly the same or different’ (see Figure 7.3). The stimuli remained in front of the participant until they had made their response.

Figure 7.3 Example of a 'changed' mouth trial, correct answer would be 'different'

Results

Following the procedure used by Karmiloff-Smith et al. (2004) the analyses are divided into 'same identity recognition' (trials involving no difference between target and test faces and involving a 'same' judgment) and 'difference detection' (trials involving the participant correctly spotting a changed aspect of the face). Difference judgments may be based on either feature or configural manipulations. This distinction is used as Karmiloff-Smith et al. (2004) note that transformations (of interest here) are only relevant to difference detection trials.

Same identity recognition

The percentage of correct responses was analysed with one-way analysis of variance (ANOVA) with factor Group (WS, VMA, NVMA, CA) and revealed a significant main effect F(3, 56)=30.64, p<.001. Post hoc t-tests showed the CA group performed significantly more accurately than the WS group (t(14)=4.89, p<.001;

mean WS 73%, CA 89%), who in turn performed more accurately than both the VMA and NVMA matches (WS-VMA t(14)=3.56, $p<.01$, WS-NVMA t(14)=3.55, $p<.01$; mean VMA 61%, NVMA 60%). There was no difference in accuracy for the verbal and nonverbal groups ($p=.71$). Therefore for matching faces on identity, when no manipulation had been made, participants with WS performed more accurately than predicted by their mental age but not as accurately as expected by their chronological age.

Difference detection

Table 7.2 summarises the mean accuracy for each group across conditions, showing that overall featural changes were detected with greater accuracy than configural manipulations. The difference detection involves the variables associated with participant group, as well as the type of manipulation (featural or configural) and the face feature (eyes or mouth). This was analysed with a three-way ANOVA with repeated factors Feature (eye, mouth) and Manipulation (featural, configural) and the independent factor Group (WS, VMA, NVMA, CA). There was a significant effect of Group $F(3,56)=27.06$, $p<.001$ and post hoc t-tests revealed that participants with WS performed with equal accuracy to their verbal matches ($p=.59$) but were more accurate than the nonverbal matches (t(14)=2.87, $p<.01$) and less accurate than the CA matches (t(14)=7.12, $p<.001$). The CA group was more accurate than all other groups as seen in Table 7.2 (CA-VMA t(14)=7.05, $p<.001$; CA-NVMA t(14)=9.94, $p<.001$). The difference in performance across the typically developing participants suggests an increase in accuracy with age and this will be addressed later in this section.

Participants were more accurate when detecting eye than mouth manipulations evidenced by the significant main effect for Feature $F(1,56)=25.82$, $p<.001$ (overall mean eyes 78%, mouth 65%). The pattern was the same across Group as the interaction between Feature and Group was not significant ($p=.89$). There was also a significant effect of Manipulation $F(1,56)=20.93$, $p<.001$ with participants more accurate for featural than configural changes (overall mean configural 65%, featural 78%). The pattern was apparent for all groups as the important interaction between Manipulation and Group was not significant ($p=.82$) and therefore the difference between accuracy for feature and configuration changes was comparable across groups. The only condition where feature changes were not detected more accurately than configural changes involved the CA group completing eye trials. The high performance of this group when using the eyes means that ceiling effects were apparent, possibly reducing the difference between conditions. Participants matched on CA were extremely accurate at detecting eye changes involving both featural and configural manipulations, contrasting performance on configural trials for all other groups and features. Conversely, for the WS group, the only condition to show performance at chance level involved the detection of configural mouth manipulations (compared to chance $p=.16$), this less salient feature and more difficult configural manipulations made the condition particularly difficult. Interestingly, however, only the CA group showed performance above chance for configural mouth alterations (compared to chance, VMA $p=.30$; NVMA $p=.99$; CA $t(14)=5.24$, $p<.01$).

The pattern was also the same for the eyes and mouth as the interaction between Manipulation and Feature was not significant ($p=.98$). Finally, the three-way interaction between Feature, Manipulation and Group was not significant ($p=.25$).

Participants were especially poor on configural trials, contrasting performance for the CA group on eyes only trials, where performance was particularly strong (90% accuracy).

Table 7.2 Percentage correct for each group for each feature condition and type of manipulation (SD in parenthesis)

		Feature change	Configural change	Overall
WS	*Eye*	87 *(15)*	65 *(21)*	76 *(11)*
	Mouth	70 *(17)*	57 *(18)*	63 *(12)*
	Combined	78 *(11)*	61 *(18)*	70 *(5)*
VMA match	*Eye*	82 *(17)*	65 *(22)*	73 *(6)*
	Mouth	68 *(21)*	57 *(21)*	63 *(18)*
	Combined	75 *(16)*	61 *(18)*	68 *(7)*
NVMA match	*Eye*	73 *(14)*	63 *(16)*	68 *(11)*
	Mouth	60 *(18)*	50 *(24)*	55 *(14)*
	Combined	67 *(12)*	57 *(17)*	62 *(10)*
CA match	*Eye*	95 *(10)*	90 *(12)*	93 *(9)*
	Mouth	90 *(13)*	72 *(16)*	81 *(12)*
	Combined	93 *(7)*	81 *(10)*	87 *(8)*
Overall		78 *(15)*	65 (*16)*	

The results indicate that although overall accuracy was not the same for all groups, the performance pattern was the same. Participants found it easier to spot eye than mouth changes and to spot featural than configural manipulations. However, all groups performed above chance for both featural and configural manipulations when the eye and mouth manipulations occurred together.

Discussion

In a study requiring participants to spot changes to the eye and mouth regions and match unfamiliar faces on identity, the group with WS showed the same performance pattern as participants who developed typically. All participants found it easier to spot eye than mouth changes, supporting evidence from other chapters using the upper and lower features and detecting the Thatcher illusion. The eyes are a particularly salient feature that play an important role in face recognition and demand our attention (Yarbus, 1976; Ellis, 1975; Malcolm et al., 2005). Although a number of the studies with children introduced earlier in this chapter (see section 7.1.2) incorporated configural and feature changes affecting the eye or mouth regions, a direct comparison between these areas has not previously been reported. Therefore it was not possible to deduce whether participants were more or less affected by eye or mouth changes. In fact some studies combined the eye and mouth manipulations in the same face distortions (e.g. Freire & Lee, 2001). The configural and featural changes in the present study were isolated to specific face areas to investigate their impact separately.

Regarding the performance of the typically developing participants, it is possible to compare the findings to previous research assessing the use of featural and configural processing. There is no suggestion that the youngest participants in this research (the nonverbal matched group, mean age 8 years 4 months) showed a different pattern to the oldest group of typically developing participants (the chronological age group, means age 15 years 8 months). However the youngest group (NVMA group) was the only group to show performance at chance level when a configural change was made to the mouth region. The combination of a less salient face area and a more difficult face manipulation may have created this effect. Importantly though, all participants were able to detect featural and configural changes, independent of their age. Participants as young as 8-years showed the ability to detect both featural and configural face changes. This is an age where a number of studies have indicated the use of configural processing emerges (e.g. Mondloch et al., 2002, 2004).

There was no qualitative change in the way faces were processed as the participants increased in chronological age. Therefore the hypothesized interaction between group and manipulation was not evident. However there was a gradual linear increase in overall accuracy with age. Supporting previous research (e.g. Baenninger, 1994; Freire & Lee, 2001; Mondloch et al., 2004) the oldest group of participants were able to accurately detect featural and configural manipulations. Ceiling effects in the chronological age group may have affected the outcome and been created by the unlimited and simultaneous presentation of stimuli. By making the task more accessible to younger participants and those with developmental disorders, the task may have become too easy for older participants. Importantly however, combining performance for eye and mouth trials (as with previous research) all groups of participants were able to complete both featural and configural trials at a level above chance. There may be some suggestion that although participants were more accurate for featural than configural trials, both types of information were available to even the youngest group, aged 8-years.

Previous work involving participants with WS shows greater accuracy for featural than configural changes for adults and adolescents (Karmiloff-Smith et al., 2004). The participants with WS in the present study (mean age 15-years, mean age for Karmiloff-Smith et al., 30-years) show the same pattern of performance with greater accuracy for featural than configural manipulations. Although previous research included changes to both the eye and mouth regions, Karmiloff-Smith et al. (2004) did not separate these areas and therefore featural trials differed from the target on both the eyes and mouth. The present research went against evidence from Karmiloff-Smith et al., (2004) and indicated that using these task conditions individuals with WS were able to also detect configural face manipulations at a level above chance (combining eye and mouth changes accuracy at 61%). Performance of adults and adolescence in the study by Karmiloff-Smith et al. (2004) indicated that configural processing was not achieved for participants with WS (mean 51%). Participants with WS on the present task were as accurate overall as typically developing individuals of comparable mental ability at detecting configural face alterations, although performance was not at a level predicted by their chronological age. It could be questioned whether participants with WS performing above chance implies some level of configural visuo-spatial ability? Certainly here where faces are included and the social importance of the stimuli is therefore heightened for these individuals, some level of configural processing is apparent.

However, when involving the less salient mouth region, configural changes were difficult to detect. There is some suggestion that young individuals with WS in the present study show an ability to detect the configuration of the face when using the eye region, supporting evidence from chapter 6 showing that inversion affects processing of the Thatcher illusion in this group (disrupting configural relational processing). Task difficulty as a whole may have played an important role in the pattern of performance cited by Karmiloff-Smith and colleagues as typical adults only performed at 75% accuracy for configural face changes. The present task was easier as a whole and may have allowed the accessibility to configural aspects of the face. Task presentation will be discussed in further detail in the general discussion of this chapter (see section 7.5). In summary, the present study gives some indication of the ability to process the configuration of the face in WS as well as extending our knowledge of the use of eye and mouth for making face judgments .

7.2.3 Experiment 6b

Experiment 6b replicates the procedure used in experiment 6a with participants who have autism and individuals who are typically developing. The experiment will identify how accurately modifications to the eye and mouth regions are detected. Based on the previous two chapters it is hypothesized that individuals who develop typically will show greater accuracy for detecting eye than mouth changes. However, based on the results of previous chapters, it is hypothesised that individuals with autism will not show greater accuracy for eye manipulations. Concerning the use of featural and configural processing, it is difficult to make firm predictions concerning the performance pattern for typically developing children of varying ages. However, based on the previous experiment reported in this chapter it is predicted that all typically developing groups will be able to detect configural and featural manipulations above chance, with greater accuracy for featural changes. It is predicted that the group with autism will be more accurate for featural than configural changes, and will find configural manipulations extremely difficult. It is predicted that there will be an interaction between participant group and manipulation type, predominantly created by the performance patterns of the group with autism and the typically developing group matched for chronological age (CA). The older group of participants in the CA group will be capable of detecting both featural and configural manipulations, although these configural changes will be particularly problematic for participants with autism.

Method

Participants

The individuals with autism taking part in this study also participated in experiments 4b and 5b and therefore details of the group and the typically developing participants to whom they were matched are available in section 5.2.2. Table 7.3 summarises the group details.

Materials and Procedure

Task materials and procedures were the same as those used in experiment 6a and are not detailed in this section. The only modification used in this study was that two symbols were placed under the trials indicating ‘same’ and ‘different’. This was used to aid participants in the group with autism who had particularly poor vocabulary abilities. However, during the testing session only one participant chose to give a nonverbal response; all other participants said ‘same’ or ‘different’ to each trial.

Table 7.3 Participant details for individuals with Autism and their matched comparison group details

Group	N	Gender ratio (male:female)	CA[1]	VMA[1]	NV score[2]
Autism	20	16:4	14y 9m *(29)*	7y 2m *(23)*	15 *(6)*
VMA Match	20	15:5	6y 6m *(18)*	7y 3m (*21)*	12 *(7)*
NVMA Match	20	13:7	7y 11m *(15)*	8y 2m *(18)*	15 *(5)*
CA Match	20	12:8	14y 11m *(27)*	14y 8m *(20)*	31 *(5)*

1 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviations

2 Nonverbal mental age ability provided as mean score on the RCPM (max. score 36). Standard deviation in parenthesis.

Results

Same identity recognition

The percentage of correct responses was analysed with a one-way ANOVA with factor Group (Autism, VMA, NVMA, CA) and revealed a significant main effect F(3, 76)=8.76, p<.001. There was no difference between the CA and NVMA groups (p=.28; mean CA 67%, NVMA 65%) even though the CA group was older than the NVMA group. Both the CA and NVMA groups were significantly more accurate than the VMA group (mean VMA 57%; CA-VMA t(19)=4.82, p<.001, NVMA-VMA t(19)=4.88, p<.001) and the groups with autism (mean autism 52%; CA-autism t(19)=4.52, *p*<.001, NVMA-autism t(19)=3.20, *p*<.01). There was no difference between the autism and verbal matches (*p*=.27).

In summary the group with autism performed the face matching task, where there was no difference between faces, at a level predicted by their verbal mental age. Additionally it should be noted that the group with autism did not perform above the level predicted by chance and therefore some care should be taken with this interpretation (compared to chance, *p*=.32).

Difference detection

As evident in Table 7.4, overall it was easier to detect featural than configural manipulations. Performance accuracy for trials involving a feature manipulation were analysed with an ANOVA with the repeated factors Feature (eye, mouth) and Manipulation (featural, configural) and the between-subject factor Group (Autism, VMA, NVMA, CA). The effect of Group was significant F(3,76)=21.64, *p*<.001 and indicated that not only did the group with autism show a different pattern of results, but they performed with lower accuracy. Post hoc t-tests revealed the group with autism performed with less accuracy than both the CA and NVMA groups (autism-CA t(19)=8.17, *p*<.001; autism-NVMA t(19)=5.21, *p*<.001). There was also a trend towards the group with autism performing less accurately than the group matched for VMA (autism-VMA t(19)=1.93, *p*=.07). The CA group also performed more accurately than the two mental age matched groups (CA-VMA t(19)=5.34, *p*<.01; CA-NVMA t(19)=3.67, *p*<.01). Additionally, the verbal ability group performed more accurately than those matched for nonverbal ability (t(19)=2.42, *p*<.05). The poor performance of the autism group, compared to the mental age matches, is primarily due to poor performance on eye trials as mouth trials were performed with equivalent, or even better, performance.

Table 7.4 Percentage correct for individuals with Autism and their matched comparison groups in each feature condition and type of manipulation (SD in parenthesis)

		Feature change	Configural change	Overall
Autism	*Eye*	56 *(21)*	48 *(7)*	52 *(11)*
	Mouth	71 *(17)*	58 *(24)*	64 *(16)*
	Combined	64 *(15)*	53 *(14)*	58 *(11)*
VMA match	*Eye*	76 *(24)*	65 *(26)*	71 *(17)*
	Mouth	64 *(21)*	54 *(22)*	59 *(15)*
	Combined	70 *(14)*	59 *(17)*	65 *(13)*
NV match	*Eye*	83 *(11)*	71 *(29)*	77 *(13)*
	Mouth	73 *(20)*	63 *(15)*	68 *(13)*
	Combined	78 *(12)*	67 *(14)*	73 *(9)*
CA match	*Eye*	95 *(10)*	84 *(14)*	89 *(11)*
	Mouth	85 *(17)*	71 *(19)*	78 *(13)*
	Combined	90 *(8)*	78 *(15)*	84 *(9)*
Overall		75 *(16)*	64 *(17)*	

There was a significant main effect of Manipulation $F(1,76)=29.07$, $p<.001$ with greater accuracy for featural than configural changes (mean featural 75%, configural 64%). The interaction between Manipulation and Group was not significant, indicating the same pattern for all participants ($p=.99$). All typically developing groups were above chance on configural trials (combining eye and mouth trials), but the autism group did not differ from chance (compared to chance $p=.43$). In fact the autism group was no different to chance for either configural eye or mouth trials (eyes compared to chance $p=.33$, mouth $p=.07$). All groups, including participants with autism, performed above chance for featural trials, manipulating either the eyes or mouth.

There was a significant main effect of the Feature $F(1,76)=5.16$, $p<.05$ with eye changes easier than mouth changes (overall mean eyes 72%, mouth 67%). However the significant interaction between Feature and Group indicated different patterns across groups $F(3,76)=7.45$, $p<.001$. Post hoc t-tests (and inspection of Table 7.4) revealed that typically developing groups detected eye manipulations more accurately than mouth modifications (CA $t(19)=3.45$, $p<.01$; VMA $t(19)=2.30$, $p<.05$; NVMA $t(19)=2.28$, $p<.05$). For the participants with autism, accuracy was greater for mouth than eye trials ($t(19)=3.08$, $p<.01$).

Finally, the two way interactions between Modification and both Group and Feature were not significant ($p=.99$ and $p=.71$ respectively) and nor was the three way interaction between Feature, Modification and Group ($p=.85$).

Discussion

Although typically developing participants were most accurate detecting changes made to the eye region, participants with autism were most accurate using the mouth. This supported the proposed hypothesis that greater accuracy for eye manipulations would not be mirrored in autism. Spotting eye manipulations was particularly problematic for the group with autism and performance was no different to chance when the eyes were moved (as in Table 7.4). This finding links directly to the results of other chapters; specifically problems interpreting gaze cues (chapter 3), a tendency away from internal features (chapter 4), the absence of an upper feature advantage (chapter 5) and use of the eyes and mouth when detecting the Thatcher illusion (chapter 6). Interpreting the eye region is particularly problematic for individuals with autism, as predicted by an abundance of previous research (e.g. Langdell, 1978; Baron-Cohen et al., 1993). Once again, typically developing participants were relatively more accurate for upper manipulations than lower changes, replicating previous research suggesting that this area is particularly salient and reliably interpreted (e.g. Langdell, 1978, Malcolm et al., 2005).

All participants, the typically developing groups as well as the group with autism, were more accurate at detecting the difference between faces based on features than configuration. However, all typically developing participants were also able to detect configural manipulations better than chance (combining the eyes and mouth). This indicated that typically developing children as young as 6 years (mean age verbal matched group 6 years 6 months) were able to detect aspects of both face features and configuration. This supports previous research with young typically developing children (e.g. Baenninger, 1994; Freire & Lee, 2001). Indeed Mondloch et al., (2006) note that this skill develops sometime around 4-6 years of age.

Participants with autism were only able to detect featural rather than configral manipulations above chance, supporting suggestions of feature-based face processing in autism (e.g. Rondon & Deruelle, 2004). In fact, taking into consideration false alarm rates (FA) reveals that participants with autism were poor not only at configural eye changes but also at detecting featural eye changes (HIT-FA=8% for eye featural change and HIT-FA=0% for eye configural change trials). This finding confounds previous research suggesting that aspects of configural face processing are possible for individuals with autism when specific conditions are available (for example reduced memory demands and an inversion effect found by Teunisse & de Gelder, 2003). Indeed this goes against evidence from chapter 6 showing some susceptibility to configural relations in the Thatcher illusion. In the present study the memory demands were reduced by using simultaneous presentation and participants with autism still found the task more difficult when faces differed on configuration than features. Therefore, it appears that individuals with autism found it particularly difficult to use the configural aspects of the face to judge identity similarities. This also brings into question whether the Thatcher illusion task (in chapter 6) is actually assessing configural processing in autism, as the results contradict those evident using different paradigms (this will be addressed further in chapter 8).

7.3 Chronological age and performance

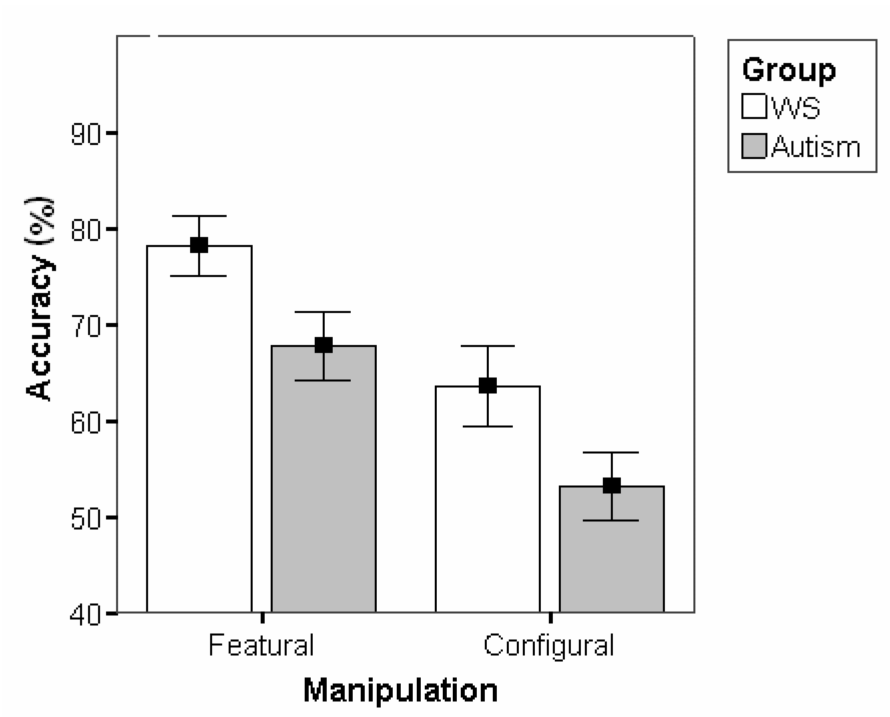
Combining the data for typically developing participants in all groups it is possible to investigate whether children and adolescents are more able to detect face manipulations as they increase in age. Research suggests that children are able to process featural information but have more difficulty with configural information (e.g. Carey, 1977; Diamond & Carey, 1994; Mondloch et al., 2002, 2004, 2006). Therefore we might predict that featural changes are much more readily detected by younger participants than configural changes. The relationship between chronological age and performance was investigated for each face manipulation for 81 typically developing participants (taking into consideration a small number of individuals who were included in more than one comparison group for different measures and are only considered here once). Performance increased with age for both type of face manipulation and at all ages featural detection was easier than configural detection. Therefore comparing performance across ages, participants were more accurate for featural and configural trials $t(80)=6.11$, $p<.001$. Spearmans Rho correlation revealed a significant positive correlation between chronological age and performance on featural and configural trials ($r=.58$, $p<.001$ and $r=.53$, $p<.001$ respectively).

7.4 Comparing individuals with WS and autism, evidence from experiments 6a and 6b

As with previous chapters, a small group of individuals with WS and autism were matched to each other to compare performance across the groups with developmental disorders. Each matched group comprised 12 individuals and the groups did not differ on chronological age (WS mean 13 years 8 months, Autism mean 13 years 9 months; $t(11)=1.08$, $p=.31$) or nonverbal ability (WS mean 14, Autism mean 15; $t(11)=.34$, $p=.74$). For this analysis of processing style eye and mouth trials were combined. An ANOVA with Factors Group (WS, Autism) and Manipulation (Featural, Configural) revealed that featural trials were more accurately completed than configural trials $F(1,22)=11.72$, $p<.01$ (mean featural 73%, configural 58%). Additionally participants with WS were more accurate than individuals with autism, evident as an effect of Group $F(1,22)=13.42$, $p<.01$ (WS 71%, autism 60%). There was no interaction between Group and Manipulation as both groups were more accurate for featural than configural manipulations ($p=.84$). Figure 7.4 shows that both groups show a gradual decrease in performance from featural to configural trials, but due to the overall lower accuracy of individuals with autism, their ability to complete configural trials fell to chance (50%). This effect may therefore be created, in part, due to an overall lower level of accuracy for the task. Therefore, individuals with WS, but not those with autism, were able to detect configural manipulations above chance level, this difference dissociates performance in the two groups.

Considering the use of different features, an ANOVA was conducted to investigate the ability to detect eye and mouth changes for these two matched groups. The ANOVA with Factors Group (WS, Autism) and Feature (eyes, mouth) revealed an effect of Group $F(1,22)=22.13$, $p<.001$ as individuals with WS were more accurate at processing these faces (WS 72%, autism 49%). There was also an effect of Feature $F(1,22)=8.59$, $p<.01$ as eyes were detected more accurately than the mouth (eyes 66%, mouth 54%) and an interaction between the variables $F(1,22)=8.69$, $p<.01$. The interaction was created by the WS group being more accurate for eye than mouth trials (t(11)=4.75, $p<.01$ (eyes 83%, mouth 60%), but participants with autism showing no difference for eye and mouth trials ($p=.95$; eyes 48%, mouth 49%). This effect replicates the evidence presented elsewhere in this thesis and confirms that WS and autism can be dissociated from each other by their use of the eye region, which inhibits overall performance in autism but not WS.

Figure 7.4 Percentage correct for detecting featural and configural manipulations by matched groups of individuals with WS and autism



7.5 General Discussion

Considered together, experiments 6a and 6b provide an insight into how individuals with Williams syndrome and autism are able to detect subtle manipulations made to the eye and mouth regions. Williams syndrome participants perform better than mental age matched typically developing children but not as strongly as predicted by their chronological age. Although this performance may not be at chronological age level, there is no evidence of *atypicality* when interpreting these face regions. Indeed, along with the typically developing groups, participants with WS found it easier to detect eye than mouth changes. This finding fits with the prediction that the eyes are highly salient and socially important face features (Malcolm, Leung, & Barton, 2005).

In contrast, evidence from the group with autism showed a clear problem interpreting the eye region and greater proficiency using the mouth. Indeed accuracy for detecting eye changes was particularly poor for the group with autism. The eye region is extremely important for social interactions and holding joint attention between individuals which has previously been found to be a core deficit in autism (Wing, 1976; Johnson, 2005). In contrast, children with autism were proficient at detecting featural changes in the mouth region and performed at a level comparable to mental age matched typically developing children.

7.5.1 Moving or changing features

All participants (typically developing, WS and autism) were more accurate detecting featural than configural face changes for assessing whether two pictures were the same or different. This finding supports research with typically developing children and adults (e.g. Freire & Lee, 2001, Mondloch et al., 2002, 2004, 2006). Regarding adults with WS, the results also support previous research using the 'Jane' face paradigm (Karmiloff-Smith et al., 2004).

Participants were also able to make judgments about the face configuration and match pictures when the configuration of features had been distorted. This was not the case for the group with autism however, as performance was at chance level for configural changes (combining the eyes and mouth). Importantly, all typically developing children were able to detect configural manipulations above chance level, even the youngest group of children with an average age of 6 years. This finding suggests that young typically developing children are able to make assessments of identity using the face configuration and does not suggest a qualitatively different way of processing faces compared to adults at this age. Previous research has found that children of varying ages are able to detect configural movements, for example Freire and Lee (2001) showed this effect in children aged 4-7 years, Baenninger (1994) found that children aged 7-years were affected by distorted configurations, and Mondloch (2004) showed sensitivity to configural aspects of the face in 8-year olds. Therefore young typically developing children were able to match the identity of unfamiliar faces making judgments concerning both the featural and configural aspects of the face.

The findings of the group with WS mirror those of the typically developing children, showing susceptibility to both featural and configural face changes. The participants with WS were able to detect changes made to faces when the images differed on the configuration of features, although performance was not as good as when feature changes were made. Importantly there was no interaction between the participant group and the manipulation type, therefore indicating qualitatively the same performance pattern in typical development and WS. The findings confound those of Karmiloff-Smith et al. (2004) who found that adolescents and adults were unable to detect configural face changes using the 'Jane' faces. Task difficulty as a whole may have played an important role in the difference between tasks. The findings of the present study support claims for aspects of configural face processing in WS.

7.5.2 Methodological considerations

On a methodological note, it is difficult to determine if the two types of change (feature versus configuration) were equally difficult. Although the task was pilot tested for the degree of change needed for spacing manipulations, the pilot test did not include feature changes. Featural alterations used in the present study may have been inherently easier to detect, alongside a different affect for eye and mouth regions. Future research should pilot the difficulty of each of the manipulations before working with participants on the experimental trials. It is noted however, that changes such as these do not appear to have been equated for difficulty on previous research studies (for example Mondloch, 2002, 2006; Freire & Lee, 2001). In fact a number of studies using the paradigm change the colour of individual aspects of the face for feature change trials and this may be particularly easy compared to more subtle shifts of positioning. Mondloch et al. (2004, exp.3) whitened the eyes and blackened teeth to enforce feature distortions and Baenninger (1994) used particularly distorted configurations with features incorrectly located (mouth above eyes). Care should be taken that the stimuli are controlled in such a way as to avoid possible confounds.

Pilot testing of the configural face changes encouraged the use of manipulations that were more exaggerated than those used in previous studies involving ‘Jane’ faces (i.e. Freire & Lee, 2001; Mondloch et al., 2002, 2004; Karmiloff-Smith et al., 2004).

Previous research made spacing changes of 4mm interocular distance and 2mm for the mouth region. One of the reasons for the difficulty of that task was to enable use with adult participants. The pilot testing of experiments 6a and 6b revealed that larger changes were required for child participants, and especially for special populations who may find face processing particularly difficult. However, the increased degree of change for the configural trials of the present experiments may have exaggerated performance in this condition and additionally masked differences between featural and configural trials. Inherent within this paradigm is the difficulty of making one type of face manipulation and not changing another. For example, by changing the shape of one specific feature it is difficult not to also alter the configuration of features to some extent. Importantly the changes used in this task *predominantly* focused on either the feature or configuration.

Although no ‘illegal’ changes were included, for example making one eye higher than the other or moving the mouth sideways, this additional modification may have been interesting. Such changes take the task away from aspects of real faces identifiable in our social world by making unrealistic changes. Malcolm et al. (2005) used ‘illegal’ modifications that destroy normal face symmetry for some of their faces and found that adult participants were able to detect these changes with good accuracy in both upright and inverted face conditions. It would be interesting to see whether participants with WS and autism also find these type of manipulations relatively easy to detect. Indeed such manipulations may make the task accessible to participants with autism, however it would also limit the ecological validity of the results.

The inclusion of inverted face trials would have allowed an investigation of the inversion effect using featural and configural changes. Karmiloff-Smith et al., (2004) found that adults with WS were less affected by inversion for configural trials than adults who had developed typically, thus concluding a greater reliance upon feature-based processing in WS. The comparison between upright and inverted face processing would be valuable for further investigations of this paradigm and the use of featural and configural face information in both WS and autism. This would have also been useful for comparison with the inverted Thatcher illusion trials and may have supported or confounded evidence of an inversion effect for the participants with WS and autism in that study (chapter 6). Future research should therefore include inverted trials using this paradigm.

Some difficulty has arisen from attempting to make comparisons between the developmental disorder groups and the typically developing groups, where the typical pattern of performance is somewhat uncertain. Previous research using this paradigm has found contradictory evidence of the age when configural manipulations are easily detected (e.g. Baenninger, 1994, 7-year olds; Freire & Lee, 2001, 4-7 year olds, Mondloch, 2004, 8 years). Therefore this paradigm may be particularly useful for the development of trajectories of performance patterns as conducted by Karmiloff-Smith et al. (2004) with older adolescents and adults. It would be useful to use the procedures advocated by Karmiloff-Smith and colleagues with younger participants with both WS and autism to see how performance patterns compare to typical development. Alternatively this may be a paradigm that is more possible for use with adult participants, or at least adolescents, where the pattern of typical performance has reliably been determined.

It would be useful to incorporate reaction time assessments when participants complete the task. Participants may have taken longer to make feature trial assessments and therefore shown a speed accuracy trade-off. However, previous research using this paradigm has shown that reaction time and accuracy data were confirmatory (Mondloch et al., 2002; 2004). Additionally, it may be unreliable to use reaction time analyses when accuracy is low and there is great variation in the data as seen in Table 7.2. The presentation method used in the present study does have limitations as unlimited presentation time may have allowed participants to engage in direct comparison between the stimuli, and thus rely on pictorial cues or feature-by-feature comparisons. If this is the case then future reaction time analyses may give insight into whether there is a speed difference in the completion of featural and configural change trials, in both typical development and learning difficulty groups.

Trials incorporating no change in identity were analysed as an assessment of same identity recognition. In summary, participants with WS performed more accurately than predicted by their mental ability but not as accurately as predicted by their chronological age. The participants with autism performed at the same level as their verbal mental age matches, and again less accurately than predicted by chronological age. These findings provide some support for the results of experiments 1a and 1b (chapter 3) using a variety of face tasks and showing identity matching difficulties in the autism group. Additionally, the results do not support early claims of 'intact' face recognition processing in WS as the group did not perform as well as predicted by their chronological age (e.g. previous research by Bellugi et al., 1999).

7.6 Conclusions

As well as adding to the literature concerning the typical age when configural changes can be detected, the present chapter has extended the investigation to WS and autism, using the same task and placing the same demands upon participants. Although aspects of configural face processing appear possible in WS they are more difficult for participants with autism, especially when the eye region is involved. Supporting evidence from previous chapters, typically developing and WS participants are particularly susceptible to the salient eye region, whereas this susceptibility is not evident in autism.

The current chapter has extended our discussion of the type of information that can be detected in the face and typical / atypical use of the eye and mouth regions in WS and autism. The final chapter of the thesis brings together the evidence from this experimental chapter, alongside evidence from the previous experimental chapters, to consider how the findings can further our understanding or face perception and social functioning in these two distinct developmental disorders.

Chapter Eight

Summary, Evaluation and Future Research

8.1 Interpreting faces

This thesis has introduced the reader to important aspects of face processing skill in two developmental disorders; namely Williams syndrome (WS) and autism. We began by reviewing the relevant literature, introducing the two disorders of interest and moving on to consider how face perception research is particularly relevant to these two groups. The main methodological issues that were central to the current thesis were then introduced to set the way for the 5 experimental chapters exploring aspects of face skills. The original theoretical drive for this thesis came from research claims that both WS and autism are characterised by a similar atypical face processing style but the groups clearly show divergent social phenotypes. This led to an interest in exploring not only face identification abilities in these groups but socio-communicative face skills. At the beginning of the exploration, the importance of the human face in everyday social interactions was noted, not only must we identify people we know, and indeed whom we know, but we must successfully interpret communicative cues evident in facial movements. The eyes represent a ‘window to the soul’ inferring intentions, desires and attention, whilst the configuration of features depicts feelings through expression or gesture. This configuration of features is particularly important to typical adult face processing, yet previous research suggests that it is less crucial to face processing by individuals with autism and WS. Grounded in research methods used to explore typical face perception, this thesis has allowed insights into how individuals with WS and autism interpret this crucial social stimulus. The current chapter brings together evidence from the five experimental chapters. First, the findings are condensed to summarise interesting facets of performance and discuss how the findings relate to more general aspects of their relevant phenotypes. We then ask how this research can inform wider behavioural aspects of the disorders and how future investigations could expand and develop the ideas proposed here.

8.2 Summarising the prominent findings

This section summarises the prominent results of the thesis and considers how the findings fit together to tell the story of the thesis.

Profiling abilities and models of face perception

Chapter 3 began with a large scale exploration of face processing, investigating the processing of identity, eye gaze, expressions and lip movements using tasks previously implemented with typically developing children (Bruce et al., 2000). Based on published research involving participants with autism (e.g. Gepner, de Gelder, & de Schonen, 1996; Teunisse & de Gelder, 1994; Deruelle, Rondon, Gepner, & Tardiff, 2004) further explorations were required taking into consideration level of functioning, appropriate comparison groups, task demands, participant age and a model of face perception. Similarly, previous WS studies (e.g. Karmiloff-Smith 1997, Deruelle, Mancini, Livet, Casse-Perrot, & de Schonen, 1999) emphasized the need for further investigations involving various task demands, an appropriate level of difficulty, including children and considering the applicability of a model of face perception. Whilst bearing in mind these requirements, Chapter 3 investigated how these developmental disorders uniquely impact upon the processing of identity, eye gaze, expressions and lip reading.

When summarising the prominent results, it is clear that the involvement of the eye region is central to the pattern of evidence for each group. Interpreting eye gaze direction, and to some extent expressions of emotion, requires sensitive assessment of eye cues. Participants with WS and autism could be dissociated from those with general developmental delay, and from each other, primarily on the basis of eye gaze ability. Individuals with WS performed more accurately than participants with general developmental delay and this provided the first suggestion that the eyes might be a feature that individuals with WS are able to successfully interpret. We will return to this throughout the current chapter. The domain of expression processing also dissociated WS from general developmental delay and autism, as WS participants performed more accurately (using happy, sad, angry, surprise). Importantly however, based on existing evidence (Bruce et al., 2000) individuals with WS did not perform as well as expected for their chronological age when processing eye gaze or expressions of emotion.

Again, involvement of the eye region was central to the results pattern obtained for individuals with autism. Autism uniquely impacted upon eye gaze processing as participants were less accurate when matching and recognizing gaze direction than individuals with general developmental delay (of comparable verbal or nonverbal ability) and those with WS. Participants with autism did not perform above chance when processing gaze direction and the data emphasised that a gaze processing deficit was specific to autism. The results of the exploration support previous suggestions that the eye region does not capture attention in autism (e.g. Baron-Cohen et al., 1997; Ristic et al., 2005). Additionally, expression processing revealed an autism-specific deficit regarding ‘surprise’ supporting previous claims (Baron-Cohen, Spitz, & Cross, 1993). On the whole, expression processing was less accurate in autism than in the developmental delay group matched for nonverbal but not verbal ability. This replicates the pattern found in previous research and emphasizes the importance of involving both types of comparison. In summary therefore, alongside a general deficit in performance across all aspects of face skill, individuals with autism showed a small number of ‘autism-specific’ deficits.

Condensing across domains, evidence of ‘intact’ face skills in WS are not supported by the exploration in Chapter 3. Individuals with WS did not perform at a level predicted by their chronological age in any domain (based on evidence from Bruce et al., 2000). However, strengths at interpreting expressions of emotion and eye gaze cues may link directly to the social phenotype of WS, as individuals are described as empathetic and show a keen interest in holding eye contact with other people (e.g. Gosch & Pankau, 1994; Mervis et al., 2003). As well as making an important contribution to our understanding of face perception and social functioning in WS, the exploration provided the first evidence in this thesis that identity processing might not be at chronological age level in WS. This is important considering previous claims and shows that WS does not leave identity processing ‘intact’ as has previously been proposed (Bellugi et al., 1994).

A similar conclusion can be drawn regarding autism; the profile of abilities confirmed a number of previous suggestions in the literature and linked directly to evidence of social functioning abilities. The importance of level of functioning on the autistic spectrum was shown as this was related to face processing ability on all assessments except lip reading ability. Not only did level of functioning affect general social abilities and general ability to process faces, this study showed how level of functioning effects socio-communicative skills such as emotion and eye gaze processing. This is important when interpreting the findings from published literature and emphasizes the importance of acknowledging participant characteristics.

One of the most important contributions of the exploration was the consideration of a model of face perception in WS and autism. Such a model would typically be characterized by a modular structure and independent nodes of ability (e.g. dissociating identity and expression processing, evident in the Bruce and Young, 1986 model). This is discussed further in section 8.3. In brief, evidence from participants with WS implied a typical modular structure to face perception, however, in autism performance was characterised by a general atypical core deficit. Therefore, not only did Chapter 3 provide an overview of abilities regarding face skills, but with the same group of individuals across domains it was possible to show evidence for typical and atypical models of face perception in WS and autism respectively.

A modular face processing system in WS but not in autism

As recently detailed, the thesis provided a unique contribution to our understanding of models of face perception in WS and autism. Here we ask what implications these models may have for understanding face perception in these disorders. For the first time it is possible to consider a typical model of face perception in WS, characterized by the independence of skills for different aspects of face perception such as identity and expression processing. That is not to say that all nodes of the model function typically, as suggested by previous research exploring structural encoding (e.g. Deruelle et al., 1999). The functional independence of nodes implies that deficits may occur independently in different areas of the model (as illustrated in Chapter 1). Therefore it is conceivable that the overall structure of the model is ‘typical’ but deficits plague the individual nodes, such as the one responsible for structural encoding. This suggestion may be supported by previous research (such as Deruelle et al., 1999 or Karmiloff-Smith et al., 2004) but deficits of structural encoding gain less support in this thesis. When participants were required to compute configural manipulations they performed above chance and therefore were able to use this information to make face judgements. This study is considered in detail in Chapter 7 but in summary may provide more clues to the typicality of the way faces are viewed and encoded in WS. Overall therefore, the evidence presented here depicts a more ‘typical’ view of face perception in WS than previously suggested, as evident in the structure of a face perception model.

A very different story is told by the data concerning face perception in autism. Although previous research has implied similarly atypical aspects of face processing in autism and WS, evidence towards models of face perception shows clear dissociations between the disorders. Although the evidence suggests a typical style model of face perception in WS this is not the case in autism. The data suggest an atypical model characterized by a general core deficit. A significant relationship between numerous face skills shows that the interplay between skills is greater in autism than in typical development or WS. The correlation between domains suggests a more general / common skill or deficit affecting performance. Gepner, de Gelder and de Schonen (1996) previously concluded that children with autism exhibit a generalised face processing deficit, however the extent of impairment varies depending on task domain. This finding is supported and extended to consider how this fits with a model of face perception in the current thesis. Although Gepner et al. (1996) made these claims based on 7 participants they are generalised here with a larger sample (n=20). A lack of modularity for face perception may therefore be characteristic of autism and any atypicality may be linked to both expression and identity processing. Both these skills may be affected by another important property, for example a willingness to study faces, whereas in typical development and WS they are not constrained by this behaviour and the variability between the two skills is shaped by different constraints. In autism the eyes might have negative valence (hence individuals do not look at faces in a typical manner) and atypical exposure to / willingness to look at faces may simultaneously depress both emotion and identity recognition. This atypical model may be exemplified by atypical structural encoding which has been supported across a number of face tasks used in the latter chapters of the thesis and in previous research. We have therefore gained valuable theoretical insights into the structure of face perception models in autism and WS that show dissociations between the disorders.

Any further consideration of models of face perception in WS or autism may take a more developmental perspective, exploring the development of face skills in relation to a dynamic theory. The model considered here relies on typical adult data to present a static model of face perception and to consider how the development of these children may be the same as / vary from typical development it should be remembered that development as a whole is affected by the disorder. The model used here is derived from adult data and may therefore be less appropriate for children, and particularly children who are developing atypically. Therefore further work may be required to consider the role of typical and atypical development in any model of face perception proposed for these disorders.

Atypical unfamiliar face processing in Williams syndrome

Moving on to consider another aspect of face perception in WS, Chapter 4 applied a paradigm previously used to dissociate familiar and unfamiliar face processing styles in typical development. Previous research indicates that adults are more accurate when recognizing familiar people from their internal rather than external features, but that pattern is not evident for unfamiliar faces (e.g. Ellis et al., 1979; Young et al., 1985). Research has considered the age when a shift to this ‘adult-like’ pattern of processing occurs (e.g. Bonner & Burton, 2004; Campbell et al., 1995, 1999; Campbell & Tuck, 1995; Newcombe & Lie, 1995). Importantly, no previous research with adults, children, or participants with developmental disorders, has found greater accuracy for internal features of unfamiliar faces.

Replicating the procedure used in research with typically developing children (Bonner & Burton, 2004), Chapter 4 revealed atypical processing in WS. Unfamiliar faces were matched more accurately from internal than external features. Performing at a level predicted by their verbal ability, participants with WS matched unfamiliar faces in a style previously cited only for familiar faces. A finding of atypical unfamiliar face processing for these 10- to 18-year olds may directly relate to the social phenotype of WS; notably hyper-sociability towards strangers (e.g. Jones et al., 2000; Doyle, Bellugi, Korenberg, & Graham, 2004). These findings may also be related to atypical assessments of the approachability of unfamiliar faces (Jones et al., 2000) although this feature has recently not been replicated (Frigerio et al., 2006). Due to the danger of increased approach to strangers and use of inappropriate interaction styles with unfamiliar people it is important that this feature is fully understood. Further investigations of this nature are warranted to increase the number of trials and sample size. This may lead the way for future studies of the developmental trajectory of familiar and unfamiliar face processing in WS and the inclusion of adult participants (with age-appropriate assessments). Again questioning early claims of 'intact' face processing in WS, the 13 participants performed with an overall accuracy comparable to their verbal rather than chronological age. As noted by Campbell et al. (1999) with learning difficulty participants, performance appears related to level of functioning and independent of chronological age in this paradigm.

Feature analysis and salience

The later experimental chapters used established experimental paradigms to understand identity matching in more detail. Research centred on the use of specific face features; namely the eye and mouth regions. The eyes and mouth are important for successful face recognition as well as the interpretation of conversational signals (Ellis, 1975). Previous research suggests that individuals with autism find the eye region particularly problematic to interpret (e.g. Langdell, 1978; Ristic et al., 2005) whereas no published research is available dissociating these regions in WS. Chapters 5 -7 applied typical face perception methods to explore the use of different face areas whilst extending previous research. Importantly, the pattern of performance for each group was mirrored across chapters.

Individuals with WS were more accurate matching unfamiliar faces from the upper / eye regions than the lower / mouth region. Importantly this provided evidence that individuals with WS showed the same performance *pattern* as a typically developing group and that the eye region is more salient than the mouth region (across paradigms). Participants with autism did not show increased accuracy for upper than lower features and performance was characterized by a lack of sensitivity to the eye region, rather than compensatory strong performance using the mouth region. A lack of sensitivity to the eyes supports previous research in addition to evidence from other chapters of the thesis. Throughout the thesis a theme is emerging to strengthen the idea of an eye processing deficit in autism and support previous research (e.g. Deruelle, Rondon, Gepner, & Tardiff, 2004; Senju, Tojo, Dairoku, & Hasegawa, 2004; Ristic, Mottron, Freisen, Iarocci, Burack, & Freisen, 2005). Baron-Cohen (1997) proposed that individuals with autism have a relatively proficient ‘eye direction detector’, however this is not supported by evidence from the current thesis. Of course, any neglect interpreting eye gaze cues has consequences for social development as a whole, for example the establishment of joint attention during early childhood. Early gaze behaviour is not only important for regulating attachment but is also thought to be one of the precursors for later social development (Jaffe, Stern, & Perry, 1973). The *direction* of any relationship between eye gaze deficits and atypical social development is currently questionable but there appears a clear link between these issues.

These investigations of feature use provide a subtle assessment of face interpretation in WS and autism and allow face processing to be stripped down to the use of different parts of the face. Using more subtle and sensitive interpretations of the face, these tasks tell us more about the type of information that individuals with autism and WS are able to interpret. In this sense, evidence from the individuals with WS suggests a more 'typical' style of face perception than previously suggested, certainly these individuals showed the same pattern of feature use as typically developing individuals. Claims of 'intact' face perception in WS are not supported by the thesis as a whole, but when considering the ability to use different *parts* of the face to make identity judgments individuals with WS show a typically performance *pattern*. The eyes did not 'override' the use of other features as may be predicted from previous research suggesting disengagement difficulties (e.g. Mervis et al., 2003). Therefore further insights into use of eye contact are clearly warranted (see later in this chapter and Appendix B) as the experiments in this thesis did not support a disengagement deficit in WS (e.g. Brown et al., 2003) as other features of the face were also successfully interpreted.

Structural encoding of faces

An investigation of face processing in WS and autism would not be complete without some discussion of the *way* faces are processed. Previous research has suggested that individuals with WS and autism process face and non-face objects using featural rather than configural representations. This implies that although social interaction abilities and face skills vary greatly in WS and autism, the *way* faces are perceived is characterized by the same type of atypicality. This claim is not supported by evidence from the current thesis. Across the paradigms employed here, individuals with WS showed the same performance *pattern* as typical individuals, with access to configural face cues under these specific task conditions. On tasks requiring detection of configural face manipulations (to some extent Chapter 6 and throughout Chapter 7) participants with WS between 10- and 18-years of age performed above chance. However, less consistency is evident across tasks for participants with autism who showed susceptibility to the Thatcher illusion but were unable to detect more robust configural face manipulations in Chapter 7. Although individuals with autism performed in a manner predicted by previous research, individuals with WS in the current thesis did not support claims of impaired configural face processing. Although it is well accepted that individuals with WS show a general featural style of processing visuo-spatial information (e.g. Farran & Jarrold, 2003), when faces are involved it seems that some level of configural processing is also possible. The added social nature of face stimuli, which are highly attractive to individuals who thrive on social contact or who have a 'pro-social compulsion' (Frigerio et al., 2006), may impact upon their ability to interpret aspects of this stimuli and affect the *way* it is processed. In autism, where the social drive is lessened there may be no other factor to influence the way the face is interpreted. We will return to this issue in the following section when we discuss theories of autism and specifically address how the results may relate to the Weak Central Coherence in autism (e.g. Frith, 1989; Happé, 1996; Happé & Frith, 1996). Considering further evidence of configural face processing in WS we must ask why participants with WS were able to compute configural face cues in the current thesis where previous evidence has suggested this skill is lacking? Under the specific task demands employed here, participants completed a number of matching tasks where memory requirements were reduced with simultaneous presentation. When Mondloch et al. (2004) utilized simultaneous presentation they found that young participants (aged 8-years) were able to detect configural manipulations more reliably than when sequential presentation was used (as in Mondloch et al., 2002). Indeed our young typically developing participants (aged 6-years) were also able to detect such manipulations under the task conditions used in the current thesis (supporting recent evidence from young children by Pellicano, Rhodes, & Peters, 2006). It is apparent that task difficulty may result in the apparent presence or absence of a particular processing style or skill (also advocated by Brace et al., 2001; Carey, 1981; Flin, 1985). This clearly requires further exploration before firm conclusions are drawn concerning face processing *style* in WS. The structural encoding of faces is considered in more detail in section 8.3 when we compare the cognitive profiles of individuals with WS and autism.

Further exploration of structural encoding may be provided by reaction time analyses, as participants with WS may have used a featural strategy for configural manipulations which would be apparent by longer reaction times (Donnelly & Hadwin, 2003). The inclusion of reaction time data may be particularly problematic for research involving young participants, individuals with autism who require unique testing conditions and tasks which result in low accuracy. This is illustrated in Appendix A where data is presented for one group of typically developing individuals on the internal versus external feature matching assessment used in Chapter 4. Reaction time data were collected for some participant groups on a number of tasks, however Appendix A is included to emphasise the problematic nature of this reaction time data. For example, large variance in response time is evident both within and between participants (across trials). This renders the use of mean, and even median, reaction times uninformative. Appendix A also illustrates the large number of cells to be removed due to incorrect responses and therefore the small number of trials upon which the mean reaction time would be based. It is therefore more reliable to base our comparisons between groups on accuracy of performance. This is not to say that future research could not explore the use of reaction time data in more detail.

8.3 The wider issues

This section considers how the results fits into our wider knowledge of autism and WS. Importantly, how have face processing methods provided insights into the social and cognitive phenotypes of autism and WS and models / theories central to these developmental disorders? It is necessary to consider how the research has broadened our understanding of not only face perception but social expertise in these populations.

Theories of autism

To ground these findings within the autism literature, it is important to note how results of atypical face processing styles can inform researchers of important theories of autism. The present findings link to claims that from an early age individuals with autism may have less exposure to the facial, gestural and eye gaze information that, in the typical development, draws individuals into social interactions. Relating this to the pathology of autism Mundy and colleagues (Mundy 1995; Mundy & Neal, 2001) note in their ‘social orienting’ model that disturbances occur in brain regions that normally prioritize social information (e.g. frontally mediated neuro-affective motivation systems). This has important implications for models such as those proposed by Haxby and colleagues (2000) which emphasise the involvement of various brain regions for successful interpretation of face cues. Furthermore, Klin, Jones, Schultz and Volkmar (2004) in their 'enactive mind' theory of social cognitive development in autism, note that the typical overriding salience of social stimuli is not present for autistic individuals. In the current thesis this may be particularly evident from tasks involving the eyes. Klin et al. (2004) propose that individuals with autism learn about people in a way that departs from the normative processes of social development. Thus deficits, or atypical styles, for processing this highly social stimulus are at the core of autistic deficits. It should not be forgotten, however, that the direction of any relationship between face processing skill and social expertise (or the development of either of these) remains uncertain.

Chapter 1 introduced key theories of autism and the current findings link directly to a number of these theoretical approaches. Baron-Cohen's (2001) theory of mind (ToM) concept of autism links directly to evidence for the processing of both eye gaze and expressions of emotion. Individuals with autism showed clear deficits for these two skills, which dissociated them from individuals with general developmental delay and from individuals with WS. Both these tasks require some aspect of ToM skill as they inherently require the participant to infer either what someone is feeling or the object of someone's attention. Providing evidence for an autism-specific deficit in ToM ability, Chapter 3 showed the dissociation between autism and developmental delay groups on these skills. Once again the direction of any relationship between ToM and eye gaze or emotion processing remains somewhat unclear. However, Baron-Cohen (1997) suggested that the interpretation of eye gaze plays an important role in a normal functioning of a ToM system in typical development and this may have consequences for social and cognitive development in autism.

Concerning processing styles evident in autism, Chapter 1 introduced the theory of weak central coherence (WCC; Frith, 1989, Frith & Happé, 1994). This theory is based on the notion that although individuals with autism are able to process parts of information, they have difficulty linking these together as a coherent whole. The theory gains particular support from evidence of face processing *style* in autism, and indeed the current thesis provides support for WCC. Previous research has shown that participants with autism are more accurate matching faces from isolated face parts than in the context of a whole face (Teunisse & de Gelder, 2003; exp.2) and show a lack of inversion effect for faces (e.g. Hobson, Ouston, & Lee, 1988; Tantam, Monaghan, Nicholson, & Stirling, 1989). In the current thesis we provide support for feature or part-based face processing but a deficit of configural processing in autism (e.g. chapter 7) but not in typical development. Typically developing individuals as young as 6-years computed configural manipulations (in chapter 7) but this is not possible for older participants with autism. As discussed in the previous section of this chapter, structural encoding of faces is atypical in autism and supports evidence of a WCC theory of autism, characterized by a deficit in constructing comprehensive interpretations into whole representations (supporting Frith, 1989a).

It is evident that face perception research plays an important role in furthering our knowledge of theories of autism. The current thesis provides support for a number of existing theoretical approaches and therefore adds to our understanding of autism.

Considering level of functioning on the autistic spectrum

The importance of considering the characteristics of participants, especially for individuals functioning on the autistic spectrum, has been emphasised in the thesis. This is also important when comparing the current results to those found in previous research. On many tasks overall accuracy was correlated with level of functioning as assessed by the Childhood Autism Rating Scale (Schopler, Reichler, & Rochen Renner, 1988) completed by teachers. Therefore level of functioning is emphasised as a more reliable and insightful measure of ability than chronological age in autism, as would be expected. Recent research has shown that not only does level of functioning on the autistic spectrum affect overall ability, but it may also affect the way items are processed. This has been noted by Spencer and O'Brien (2006) for participants completing visual form processing. This feature is central to the interpretation of data and critical to published research in this field where confounding results appear in abundance. However, underlying a number of these confounds may be participant characteristics and level of functioning.

Hypersociability in Williams syndrome

Having considered how the studies presented here inform us of aspects of autism, the following section considers WS. One of the aspects of WS that originally received much less research attention than the cognitive profile is that of sociability. It is now acknowledged that individuals with WS are characterised by hypersociability and a drive towards social interactions, which has led to a theory of 'pro-social compulsion' (Frigerio et al., 2006). With the face acting as such an important social cue it is interesting to study face processing as an insight into social interaction abilities. After all, socio-communicative face cues such as expressions of emotion and eye gaze must successfully be interpreted in everyday social interactions between two or more people. Additionally, any interest in faces and social interaction styles may be bi-directional; an interest in faces may contribute to proficiency in interpreting this social stimuli, or indeed the effect may appear in the opposite direction. At this point it is not possible to provide clear evidence of the direction of this effect, although future research may investigate this issue further.

The story depicted in the experimental chapters tells of more 'typical' face perception in WS than previously claimed. It might be suggested that the story ends here, if it were not for the assertions of extended eye gaze in natural situations (e.g. Mervis et al., 2003) or the social profile characterised by hypersociability (e.g. Jones et al., 2000; Frigerio et al., 2006). The results of previous experimental chapters imply a general delay in performance levels but overall a typical pattern of performance across a number of face tasks. Indeed the evidence does not support suggestions of disengagement problems in WS (e.g. evident from other cognitive tasks such as visual search paradigms, see Scerif, Cornish, Wilding, Driver, & Karmiloff-Smith, 2004; Cornish, Scerif, & Karmiloff-Smith, in press). If that were the case we might expect participants with WS to show problems disengaging from particular face features when they are required to use different parts of a face, a suggestion which is not borne out in the results. Perhaps face perception is more ‘typical’ in WS than previously suggested? Or perhaps the tasks utilised here mask some of the idiosyncrasies evident in natural everyday social situations? Furthermore, the link between hypersociability and face perception in WS may not be clear cut, and an interest in people and faces may be less to do with faces per se than social skills and, for example, attachment issues or physiological arousal. Indeed a small pilot study has been conducted to investigate aspects of eye contact associated with physiological arousal in WS and the use of gaze aversion techniques. Full details of this pilot research are available in Appendix B, though a larger sample size and further explorations are clearly warranted. The premise for the research is the idea that individuals with WS may be able to hold direct eye contact for a longer period of time than is typically evident due to decreased arousal levels.

It has long been recognised that there is a link between eye gaze and arousal (e.g. Nichols & Champness, 1971; Gale, Spratt, Chapman, & Smallbone, 1975). Making and holding direct eye contact with another person influences physiological arousal, leading to increased heart rate and skin conductance (e.g. Gale et al., 1972; Hirstein, Iversen, & Ramachandran, 2001; Kleinke, 1986). Specifically, direct eye contact has been found to increase arousal, whereas the effect is absent from averted eye gaze (e.g. Kleinke, 1986). One way to decrease arousal is to avert the eyes (look away) during face-to-face contact; thus applying a gaze aversion (GA) technique. Linking to cognitive performance, a number of researchers suggest that a period of GA allows us to consolidate and process information more reliably than during a period of heightened arousal and direct eye contact (e.g. Brazelton et al., 1974; Field, 1981). An alternative (but possibly consonant) hypothesis proposes that cognitive load is a critical factor of GA, (Doherty-Sneddon & Phelps, 2005). Gaze aversion is applied at important points during a task (e.g. when demands are high) to avoid processing unnecessary information. Glenberg and colleagues (e.g. Glenberg, 1997; Glenberg et al., 1998) have supported this with the suggestion that GA allows us to have more capacity to deploy to the task in hand and avoid an information overload.

Typically developing children and adults show an increase in arousal when looking at a face compared to the floor (Doherty-Sneddon, Phelps, & Calderwood, submitted; Calderwood, Doherty-Sneddon, & Phelps, in prep.) The pilot research presented in Appendix B suggests that an increase in arousal is also evident when individuals with WS view faces. However, those with WS appear to begin with a lower level of general arousal (compared to typical adults and children) which means that the resultant increase does not get to the extent of being uncomfortable. Therefore individuals with WS do not need to look away to reduce their arousal, resulting in longer periods of direct gaze. This is a crucial insight into the underlying mechanisms involved in intense eye contact by individuals with WS and leads on nicely from the ‘typical’ face processing results of the current thesis. Although the evidence from face processing tasks utilised in the current thesis show a relatively ‘typical’ style and ability to interpret faces, although not at a level predicted by chronological age, the tasks do not show any social immediacy. Atypical results appear when a real person is involved in the research, as in the pilot study, and face-to-face contact occurs. Therefore, this intense use of eye gaze may be less an issue of face perception and more an issue of arousal. This notion of prolonged eye contact also gains support from the gaze aversion phase of the pilot study, showing that participants avert their gaze less frequently than is typical, even in demanding situations. The pilot study is therefore a useful insight and an important development of the research carried out for the thesis. Further work in this area is essential for following up this exploration of the physiological impacts of eye gaze in WS. The research in this thesis has therefore given valuable insights into how face perception tasks can reveal important aspects of social functioning, and importantly can inform us of aspects of hypersociability in WS.

Comparing WS and Autism

As mentioned, the impetus for the current thesis was previous claims of similarly atypical (featural) face processing in WS and autism, alongside divergent face processing abilities. Therefore it was important that the thesis made some attempt to directly compare the abilities of individuals with these two disorders. The primary comparison was to typical development to assess issues of *typicality* of performance, but the secondary analyses addressed the *uniqueness* of WS and autism. Small subgroups of individuals with each disorder were compared across the thesis and showed divergent abilities that mirrored the evidence from the groups matched to typically developing individuals. As the same pattern of results was achieved for the primary and secondary analyses this implies that we are able to make indirect comparisons between individuals with WS and autism by examining how each group differs from typical development. This may be important for future explorations and allows the inclusion of larger samples, where directly matching individuals with WS and autism is difficult due to divergent abilities and the availability of participants. The following two sections of this chapter consider how the thesis informs us of wider issues related to the dissociation between WS and autism.

Comparing the social profiles of WS and Autism

"an 18-month-old girl with the disorder interacting with an normal 5-year-old boy who's sitting on the floor. She walks up to within a few inches of him and peers into his face with great intensity. When the boy starts to get uncomfortable after a few seconds and turns his head, she shifts position to continue staring at him from up close. Even after he stands up and begins bouncing a basketball on the floor, she doesn't relent" (Bhattacharjee, 2005, 802).

It is clear that the above quote refers to a toddler with WS rather than autism as these two developmental disorders are characterized by dissociable social profiles. Having just detailed and discussed the social profile of WS, the opposite is cited regarding autism, with social withdrawal being a defining feature of the disorder (e.g. Baron-Cohen, 1988). The dissociable social profiles of WS and autism may be understood more clearly by their differing abilities to interpret the most socially demanding aspect of faces; the eyes. The current thesis has provided evidence not only of divergent abilities concerning eye gaze for these two groups, but clear differences using the eye region across a number of task demands. Participants with WS mirror evidence from typical development showing a susceptibility to the eye region and an ability to interpret this feature that is lacking in autism. Across tasks with different requirements participants with autism had difficulty using the eye region to match unfamiliar faces.

This region contains essential socio-communicative cues, linking to emotions and eye gaze, two domains of deficiency in Chapter 3.

The majority of stimuli used in tasks for this thesis involved the use of direct eye gaze direction (except gaze direction matching) and perhaps the direct nature of this gaze was problematic for participants with autism. It would be interesting to see if processing deficits remain when eye gaze is averted. This may even affect performance on tasks where eye region processing is not explicitly required. Pilot research has been carried out to investigate the effect of eye direction on eye gaze matching and the impact of the eyes on identity matching (full details available in Appendix C). Although more work is needed in this area, the preliminary pilot results presented in Appendix C suggest that individuals with autism are affected less by covering the eyes (with sunglasses) during an identity matching task than typically developing individuals. Again, this suggests that the eyes are not being used to process identity to the same extent as is typical. Eye-tracking methods may provide a more detailed insight into this aspect of performance (see section 8.4). The pilot task also revealed that, surprisingly, individuals with autism were able to dissociate eye and head direction and were actually more accurate matching direct than averted gaze direction. The typically developing participants showed the opposite pattern and found it easier to match gaze directions using averted than direct eye gaze. This seems surprising and further work is needed to interpret this finding and follow up this pilot result with a larger sample and new stimuli. So when comparing the profile of abilities shown by individuals with WS and autism, some specific aspects of task design must be taken into consideration.

These two groups had previously been compared due to their similar cognitive styles for processing faces but their divergent social profiles. The current thesis emphasises the divergent social profile and how this relates directly to the type of information that is retrieved from faces. In doing so, we emphasise the clear dissociations between face processing in WS and autism.

Comparing the cognitive profiles of WS and Autism

The social profiles of WS and autism are known to be extreme opposites but cognitively the groups had both been said to utilise the same featural style for processing faces. However, the current thesis emphasises that there are cognitive differences in the style used to process faces in these groups, as well as the more obvious social differences. So linking directly to the cognitive aspects of face processing in WS and autism, the current thesis suggests that faces may be processed in a typical *way* in WS but not in autism. This claim is centred around the structural encoding of faces and feature use for the two groups. Again, there may be an inter-play between the social and cognitive characteristics of each group as a social drive may effect processing in the group with WS where it is absent in autism. The importance of direct comparisons between groups, as used in this thesis, is emphasised here where we see important dissociations that have previously not been noted. Future research may develop this comparison between WS and autism in more detail, as direct comparisons can address the unique aspects of the disorders rather than any aspect of typicality. A number of additional future investigations are discussed in the following section.

Developing skills

One important feature of the current thesis is that abilities were assessed at a specific age point, rather than employing a developmental approach to face perception. Taking a developmental cognitive neuroscience approach, a number of prominent researchers emphasise that development as a whole follows a different path for these groups (e.g. Bishop, 1997; Karmiloff-Smith, 1997). One of the most important quotes comes from Karmiloff-Smith (1997) who emphasises that “the brains of genetically impaired children are not simply normal brains with parts intact and parts damaged. Rather they develop differently throughout embryogenesis and postnatal brain growth” (p. 514). Therefore, when considering how face perception skills fit into a larger picture of these two distinct developmental disorders it is important to remember that the whole developmental process may be different. In WS, where a ‘typical’ model of face perception is proposed by the current thesis, it is important to note that this skill occurs alongside other more problematic abilities, which are likely to merge with each other rather than occur in isolation. The presence of a relatively ‘typical’ pattern of face skills also occurs alongside a general delay in ability levels. It is unlikely that a ‘face module’ remains ‘intact’, rather the developmental process involved in face perception may follow a different pathway in WS which may be more associated with social development as a whole. In autism, an atypical developmental pathway may inhibit an interest in social stimuli and thus an interest in the face.

Importantly, future research may take a more developmental perspective to face perception in these groups. Research may take either a developmental trajectory approach (studying many individuals across different ages) or a microgenetic approach (studying a small number of individuals over a larger time scale). This leads on to a discussion of other possible future investigations.

8.4 Future research

There are a number of ways that the research presented here could be extended to further our understanding of face processing and social functioning in WS and autism. Such research could focus directly on processing strategies or could focus on the more social aspects of face skill. The future investigations detailed here focus more on the social importance of face processing abilities. However, the first consideration is how the specific research presented in this thesis could be extended.

Using a variety of paradigms with the same individuals (an important feature of Chapter 3) allows further insights into abilities and should be advocated in future research. This is particularly important in autism where individuals show extremes of ability due to the spectral nature of the disorder. Chapter 3 emphasised the relationship between level of functioning on the autistic spectrum and task performance, which may be assessed in more detail in future investigations. This relationship provides a valuable insight into inconsistencies evident in the published autism literature, which may largely be a consequence of participant characteristics and level of functioning. Therefore a battery of face tasks carried out with individuals who vary along the autistic continuum should be advocated to truly profile face skills and their relationship to other aspects of behaviour and abilities. In this way previous research evidence could be consolidated and a fully detailed assessment could be provided. This may also take a developmental perspective, focusing on changes over time and experience.

The current thesis has expanded our knowledge of how individuals with WS use different face features, an issue relatively neglected in previous investigations, and has shown typical eye salience in WS. Feature-use, as assessed here, has therefore provided little insight into the claims of exaggerated eye contact. The social phenotype of WS is very distinctive with a hyper-sociability towards unfamiliar people (e.g. Doyle, Bellugi, Korenberg, & Graham, 2004; Jones et al., 2000) and extended eye contact (e.g. Mervis et al., 2003), this may be explored further in more ecologically valid investigations of face processing and social functioning. The pilot research presented in Appendix B provides preliminary research that individuals with WS show lower levels of physiological arousal as well as less use of gaze aversion strategies. Further research is clearly warranted to extend the sample size and explore this finding in more detail. For the first time the research could tell us more about the underlying features of intense eye contact in WS. The inclusion of ‘real people’ rather than computer-based tasks also emphasizes the importance of ecological validity in any assessment of face skill and social functioning.

Of course there may be other underlying reasons for individuals with WS to have an increased desire to interact with people who are both familiar and unfamiliar to them. One suggestion that has been neglected in the literature to date is the importance of attachment. Individuals with WS may have a heightened need for attachment relationships and this may relate to their desire to interact with people. This is clearly an area for future investigations as interactions with unfamiliar people have important implications for personal safety and should be a primary concern for people working with individuals who have WS.

Following on from the previous section on WS, further research concerning the use of gaze aversion and physiological arousal to eye contact in autism is warranted. The current thesis emphasizes that deficits interpreting the eyes not only cause problems using gaze cues but affect a variety of skills. Individuals with autism are characterized as socially withdrawn and show less eye contact (e.g. Frith, 1999; Gillberg & Gillberg, 1989). Young children who are low functioning on the autistic spectrum have been shown to use and initiate social gaze (e.g. for checking, referential looking) less frequently and at inappropriate times during social interactions in a play setting (Willemsen-Swinkels, Buitelaar, Weijnen, & van Engeland, 1998). Physiological arousal to eye contact also appears atypical in autism and may be linked to less use of eye contact. Hutt and Hutt (1970) formed a ‘neurophysiological hypothesis’ of autism whereby individuals are considered to be in a continual state of high physiological arousal, contrasting those with WS. Mutual eye contact is additionally arousing and gaze may be avoided to lessen any subsequent discomfort (e.g. Hutt & Ounsted, 1966). Kylliäinen and Hietanen (2006) used faces presented on a computer screen and found that compared to baseline, arousal levels showed greater increase to direct than averted gaze for participants with autism. The use of real people in this type of research would further our knowledge of natural levels of arousal to faces, which here may be lessened by removing the social immediacy using video extracts. Extending the pilot study presented in Appendix B would be beneficial here, although measuring galvanic skin response in this group is particularly difficult due to heightened sensitivity to skin contact and the need to remain still for a length of time. It may, however, be possible to assess physiological arousal using an alternative method such as breathing or pulse rate and utilising body vests. This would need further consideration.

One interesting endeavour for future investigations would be the inclusion of eye tracking techniques to understand how individuals with WS and autism view faces and social scenes. Eye tracking provides a real-time behavioural index, with unobtrusive and sensitive measures (Henderson, 2003) and may be valuable in research exploring face processing. Moving away from laboratory-based studies, using eye tracking to investigate how individuals naturally attend to faces will provide a more ecologically valid assessment (advocated by Kingstone, Smilek, Ristic, Friesen, & Eastwood, 2003). Eye tracking methods may inform us of why individuals with autism have such a different view of the world and more ecological investigations are particularly important where performance on face perception tasks does not mirror evidence from real-life interactions. Eye tracking methods could be used to investigate gaze fixations whilst individuals view complex social scenes containing people. Van der Geest et al. (2002b) and Klin et al. (2002) (already cited and detailed in this thesis) find contrasting evidence when individuals with autism view social scenes. Identifying a more reliable assessment method and extending this to WS would be beneficial. Using both dynamic (video-clips) or static scenes would enhance out understanding of the overriding aspects of a social scene whilst also varying the complexity of the environment. In subsequent experiments individuals could analyse these social scenes to identify gaze cues and infer intentions and desires from these cues. The use of eye tracking methods detailed here will ultimately extend our understanding of social abilities and face viewing patterns in WS and autism.

There is clearly much work to be done for a thorough insight into how individuals with WS and autism function in their social environments and interpret important facial cues. This thesis has provided new insights into aspects of face expertise in these populations which can further our understanding of face perception, social functioning and cognitive styles in autism and WS. There are a number of ways that the research can be taken forward in future investigations.

8.5 Conclusions

In conclusion, the current research makes a significant contribution to our understanding of face processing in WS and autism and shows how this ability can be dissociated in the two populations. Individuals with these developmental disorders show extreme differences in social abilities which are mirrored by differences in the way faces are interpreted and the type of information that is retrieved. Neither group performs at a level predicted by their chronological age, and although face processing in WS is characterised by general delay, in autism this delay is accompanied by atypicality. Not only are features interpreted differently, but individuals with autism show evidence of an atypical face perception model. Conversely, face perception in WS appears more ‘typical’ than previously suggested by studies of structural encoding. A typical face perception model is evident and a typical use of features is shown. An important step has also been taken towards understanding the possible source of intense eye contact in WS which may be linked more to physiological arousal than face processing style. Therefore the current thesis provides a valuable insight into how typical face perception methods can be extended to allow explorations of face processing in WS and autism, although there is clearly much more work to be done.

Chapter Nine

References

Amaral, D. G. (2003). The amygdala, social behaviour, and danger detection. In P. Ekman J. Campos; R. Davidson & F de Waal (Eds). *Emotions inside out. 130 years after Darwin's: The expression of the emotions in man and animals*. (pp. 337-347). New York, US: New York University Press.

Ambadar, Z., Schooler, J. W., & Cohn, J. F. (2005). Deciphering the enigmatic face: The importance of facial dynamics in interpreting subtle facial expressions. *Psychological Science, 16*, 403-410.

Argyle, M. & Cook, M. (1976). *Gaze and mutual gaze*. Oxford, England: Cambridge University Press.

Ashwin, C., Wheelwright, S., & Baron-Cohen, S. (2005). Laterality biases to chimeric faces in Asperger syndrome: what is 'right' about face-processing? *Journal of Autism and Developmental Disorders, 35*, 183-196.

Baddeley, A. & Gathercole, S. (1999). Individual differences in learning and memory: Psychometrics and the single case. In P. L. Ackerman, P. C. Kyllonen & R. D. Roberts (Eds). *Learning and individual differences: Process, trait, and content determinants.* (pp. 31-54). Washington, DC, US: American Psychological Association.

Bar-Haim, Y., Shulman, C., Lamy, D., & Reuveni, A. (2006). Attention to eyes and mouth in high-functioning children with autism. *Journal of Autism and Developmental Disorders, 36*, 131-137.

Baron-Cohen, S. (1988). Social and pragmatic deficits in autism: Cognitive or affective? *Journal of Autism and Developmental Disorders, 18,* 379-402.

Baron-Cohen, S. (1989). The autistic child's theory of mind: a case of specific developmental delay. *Journal of Child Psychology and Psychiatry, 30*, 285-298.

Baron-Cohen, S. (1991). Precursors to a theory of mind: Understanding attention in others. In A. Whiten (Ed), *Natural theories of mind*. Oxford, UK: Blackwell.

Baron-Cohen, S. (1995). *Mindblindness: An essay on autism and theory of mind.* Cambridge, MA MIT Press. .

Baron-Cohen, S. (2001). Theory of mind in normal development and autism. *Prisme, 34,* 174-183.

Baron-Cohen, S., Leslie, A. M., & Frith, U. (1986). Does the autistic child have a 'theory of mind?' *Cognition*, *21*, 37-46.

Baron-Cohen, S., Campbell, R., Karmiloff-Smith, A., Grant, J., & Walker, J. (1993). Are children with Autism blind to the mentalistic significance of the eyes? *British Journal of Developmental Psychology, 13,* 379-398.

Baron-Cohen, S., Spitz, A., & Cross, P. (1993). Do children with autism recognise surprise? A research note. *Cognition and Emotion, 7,* 507-516.

Baron-Cohen, S., Wheelwright, S., & Jolliffe, T. (1997). Is there a 'language of the eyes'? Evidence from normal adults and adults with autism or Asperger syndrome. *Visual Cognition, 4*, 311-331.

Baron-Cohen, S., Cox, A., Baird, G., Swettenham, J., Nightingale, N., Morgan, K. et al (1996). Psychological markers of autism at 18 months of age in a large population. *British Journal of Psychiatry, 168,* 158-163.

Baron-Cohen, S., Ring, H., Wheelwright, S., Bullmore, E. T., Brammer, M., Simmons, A., & Williams, S. C. (1999). Social intelligence in the normal and autistic brain: An fMRI study. *European Journal of Neuroscience, 11*, 1891-1898.

Baron-Cohen, S., Ring, H., Bullmore, E. T., Wheelwright, S., Ashwin, C., & Williams, S. C. (2000). The amygdala theory of autism. *Neuroscience and Biobehavioural Reviews, 24*, 355-364.

Baron-Cohen, S., & Wheelwright, S. (2004). The Empathy Quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders, 34*, 163-175.

Bartlett, J. C., & Searcy, J. (1993). Inversion and configuration of faces. *Cognitive Psychology, 25*, 281-316.

Barton, J. J., Keenan, J. P. & Bass, T. (2001). Discrimination of spatial relations and features in faces: Effects of inversion and viewing duration. *British Journal of Psychology, 92*, 527-549.

Barton, J. J., Deepak, S., & Malik, N. (2003). Attending to faces: Chance detection, familiarisation, and inversion effect. *Perception, 32,* 15-28.

Bellugi, U., Sabo, H., & Vaid, J. (1988). Spatial deficits in children with Williams syndrome. In J. Stiles-Davis, M. Kritchevsky, & U. Bellugi (Eds). *Spatial cognition: Brain bases and development*. (pp. 273-298). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Bellugi, U., Bihrle, A., Neville, H., Doherty, S., & Jernigan, T. (1992). Language, cognition, and brain organization in a neuro-developmental disorder. In M. R. Gunnar, & C. A. Nelson (Eds). *Developmental behavioural neuroscience*. (pp. 201-232). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Bellugi, U., Wang, P., & Jernigan, T. (1994). Williams syndrome: An unusual neuropsychological profile. In S. Broman & J. Grafman, (Eds.). *Atypical cognitive deficits in developmental disorders: Implications for brain function,* Hillsdale, NJ: Lawrence Erlbaum Associates.

Bellugi, U., Adolph, R., Cassady, C., & Chiles, M. (1999a). Towards the neural basis for hypersociability in a genetic syndrome, *NeuroReport*, *10*, 1653-1657.

Bellugi, U., Lichtenberger, E., Mills, D., Galaburda, A., & Korenberg, J. R. (1999b). Bridging cognition, brain, and molecular genetics: Evidence from Williams syndrome. *Trends in Neuroscience*, *5*, 197-208.

Bellugi, U., Lichtenberg, L., Jones, W., Lai, Z., & St. George, R. (2000). The neurocognitive profile of Williams syndrome: A complex pattern of strengths and weaknesses. *Journal of Cognitive Neuroscience, 12,* 7-29.

Benton, A., VanAllen, M., Hamsher, K., & Levin, H. (1978). *Test of Facial Recognition Manual*. Iowa City, Iowa: Benton Laboratory of Neuropsychology.

Bertin, E., & Bhatt, R. S. (2004). The Thatcher illusion and face processing in infancy. *Developmental Science, 7,* 431-436.

Bertrand, J., Mervis, C., Rice, C. E., & Adamson, L. (1993). Development of joint attention by a toddler with Williams syndrome. Paper presented at the Gatlinberg Conference on Research and Theory in Mental Retardation and Developmental Disabilities, Gatlinberg.

Bhatt, R. S., Bertin, E., Hayden, A., & Reed, A.(2005). Face processing in infancy: Developmental changes in the use of different kinds of relational information. *Child Development*, *77*, 1094-1111.

Bhattacharjee, Y. (2005). Friendly faces and unusual minds. *Science, 310*, 802-804.

Bishop, D. V. M. (1997). Cognitive neuropsychology and developmental disorders: Uncomfortable bedfellows. *The Quarterly Journal of Experimental Psychology, 50,* 899-923.

Blair, R. J. R. (2005). Responding to the emotions of others: Dissociating forms of empathy through the study of typical and psychiatric populations. *Consciousness and Cognition, 14*, 698-718.

Blaney, R. L., & Winograd, E. (1978) Developmental differences in children's recognition memory for faces. *Developmental Psychology, 14*, 441-442.

Böhning, M., Campbell, R., & Karmiloff-Smith, A. (2002). Audiovisual speech perception in Williams syndrome, *Neuropsychologia, 40,* 1396-1406.

Bonner, L., Burton, A. M., & Bruce, V. (2003). Getting to know you: How we learn new faces. *Visual Cognition, 10,* 527-536.

Bonner, L. & Burton, M. (2004). 7-11-year-old children show an advantage for matching and recognizing the internal features of familiar faces: Evidence against a developmental shift. *Quarterly Journal of Experimental Psychology, 57*, 1019-1029.

Borke, H. (1971). Interpersonal perception of young children: Egocentrism or empathy? *Developmental Psychology, 5,* 263-269.

Bormann-Kirchkel, C., Vilsmeir, M., & Baude, B. (1995). The development of emotional concepts in autism. *Journal of Child Psychology and Psychiatry, 36,* 1243-1259.

Boucher, J., & Lewis, V. (1992). Unfamiliar face recognition in relatively able autistic children. *Journal of Child Psychology and Psychiatry, 33*, 843-859.

Boucher, J., Lewis, V., & Collis, G. (1998). Familiar face and voice matching and recognition in children with autism. *Journal of Child Psychology and Psychiatry and Allied Disciplines 39*, 171-181.

Brace, N. A., Hole, G. J., Kemp, R. I., Pike, G. E., van Duuren, M., & Norgate, L. (2001). Developmental changes in the effect of inversion: Using a picture book to investigate face recognition. *Perception, 30,* 85-94.

Brazelton, T. B., Koslowski, B., & Main, M. (1974). The origins of reciprocity: The early infant-mother interaction. In M. Lewis & L. A. Rosenblum (Eds.), *The effect of the infant on its caregiver* (pp. 49-76). New York: Wiley.

Brothers, L. (1990). The social brain: A project for integrating primate behaviour and neurophysiology in a new domain. *Concepts in Neuroscience, 1*, 27-51.

Brown, J. H., Johnson, M. H., Paterson, S. J., Gilmore, R., Longhi, E., & Karmiloff-Smith, A. (2003). Spatial representation and attention in toddlers with Williams syndrome and Down syndrome. *Neuropsychologia, 41*, 1037-1046.

Browndyke, J. N. (2002). *Autistic behaviour: Etiology and evaluation*. www.neuropsychologycentral.com. Accessed 6th January 2004.

Bruce V. (1988). *Recognising faces*. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Bruce, V., & Young, A. (1986). Understanding face recognition. *British Journal of Psychology, 77*, 305-327.

Bruce, V., & Young, A. (2000). *In the eye of the beholder: The science of face perception.* Oxford University Press, Oxford.

Bruce, V., Campbell, R. N., Doherty-Sneddon, G., Import, A., Langton, S., McAuley, S & Wright, R. (2000). Testing face processing skills in children. *British Journal of Developmental Psychology, 18*, 319-333.

Burack, J. A., Iarocci, G., Bowler, D., & Mottron, L. (2002). Benefits and pitfalls in the merging of disciplines: The example of developmental psychopathology and the study of persons with autism. *Development and Psychopathology, 14,* 225-237.

Burnham, D. (1998). Language specificity in the development of auditory-visual speech perception. In R. Campbell, B. Dodds, & D. Burnham. (Eds.). *Hearing by eye II: Advances in the psychology of speech reading and auditory-visual speech.* (pp. 27-60). Hove UK: Psychology Press.

Calderwood, L., Doherty-Sneddon, G., & Phelps, F. (in prep). *Physiological correlates of gaze aversion in 6- and 8-year olds.*

Campbell, R., & Tuck, M. (1995). Recognition of parts of famous-face photographs by children: an experimental note. *Perception, 24,* 451-456.

Campbell, R., Walker, J., & Baron-Cohen, S. (1995). The development of differential use of inner and outer face features in familiar face identification. *Journal of Experimental Child Psychology, 59,* 196-210.

Campbell, R., Coleman, M., Walker, J., Benson, P. J., Wallace, S., Michelotti, J., & Baron-Cohen, S. (1999). When does the inner-face advantage in familiar face recognition arise and why? *Visual Cognition, 6*, 197-216.

Carey, S. (1978). A case study: face recognition. In E. Walker (Ed.) *Explorations in the biology of language.* Montgomery, VT: Bradford books, p 175-201.

Carey, S. (1981). The development of face perception. In G. Davies, H. Ellis, & J. Shepherd (Eds.), *Perceiving and remembering faces* (pp.9-38). London: Academic Press.

Carey, S., & Diamond, R. (1977). From piecemeal to configurational representation of faces. *Science, 195*, 312-314.

Carey, S., & Diamond, R. (1994). Are faces perceived as configurations more by adults than by children? *Visual Cognition, 1*, 253-274.

Carey, S., Diamond, R., & Woods, B. (1980). Development of face recognition: A maturational component? *Developmental Psychology, 16,* 257-269.

Cassidy, S. B. (1997). Prader-Willi syndrome. *Journal of Medical Genetics, 34,* 917-923.

Castelli, F. (2005). Understanding emotions from standardised facial expressions in autism and normal development. *Autism, 9*, 428-449.

Chung, M., & Thomson, D. M. (1995). Development of face recognition. *British Journal of Psychology, 86,* 55-87.

Celani, G., Battacchi, M. W., & Arcidiacono, L. (1999). The understanding of the emotional meaning of facial expressions in people with autism. *Journal of Autism and Developmental Disorders, 29,* 57-66.

Chakrabarti, S., & Fombonne, E. (2001). Pervasive developmental disorders in preschool children. *Journal of the American Medical Association, 285,* 3093-3099.

Chao, L. L., Martin, A., Haxby, J. V. (1999). Are face-responsive regions selective only for faces? *Neuroreport: For Rapid Communication of Neuroscience Research, 10,* 2945-2950.

Charman, T. (2004). Why is joint attention a pivotal skill in autism? In Frith, U. & Hill, E. (Eds.) *Autism: Mind and Brain,* New York: Oxford University Press.

Cheney, D. L., & Seyfarth, M. R. (1990). Attending to behaviour versus attending to knowledge: Examining monkeys' attribution of mental states. *Animal Behaviour, 40*, 742-753.

Chung, M. S., & Thomson, D. M. (1995). Development of face recognition. *British Journal of Psychology, 86*, 55-87.

Clark-Carter, D. (1997). *Doing quantitative psychological research: From design to report.* East Sussex: Psychological Press Ltd.

Cornish, K., Scerif, G., & Karmiloff-Smith, A. (in press). Tracing syndrome-specific trajectories of attention across the lifespan. *Cortex.*

Critchley, H.D., Daly, E.M., Bullmore, E.T., Williams, S.C., van Amelsvoort, T., Robertson, D.M., Rowe, A., Phillips, M., McAlonan, G., Howlin, P., & Murphy, D.G. (2000). The functional neuroanatomy of social behaviour: changes in cerebral blood flow when people with autistic disorder process facial expressions. *Brain, 123*, 2203-2212.

Dall'Oglio, A. M., & Milani, L. (1995). Analysis of the cognitive development in Italian children with Williams syndrome. *Genetic Counselling, 6,* 175-176.

Dalton, K. M., Nacewicz, B. M., Johnstone, T., Scheafer, H., Gernsbacher, M., Goldsmith, H. H., Alexander, A., & Davidson, R. J. (2005). Gaze fixation and the neural circuitry of face processing in autism. *Nature Neuroscience, 8,* 519-526.

Davies, S., Bishop, D., Manstead, A. S. R., & Tantum, D. (1994). Face perception in children with autism and Asperger's syndrome. *Journal of Child Psychology and Psychiatry, 35,* 1033-1057.

Dawson, G., Carver, L., Meltzoff, A. N., Panagiotides, H., McPartland, J., & Webb, S. J. (2002). Neural correlates of face and object recognition in young children with autism spectrum disorder, developmental delay and typical development, *Child Development, 73,* 700-717.

Denham, S. A. (1986). Social cognition, prosocial behaviour and emotion in preschoolers. *Child Development, 57,* 194-201.

Deruelle, C., Mancini, J., Livet, M., Cassé-Perrot, C., & de Schonen, S. (1999). Configural and local processing of faces in children with Williams syndrome. *Brain and Cognition, 41,* 276-298.

Deruelle, C., Rondon, C., Mancini, J., & Livet, M. O. (2003). Exploring face processing in Williams syndrome. *Cognitie, Crier, Comportament, 7,* 157-171.

Deruelle, C., Rondon, C., Gepner, B., & Tardiff, C. (2004). Spatial frequency and face processing in children with autism and Asperger syndrome. *Journal of Autism and Developmental Disorders, 34,* 199-210.

Diamond, R., & Carey, S. (1977). Developmental changes in the representation of faces. *Journal of Experimental Child Psychology, 23,* 1-22.

Diamond, R., & Carey, S. (1986). Why faces are and are not special: An effect of expertise, *Journal of Experimental Psychology: General, 2,* 107-117.

Dodd, B. (1979). Lip reading in infants: attention to speech presented in- and out-of-synchrony. *Cognitive Psychology, 11,* 478-484.

Dodd, B., & Campbell, R. (Eds) (1987). *Hearing by eye: The psychology of lip-reading*. Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Doherty-Sneddon, G., Bruce, V., Bonner, B., Longbotham, S., & Doyle, C. (2002). Development of gaze aversion as disengagement from visual information. *Developmental Psychology, 38,* 438-445.

Doherty-Sneddon, G. (2003). *Children's unspoken language*. Jessica Kingsley Publishers, London

Doherty-Sneddon, G., Phelps, F., & Calderwood, L. (submitted). *Face-to-face contact and physiological arousal.*

Doherty, M. R., & Anderson, J. R. (1999). A new look at gaze: Preschool children's understanding of eye-direction. *Cognitive Development, 14*, 549-571.

Donnelly, N. & Hadwin, J. A. (2003). Children's perception of the Thatcher illusion: Evidence for de+velopment in configural face processing. *Visual Cognition, 10,* 1001-1017.

Doyle, T. F., Bellugi, U., Korenberg, J. R., & Graham, J. (2004). "Everybody in the world is my friend": Hypersociability in young children with Williams syndrome. *American Journal of Medical Genetics, 124,* 263-273.

Duchaine, B. C., & Weidenfeld, A. (2003). An evaluation of two commonly used tests of unfamiliar face recognition. *Neuropsychologia, 41*, 713-720.

Dunn, L. M., Dunn, L. M., Whetton, C., & Burley, J. (1997). *British Picture Vocabulary Scale II*. Windsor, UK: NFER-Nelson Publishing.

Dyck, M. J., Ferguson, K., & Shochet, I. M. (2001). Do autism spectrum disorders differ from each other and from non-spectrum disorders on emotion recognition tests? *European Child and Adolescent Psychiatry, 10*, 105-116.

Eaves, R. C., & Milner, B. (1993). The criterion-related validity of the Childhood Autism Rating Scale and the Autism Behaviour Checklist. *Journal of Abnormal Child Psychology, 21*, 481-491.

Eckert, M. A. Galaburda, A. M., Mills, D. L., Bellugi, U., Korenberg, J. R., & Reiss, A. L. (2006). The neurobiology of Williams syndrome: Cascading influences of visual system impairment? *Cellular and Molecular Life Sciences, 63,* 1867-1875.

Eckert, M. A., Galaburda, A. M., Mills, D. L., Bellugi, U., Korenberg, J. R., & Reiss, A. L. (2006). The neurobiology of Williams syndrome: Cascading influences of visual impairment? *Cellular and Molecular Life Sciences*, *63*, 1867-1875.

Elgar, K., & Campbell, R. (2001). Annotation: The cognitive neuroscience of face recognition: Implications for developmental disorders. *Journal of Child Psychology and Psychiatry, 42*, 705-717.

Ellis, H. D. (1975). Recognizing faces. *British Journal of Psychology*, *66*, 409-426.

Ellis, H. D., Shepherd, J. W., & Bruce, A. (1973). The effects of age and sex upon adolescents' recognition of faces. *British Journal of Developmental Psychology, 123*, 173-174.

Ellis, H. D., Shepherd, J. W., & Davies, G. M. (1979). Identification of familiar and unfamiliar faces from internal and external features: Some implications for theories of face recognition. *Perception, 8*, 431-439.

Ellis, H. D., & Flin, R. H. (1990). Encoding and storage effects in 7-year-olds' and 10-year-olds' memory for faces. *British Journal of Developmental Psychology, 8,* 77-91.

Ekman, P. (1973). Universal facial expressions in emotion. *Studia Psychologica, 15,* 140-147.

Ekman, P. (1982). Methods of measuring facial action. In K. R. Scherer & P. Ekman (Eds.), *Handbook of methods in nonverbal behaviour* (pp. 45-90). Cambridge, UK: Cambridge University Press.

Ekman, P., & Friesen, W. D. (1976). Measuring facial movement.. *Environmental Psychology and Nonverbal Behaviour, 1*, 56-75.

Endo, M., Takahashi, K., & Maruyama, K. (1984). Effects of observer's attitude on the familiarity of faces: using the difference in cue value between central and peripheral facial elements as an index of familiarity. *Tohoku Psychologica Folia, 43*, 23-34.

Evans, D. W., Hodapp, R. M., & Zigler, E. (1995). Mental and chronological age as predictors of age-appropriate leisure activity in children with mental retardation. *Mental Retardation, 33*, 120-127.

Ewart, A. K., Morris, C. A., Ensing, G. J., Loker, J., Moore, C., Leppert, M., & Keating, M. T. (1993). A human vascular disorder, supravalvular aortic stenosis maps to chromosome 7. *Proceedings of the National Academy of Sciences, 90*, 3226-3230.

Farah, M. J., Tanaka, J. W., & Drain, H. M. (1995). What causes the face inversion effect? *Journal of Experimental Psychology: Human Perception and Performance, 21*, 628-634.

Farran , E. K., & Jarrold, C. (2003). Visuospatial cognition in Williams syndrome: reviewing and accounting for the strengths and weaknesses in performance. *Developmental Neuropsychology, 23*, 173-200.

Farran, E. K., Jarrold, C., & Gathercole, S. E. (2001). Block design performance in the Williams syndrome phenotype: A problem with mental imagery? *Journal of Child Psychology and Psychiatry, 42*, 719-728.

Farroni, T., Csibra, G., Simion, F., & Johnson, M. H. (2002). Eye contact in humans from birth. *Proceedings of the National Academy of Sciences of the United States of America, 99*, 9602-9605.

Field, T. (1981). Infant gaze aversion and heart rate during face-to-face interactions. *Infant Behaviour and Development, 4*, 307-315.

Fogel, A., Nwokah, E., Young D. J., Messinger, D., Dickson, K.L., Matusov, E., & Holt, S.A. (1992). Social process theory of emotion: a dynamic systems approach. *Social Development*, *1*, 122-150.

Frangiskakis, J. M., Ewart, A. K., Morris, C. A., Mervis, C. B., Bertrand, J., Robinson, B. F., Klein, B., Ensing, G. J., Everett, L. A., Green, E. Proschel, C., Gutowski, N., Noble, M., Atkinson, D., Odelberg, S. J., & Keating, M. (1996). LIM-kinease1 himzygosity implicated in impaired visuospatial constructive cognition, *Cell, 5,* 59-69.

Freire, A., & Lee, K. (2001). Face recognition in 4- to 7-year olds: processing of configural, featural and paraphernalia information. *Journal of Experimental Child Psychology, 80*, 347-371.

Freire, A., Lee, K, & Symons, L. A. (2000). The face-inversion effect as a deficit in the encoding of configural information: Direct evidence. *Perception, 29,* 159-170.

Friesen, C. K., & Kingstone, A. (1998). The eyes have it!: reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin and Review, 5*, 490–495.

Frigerio, E., Burt, D. M., Gagliardi, C., Cioffi, G., Martelli, S., Perrett, D. I., & Borgatti, R. (2006). Is everybody always my friend? Perception of approachability in Williams syndrome. *Neuropsychologia*, *44*, 254-259.

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

Frith, U. (1999). Cognitive development and cognitive deficit. In M. Darwin & A. Slater (Eds), *The Blackwell reader in development psychology*. Malden, MA, US: Blackwell Publishers. pp.509-522.

Frith, U., & Happé, F. (1994). Autism: Beyond "theory of mind." *Cognition, 50*, 115-132.

Gagliardi, C., Frigerio, E., Burt, D. M., Cazzaniga, I., Perrett, D. I., & Borgatti, R. (2003). Facial expression recognition in Williams syndrome, *Neuropsychologia, 41,* 733-738.

Gale, A., Lucas, B., Nissim, R., & Harpham, M. (1972). Some EEG correlates of face-to-face contact. *British Journal of Social and Clinical Psychology, 11*, 326-332.

Gale, A., Spratt, G., Chapman, B., & Smallbone, A. (1975). Stimulus complexity, EEG abundance gradients, and detection efficiency in a visual recognition task. *British Journal of Psychology, 66*, 289-298.

Gallup, G. G. (1982). Self-awareness and the emergence of mind in primates. *American Journal of Primatology, 2*, 237-248.

Galton, F. (1907). *Inquiries into human faculty and its development*. J. M. Dent & Co.

Gauthier, I., Tarr, M. J., Moylan, J., Anderson, A. W., Skudlarski, P. Gore, J. C. (2000). Does visual subordinate-level categorisation engage the functionally defined fusiform face area? *Cognitive Neuropsychology, 17,* 143-163.

van der Geest, J. N., Kemner, C., Varbaten, M. N. & & van Engeland, H. (2002b). Gaze behavior of children with pervasive developmental disorder toward human faces: a fixation time study. *Journal of Child Psychology and Psychiatry, 43,* 669-681.

van der Geest, J. N., Kemner, C., Camfferman, G., Varbaten, M. N. & & van Engeland, H. (2002b). Looking at images with human figures: comparison between autistic and normal children. *Journal of Autism and Developmental Disorders, 32,* 69-75.

George, P. A., Hole, G. J., & Scaife, M. (2000). Factors influencing young children's ability to discriminate unfamiliar faces by age. *International Journal of Behavioural Development, 24,* 480-491.

Gepner, B., de Gelder, B., & de Schonen, S. (1996). Face processing in autistics: Evidence for a generalised deficit. *Child Neuropsychology, 2,* 123-139.

Gilchrist, A., & McKone, E. (2003). Early maturity of face processing in children: Local and relational distinctiveness effect in 7-year olds. *Visual Cognition, 10,* 769-793.

Gillberg, I. C., & Gillberg, C. (1989). Asperger syndrome: Some epidemiological considerations: a research note. *Journal of Child Psychology and Psychiatry, 30*, 631-8.

Glenberg, , A. M. (1997). What memory is for. *Behavioural and Brain Sciences, 20*, 1-19.

Glenberg, , A. M., Schroeder, J. L, & Robertson, D. A. (1998). Averting the gaze disengages the environment and facilitates remembering. *Memory and Cognition, 26*, 651-658.

Golarai, G., Grill-Spector, K., Reiss, A. (2006). Autism and the development of face processing. *Clinical Neuroscience Research, 6*, 145-160.

Goldstein, A. G. (1975). Recognition of inverted photographs of faces of children and adults. *Journal of Genetic Psychology, 127*, 109-123.

Goldstein, A. G. & Chance, J. E. (1980). Memory for faces and schema theory. *Journal of Psychology, 105*, 47-59.

Goldstein, A. G., & Chance, J. E. (1981). Laboratory studies of face recognition. In G. M. Davies, H. D. Ellis, & J. W. Shepherd (Eds.), *Perceiving and remembering faces*. London, England: Academic Press.

Gorno-Tempini, M. L., & Price, C. J. (2001). Identification of famous faces and buildings: A functional neuroimaging study of semantically unique items. *Brain: A Journal of Neurology, 124*, 2087-2097.

Gosch, A., & Pankau, R. (1997). Personality characteristics and behaviour problems in individuals of different ages with Williams syndrome. *Developmental Medicine and Child Neurology, 39*, 527-533.

Grice, S. J., Spratling, M. W., Karmiloff-Smith, A., Halit, H., Csibra, G., de Haan, M., & Johnson, M. H.(2001). Disordered visual processing and oscillatory brain activity in autism and Williams syndrome. *Neuroreport: For Rapid Communication of Neuroscience Research, 12*, 2697-2700.

Grelotti, D. J., Gauthier, I., & Schultz, R. T. (2002). Social interest and the development of cortical face specialisation: what autism teaches us about face processing. *Developmental Psychobiology, 40*, 213-225.

Grice, S. J., Halit, H., Farroni, T., Baron-Cohen, S. Bolton, P., & Johnson, M. (2005). Neural correlates of eye-gaze detection in young children with autism. *Cortex*, *41*, 342-353.

Grill-Spector, K., Knouf, N., & Kanwisher, N. (2004). The fusiform face area subserves face perception, not generic within-category identification. *Nature Neuroscience, 7*, 555-562.

Groner, R., Walder, F., & Groner, M. (1984). Looking at faces: Local and global aspects of scan paths. In A. G. Gale & F. Johnson (Eds.), *Theoretical and applied aspects of gaze behaviour research* (pp. 523-533). Amsterdam: Elsevier.

Gross, T. F.,(2004). The perception of four basic emotions in human and nonhuman faces by children with autism and other developmental disabilities. *Journal of Abnormal Child Psychology, 32*, 469-480.

Grossman, J. B., Klin, A., Carter, A. S., & Volkmar, F. R. (2000). Verbal bias in recognition of facial emotions in children with Asperger syndrome. *Journal of Child Psychology and Psychiatry, 41*, 369-379.

de Haan, E. H. F., & Hay, D. C. (1986). The matching of famous and unknown faces given either the internal or the external features: A study on patients with unilateral brain lesions. In H. E. Ellis, M. A. Jeeves, F. Newcombe, & A. W. Young (Eds) *Aspects of face processing*. The Netherlands: Martinus Niijhoff. pp.302-309.

Happé, F. G. (1993). Communicative competence and theory of mind in autism: a test of relevance theory. *Cognition, 48,* 101-19.

Happé, F. G. (1995). The role of age and verbal ability in theory of mind task performance of subjects with autism. *Child Development, 66*, 843-855.

Haxby, J. V., Hoffman, E. A., Gobbini, M. I. (2000). The distributed human neural system for face perception. *Trends in cognitive sciences, 4*, 223-233.

Haxby, J .V., Hoffman E. A., & Gobbini, M. I. (2002). Human neural systems for face recognition and social communication. *Biological Psychiatry, 51*, 59-67.

Hay, D. C. & Cox, R. (2000). Developmental changes in the recognition of faces and facial features. *Infant and Child Development, 9*, 199-212.

Heerey, E. A., Keltner, D., & Capps, L. M. (2003). Making Sense of Self-Conscious Emotion: Linking Theory of Mind and Emotion in Children With Autism. *Emotion, 3*, 394-400.

Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends in Cognitive Sciences, 7*, 498-504.

Hermelin, B. & O'Connor, N. (1970). *Psychological experiments with autistic children*. Oxford: Pergamon Press.

Hines, D., Jordan-Brown, L., & Juzwin, K. R. (1987). Hemispeheric visual processing in face recognition. *Brain & Cognition, 6*, 91-100.

Hirstein, W., Iversen, P., & Ramachandran, V. S. (2001). Autonomic responses of autistic children to people and objects, *Proceedings of the Royal Society, 268*, 1883-1888.

Hobson, P. R. (1986). The autistic child's appraisal of expressions of emotion. *Journal of Child Psychology and Psychiatry, 27*, 321-342.

Hobson, P. R. (1993). The emotional origins of social understanding. *Philosophical Psychology, 6*, 227-249.

Hobson, R. P., Ouston, J., & Lee, A. (1988). What’s in a face? The case of autism. *British Journal of Psychology, 79*, 441-453.

Hobson, R. P., Ouston, J., & Lee, A. (1989). Naming emotion in faces and voices: Abilities and disabilities in autism and mental retardation. *British Journal of Developmental Psychology, 7*, 237-250.

Howard, M.A., Cowell, P.E., Boucher, J., Broks, P., Mayes, A., Farrant, A/. & Roberts, N. (2000). Convergent neuroanatomical and behavioural evidence of an amygdale hypothesis of autism. *Neuroreport, 11,* 2931-2935.

Hutt, S. J., & Hutt, C. (1970). *Direct observation and measurement of behaviour*. Oxford, England: Charles C Thomas.

Hutt, C., & Ounsted, C. (1966). The biological significance of gaze aversion with particular reference to the syndrome of infantile autism. *Behavioural Science, 11*, 346-356.

Jaffe, J., Stern, D., & Perry, J. (1973). Conversational coupling of gaze behaviour in pre-linguistic human development *Journal of Psycholinguistic Research, 2*, 321-329.

Janik, S. W., Wellens, A. R., Goldberg, M. L., & Dell'Osso, L. F. (1978). Eyes as the center of focus in the visual examination of human faces. *Perceptual & Motor Skills, 47*, 857-858.

Jarrold, C., Hartley, S., Phillips, C., & Baddeley, A. D. (2000). Word fluency in Williams syndrome: Evidence for unusual semantic organisation? *Cognitive Neuropsychiatry, 5*, 293-319.

Jarrold, C., & Brock, J. (2004). To match or not to match? Methodological issues in autism-related research. *Journal of Autism and Developmental Disorders, 34,* 81-86.

Jemel, B., Mottron, L., & Dawson, M. (2006). Impaired Face Processing in Autism: Fact or Artifact? *Journal of Autism and Developmental Disorders, 36,* 91-106.

Johnson, M. H. (2005). *Developmental Cognitive Neuroscience: Second edition.* Malden, MA, US: Blackwell Publishing.

Johnson, S. C., & Carey, S. (1998) Knowledge enrichment and conceptual change in folkbiology: Evidence from Williams syndrome. *Cognitive Psychology, 37*, 156-200.

Jones, W., Hickok, G., & Lai, Z. (1998). Does face processing rely on intact visual-spatial abilities? Evidence from Williams syndrome. *Cognitive Neuroscience Society Abstract Program, 80*, 67.

Jones, W., Bellugi, U., Lai, Z., Chiles, M., Reilly, J., Lincoln, A., & Adolph, R. (2000). Hypersociability: The social and affective phenotype of Williams syndrome. In: Bellugi, U., & St George, M. (Eds.) Linking cognitive neuroscience and molecular genetics: New perspectives from Williams syndrome, *Journal of Cognitive Neuroscience, 12,* 30-46.

Joseph, R. M., & Tanaka, J. (2003). Holistic and part-based face recognition in children with autism. *Journal of Child Psychology and Psychiatry, 44,* 529-542.

Joseph, R. M., Tager-Flusberg, H., & Lord, C. (2002). Cognitive profiles and social-communicative functioning in children with autism spectrum disorder. *Journal of Child Psychology and Psychiatry, 43,* 807-821.

Kanner, L. (1943). Autistic disturbances of affective contact. *Nervous Child, 2*, 217-250.

Kanwisher, N. (1998) The modular structure of human visual recognition: Evidence from functional imaging.In M. Sabourin, F. Craik & M. Robert (Eds.) *Advances in psychological science, Vol. 2: Biological and cognitive aspects*. (pp. 199-213). Hove, England: Psychology Press.

Kanwisher, N. (2000). Domain specificity in face perception. *Nature Neuroscience, 3*, 759-763.

Kanwisher, N., McDermott, J., & Chun, M. (1997). The fusiform face area: A module in human extrastriate cortex specialised for face perception. *The Journal of Neuroscience, 17,* 4302-4311.

Karmiloff-Smith, A. (1997). Crucial differences between developmental cognitive neuroscience and adult neuropsychology, *Developmental Neuropsychology, 13,* 513-524.

Karmiloff-Smith, A., Klima, E., Bellugi, U., Grant, J., & Baron-Cohen, S. (1995). Is there a social module? Language, face processing, and theory of mind in individuals with Williams syndrome. *Journal of Cognitive Neuroscience, 7,* 196-208.

Karmiloff-Smith, A., Brown, J. H., Grice, S. & Paterson, S. (2003). Dethroning the myth: Cognitive dissociations and innate modularity in Williams syndrome. *Developmental Neuropsychology, 23,* 227-242.

Karmiloff-Smith, A., Thomas, M., Annaz, D., Humphreys, K., Ewing, S., Brace, N., Van Duuren, M., Pike, G., Grice, S., & Campbell, R. (2004). Exploring the Williams syndrome face processing debate: The importance of building developmental trajectories. *Journal of Child Psychology and Psychiatry, 45*, 1258-1274.

Kawashima, R., Sugiura, M., Kato, T., Nakamura, A., Hatano, K., Ito, K., Fukuda, H., Kojima, S., & Nakamura, K. (1999). The human amygdala plays an important role in gaze monitoring: A PET study. *Brain, 122,* 779-783.

Kendon, A. (1967). Some functions of gaze-direction in social interaction. *Acta Psychologica, 26,* 22-63.

Kingstone, A., Smilek, D., Ristic, J., Friesen, C., & Eastwood, J. D. (2003). Attention, researchers! It is time to take a look at the real world. *Current Directions in Psychological Science, 12*, 176-180.

Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological Bulletin, 100*, 78-100.

Klein, B. P., & Mervis, C. B. (1999). Contrasting patterns of cognitive abilities of 9- and 10-year-olds with Williams Syndrome or Down Syndrome. *Developmental Neuropsychology, 16,* 177-196.

Klin, A., Jones, W., Schultz, R., Volkmar, F., & Cohen, D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. *Archives of General Psychiatry, 59,* 809-816.

Klin, A., Jones, W., Schultz, R., & Volkmar, F. (2004) The enactive mind, or from actions to cognition: Lessons from autism. In Frith, U. & Hill, E. *Autism: Mind and brain*, Chapter 7. New York: Oxford University Press.

Klin, A., Pauls, D., Schultz, R., & Volkmar, F. (2005). Three Diagnostic Approaches to Asperger Syndrome: Implications for Research. *Journal of Autism and Developmental Disorders, 35*, 221-234.

Klinnert, M. D., Emde, R. M., Butterfield, P., & Campos, J. J. (1986). Social referencing: The infant's use of emotional signals from a friendly adult with mother present. *Developmental-Psychology, 22*, 427-432.

Knapp, M. L. (1978). *Nonverbal communication in human interaction, second edition*. Holt, Rinehart and Winston, USA.

Konstantareas, M. M., & Hewitt, T. (2001). Autistic disorder and schizophrenia: Diagnostic overlaps. *Journal of Autism and Developmental Disorders*, *31*, 19-28.

Korenberg, J. R., Chen, X. N., Hirota, H., Lai, Z., Bellugi, U., Burian, D., Roe, B., & Matsuoka, R. (2001). Genome structure and cognitive map of Williams syndrome. In M. St. George, & Bellugi, U. (Eds), *Journey from cognition to brain to gene: Perspectives from Williams syndrome*. (pp.147-177).Cambridge, MA, US: The MIT Press.

Kurucz, J., Feldmar, G., & Werner, W. (1979). Prosopo-affective agnosia associated with chronic organic brain syndrome. *Journal of the American Geriatrics Society, 27*, 91-95.

Kylliäinen, A., & Heitanen, J. K. (2004). Attention orienting by another's gaze direction in children with autism. *Journal of Child Psychology and Psychiatry, 45*, 435-444.

Kylliäinen, A., & Hietanen, J. K. (2006). Skin Conductance Responses to Another Person's Gaze in Children with Autism. *Journal of Autism and Developmental Disorders, 36*, 517-525.

Lahaie, A., Mottron, L., Arguin, M., Berthiaume, C., Jemel, B., & Saumier, D. (2006). Face perception in high-functioning autistic adults: Evidence for superior processing of face parts, not for a configural face-processing deficit. *Neuropsychology, 20*, 30-41.

Laing, E., Butterworth, G., Ansari, D., Gsodl, M., Longhi, E., Panagiotaki, G., Paterson, S., & Karmiloff-Smith, A. (2002). Atypical development of language and social communication in toddlers with Williams syndrome. *Developmental Science, 5,* 233-246.

Landry, S. H., & Loveland, K. A. (1988). Communication behaviors in autism and developmental language delay. *Journal of Child Psychology and Psychiatry, 29*, 621-634.

Langdell, T. (1978). Recognition of faces: An approach to the study of autism. *Journal of Child Psychology and Psychiatry, 19*, 255-268.

Langton, S. R. H., & Bruce, V. (1999). Reflexive visual orienting in response to the social attention of others. *Visual Cognition, 6*, 541-567.

Langton, S. R. H., Watt, R. J., & Bruce, V. (2000). Do the eyes have it? Cues to the direction of social attention. *Trends in Cognitive Sciences, 4*, 50-59.

Leder, H., & Bruce, V. (1998). Local and relational aspects of face distinctiveness. *The Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 51*, 449-473.

Leder, H., & Bruce, V. (2000). Inverting line drawings of faces. *Swiss Journal of Psychology, 59*, 159-169

Leekam, S., Baron-Cohen, S., Perrett, D., Milders, M., & Brown, S. (1997). Eye-direction detection: A dissociation between geometric and joint attention skills in autism. *British Journal of Developmental Psychology, 15*, 77-95.

Leekam, S. R., Hunnisett, E., & Moore, C. (1998). Target and cues: Gaze-following in children with autism. *Journal of Child Psychology and Psychiatry, 39*, 951-962.

Leekam, S. R., Lopez, B., & Moore, C. (2000). Attention and joint attention in preschool children with autism. *Developmental Psychology, 36*, 261-273.

Leslie, A. M., & Frith, U. (1988). Autistic children's understanding of seeing, knowing and believing. *British Journal of Developmental Psychology, 6*, 315-324.

Levy, Y., & Herman, S. (2003). Morphological abilities of Hebrew-speaking adolescents with Williams syndrome. *Developmental Neuropsychology, 23,* 59-83.

Lewis, M. B.,& Johnston, R. A. (1997). The Thatcher Illusion as a test of configural disruption. *Perception, 26*, 225-227.

Lewis, M. B. (2001). The lady's not for turning: Rotation of the Thatcher illusion. *Perception, 30*, 769-774.

Lewis, M. B. (2003). Thatcher's children: Development and the Thatcher illusion. *Perception, 32,* 1415-1421.

Lewis, V. (2003). *Development and Disability*. Oxford: Blackwell Publishers.

Lewis, M. B., & Johnston, R. A. (1997). The Thatcher illusion as a test of configural disruption. *Perception, 26,* 225-227.

Lewis, M. B., & Glenister, T. A. (2003). A sideways look at configural encoding: Two different effects of face rotation. *Perception, 32*, 7-14.

López, B., Donnelly, N., Hadwin J. A., & Leekam, S. R. (2004). Face processing in high-functioning adolescents with autism: Evidence for weak central coherence. *Visual Cognition, 11*, 673-688

Loveland, K. A., & Landry, S. H. (1986). Joint attention and language in autism and developmental language delay. *Journal of Autism and Developmental Disorders, 16,* 335-349.

Lowery, M. C., Morris, C.A., Ewart, A., Brothman, L. J., Zhu, X. L., Leonard, C. O., Carey, J. C., Keating, M., & Brothman, A.R. (1995). Strong correlation of elastin deletions, detected by FISH, with Williams syndrome: evaluation of 235 patients. *American Journal of Human Genetics, 57,* 49-53.

Lundqvist, D. & Ohman, A. (2005). Emotion regulates attention: The relation between facial configurations, facial emotion, and visual attention.. *Visual Cognition, 12*, 51-58.

Maestrini, E. (1997). A genome-wide search for autism susceptible genes. *American Journal of Medical Genetics, 74,* 567.

Malcolm, G. L., Leung, C., & Barton, J. J. (2005) regional variation in the inversion effect for faces: Differential effects for feature shape, feature configuration, and external contour. *Perception*, *34*, 1221-1231.

Matthews, M. L. (1978). Discrimination of Identikit constructions of faces: evidence for a dual processing strategy. *Perception & Psychophysics, 23,* 153-161.

Maurer, D., & Salapatek, P. (1976) Developmental changes in the scanning of faces by young infants. *Child Development, 47,* 523-527.

McKelvie, S. J. (1976). The role of eyes and mouth in the memory of a face. *American Journal of Psychology, 89*, 311-323.

McKelvie, S. J. (1976). The role of eyes and mouth in the memory of a face. *American Journal of Psychology, 9,* 311-323.

McPartland, J., Dawson, G., Webb, S. J., Panagiotides, H., & Carver, L. J., (2004). Event-related brain potentials reveal anomalies in temporal processing of faces in autism spectrum disorder. *Journal of Child Psychology and Psychiatry, 45*, 1235-1245.

Mertens, I., Siegmund, H., & Grusser, O. J. (1993). Gaze motor assymetires in the perception of faces during a memory task. *Neuropsychologia, 31*, 989-998.

Mervis, C. B., &Bertrand, J. (1995). Early lexical development of children with Williams syndrome. *Genetic Counseling, 6*, 134-135.

Mervis, C. B., Morris, C. A., Klein T., Bonita P., Bertrand, J. Kwitny, S., Appelbaum, L. G., & Rice, C. E. (2003) Attentional characteristics of infants and toddlers with Williams syndrome during triadic interactions. *Developmental Neuropsychology, 23,* 243-268.

Mesibov, G., Schopler, E., Schaffer, E., & Michal, N. (1989). Use of the Childhood Autism Rating Scale with autistic adolescents and adults. *Journal of the American Academy of Child and Adolescent Psychiatry, 28,* 538-541.

Meyer-Lindenberg, A., Mervis, C. B., & Berman, K. F. (2006). Neural mechanisms in Williams syndrome: a unique window to genetic influences on cognition and behaviour. *Nature Reviews Neuroscience, 7*, 380-393.

Mills, D. L., Alvarez, T. D., St. George, M., Appelbaum, L. G., Bellugi, U., & Neville, H.(2000). Electrophysiological studies of face processing in Williams syndrome. *Journal of Cognitive Neuroscience*, *12*, 47-64.

Mills, D. L., Alvarez, T. D., St. George, M., Appelbaum, L. G., Bellugi, U., & Neville, H. (2001) Neurophysiological markers of face processing in Williams syndrome. In U. Bellugi, M. St. George (Eds) (2001). *Journey from cognition to brain to gene: Perspectives from Williams syndrome.* (pp. 73-104). Cambridge, MA, US: The MIT Press. xxiv, 189 pp.

Miyashita, T. (1988). Discrimination of facial components in autistic children. *The Japanese Journal of Psychology, 59*, 206-212.

Mobbs, D., Garrett, A., Menon, V., Rose, F., Bellugi, U., & Reiss, L. (2004). Anomalous brain activation during face and gaze processing in Williams syndrome. *Neurology, 62,* 2070-2076.

Mondloch, C. J., Le Grand, R. & Maurer, D. (2002). Configural face processing develops more slowly than featural face processing. *Perception, 31,* 553 – 566.

Mondloch, C. J., Geldart, S., Maurer, D. & Le Grand, R. (2003). Developmental changes in face processing skills. *Journal of Experimental Child Psychology, 86*, 67-84.

Mondloch, C. J., Dobson, K. A., Parsons, J., & Maurer, D. (2004). Why 8-year-olds cannot tell the difference between Steve Martin and Paul Newman: Factors contributing to the slow development of sensitivity to the spacing of facial features. *Journal of Experimental Child Psychology, 89*, 159-181

Mondloch, C. J., Leis A., & Maurer, D. (2006). Recognizing the Face of Johnny, Suzy, and Me: Insensitivity to the Spacing Among Features at 4 Years of Age. *Child Development*, *77*, 234-243.

Morris, C. A., Demsey, S. A., Leonard, C. O., Dilts, C., & Blackburn, B. (1988). Natural history of Williams syndrome: physical characteristics. *Journal of Pediatrics, 113,* 318-326.

Morris, C. A., & Mervis, C. B. (1999). Williams syndrome. In C. R. Reynolds & Goldstein, S. (Eds), *Handbook of neurodevelopmental and genetic disorders in children*. New York, NY, US: Guilford Press. (pp.555-590).

Mottron, L.(2004). Matching Strategies in Cognitive Research with Individuals with High-Functioning Autism: Current Practices, Instrument Biases, and Recommendations. *Journal of Autism and Developmental Disorders*, *34*, 19-27.

Mundy, P., Sigman, M., Ungerer, J., & Sherman, T. (1986) Defining the social deficits of autism: The contribution of non-verbal communication measures. *Journal of Child Psychology and Psychiatry*, *27*, 657-669.

Mundy, P. (1995). Joint attention and social-emotional approach behaviour in children with autism. *Developmental Psychopathology, 7*, 63-82.

Mundy, P. & Neal, R. (2001). Neural plasticity; joint attention and autistic developmental pathology. *International Review of Research in Mental Retardation*, *23*, 139-168.

Murray, J. E., Yong, E., & Rhodes, G. (2000). Revisiting the perception of upside-down faces. *Psychological Science*, *11*, 498-502.

Nachson, I., Moscovitch, M., & Umilta, C. (1995). The contribution of external and internal features to the matching of unfamiliar faces. *Psychological Research, 58,* 31-37.

Namihira, T., Hirayasu, Y., & Koga, Y. (2004). The assessment of cognitive function in a Williams syndrome patient: A case report. *Psychiatry and Clinical Neurosciences, 58*, 99.

Newcombe, N., & Lie, E. (1995). Overt and covert recognition of faces in children and adults. *Psychological Science, 6*, 241-245.

Nickerson, E., Greenberg, F., Keating, M. T., McCaskill, C., & Shaffer, L. (1995). Deletions of the elastin gene at 7q11.23 occur in ~ 90% of patients with Williams syndrome. *American Journal of Human Genetics, 56*, 1156-1561.

Nichols, K. A., & Champness, B. G. (1971) Eye gaze and the GSR. *Journal of Experimental Social Psychology, 7,* 623-626.

O'Donnell, C. & Bruce, V. (2001). Familiarisation with face selectively enhances sensitivity to changes made to the eyes. *Perception*, *30*, 755-764.

Osborne, L., & Pobert, B. (2001). Genetics of childhood disorders: XXVII. Genes and cognition in Williams syndrome. *Journal of the American Academy of Child and Adolescent Psychiatry, 40*, 732-735.

Osterling, J. A., Dawson, G., & Munson, J. A. (2002). Early recognition of 1-year-old infants with autism spectrum disorder versus mental retardation, *Development and Psychopathology, 14*, 239-251.

Ozonoff, S., Pennington, B. F., Rogers, S. J. (1990). Are there emotion processing deficits in young autistic children? *Journal of Child Psychology and Psychiatry, 31*, 343-361.

Ozonoff, S., Pennington, B. F., & Rogers, S. J. (1991). Executive function deficits in high-functioning autistic individuals: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry, 32,* 1081-1105.

Pascalis, O., Demont, E., de Haan, M., & Campbell, R. (2001). Recognition of faces of different species: A developmental study between 5 and 8 years of age. *Infant and Child Development, 10,* 39-45

Paterson, S. J., Brown, J.H., Gsodl, M. K., Johnson, M. H., & Karmiloff-Smith, A. (1999). Cognitive modularity and genetic disorders. *Science, 286*, 2355-2358.

Paterson, S., Girelli, L., Butterworth B., & Karmiloff-Smith, A.(2006). Are numerical impairments syndrome specific? Evidence from Williams syndrome and Down's syndrome. *Journal of Child Psychology and Psychiatry, 47*, 190-204.

Peeters, T., & Gillberg, C. (1999). *Autism: Medical and educational aspects. Second edition.* London UK: Whurr Publishers.

Pellicano, E., & Rhodes, G . (2003). Holistic processing of faces in preschool children and adults. *Psychological Science, 14,* 618-622.

Pellicano, E., Rhodes, G., & Peters, M. (2006). Are preschoolers sensitive to configural information in faces? *Developmental Science, 9*, 270-277.

Pelphrey, K. A., Sasson, N. J., Reznick, J. S., Paul, G., Goldman, B. D., & Piven, J. (2002). Visual scanning of faces in autism. *Journal of Autism and Developmental Disorders, 32*, 249-261.

Pelphrey, K. A., Viola, R. J., & McCarthy, G. (2004). When strangers pass. Processing of mutual and averted social gaze in the superior temporal sulcus. *Psychological Science, 15*, 598-603.

Phillips, R. J. (1979). Some exploratory experiments on memory for photographs of faces. *Acta Psychologica, 43,* 39-56.

Pierce, K., Muller, R., Ambrose, J., Allen, G., & Courchesne, E. (2001). Face processing occurs outside the fusiform 'face area' in autism: Evidence from functional MRI. *Brain: A Journal of Neurology, 124*, 2059-2073.

Pierce, K., Sedaghat, F., Haist, F., & Courchesne, E. (2004). The brain response to personally familiar faces in autism: Findings of fusiform activity and beyond. *Brain: A Journal of Neurology, 127*, 2703-2716.

Piven, J., Simon, J., Chase, G. A., Wzorek, M., et-al (1999). Etiology of autism: Pre-, peri- and neonatal factors. *Journal of the American Academy of Child and Adolescent Psychiatry, 32*, 1256-1263.

Plesa-Skwerer, D., Verbalis, A., Schofield, C., Faja, S., & Tager-Flusberg, H. (2006). Social-perceptual abilities in adolescents and adults with Williams syndrome. *Cognitive Neuropsychology, 23*, 338-349.

Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences, 1*, 515-526.

Raven, J. C., Court, J. H., & Raven, J. (1990*). Raven's Coloured Progressive Matrices*. Oxford: Oxfords Psychologists Press.

Reiss, A. L., Eckert, M. A., Rose, F. E., Karchemskiy, A., Kesler, S., Chang, M., Reynolds, M. F., Kwon, H., Galaburda, A., Rellini, T., Trillo, C., M. (2004). An experiment of Nature: Brain Anatomy Parallels Cognition and Behaviour in Williams Syndrome. *Journal of Neuroscience, 24*, 5009-5015.

Riby, D. M. (2003). Inner versus Outer: A developmental study of the relative salience of facial features. MSc dissertation unpublished.

Ristic, J., Mottron, L., Freisen, C. K., Iarocci, G., Burack, J. A., Kingstone, A.(2005). Eyes are special but not for everyone: The case of autism, *Cognitive Brain Research*, *24*, 715-718.

Rogers, S. J., & Ozonoff, S. (2005). Annotation: What do we know about sensory dysfunction in autism? A critical review of the empirical evidence. *Journal of Child Psychology and Psychiatry, 46*, 1255-1268.

Rondon, C., Gepner, B., & Deruelle, C. (2003). Inner and outer face perception in children with autism. *Child Neuropsychology, 9*, 289-297.

Rose, F. E., Lincoln, A. J., Lai, Z., Ene, M., Searcy, Y. M., & Bellugi, U. (in press). Orientation and affective expression effects on face recognition in Williams syndrome and autism. *Journal of Autism and Developmental Disorders*.

Rossen, M. L., Jones, W., Wang, P., & Klima, E. S. (1995). Face processing: Remarkable sparing in Williams syndrome. *Genetic Counselling*, *6*, 38-40.

Roth, I., & Bruce, V. (1995). *Perception and Representation: Current issues 2nd Edition*. Open University Press, Buckingham.

Rouse, H., Donnelly, N., Hadwin, J. A., & Brown, T. (2004). Do children with autism perceive second-order relational features? The case of the Thatcher Illusion. *Journal of Child Psychology and Psychiatry, 45*, 1246-1257.

Ruffman, T., Garnham, W., & Rideout, P. (2001). Social understanding in autism: eye gaze as a measure of core insights. *Journal of Child Psychology and Psychiatry, 42,* 1083-1094.

Russell, J. (1997). How executive disorders can bring about an inadequate 'theory of mind' In J. Russell (Ed). *Autism as an executive disorder*. (pp. 256-304). New York, NY, US: Oxford University Press.

Russell, J. A.(1994). Is there universal recognition of emotion from facial expressions? A review of the cross-cultural studies. *Psychological Bulletin, 115,* 102-141.

Rutter, M. (1984). Cognitive deficits in the pathogenesis of autism. *Annual Progress in Child Psychiatry and Child Development, 46,* 321-345.

Rutter, M. & Schopler, E. (1987). Autism and pervasive developmental disorders: Concepts and diagnostic issues. *Journal of Autism and Developmental Disorders, 17*, 159-186.

Rutter, M. (2005a). Aetiology of autism: findings and questions. *Journal of Intellectual Disability Research*, *49*, 231-238.

Rutter, M.(2005b). Autism Research: Lessons from the Past and Prospects for the Future. *Journal of Autism and Developmental Disorders*, *35*, 241-257.

Safran, S. P. (2001). Asperger syndrome: The emerging challenge to special education. *Exceptional Children, 67*, 151-160.

Schopler , E., Rechler, R. J., & Rochen Renner, B. R. (1988). *The Childhood Autism Rating Scale.* LA: Western Psychological Services.

Scerif, G., Cornish, K., Wilding, J., Driver, J. & Karmiloff-Smith, A. (2004). Visual search in typically developing toddlers and toddlers with Fragile X or Williams syndrome. *Developmental Science, 7*, 116-130.

Schultz, R. T. (2005). Developmental deficits in social perception in autism: The role of the amygdala and fusiform face area. *International Journal of Developmental Neuroscience, 23*, 125-141.

Schultz, R.T., Gauthier, I., Klin, A., Fulbright, R.K., Anderson, A.W., Volkmar, F., Skudlarski, P., Lacadie, C., Cohen, D.J., & Gore, J.C. (2000). Abnormal ventral temporal cortical activity during face discrimination among individuals with autism and Asperger syndrome. *Archives of General Psychiatry, 37*, 331-340.

Schultz, R. T., Grelotti, D. J., & Pober, B. (2001). Williams syndrome and brain behaviour relationship. *Journal of the Academy of Child and Adolescent Psychiatry, 40*, 606-609.

Schwaninger, A., Carbon, C-C. Leder, H., (2003). Expert face processing: specialisation and constraints. In C. Swhwarzer & H. Leder, *Development of face processing* (p.81-97). Gottingen.

Schwarzer, G. (2000). Development of face processing: The effect of face inversion. *Child Development, 71,* 391-401.

Schwarzer, G. (2002). Processing of facial and non-facial visual stimuli in 2-5-year-old children. *Infant and Child Development, 11*, 253-270.

Searcy, J. H., & Bartlett, J. C. (1996). Inversion and processing of component and spatial-relational information in faces. *Journal of Experimental Psychology: Human Perception and Performance, 22*, 904-915.

Senju, A., Tojo, Y., Dairoku, H., & Hasegawa, T. (2004) reflexive orienting in response to eye gaze and an arrow in children with and without autism. *Journal of Child Psychology and Psychiatry, 44*, 1-14.

Sergent, J. (1984). An investigation into component and configural processes underlying face perception *British Journal of Psychology, 75*, 221-242.

Shao, Y., Cuccaro, M. L., Hauser, E. R., Raiford, K. L., Menold, M. M., Wolpert, C. M., Ravan, S. A., Elston, L., Decena, K., Donnelly, S. L., Abramson, R. K., Wright, H. H., DeLong, G. R., Gilbert, J. R., & Pericak, M. A., (2003). Fine Mapping of Autistic Disorder to Chromosome 15q11-q13 by Use of Phenotypic Subtypes. *American Journal of Human Genetics, 72,* 539-548.

Shepherd, J., Davies, G., & Ellis, H. (1981). Studies of cue saliency. In G. Davies, H. Ellis, & J. Shepherd (Eds.) *Perceiving and remembering faces,* Academic Press, London.

Singh, N. N., Oswald, D. P., Lancioni, G. E., Ellis, C. R., Sage, M., & Ferris, J. R. (2005). The neuropsychology of facial identity and facial expression in children with mental retardation. *Research in Developmental Disabilities, 26*, 33-40.

Sjoberg, W., & Windes, J. (1992). Recognition times for rotated normal and ‘Thatcher’ faces. *Perceptual and Motor Skills, 75*, 1176-1178.

Spencer, J. V., & O’Brien, J. M. D. (2006). Visual form-processing deficits in autism. *Perception, 35*, 1047-1055.

Summerfield, A. Q. (1987). Some preliminaries to a comprehensive account of audio-visual speech perception. In. B. Dodd and R. Campbell. (Eds). *Hearing by eye: The psychology of lip-reading*. (pp.3-51). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Swettenham, J., Condie, S., Campbell, R., Milne, E., & Coleman, M. (2003). Does the perception of moving eyes trigger reflexive visual orienting in autism? In U. Frith & Hill, E. (Eds). *Autism: mind and brain*, New York: Oxford University Press Inc. (pp.89-108)

Szatmari, P. (2003) the causes of autism spectrum disorders. *British Medical Journal*, *326*, 173-174.

Tager-Flusberg, H., Sullivan, K., & Boshart, J. (1997). Executive functions and performance on false belief tasks. *Developmental Neuropsychology, 13*, 487-493.

Tager-Flusberg, H., Boshart, J., & Baron-Cohen, S. (1998). Reading the windows to the soul: evidence of domain-specific sparing in Williams syndrome. *Journal of Cognitive Neuroscience, 10*, 631-639.

Tager-Flusberg, H. & Sullivan, K. (2000). A componential view of theory of mind: Evidence from Williams syndrome. *Cognition, 76,* 59-89.

Tager-Flusberg, H., Plesa-Skwerer, D., Faja, S. & Joseph, R. M. (2003). People with Williams syndrome process faces holistically. *Cognition, 89*, 11-24.

Tanaka, J. W., & Farah, M. J. (1993). Parts and wholes in face recognition. *Quarterly Journal of Experimental Psychology, 46*, 225-245.

Tanaka, J., Kay, J., Grinnell, E., Stansfield, B., & Szechter, L. (1998). Face recognition in young children: When the whole is greater than the sum of its parts. *Visual Cognition, 5,* 479-496.

Tantam, D., Monaghan, L., Nicholson, H., & Stirling, J. (1989). Autistic children's ability to interpret faces: A research note. *Journal of Child Psychology and Psychiatry, 30,* 623-630.

Tassabehji, M., Metcalfe, K., Karmiloff-Smith, A., Carette, M. J., Grant, J., Dennis, N., Reardon, W., Splitt, M., Read, A. P., & Donnai, D. (1999). Williams syndrome: Use of chromosomal microdeletions as a tool to dissect cognitive and physical phenotypes. *American Journal of Human Genetics, 64*, 118-125.

Tassabehji, M. (2003). Williams-Beuren syndrome: A challenge for genotype-phenotype correlations. *Human Molecular Genetics, 12*, 229-237.

Teunisse, J. P. & de Gelder, B. (1994). Do autistics have a generalized face processing deficit? *International Journal of Neuroscience, 77,* 1-10.

Teunisse, J. P., & de Gelder, B. (2003). Face processing in adolescents with autistic disorder: the inversion and composite effects. *Brain and Cognition, 53,* 285-294.

Thompson, P. (1980). Margaret Thatcher: A new illusion. *Perception, 9,* 483-484.

Tonn, R. T., & Obrzut, J. E.(2005). The neuropsychological perspective on autism. *Journal of Developmental and Physical Disabilities, 17,* 409-419.

Tranel, D., & Damasio, A. R. (1985). Knowledge without awareness: An autonomic index of facial recognition by prosopagnosics. *Science, 228*, 1453-1454.

Turner, M. (1999). Repetitive behaviour in autism: A review of psychological research. *Journal of Child Psychology and Psychiatry, 40,* 839-849.

Udwin, O., & Yule, W. (1991). A cognitive and behavioural phenotype in Williams syndrome. *Journal of Clinical and Experimental Neuropsychology, 13,* 232-244.

Valentine, T. (1988). Upside-down faces: A review of the effect of inversion upon face recognition. *British Journal of Psychology, 79,* 471-491.

Valentine, T. & Bruce, V. (1988). Mental rotation of faces. *Memory and Cognition, 16,* 556-566.

Van der Geest, J. N., Kemner, C., Verbaten, M. N., & van England, H. (2002). Gaze behavioiur of children with pervasive developmental disorders toward human faces: A fixation time study. *Journal of Child Psychology and Psychiatry, 43,* 669-678.

Volkmar, F. R., Lord, C., Bailey, A., Schultz, R. T, Klin, A. (2004). Autism and pervasive developmental disorders. *Journal of Child Psychology and Psychiatry, 45*, 135-170.

Walden, T., & Field, T. (1982) Discrimination of facial expressions by preschool children. *Child Development, 53,* 1312-1319.

Walker-Smith, G. J., Gale, A. G., & Findlay, L. M. (1977). Eye movement strategies involved in face perception, *Perception, 6,* 313-326.

Wang, P. P., Doherty, S., Rourke, S. B., & Bellugi, U. (1995).Unique profile of visuo-perceptual skills in a genetic syndrome, *Brain and Cognition, 29*, 54-65.

Wang, P. P., & Bellugi, U. (1994). Williams syndrome, Down syndrome and cognitive neuroscience, *American Journal of Diseases in Children, 147*, 1246-1251.

Want, S. C., Pascalis, O., Coleman, M. & Blades, M. (2003). Recognising people from the inner or outer parts of their faces: developmental data concerning ‘unfamiliar’ faces. *British Journal of Developmental Psychology, 21,* 125-135.

Wechsler, D., (1979). *Wechsler Intelligence Scale for Children – Revised*. New York: the Psychological Corporation.

Wechsler, D. (1981). *Wechsler Adult Intelligence Scale-Revised*. San Antonio, TX: The Psychological Corporation.

Weeks, S. J., & Hobson, R. P. (1987). The salience of facial expression for autistic children. *Journal of Child Psychology and Psychiatry, 1*, 137-152.

Welchew, D. E., Ashwin, C., Berkouk, K., Salvador, R., Suckling, J., Baron-Cohen, S., & Bullmore, E. (2005). Functional Disconnectivity of the Medial Temporal Lobe in Asperger's Syndrome. *Biological Psychiatry, 57,* 991-998.

Wellman, H., Cross, D., & Watson, J. (2001). Meta-analysis of theory-of-mind development: The truth about false belief. *Child Development, 72*, 655-684.

Willemsen-Swinkels, S. H. N., Buitelaar, J. K., Weijnen, F. G., & van Engeland, H. (1998). Timing of social gaze behaviour in children with a pervasive developmental disorder. *Journal of Autism and Developmental Disorders, 28*, 199-210.

Williams, J., Barratt-Boyes, B., & Lowe, J. (1961). Supravalvular Aortic Stenosis. *Circulation, 24*, 1311 - 1318.

Williams, M. A., Moss, S. A., & Bradshaw, J. L. (2004). A unique look at face processing: The impact of masked faces on the processing of facial features. *Cognition, 91*, 155-172.

Williams, K., Wishart, J. G., Pitcairn, T. K., & Willis, D. (2005). Emotion Recognition by Children With Down Syndrome: Investigation of Specific Impairments and Error Patterns. *American Journal on Mental Retardation, 110*, 378-392.

Wimmer, H., & Perner, J. (1983) Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition, 13,* 103-128.

Wing, L. (1976). *Early childhood autism: clinical, educational and social aspects.* New York: Pergamon Press.

Wishart, J. G., & Pitcairn, T. K. (2000). Recognition of identity and expression in faces by children with Down syndrome. *American Journal on Mental Retardation, 105,* 466-479.

Wolff, P. H. (1963). Observations on the early development of smiling. In B. Foss (Ed.), *Determinants of Infant Behavior* (2nd edn). New York: John Wiley & sons.

Yarbus, A. L. (1967). *Eye movements and vision*. New York: Plenum Press.

Yin, R. K. (1969). Looking at upside down faces. *Journal of Experimental Psychology, 81*, 141-145

Young, A. W., Hay, D. C., McWeeny, K. H., Flude, B. M., & Ellis, A. W. (1985). Matching familiar and unfamiliar faces on internal and external features. *Perception, 14*, 737-746.

Young, A. W., Hellawell, D. & Hay, D. C. (1987). Configural information in face perception. *Perception, 16*, 747-759.

Appendix A

Reaction time analysis – Evidence from typical development

Reaction time data were collected for typically developing participants on a number of tasks to investigate the relationship between task accuracy and the time taken to complete the task. However, reaction time data and analyses were omitted from the thesis due to a number of reasons as outlined below:

1. Reaction time information can be unreliable when task accuracy is low. It is generally accepted that latency data are only considered for trials where the participant responds correctly (cf. Clark-Carter, 1997). Therefore when accuracy is low a large number of times must be removed and the reaction time analysis will be based on a small number of trials. This may be overcome for adult participants by increasing the number of trials, but this is problematic when working with groups who have a limited attention span.

2. Reaction time data may show a larger variance both within and between participants and therefore mean reaction time may be an unreliable measure, median measurement may be used instead if appropriate.

3. Many of the individuals with autism who took part in the research required individualised testing sessions and would have found it not only difficult, but distressing, if the session was more controlled for the use of reaction time data. Where reaction times are used for individuals with autism, the sample often comprises particularly high functioning individuals (e.g. Swettenham, Condie,

Campbell, Milne, & Coleman, 2003) and the current thesis was not constrained to the use of individuals who were high functioning on the autistic spectrum.

Table 10.1 shows the reaction times for typically developing participants carrying out a task whereby upper or lower parts of the face must be matched for identity (see Chapter 5). The table demonstrates the large variance in reaction times even for individuals with are developing typically. Incorrect responses for these typically developing young participants are shaded in grey. Reaction times are presented in milliseconds (msec). The table shows that not only was the overall variance (reported here as standard deviation) of the group large, but the individual variation between trials was particularly large. This is also evident by the difference between the mean and median for each participant. These issues render the use of reaction time data somewhat difficult for the purposes of this research.

Future research could more reliably investigate the use of reaction time methodologies for individuals with developmental disorders, but in the current thesis the focus rests on the use of accuracy data.

Table 10.1 Reaction time data (msec) for 15 typically developing participants completing a face matching task. Information provided for number of incorrect trials, mean and median reaction times and variance in time presented as standard deviation.

	trial															
Participant	1	2	3	4	5	6	7	8	9	10	11	12	No. removed	mean	SD	median
1	5234	1856	7234	1675	2765	3456	934	12764	12876	3500	9252	16543	6	6528	6516	3478
2	2345	2635	1654	3456	3450	8765	3576	1762	4187	1654	12774	1647	3	4372	3862	2635
3	3465	2451	2276	9543	13459	4550	1876	1827	1936	11424	3747	3794	2	5281	4452	2958
4	6520	1345	1654	1765	7865	1256	1498	3743	1837	3167	3736	8339	2	3954	2692	3452
5	1624	1543	734	3098	9045	5678	1398	2747	1379	1172	2847	4484	5	3192	2843	1624
6	2747	1876	987	923	5427	3466	1765	2858	3268	1783	2500	3468	1	2597	1317	2747
7	9460	1487	1654	945	5679	7090	2178	3748	2368	3459	2732	4584	2	4226	2549	3604
8	2547	1768	3765	6450	9873	9287	1762	13647	3454	3594	10823	14950	4	8667	4793	9580
9	3680	945	3464	984	8734	1345	1847	2765	1820	943	4167	3748	5	2215	1113	1847
10	3946	1273	6784	5674	4578	5433	2842	5678	4560	8762	1036	4874	3	5588	1450	5433
11	824	6285	3056	1765	4358	2765	1628	6583	4325	5426	11838	8484	6	6131	3523	5322
12	2579	2654	7653	3457	5423	2765	1747	2867	7065	2853	18364	8538	2	3906	2055	2860
13	3745	2823	2765	5433	8763	1568	3578	6482	3206	3520	1768	3858	2	4318	2038	3662
14	7994	1720	2348	3456	2346	2873	2748	4816	4059	4844	1577	3747	2	3806	1823	3602
15	6245	7345	11657	8654	11678	1876	23794	3835	3450	11862	2846	12847	2	10556	6704	11668
														5022	3182	4298

Appendix B

Physiological arousal to faces and gaze aversion in Williams syndrome – Pilot data

“the most important place to look is another’s eyes”

(Argyle & Cook, 1976; 1)

A small group of participants with Williams syndrome (WS) participated in pilot research to investigate the use of gaze aversion (GA) and the effect of direct eye contact on physiological arousal. A number of researchers have posited a 'cognitive load hypothesis' of GA (e.g. Glenberg, 1997; Glenberg, Schroeder, & Robertson, 1998), proposing that GA is applied at important points during a task (e.g. when demands are high) to avoid processing unnecessary information. Gaze aversion subsequently allows the individual to have more capacity to deploy to the task in hand and avoid an information overload. Based on evidence of extended looking behaviour in WS (e.g. Mervis et al., 2003) it was hypothesised that individuals with WS would show a lower frequency of GA, even when task demands were high.

It was also hypothesised that individuals with WS would show a lower level of physiological arousal to direct eye contact than is typically shown, thus allowing them to hold eye contact for a longer period of time (e.g. Mervis et al., 2003). It has long been recognised that there is a link between eye gaze and arousal (e.g. Nichols & Champness, 1971; Gale, Spratt, Chapman, & Smallbone, 1975). Making and holding direct eye contact with another person influences physiological arousal, leading to increased heart rate and skin conductance (e.g. Gale, Lucas, Nissim, & Harpham, 1972; Hirstein, Iversen, & Ramachandran, 2001). Specifically, direct eye contact has been found to increase arousal, where the effect is absent from averted eye gaze (e.g. Kleinke, 1986). The procedures used in this pilot study replicated those used previously with typically developing children and adults to allow some level of comparison (procedures used by Doherty-Sneddon, Bruce, Bonner, Longbotham, & Doyle, 2002; Doherty-Sneddon, Phelps, & Calderwood, submitted).

Method

Participants

Ten individuals with Williams syndrome participated, ranging from 8 years 10 months to 28 years 2 months (mean 15 years 1 month). Verbal mental age was assessed using the BPVS II (Dunn, Dunn, Whetton, & Burley, 1997) and provided a mean verbal mental age (VMA) for the group of 8 years 7 months (ranging 5 years 0 months to 17 years 6 months). The sample included 6 females and 4 males.

Three participants had to be excluded as they were unable to remain still for the GSR measurements or were unable to answer mathematics questions. Therefore the final sample was comprised of 7 participants aged 11 years 1 month to 28 years 2 months (mean 17 years 9 months, mean VMA 9 years 10 months). The final sample included 3 females and 4 males.

Stimuli and Procedure

All testing involved the experimenter sitting opposite the participant with a video-camera recording the interaction between the participant and experimenter. The video-camera was set up so that it was possible to see where the participant was directing their eye gaze at all times.

Part 1: Physiological arousal and task difficulty

Trials manipulated the direction of eye gaze (towards the experimenter versus towards the floor) and task difficulty (doing nothing, easy mathematics questions, difficult mathematics questions). By combining each of these conditions and variables, participants completed 3 trials in each condition, totalling 18 trials. The order of all trials was counterbalanced across participants. Physiological arousal / skin conductance response was measured throughout the experiment as detailed below.

The difficulty of mathematics questions was based on evidence from Paterson, Girelli, Butterworth and Karmiloff-Smith (2006) for individuals with WS. Details of questions are provided later in this section.

Part 2: Natural levels of gaze aversion as moderated by task difficulty

This part of the assessment recorded naturally occurring gaze aversion. Participants completed 9 questions in each of easy, medium and hard conditions with the order randomised (total 27 questions). The experimenter looked at the participant at the beginning of each question and gazed at participant for as long as they required to answer the mathematics question. No feedback was provided as to whether the answer was correct or not. The video-recorder was set up behind the experimenter to monitor the eye gaze behaviour of the participant for later analysis. Sample questions are provided later in this section

Skin conductance response measurement

Skin conductance response (SCR) has been found to be a reliable and sensitive method of assessing physiological arousal. The experimenter recorded electrodermal activity by connecting electrodes to the middle and index finger of the participant. These electrodes were then connected to a Biopac MP30 amplifier which fed the data to a computer. The data were recorded and displayed in microSiemens (μSiemens) for subsequent analysis.

Baseline SCL data was recorded for approximately 2 minutes prior to the experiment to allow participants to get used to the electrodes and to allow time for their arousal levels to settle. After each trial, there was a rest period of approximately 30 seconds to allow arousal levels to plateau before the subsequent trial. Two measures of activity were computed for each trial. First, the number of spontaneous skin conductance responses (SCR) exceeding 0.05μSiemens were counted. This number was expressed as a rate per 15 seconds. Secondly, the mean amplitude was calculated. The peak of each response was subtracted from the baseline skin conductance level preceding that particular response. If there was more than one response within the 15 seconds of a trial, the amplitude of each response was computed and the mean amplitude was calculated.

Results

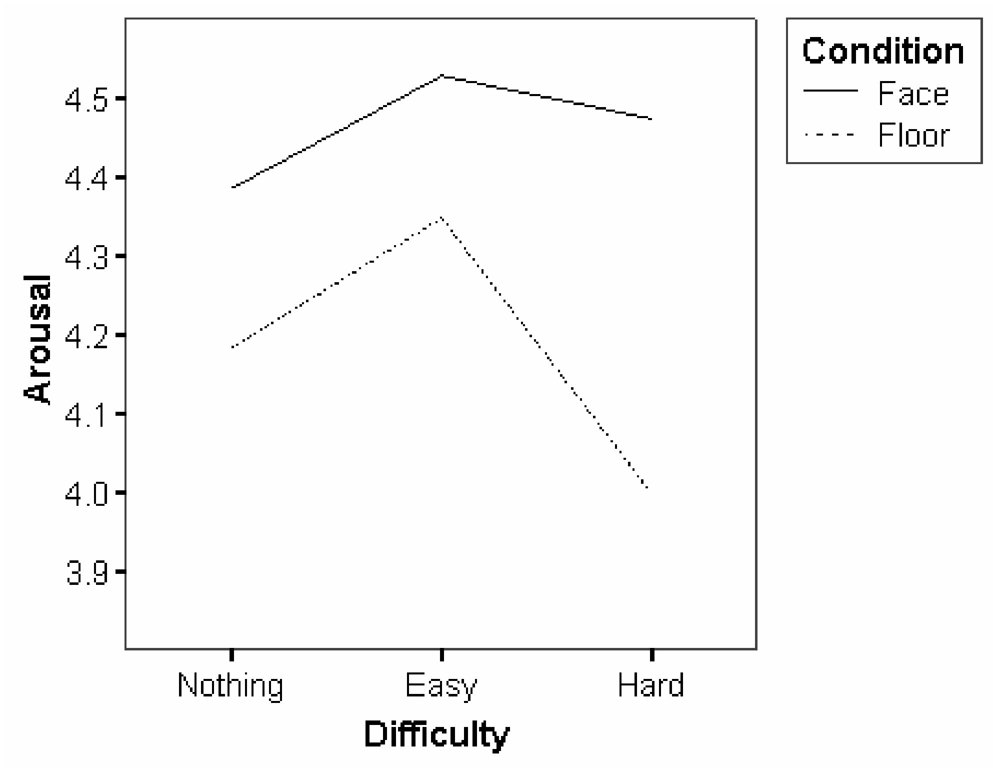
Physiological arousal and task difficulty

The galvanic skin response data[1] could be analysed in a number of ways due to the recordings that were made and the available physiological data. Results analyses were therefore conducted using three different readings i) the mean SCL for each trial ii) the number of increases of arousal greater than 0.05 iii) the size of the first amplitude change per trial. All these measures reveal the participants' level of arousal and any change in arousal associated with face or floor viewing. In summary the results were replicated using the three methods. Greater arousal was evident when looking at the experimenters' face than looking at the floor (mean SCL face 4.46, mean SCL floor 4.18; see Figure 11.1). Difficulty of questioning also effected level of arousal (mean SCL doing nothing 4.19, mean SCL easy 4.35, mean SCL hard 4.41) and as participants increased in arousal as the difficulty of the questions increased.

One important aspect of the data is the effect of face or floor viewing on the *change* in arousal level and how this effects individuals with WS compared to those who have developed typically (adults or children). The first amplitude data tells us about the change in arousal and reveals that individuals with WS showed a greater change in arousal for faces than for the floor, although this difference was not statistically significant (mean first amplitude face .39, mean floor .27; p=.15). Compared to data collected using the same methods with typically developing children aged 6-years and

[1] The recording equipment failed to mark the beginning or end of a number of trials for some participants due to a technical error and therefore video data were used to correspond the GSR data with the behaviour of the participant.

Figure 11.1 Arousal associated with face and floor viewing for participants with WS



8-years this reveals a relatively typical change in arousal associated with viewing the face and floor (combined 6- and 8-year olds from Calderwood, Doherty-Sneddon, & Phelps, in prep.; face mean .28, floor mean .27). Although these levels are slightly lower than those found with adults (mean face .99, mean floor .67; Doherty-Sneddon, Phelps, & Calderwood, submitted). Importantly the direction of any effect (greater for face than floor) is the same in this small group of participants with WS.

However, the SCL data for the individuals with WS tells a very different story and reveals that although the *change* in arousal may be relatively 'typical' the starting level of arousal is decreased in WS. The SCL for individuals with WS is compared to existing data for typically developing children and adults. The mean SCL level for face viewing in the WS sample was 4.46 and this was 4.18 for looking at the floor (overall mean SCL 4.42). This compares to an overall mean SCL for typically developing 6-year olds (across conditions using the same methods) of 11.58 and an overall mean of 13.46 for 8-year olds (Calderwood et al., in prep). This is also lower than that evident by typical adults when viewing the face (12.43) or the floor (12.05) (overall mean 12.24; Doherty-Sneddon et al., submitted). Therefore, individuals with WS generally have a lower level of physiological arousal and even though their arousal increases when they view faces, the increased level remains below that found in typical development, hence allowing them to engage in direct eye-contact for a longer period.

Gaze aversion as moderated by task difficulty

Gaze behaviour was coded from the video recording of the participant during the testing session and was categorised by the level of difficulty of the questions (easy, medium, hard). For each question the gaze behaviour was coded during the period of ‘thinking’. This period began as the experimenter finished asking a question and stopped once they began to verbalise their response. The amount of time that gaze was directed away from the experimenter was calculated as a percentage of the total time used for thinking. An analysis of variance was conducted on the percentage of time spent averting gaze with the factor Difficulty (easy, medium, hard). This revealed that the level of gaze aversion differed for questions of different difficulty $F(2,12)=11.32$, $p<.01$ (mean easy 32%, medium 43%, hard 55%). Time spent averting gaze increased as the difficulty of questioning increased. Post hoc t-tests revealed that individuals averted their gaze more for the hard questions than the medium difficulty questions (t(6)=4.23, $p<.01$ but there was no difference between the medium and easy questions ($p=.11$). However there was a great deal of individual variability as evident in Table 11.1.

Table 11.1 Percentage of time averting gaze during 'thinking time' as a function of task difficulty for the seven participants with WS

	Difficulty of Mathematic Questions			
	Easy	Medium	Hard	Overall
1	13	44	47	35
2	43	38	65	49
3	22	40	51	38
4	14	32	47	31
5	17	9	18	15
6	37	61	71	56
7	80	78	87	82
Overall	32	43	55	43

When the mean level of gaze aversion for the group is compared to that of typically developing children the results reveal that they are even lower than those shown in a typical sample of 5-year olds (mean easy questions 73%, hard questions 77%; from Doherty-Sneddon et al., 2002) who show a general lack of gaze aversion. Glenberg, Schroeder and Robertson (1998) studied adults and found that gaze aversion increased with task difficulty (although the procedure differed from that used here). For general knowledge questions answered correctly adults averted their gaze with a mean frequency of approximately 30%, whereas for questions only answered about 75% correctly (thus deemed hard) participants averted their gaze with a mean of approximately 60%. Although these results appear closer to those achieved by adults than children differences in the procedures cannot be ignored; particularly as the experimenter was not in the room and participants viewed questions on a screen for the Glenberg et al. study. Although this gives an insight into the use of GA and suggests that individuals with WS may avert their eye gaze less than is evident in typical development, further work with a larger sample size is warranted.

Brief Discussion

These preliminary results suggest that individuals with WS avert their gaze (even when cognitive demands are high) less than typically developing individuals. However, it is important that further work is conducted to provide exact matches of typically developing individuals of the same chronological age as the WS participants included here. Therefore 7 typically developing participants will be recruited for participation with the same methods employed thus far. The source of this lack of gaze aversion may be the overall lower level of arousal evident from the GSR data. This preliminary investigation of arousal levels in WS suggests that even though arousal is increased when individuals look at faces, their lower level of arousal to start with means that this increase does not reach a level that is uncomfortable. The resultant level of arousal may not be demanding enough to resort in looking away, or averted gaze. Therefore evidence of extreme and intense eye contact (e.g. Mervis et al., 2003) may be linked directly to physiological arousal levels in WS.

Table 11.1 emphasises the individual differences evident in the data. To some extent these differences in gaze aversion levels (e.g. for extreme differences see participants

5 and 7) may be related to mathematics abilities or general level of functioning. Some individuals had extreme difficulties with mathematics, hardly surprising given this is a nonverbal skill. Evidence from the BPVS data showed no correlation between verbal ability and gaze aversion levels, however the difference across domains of functioning in WS may be somewhat responsible here. Also any effect of difficulty may be complicated in the current data by the mathematics abilities of each participant. Although every effort was made to individually assess and manipulate the difficulty of questions, some individuals found all questions somewhat difficult due to deficits in this area (see participants 5 and 7 again). Therefore the effect of difficulty may actually be greater than that evident here. A larger sample size is particularly important given the extreme differences found in the gaze aversion data for these 7 individuals.

This pilot research provides a unique insight into the physiological association between arousal and gaze aversion that has previously not been studied in WS and provides evidence of the possible source of intense or exaggerated eye contact.

Physiological arousal and task difficulty

The questions below were used as the basic framework for questioning participants but depending on level of ability and individual differences the difficulty of questions was individually controlled for each participant.

Easy	**Hard**	**Nothing**
Count in 1s from 1-15	Count in 3s from 0-30	
Count in 1s from 50-70	Count backwards from 20 in 2s	
Count in 2s from 0-20	Count backwards from 50 in 2s	
Out in 10s from 0-150	Count backwards from 99 in 3s	
Count in 5s from 0-75	Count backwards from 40 in 4s	
Count in 2s from 20-40	Count backwards from 100 in 5s	

Natural levels of gaze aversion as moderated by task difficulty

Depending on level of ability and individual differences the difficulty of questions was individually controlled for each participant.

Easy

You have 1 biscuits and I give you another one. How many biscuits do you have now?
What's 2 add on 1?
You have 5 apples and I give you one more – how many do you have now?
I had 5 apples and then ate one – how many do I have now?
4 boys are playing football. 1 boy goes home. How many boys are left?
What's 2 take away 1?
What number comes before 10?
What number comes after 5?
If you have 2 sweets and I have 10 sweets, who has more sweets?

Middle

There are 2 cows and 2 horses in a field. How many animals is that altogether?
If you have 5 sweets and eat 1 of them, how many sweets would you have left?
What number comes before 50?
If there were 5 children at the park and then 3 of them went home, how many children would be left?
If you had 3 toys and I gave you another 4 toys, how many toys would that be altogether?
What's 5 add on 4?
I had 9 marbles, but lost 3 of them. How many do I have left?
What number comes after 99?
Can you count in 2s up to 20?

Hard

What's 13 add on 2?
You have 6 sweets and I give you another 8 sweets. How many sweets do you have now?
You had 12 toys and gave 7 to your friend. How many toys do you have left?
There are 3 children and each has 2 books. How many books is that altogether?
What number comes before 108?
Can you count backwards from 20 in 2s?
Chip has 13 sweets and he gives 3 to Biff. How many sweets does Chip have now?
11 children are sitting in a classroom and another 3 children come in. How many children are there now?
You have 10 computer games and lose 7 of them. How many do you have left?

Appendix C

Eye gaze and identity matching in autism– Pilot data

Two pilot tasks were carried out with individuals who have autism based on the findings of Chapter 3. One task investigated the effect of the eye region on identity matching for individuals with autism and groups of typically developing children matched for verbal mental age (VMA) and nonverbal ability (NVMA). The other task involved the same group of participants but involved eye gaze matching involving direct and averted gaze and having head and eye direction carefully controlled. The tasks were based on the Bruce et al. (2000) battery of assessments with subtle manipulations. It was hypothesised that individuals with autism would be less effected by covering the eye region for identity matching than typically developing participants. It was also hypothesised that individuals with autism would find it more difficult to process direct than averted eye gaze.

Method

Participants

Details of participants is included in Table 12.1. The participants with autism were aged between 10 years 4 months and 18 years 9 months (mean age 14 years 9 months). Two typically developing participants were individually matched to each individual with autism; one on verbal ability as measured by the British Picture Vocabulary Scale II (BPVS II; Dunn, Dunn, Whetton, & Burley, 1997), and the second on non-verbal ability assessed by the Ravens Progressive Coloured Matrices

Test (RCPM; Raven, Court, & Raven, 1990). A third typically developing group matched for chronological age was not included as the participants with autism had not previously performed at a level close to their chronological age on any assessments.

Table 12.1 Group characteristics for identity and eye gaze matching tasks

	N	CA[1]	VMA[1]	NV score[2]
Autism	10	177 *(32)*	113 *(20)*	18 *(7)*
Verbal Matches	10	112 *(21)*	114 *(19)*	24 *(5)*
Nonverbal Matches	10	93 *(21)*	98 *(19)*	18 *(6)*

1 Chronological and verbal mental ages provided in years and full months for mean and full calendar months for standard deviation

2 Nonverbal ability is provided as mean score on the Ravens coloured progressive matrices task (max. score 36)

Materials and Procedure

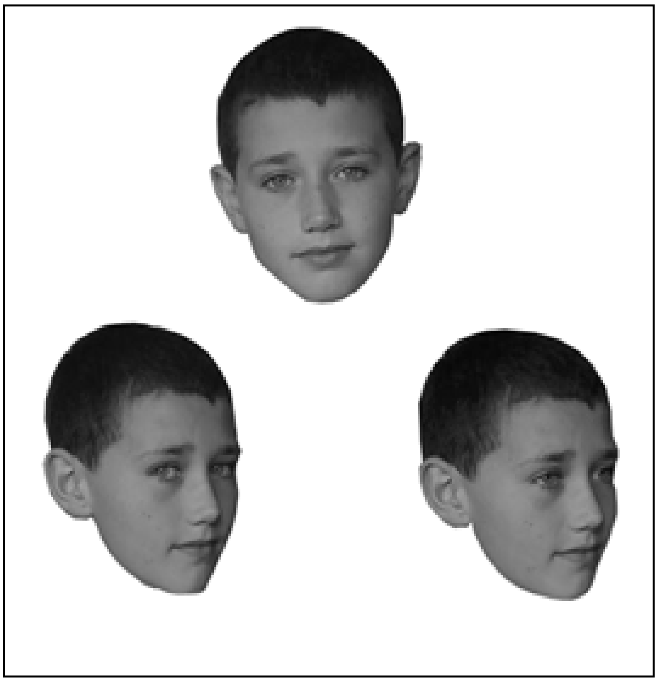
Sunglasses Task

This task had two phases; in part 1 participants carried out an identity matching task showing the whole face whilst in part 2 participants carried out the same identity matching task with the eyes covered with sunglasses. Half the participants carried out part 1 first whilst half carried out part 2 first, within this counterbalancing the order of trials was randomised.

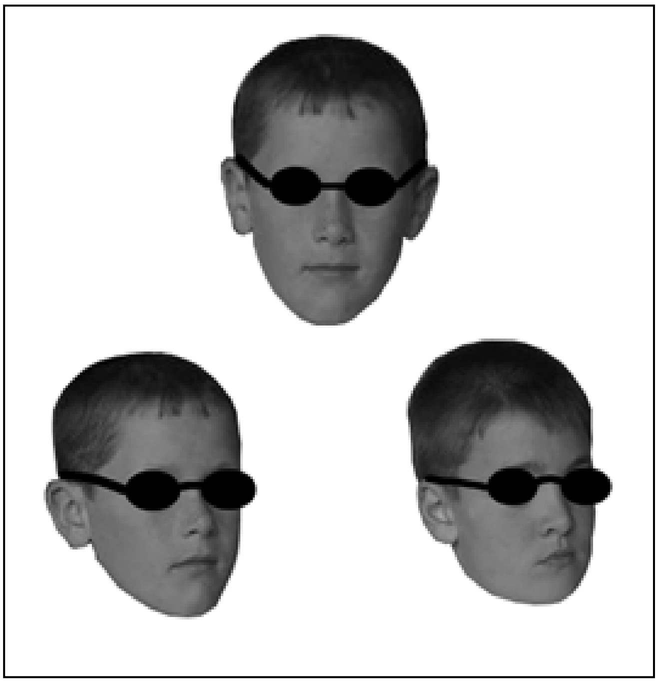
Each part of the task comprised of 12 trials, with participants matching the identity of 12 different individuals (6 female and 6 male). Participants saw three faces on the page, one at the top and two below, as evident in Figure 11.1. For each trial, the participant was required to match the identity of the face shown at the top to one of the faces seen below. The correct answer appeared on the left or right equally often. In total the participant saw each face twice, once as the target and once as the distracter. The correct answer and distracter always showed a different face orientation to the target face. The target appeared equally often as a front-view and 45degree image. The target and distracter faces were of individuals who were the same age, gender and roughly similar appearance. All faces were unfamiliar to the participants.

Figure 12.1 Task stimuli for i) eye gaze matching task ii) identity matching with eyes covered task

i)



ii)



Eye Gaze Matching: Direct versus averted gaze

For each trial the participant was asked which face at the bottom was looking in the same place as the face at the top. The trials remained in front of the participant until they provided their response and thus the task was self-paced.

This task entailed sixteen trials whereby head and eye direction were either the same (congruent) or different (incongruent). Four trials had target faces which showed direct gaze with facial orientation in the same direction as gaze. Four showed target faces with averted gaze where facial orientation was in the same direction as gaze. Four showed direct eye gaze with the face orientated in a different direction and four showed averted gaze with the face orientated in a different direction to gaze. The correct answer appeared on the left or right equally often.

Results

Sunglasses Task

Accuracy to match identity with the eyes covered by sunglasses was assessed with an ANOVA with the factors Group (autism, VMA, NVMA) and Task (whole, sunglasses). This revealed a significant effect of Group $F(2,27)=16.21$, $p<.001$. Post-hoc t tests revealed that the group with autism performed less accurately than both typically developing groups (autism-VMA $t(9)=4.48$, $p<.01$; autism-NVMA $t(9)=3.89$, $p<.01$) who did not differ from each other ($p=.59$). There was a significant effect of Task $F(1,27)=12.12$, $p<.01$ was it was easier to match identity when the whole face was on view than when the eyes were covered (whole face 77%, sunglasses 71%). Finally there was a trend for an interaction between Group and Task

F(2,27)=2.68, *p*=.08. As evident in Table 11.2, the group with autism were less affected by covering the eye region than the typically developing participants.

Table 12.2 Accuracy for matching identity with the whole face or eyes covered by sunglasses, and for gaze matching involving direct and averted gaze

	Identity Processing			Gaze Processing		
	Whole	Sunglasses	Overall	Direct	Averted	Overall
Autism	65 *(9)*	63 *(9)*	64 *(9)*	68 *(21)*	59 *(24)*	63 *(18)*
VMA	84 *(7)*	72 *(4)*	79 *(5)*	70 *(27)*	84 *(22)*	79 *(28)*
NVMA	83 *(9)*	77 *(9)*	80 *(7)*	49 *(36)*	64 *(27)*	56 *(29)*

<u>Eye Gaze Matching: Direct versus averted gaze</u>

The effect of direct or averted eye gaze on the ability to match eye gaze direction was assessed The results of direct versus averted eye gaze trials was first explored with a 2 x 3 analysis of variance (ANOVA) with the repeated factor Direction (averted, direct) and the between groups factor Group (autism, VMA, NVMA). This revealed no overall effect of direction (*p*=.14; mean averted 69%, mean direct gaze 63%) and a trend of an interaction between Direction and Group F(2,27)=6.07, *p*=.07 (see Table 11.2). This interaction was evident as the group with autism performed more accurately for direct than averted gaze trials but both typically developing matched groups performed more accurately for averted than direct gaze. Overall there was no effect of Group (*p*=.19).

The effect of head and eye congruency was investigated by a 2 x 3 ANOVA with factors Congruency (same, different) an Group (autism, VMA, NVMA). This revealed a significant effect of Congruency $F(1,27)=4.71$, $p<.05$ as eye gaze was matched more accurately when head and eye direction were different (mean same head and eye direction 63%, different head and eye directions 68%). However there was a significant interaction between Group x Congruency $F(2,27)=5.77$, $p<.05$ which showed this pattern was not evident across groups. Only the group with autism showed a significant difference between Congruency conditions, whereby different head and eye directions resulted in greater matching accuracy than the same head and eye directions ($t(9)=3.16$, $p<.05$; autism different 70%, same 56%). There was no effect of congruency in either typically developing group (VMA $p=.28$; NVMA $p=.27$). Overall there was no effect of Group ($p=.19$). Therefore the group with autism showed a different pattern of results to the typically developing matched groups.

Brief Discussion

This small group with autism did not perform in a way predicted by previous literature as they found it easier to match eye gaze direction using direct than averted eye gaze. Interestingly the typically developing groups showed the opposite pattern and found it easier to match gaze directions using averted than direct eye gaze. To confuse this issue further, individuals with autism were able to accurately detect eye and head direction cues and were more accurate matching eye gaze for incongruent than congruent images. They were therefore not basing judgements solely on head direction. In typical development participants showed equal accuracy for congruent and incongruent trials. These results need further exploration with a larger sample size to investigate the effect of direct and averted eye gaze matching in more detail. This provides a pilot study of the effect of gaze direction and identity matching but warranted further work.

Considering the effect of covering the eyes with a natural mask (sunglasses), the results reveal that individuals with autism were less affected by covering the eyes, compared to their performance when the eyes were not covered. This might suggest that, in support of previous chapters, the group with autism were not using this region of the face for their identity matching, but typically developing individuals were using this area when it was available. Further exploration is required regarding this aspect of task performance.