Face Processing Strategies in Children with Autism Spectrum Disorder

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Declaration

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ABSTRACT

The primary aim of this thesis was to investigate the face processing strategies of children with high-functioning autism. Based on the assumptions that face processing relies on holistic, configural and featural information processing of faces, and on previous findings that individuals with autism show atypicalities in configural and/or holistic face processing, experiments in the current thesis were designed in order to further investigate configural and holistic processing of faces in ASD. Experiment 1 investigated configural processing with the use of the 'Jane Task' (Mondloch, et al., 2002). Experiment 2 investigated holistic processing by replicating the part-whole paradigm (Joseph & Tanaka, 2003). Experiments 3 and 4 aimed to clarify the relationship between configural and holistic processing and their operationalisation, by applying the face distinctiveness effect paradigm (Johnston & Ellis, 1995). Experiment 5 aimed to further investigate the face inversion effect and its implications on configural processing. Overall, our participants with ASD showed typical holistic and configural face processing when faces were upright. However, when face stimuli were presented in inverted conditions, participants with ASD showed atypicalities and differences compared to a typically developing comparison group of children. It was concluded that children with ASD develop compensatory strategies for processing faces which are effective for upright faces, however when faces are upside down these strategies fail to support recognition and so impairments become apparent. Implications of the current findings are discussed in relation to the broader theories of autism as well as the face processing literature and the current paradigms used to investigate the different types of face processing

CHAPTER 1

AUTISM SPECTRUM DISORDERS: AN OVERVIEW

1.1 A history and definition of Autism Spectrum Disorders

The term "autistic" derives from the Greek word "autos", meaning "self" and was initially adopted by Bleuler in 1908 who used the word to describe the social withdrawal seen in adults with schizophrenia. However, years later, the same term was used to describe a specific psychiatric disorder. In 1943 Kanner produced the first diagnosis of childhood autism as a discrete psychiatric syndrome based on a clinical observation of 11 children (8 boys, 3 girls) and suggested a number of common features that distinguished autism from other child psychiatric disorders. Such features included the lack of social responsiveness (autistic aloneness), anxiously obsessive desire for the preservation of sameness, excellent rote memory (of large amounts of meaningless material), echolalia (immediate and delayed), oversensitivity to stimuli, and limited spontaneous activity.

A year after Kanner published his influential paper, Hans Asperger used the term "autistic psychopathy", and identified a syndrome, that now bears his name (Asperger, 1944). There were many similarities with Kanner's first proposal but there were also areas in which Asperger's and Kanner's reports disagree. One such area is the individuals' language abilities. So, whereas Kanner reported that three of his eleven patients never spoke at all, and that the other children did not use what language they had to communicate, Asperger reported that each of his four case study patients spoke fluently. Motor ability was also an area of disagreement between Kanner and Asperger, with Asperger suggesting that all four of his patients were clumsy and recounted their problems not only with school sports but also with fine motor skills such as writing (Happé, 1994). Finally, Kanner and Asperger disagreed in the area of the child's learning abilities. Kanner believed that his patients were best at learning rote fashion, but Asperger felt that his patients performed best when the child can produce spontaneously and suggests that they are “abstract thinkers” (Happé, 1994).

This disagreement between Kanner and Asperger, gave rise to a debate concerning whether Asperger’s syndrome is a type of autism or a discrete psychiatric syndrome. It was not until the work by Wing & Gould in 1979 that the picture became clearer and specific criteria were proposed for a diagnosis of autism. In an epidemiological study, Wing & Gould (1979) found a history of autism in 21.2 out of 10,000 children, as opposed to 4 per 10,000 children proposed before. This difference was due to a broader definition of impaired reciprocal social interaction suggested by Wing & Gould (1979). As a result it was proposed that the autistic person’s problems may manifest themselves differently according to age and ability – meaning that there is a spectrum of behaviours that arise from similar underlying handicaps (Wing & Gould, 1979). These underlying handicaps can be summarised by a triad of impairments in social, imaginative and symbolic functioning accompanied by repetitive behaviour (Wing & Gould, 1979).

Wing & Gould took a step further and identified subgroups within the autism spectrum disorder. They identified three subgroups, these being, the aloof subgroup which is composed of the most severely socially detached; these individuals are likely to avoid social interaction and reject physical or social contact. The passive subgroup includes individuals who are less severely impaired (do not seek out social contact but do not reject it when offered). Finally, the active-but-odd subgroup refers to individuals who may actively seek social contact but do so in an odd, often inappropriate manner. Although this classification proved quite informative, it seems that it is based on individuals' cognitive abilities with the aloof group being the most cognitively impaired and the active-but-odd group the least impaired. It is argued that, when level of cognitive impairment is controlled, the group differences disappear (Schreibman, 2005).

Nevertheless, there is now general agreement that autism is a set of disorders (known as Autistic Spectrum Disorder) and is characterised by several specific behavioural features. The two most accepted diagnostic systems are now in almost complete agreement regarding the diagnostic features of autism. These two systems are the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision (APA, 2000) and the 10th edition of the World Health Organisation's International Classification of Diseases (ICD-10, 1993). According to DSM IV-TR, the diagnostic features for Autistic Disorder include delayed or abnormal functioning in at least one of the following areas: a) social interaction, b) language as used in social communication, or c) symbolic or imaginative play, along with restricted repetitive and stereotyped patterns of behaviour, interests and activities. The diagnostic criteria for Asperger's Disorder in DSM – IV – TR are the same as those for the Autistic Disorder including no general delay in language or cognitive development.

The new, forthcoming DSM – V will revise the existing categorisation of Autistic Disorder and Asperger's Disorder. The proposed revision suggests the term Autistic Spectrum Disorder (ASD), which includes both the Autistic and Asperger's Disorder. The reason for the new categorisation is that distinctions between the disorders have been inconsistent and that a single spectrum disorder is a better reflection of the state of knowledge about pathology and clinical presentation (APA, 2010). The proposed criteria for ASD in DSM – V are limited to two (as opposed to three in DSM – IV – TR) - social/communication deficits (shown by marked deficits in verbal and non-verbal communication, lack of social reciprocity and failure to develop peer relationships) and fixated interests and repetitive behaviours (stereotyped motor or verbal behaviours or excessive adherence to routines) (APA, 2010).

1.2. Autism Spectrum Disorders: Possible Causes

According to Schreibman (2005), “When a definite aetiology for a disorder is unknown, theories of aetiology proliferate. Nowhere is this more apparent than in the field of autism” (p.75). This view highlights the disagreement among theorists regarding causes for the autism spectrum disorder, although significant progress has been made over the last few years. Specifically, aetiologies proposed range from those that insist on the effect the social environment has, and especially the parents (i.e. psychogenic theory), to those highlighting the genetic base for autism and disregard any social parental involvement.

Historically, Kanner was the first to suggest that there may be a parental involvement in the cause of autism. Kanner described parents of autistic children as aloof, cold, obsessive, intellectual, disdainful of frivolity, humourless, socially insulated and emotionally detached. However, he did not propose that this was a sole cause of autism but rather suggested an etiology resulting from the interaction of a biologically based predisposition for autism, coupled with the existence of unfavourable social conditions provided by the parents (Schreibman, 2005). On the other hand, the psychoanalyst Bruno Bettelheim insisted on the effect that parents and especially mothers have on their children's development of autism. He argued that mothers of autistic children responded to their infants' unresponsiveness pathologically, which resulted in children interpreting this behaviour as hostility and withdrew. The theory was controversial and little evidence emerged to support it. In the following years, it was established that parents of children with autism did not exhibit abnormal personality characteristics, whereas any personality characteristics that are different is possibly a result rather than a cause of the disorder (Koegel, Schreibman, O'Neil & Burke, 1983).

More recently, studies have been focused on identifying the genetic basis for autism spectrum disorders. Although a specific cause has not yet been identified, several possible genes have been proposed (O' Roak & State, 2008). One of the first studies to provide evidence for a genetic factor in autism was reported by Folstein & Rutter (1977). The authors investigated monozygotic (MZ) and dizygotic (DZ) twins, and found that four of 11 MZ twins were concordant for autism whereas none of the DZ twin pairs were concordant. Similarly, Bailey, Le Couteur, Gottesman, Bolton, Simonoff, Yuzda and Rutter (1995) have found that the concordance rate for MZ twins was 69% but for the DZ twins it was 0%. Studies that have examined the social and communication development of siblings of children with autism have found evidence of autism-related symptoms in the siblings (Bolton, MacDonald, Pickles, Rios, Goode, Crowson, Bailey & Rutter, 1994). For example, Bolton, et al. (1994) reported that 10-20% of siblings exhibit the broader autism phenotype (language, learning, communication and social impairments), whereas studies examining parents and other adult relatives of individuals with autism have also found similar communication and cognitive deficits, problems with friendships, etc. in these relatives (Piven, 2001; Hughes, Plument & Leboyer, 1999). Therefore, as it can be seen, there is a great deal of evidence for autism being a genetically-based disorder. However, which is the specific gene or how many genes are involved has not yet been established.

1.3 Theories of ASD

The research effort in autism in the last few years can be categorised in two broad areas of focus. The first one examines the understanding of the specific areas of difficulty, i.e. memory, perception, processing of faces, language, etc. The second research focus is on identifying a core deficit for the disorder. Research findings from both those foci have been extremely informative and have contributed to a greater understanding the disorder, however there are many questions that remain unanswered. So, for example although we now know a lot about the specific areas of difficulty in autism, research has produced inconsistent findings about the processes underlying those difficulties. This is not only because methodologies are different and they are developing throughout the years but also because now we know that individuals with autism constitute a very heterogeneous group. The heterogeneity of the disorder is also the reason why a specific aetiology has not yet been found, and therefore it is suggested that different cases have different causes.

The benefit of identifying the 'core deficit' or the basic problem that may underlie all the features of the autism spectrum disorder is twofold. First of all, if we would be able to identify the core deficit, then identifying the cause of autism might be possible or at least easier. Secondly, knowing the core deficit would mean that it might be possible to prevent, or provide the best treatment for affected populations. For these reasons, there is a great deal of effort expended by researchers to identify the basic problem that individuals with autism are faced with and explains their overall difficulties. In order to be able to claim that a deficit is core, then four criteria need to be met: first the deficit must be specific to autism (specificity), secondly, all individuals with autism must have the deficit (universality), third the deficit must continue to affect the individual during the developmental process (persistence) and finally, the deficit must begin early in development (precedence) (Schreibman, 2005). However, this has not proved easy, again mainly due to the heterogeneous nature and complexity of the disorder.

On the other hand, Happe and Ronald (2008) have provided a different explanation for the difficulties in identifying a single core deficit for autism. In Wing and Gould's (1979) initial proposal of a triad of impairments, social interaction, communication and imagination were supposed to co-occur, which led researchers into looking for a single account which will explain this triad. However, according to Happe and Ronald (2008) this approach is mistaken because the social and non-social aspects of autism spectrum disorders appear to have distinct causes at the genetic, cognitive and neural levels. Therefore, it is possible that autism is characterised by fractionable impairments, which means that some avenues of research may be best pursued within rather than across domains (Happe and Ronald, 2008).

Thus, it seems that being able to claim that there is a single core deficit in autism may not be possible, especially since research evidence has identified various deficits that seem to explain most, but not all of the difficulties that confront individuals with autism. The following are the three main areas that research efforts have focused in the last few years.

1.3.1 Difficulties with Theory of Mind

"Theory of Mind" (ToM) refers to the ability to understand that other people can know and understand the world differently from oneself. It emerges in typically developing children around the age of 1 ½ to 2 years (Leslie, 1978). Prior to this age, typical children appear to have difficulty in understanding that often people may not know something that they themselves know. The first and well-known test of ToM was developed by Wimmer & Perner (1983). Using a task called the Maxi Chocolate Task, Wimmer and Perner told children a story about a child named "Maxi," who places a piece of chocolate in the kitchen cabinet and then goes out to play. The story then proceeds as follows: While he is out to play, his mother moves the chocolate to another location. Later, Maxi comes home and he wants his chocolate. The test question to the child participant is, "Where will Maxi look for his chocolate?" Children younger than 4 years-old find it very difficult to answer this question correctly. According to Leslie (1987) the ability to take the perspective of others is related to the ability to form temporary representations of reality, such as when a child pretends a wooden block is a car. So the child essentially has two realities: he represents physical reality and also represents his own pretend attitude toward the proposition that "this block is a car". In the Maxi task, the child requires two realities: to understand where the chocolate is and where Maxi thinks it is. By the age of 4-5 years, children take the perspective of Maxi and answer that he will look for the chocolate in the kitchen cabinet where he left it because he does not know that his mother has moved it. At this point they show evidence of having developed ToM.

The first study to investigate whether children with autism had "theory of mind" (Baron-Cohen, Leslie and Frith, 1985) administered the 'Sally/Anne task', a version of the Maxi and the chocolate task. In the Sally-Anne task, Sally puts a marble into a basket and then leaves the room. Anne comes into the room, plays with the marble and then puts it in the box. Sally returns and the examiner then asks the child where Sally will look for the marble. In their study of children with autism, children with Down's syndrome and typically developing children, Baron-Cohen et al. found ToM deficits only in the autism group. They argued that this kind of deficit was specific to autism and could be explained by a failure to represent mental states (Baron-Cohen et al., 1985). Support for this view was provided by Happé (1993) and Tager-Flusberg (1992). Although for some years, there was relative consensus that ToM could be a core deficit in autism spectrum disorders, more recently, some critics have argued against this view. For example, from the earliest study (Baron-Cohen et al., 1985), it was clear that there was a minority of children with autism that was able to pass the false-belief task. That is, there was evidence against the universality of the deficit since not all children with autism failed the task. In addition, later evidence suggested that autism was not the only disorder in which affected individuals failed ToM tasks. Individuals with mental retardation or specific language impairment have similar difficulties (e.g. Miller, 2001; Russell, Hosie, Gray, Scott, Hunter, Banks & Macaulay, 1998) and therefore ToM impairments are not unique to ASD. Furthermore, as Tager-Flusberg (2001) suggests, there are features of autism that cannot be explained by "theory of mind", such as the repetitive behaviours and interests, savant abilities, deficits in emotional expression, etc.

Overall, it seems that there is insufficient evidence to support the claim that "theory of mind" deficits are the core deficit in autism. However, despite these criticisms, the theory of mind hypothesis of autism provides a concise view of many of the phenomenological features of autism that are not easily captured by alternative perspectives (Tager-Flusberg, 2001).

1.3.2. Executive Dysfunction

An alternative, but related explanation for autism suggests that functions such as planning, working memory, impulse control, inhibition and shifting set, as well as the initiation and monitoring of action- so-called executive functions (Duncan, 1986)- are impaired in individuals with ASD. The consequences of executive dysfunction include perseveration, failure to shift cognitive set, coupled with intact performance on routine or well-learned tasks (Hughes, 2001). It is being suggested that executive dysfunction may underlie many of the features of autism both in the social and non-social domains (Hill, 2004).

Studies investigating the different aspects of executive function separately (e.g. planning, inhibition, shifting set, self-monitoring, etc) in autism conclude that individuals with the disorder show difficulties in almost all of these aspects, although findings do not apply to all individuals across the spectrum (Ozonoff & Jensen, 1999). For example, in the Tower of London task (used to assess planning by asking participants to preplan mentally a sequence of moves to match a start set of discs to a goal and then execute the moves) children and adolescents with autism were found to be impaired (Ozonoff & Jensen, 1999; Ozonoff, Pennington & Rogers, 1991), while

Hughes, Russell & Robbins (1994) found that participants with autism performed similarly to comparison participants on 'easy' planning tasks but very poorly compared to comparison groups on 'difficult' tasks. On the basis of these findings Hill (2004) concluded that "autistic individuals do not struggle with planning across the board, but rather, difficulties with planning exist at more complex levels. In day-to-day life it is likely that planning occurs almost entirely at this complex level. This might explain why planning appears to be particularly problematic for individuals with autism in their daily lives" (p.195). Individuals with autism also perform poorly on the Wisconsin Card Sorting Task (WCST), in which participants are required to sort cards according to colour, number and shape, but then are expected to sort according to a different criterion of which they are unaware. This is a measure of set-shifting. Ozonoff & Jensen (1999) found that individuals with autism have difficulty in shifting to sort using the second of two rules, rather they continue to sort using the first rule. Finally, in tasks testing generativity – i.e. generation of novel ideas - (Turner, 1999) and self-monitoring – i.e. the ability to monitor one's own thoughts and actions - (e.g. Hughes, 1996) individuals with autism show marked impairments.

Although there is clear evidence that individuals with autism experience deficits in most areas of executive functioning, there is no consensus as to which aspects of executive function are typical of autism, and also that executive dysfunction is found in clinical conditions other than autism, such as ADHD (Hill, 2004). Therefore, these problems limit the potential to use executive dysfunction as a core deficit in autism.

1.3.3. Perception – Central Coherence Theory

Central Coherence refers to an information processing style, in which there is a tendency to process incoming information in its context. It is a drive that typically developing people possess that enables them to integrate and organise environmental information in order to construct comprehensive interpretations of situations (Schreibman, 2005). Frith (1989) was one of the first to discuss the issue of central coherence in typical populations. Specifically, she concluded that people processed information for meaning and gestalt (global) form, often at the expense of attention to or memory for details and surface structure.

When comparing performances of typical individuals and individuals with autism on central coherence, Frith (1989) found that individuals with ASD show weak central coherence, meaning that they failed to extract global information and instead showed a processing bias for featural or local information. Later evidence replicated these findings, providing support for the hypothesis (e.g. Frith & Happe, 1994) and argued that WCC theory addressed aspects of ASD that other accounts neglected, such as areas of talent, super-acute perception and lack of generalisation (Happe & Frith, 2006). At the same time, however, these studies failed to demonstrate that this theory was universal in and specific to autism. That is, evidence suggested that weak coherence may be characteristic of only a subset of the ASD population (Jarrold & Russell, 1997). Adding to this, this local information processing bias observed in autism seems to be evident in other clinical groups, such as schizophrenia, Williams syndrome, depression and right hemisphere damage (in Happe & Frith, 2006).

Although the WCC theory for autism has been very influential, it has also been challenged. Lopez, Leekam & Arts (2008), for example, have argued that in order to claim that there is a generalised WCC, then there should be weak conceptual (i.e. semantic memory task in which participants were asked to remember sets of pictures with a series of either related or unrelated objects) and weak perceptual coherence (i.e. block design task in which participants have to copy a pattern with the use of white and coloured blocks). Only when these two co-occur can a generalised weak integration mechanism be claimed. Lopez, et al. (2008) found that children with autism showed difficulties in either one of these two (conceptual or perceptual) but only very rarely in both. They, therefore, argued against the 'centrality' of coherence in autism.

Given that the notion of WCC in autism is controversial, Plaisted (2001) proposed an alternative theory that sought to better explain perceptual impairments in autism. The theory of Reduced Generalisation in autism (Plaisted, 2001) argues that the attentional and perceptual abnormalities in autism are the result of reduced generalisation, or a reduced processing of the similarities that hold between stimuli and between situations. Plaisted, O'Riordan & Baron-Cohen (1998b) found that individuals with autism performed better than a comparison group on a difficult discrimination task (i.e. one where stimuli to be discriminated shared elements and each possessed very few unique elements), and were also poorer at a task that required categorisation of two sets of stimuli (Plaisted, O'Riordan, Aitken, & Killcross, cited in Plaisted, 2001). One of the strengths of this theory is that it provides explanations for the difficulty observed in individuals with autism to generalise newly learned behaviour to a novel environment. According to the Theory of Reduced Generalisation, this is because the concepts of an individual with autism are narrower and have sharper and more clearly delineated boundaries.

A final theory, which has challenged WCC and the theory of Reduced Generalisation in autism, is the Enhanced Perceptual Functioning (EPF) model proposed by Mottron & Burack (2001) and refined by Mottron, Dawson, Soulieres, Hubert & Burack (2006). According to the model, perception plays a different and superior role in autistic cognition. The model agrees with the local bias found in individuals with autism and first proposed by the work of Frith and the WCC theory, but also challenges one main aspect of it. So, whereas WCC emphasized that local superiority was the result of some kind of deficit in constructing global aspects of global figures, EPF emphasises that a deficit in the processing of the global aspects of information may not be the reason for local bias in processing hierarchical material, and for superior performance in low-level perceptual operations (Mottron, et al., 2006). Instead, this bias is attributed to the superiority of low-level perceptual operations in people with autism (while in some cases global aspects can be typically processed by individuals with autism). In other words, the theory emphasises the principle of locally-oriented processing in autism as enhanced perceptual functioning (with possibly intact global processing). Although there is evidence to support this theory in relation to face processing (Lahaie, Mottron, Arguin, Berthiaume, Jemel & Saumier, 2006), findings from more recent studies have challenged it by showing that individuals with autism failed to reconstruct familiar objects from pieces of information. This deficit was enhanced when the stimulus lacked salient local information, suggesting that participants could not help but rely on the local salient cues to identify the object (Nakano, Ota, Kato & Kitazawa, 2010). These findings provided support for the WCC theory but failed to support the predictions of the enhanced perceptual functioning theory. Therefore this suggests that further studies are needed in order to establish claims from the EPF model proposed by Mottron and colleagues.

1.4. Face Processing

One cognitive-perceptual domain that has received a great deal of interest in the past few years and relates to the last of the theories of autism just mentioned in the previous section, is face processing. It is one of the most useful research areas, both because it can explain many of the characteristics of autism that relate to the perceptual theories described in section 1.3.3, and also because potentially it can contribute in the diagnostic criteria of the condition. In fact, it is both the social aspects underlying the processing of faces that is interesting as far as autism is concerned, as well as the development of those processes *per se*. The next chapter discusses the development of face processing in typically developing populations and those of ASD.

CHAPTER 2

FACE PROCESSING IN TYPICALLY DEVELOPING CHILDREN AND CHILDREN WITH ASD

2.1. Introduction

This chapter reviews theory and evidence relating to face processing strategies in typical development and in autism spectrum disorder. It begins by briefly discussing visual-perceptual development with particular reference to faces. This is followed by the discussion of empirical evidence which has informed the understanding of the developmental trajectories of face processing. Finally, the literature on face processing ability in ASD is discussed and areas in need of further investigation addressed in Chapters 3 to 6 are described.

2.2. Visual-perceptual development

When we refer to the visual environment, we refer to what we experience as we look around us. However, this experience is not a match of the physical environment, because it consists of fragments of object surfaces, sets of coloured and textured shapes that shift with every change in eye or head position (Johnson, 2003). Yet the mature visual system (adults) does not perceive the environment as fragmented; instead it is perceived as coherent and unified across space and time. In other words, adults' perception of the environment (objects) is holistic, whereas, as research demonstrates, neonates perceive objects as fragmented because they are limited to detecting only the surfaces of objects that are directly visible, and fail to perceive objects as continuous beyond the point of occlusion (Johnson, 2003). Thus, there appears to be a shift from an initial processing of visual stimuli largely in terms of individual components, toward later processing of more global information.

Johnson (2003) proposed three main possibilities for this change. First of all, it has been shown that there are many changes in the patterns of eye movements during infancy that may contribute to changes in visual perception. Johnson & Johnson (2000) found that 2-month old infants fixated specific parts when viewing rod-and-box displays (a procedure widely used to test perception of object unity in which a rod that is partly occluded by a box or full rod moves sideways – see Figure 2.1.). Older infants (4 months) by contrast fixated all the visible surfaces. A second possibility could be the learning that takes place and the experience people acquire through multiple exposures to everyday events in which objects become occluded and then re-emerge. Finally, neurophysiological development might account for the shift from fragmented to holistic processing, as well. Johnson (2003) speculates that this shift may result from to two kinds of neural maturation: that is, the interactions among cells and the organised cortical activity.

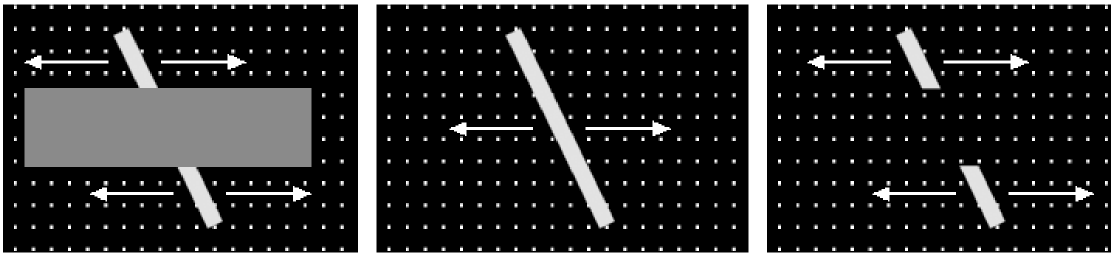


Figure 2.1. Stimuli used in the study by Johnson & Johnson (2000)

A similar shift from detail to global focus is observed in the perception of faces.

2.3. Faces as visual stimuli and the types of information contained in them

According to Freire & Lee (2003), faces are multi-dimensional visual stimuli in which the information contained can be categorised into two major categories: face states and face traits. Face states refer to information involved in processing speech, emotion, attention and intention; face traits convey information such as whether a stimulus is a face (facedness), and if it is a face, whether the face is that of a human or other animal (species), whether the face is male or female (gender), which racial group the face belongs to (race), whether the face is attractive (aesthetics), how old the face appears (age) and to whom the face belongs (face identity) (Freire & Lee, 2003).

In terms of face identity, face stimuli can be described as a collection of structural and configural/relational properties, such as up-down asymmetry in the distribution of the inner elements and a congruent spatial relation between the spatial position of those elements and the shape of the outer contour (Simion, Macchi Cassia, Turati & Valenza, 2003). At this point, it is important to note that faces comprise a unique class of visual stimuli, and that is due to the fact that, although both face and object perception are guided by local and global information, holistic processing of faces is evident in infants at birth as well as in older children and adults, whereas holistic processing of non-face objects develops over time (Johnson, 2003). The three types of information that have received the greatest attention are component (featural) information, configural or relational information, and holistic information (Schwaninger, Carbon & Leder, 2003).

Featural (or component, local, etc) information refers to separable local elements which are perceived as distinct parts of the whole, such as the eyes, nose, mouth or chin (Carey & Diamond, 1977). As Schwaninger, Carbon & Leder (2003) suggest “these components describe the basic primitives in faces and the number of dimensions on which all components can differ provides the basis for the uniqueness of all human faces” (p. 82). In other words, this “featural hypothesis” proposes that we perceive and remember faces mainly by means of facial features rather than as wholes.

Configural or relational information refers to the spatial interrelationship of facial features (Schwaninger, Carbon & Leder, 2003). Two types of configural information have been identified: a) first-order relational information for the basic arrangement of the parts (eyes above nose and nose above mouth), and b) second-order relational information that refers to the specific metric relations between features (Diamond & Carey, 1986). Although there is that distinction, in research when people talk about configural information, they refer to second-order relations, and that applies for the present review. Contrary to the featural hypothesis, the configural hypothesis holds that we perceive and remember faces by means of two kinds of information - featural and configurational. However, the importance of the latter is conceived as greater than the former (Diamond & Carey, 1986; Rhodes et al., 1993). Generally, configural information in a face is very important and has a significant impact on perception. In fact, it is the reliance on configuration that is essential for adults' expertise at processing upright faces (Leder & Bruce, 2000).

The final type of information is holistic information. In general, the term 'holistic information' refers to the idea that faces are stored as unparsed perceptual wholes in which individual parts (components) are not explicitly represented (Farah et al., 1995; Tanaka & Farah, 1993). The holistic hypothesis proposes that the recognition and perception of faces is based on the two kinds of information discussed above – featural and configural – where these kinds are perceived as a single entity, the whole face. This perceptual wholeness is difficult to break down into its parts without seriously harming perception and remembering a face and its parts (Rakover, 2002). The problematic aspect of this hypothesis is the relationship between featural and configural information in holistic processing, and that is highlighted in two different views.

The first view is the accessibility interpretation (Rakover, 2002) which argues that faces are not represented in terms of the identities of the parts (eyes, nose mouth) but rather in terms of a template-like representation of the whole (Tanaka & Farah, 1993; Farah et al., 1998). This holistic encoding has been investigated by using the part-whole paradigm. This paradigm is based on the assumption that individual parts presented in isolation should be more difficult to recognise than when the same parts are presented in the context of the whole face. This is what Tanaka & Farah (1993) found. It was also found that this effect was sensitive to orientation, and specifically it disappeared when faces were inverted. The second view of holistic encoding states that in holistic representations, the spatial relations among the parts is more important in specifying an individual face than are the representations of the individual parts. However, this seems remarkably similar to the definition of configural processing. Indeed, under this characterisation, the distinction between holistic representations and configural representations becomes blurred to the point of disappearing (Carey & Diamond, 1994). These views of face processing have been investigated in several studies with newborns, older infants, children and adults.

2.4. Development of face processing in typically developing populations

There has been a considerable research focus on face processing in children and adults in the past two decades (see Pascalis and Slater, 2003,). Face processing research involves many different aspects ranging from its neurological basis to the extent to which it involves special, dedicated mechanisms as well as its developmental trajectory both in typical development and in developmental disorders. The next section discusses the most significant of these aspects, particularly as they relate to ASD.

2.4.1. Face processing in infants

Theories on newborns' face processing skills have given rise to two hypotheses, which attempt to explain newborns' early preference for faces (Valenza et al., 1996). According to the so-called 'structural hypothesis', (Johnson & Morton, 1991), infants direct their attention to faces right after birth due to an inborn reflex-like mechanism. This mechanism is effective during the first two months of life and contains an inborn representation of the human face, including information about the spatial distribution of the main elements of the face (Schwarzer, Zauner & Korell, 2003). The second view is the so-called 'sensoric hypothesis', which argues that faces are preferred by newborns because the physical properties of the visual pattern of faces are perfectly matched to the sensory abilities of newborns (unlike other visual patterns). According to this view, faces are of great interest to newborns and carry significant amounts of information (Schwarzer, Zauner & Korell, 2003).

In a series of experiments, Valenza et al. (1996) investigated the controversial issues concerning the preference for facelike patterns in newborns. Specifically, they conducted three experiments which tested the sensoric hypothesis and the structural hypothesis. It was found that even nine minutes after birth, newborns prefer faces to other visual patterns. This finding supported the structural hypothesis. In addition, there are data to support the view that face discrimination is possible in infants only a few days old. Pascalis, Schonen, Morton, Deruelle, & Fabre-Grenet (1995), for example, found that 3-day-old neonates recognised their mother's head but not their mother's face. When presented with their mother's face and a stranger's face. However, 3-day-old infants spent longer looking at the mother. This recognition disappeared when the mother and the stranger wore a scarf that masked the hairline and the line between forehead and hair. By the end of the second month and during the third month of life, infants recognise their mother's face from their internal configuration even when the mother wore a scarf (Pascalis et al., 1995), suggesting a shift in face processing from local bias to a more holistic processing style.

Evidence for infants' configural processing comes from Cohen & Cashon (2001) who tested the 'switch design' in 7-month old infants. Infants were habituated to a particular set of faces and were then tested with a familiar habituated face, a 'switch face' and a novel face. The switch face was a composite of two habituated faces, consisting of the internal section of one face and the external section of another face. This design makes it possible to examine whether infants respond to one or more independent features of faces (analytical processing) or to a configuration of facial features. It was concluded that 7-month old infants process the configuration of the internal and external sections of faces when the faces are upright, whereas they process the sections independently of each other when the faces are inverted. Similar conclusions were drawn in a series of studies by Schwarzer & Zauner (2003) and Zauner & Schwarzer (2002) who concluded that face processing in infants depends on the age of the child and the facial feature to be processed. Specifically, between the ages of four and eight months the eyes are processed analytically, independently of the context of the whole face. The mouth is also processed analytically by 4- to 6-month-olds, but by the age of 8 months it is processed configurally (Schwarzer & Zauner, 2003).

In a study of the developmental changes in the use of different kinds of relational information in infants of 3- and 5-months old, Bhatt, Bertin, Hayden & Reed (2005) investigated the Thatcher illusion. This illusion is an orientation face illusion: a face in which the eyes and mouth are inverted relative to the rest of the face, looks grotesque when the face is shown upright but not when shown inverted (Thomson, 1980). In Bhatt, et al' s (2005) study, Thatcherised faces in an upright and inverted condition were shown as well as faces distorted in terms of their configurations (second-order and first-order relational information). They found that 5-month-olds detected second-order changes, but 3-month-olds failed to detect second-order changes. Three-month-olds did detect first-order changes, however. Also, inversion affected 5-month-olds' processing of second-order but not first-order information. These results suggested that, although sensitivity to first-order relations is available by 3 months or earlier, sensitivity to second-order information may not develop until sometime between 3 and 5 months of age (Bhatt et al., 2005). Despite of evidence of second-order relational processing in infants, the authors concluded that significant developmental changes occur in later years until adult-like face expertise is achieved (Bhatt et al., 2005).

2.4.2. Paradigms used in face processing in childhood

Despite the fact that infants already have impressive face identification abilities, face recognition continues to undergo development during the first decade of life. Young children appear to have more difficulty than adults when encoding and subsequently identifying unfamiliar faces (Schwarzer, Zauner & Korell, 2003). Marked improvement between the ages of 2 and 10 is observed on simple recognition tasks, which is explained by differences in the modes of face processing within this age range.

However, the methods used with 2- to 10-year old children differ from those used with infants. Children are too active, physically and cognitively, to participate in habituation and dishabituation studies. Therefore, it is essential to consider what exactly researchers are attempting to measure by the different methods used to test infants and children.

Generally, there is a consensus regarding the definition of featural processing and how it can be tested in facial stimuli. For example, one common paradigm is that in which specific features in a face (eyes, nose or mouth) are substituted by different ones (whereas everything else in the face remains the same), so that to create a new face that participants are asked to identify as the same as or different from the target face (e.g. Leder & Bruce, 1998; Mondloch et al., 2002, etc).

However, there is a slight problem with such paradigms: it is difficult to determine what changes in a face when one or more features are replaced with different ones. For example, Penry (1971) has argued that the substitution of only one feature greatly alters the whole facial appearance; with even a one-feature difference, the eye is tricked into assuming that the entire facial outline is different. Furthermore, one would assume that a different feature will also alter the specific metric relations in a face and, therefore, will influence configural information (another type of information contained in faces). In fact, there is an 'intrinsic connection problem' between featural and configural information since it seems that it is very difficult to attain the goal of explaining all facial phenomena by appeal to one kind of facial information such as featural or configural (Rakover, 2002). It is only by using the appropriate research designs for our purposes that we can eliminate these problems and overcome the difficulties. One such study which investigated the relationship between featural and configural processing (Collishaw, Hole & Schwaninger, 2005), found a close and complex relationship between the two types of processing. Changes of the positioning of the features altered the perception of the size of a single feature, even when spatial relationships were not changed.

One way of testing holistic processing is the part-whole paradigm, used by Tanaka and colleagues in their early research on face processing (Tanaka & Farah, 1993; Tanaka et al., 1998; Tanaka & Sengco, 1997). In this paradigm, memory for a face part is probed when the part is presented either in isolation or embedded in the whole face. The difference in performance between the two test conditions serves as an index of holistic processing (i.e. when features are better recognised within the context of the face then this shows holistic processing of faces). According to Tanaka et al. (1998), the part-whole paradigm provides a suitable test for the encoding switch hypothesis.

Despite the wide use of the part-whole paradigm there are still issues to be considered. When presenting a feature in the context of the face rather than in isolation, for example, is configural information also added? Evidence suggests that configural information is indeed added since the feature is viewed in relation to other features in the face and also in relation to the face contour. And since all these involve distances among the features and the face outline, then again configural information is more important for those who recognise the feature in the context of the whole face.

Another way of testing the holistic hypothesis is via composite face effect (Young, Hellawell & Hay,1987). In this task, the top and bottom halves of two familiar faces are used to create a new face. The two halves are either aligned or misaligned horizontally and the task is to name the person who is depicted in the top half of the image. The aligned condition is actually more difficult for adults than the misaligned condition, ostensibly because a novel holistic configuration emerges when the two face halves are aligned (Freire & Lee, 2003).

Some ways of testing configural processing include jumbled faces (changing the place of facial features which results in substantial changes in the spatial relations of the facial features – Rakover, 2001), spacing (changing the distances between the features on a target face so that to create a new face that differs from the target only in terms of the distances between the eyes or nose and mouth, Bruce, 1988) and the Thatcher illusion (Boutsen & Humphreys, 2003).

An important phenomenon in face perception is the face inversion effect. All the measurements described above and the kinds of faces they involve are typically presented in both upright and inverted conditions. The face inversion effect is the well-established observation that faces are more difficult to recognise when viewed inverted than when viewed upright (Bartlett & Searcy, 1993; Diamond & Carey, 1986; Leder & Bruce, 2000; Rhodes et al., 1993). This effect is thought to be caused by a disruption of perceptual processing of configural information as opposed to the processing of individual features or parts (Diamond & Carey, 1986). Visual processing of an upright face is sensitive to the typical spatial relations between critical face parts in their orientation-specific context (Boutsen & Humphreys, 2003). In an inverted face, this spatial configuration is altered, making configural processing less efficient. In contrast, processing of inverted faces is thought to be feature-based – that is relying on the coding of individual parts independent of their context (Diamond & Carey, 1986). More specifically, Farah, Tanaka & Drain (1995) concluded that the face inversion effect may be the result of representing complex pattern information holistically, that is with little or no part decomposition. Finally, according to Searcy & Bartlett (1996) "when mono-oriented stimuli are viewed upside down, individuals may attempt to correct their orientation through a process such as mental rotation". This argument is in line with a theory proposed by "Rock (1973), which assumes that with a complicated stimulus such as a face, correction of the entire face at once might be impossible, with the consequence that individuals might correct the orientation of each component individually" (Searcy & Bartlett, 1996).

One methodological issue that arises in face processing research concerns familiarity or unfamiliarity with face stimuli that are presented to participants during experiments. It would be expected that accuracy of recognition of a familiar face should be greater than that of an unfamiliar face. Whilst recognition of a picture of a familiar face is based on both visual information and broad semantic information about that face, recognition of an unfamiliar face is chiefly based on visual information (Rakover & Cahlon, 2003). In fact, the different processes involved in recognising familiar and unfamiliar faces are many. For instance, with familiar faces, recognition of internal features (eyes, nose, and mouth) is better than recognition of external features (hair, chin), whereas with unfamiliar faces, accuracy of recognition of internal features does not differ from the accuracy of recognition of external features (Rakover & Cahlon, 2003). Finally, according to Rakover & Cahlon (2003), the order in which the participant scans the face varies according to the type of face presented. In comparison to familiar faces, unfamiliar faces are scanned from top to bottom. This difference is explained by the hypothesis that in comparison with unfamiliar faces which are processed linearly, familiar faces are processed automatically and in parallel (Rakover & Cahlon, 2003).

Empirical support for the distinction in the processing between familiar and unfamiliar faces comes from an early study by Ellis, Shepherd and Davies (1979) who strongly argued that there could be possible dangers of treating familiar and unfamiliar faces as being equivalent stimulus materials. In that study the authors compared participants' performance in their recognition of familiar and unfamiliar faces. It was found that the recognition of familiar faces was based on the internal features whereas no difference was found between internal and external features in the recognition of unfamiliar faces. The authors concluded that theories of face recognition need to recognise the distinction between familiar and unfamiliar faces and theories of pattern recognition in general and should likewise pay heed to the apparently different ways in which familiar and unfamiliar patterns are handled by our perceptual and memory systems (Ellis, Shepherd & Davies, 1979).

2.4.3. Featural processing in childhood

Most of the research on age-related changes in face processing has been conducted on school-aged children. Relatively little is known about the face recognition abilities of children aged 2 to 4 years. This is perhaps because it is during this period that children start to develop the skills necessary to discriminate among individuals as many start to attend play-groups and nursery schools and so they are required to learn to recognise a reasonably large number of previously unfamiliar individuals. Schwarzer (2002) presented a categorisation task to children between 2 and 5 years of age in which children had to categorise faces in children-like faces or adult-like faces. The main difference between the faces was the size and shape of features (eyes, nose, mouth). It was found that 2- to 3-year old children mainly analyse single facial features, thereby still focusing alternatively on different facial features. By the age of 5, a consistent focus on a specific facial feature had been established. Overall, it seems to be the case that younger children are using a more feature-based strategy in processing faces.

On the other hand, Brace, Hole, Kemp (2001) devised a task that was suitable for children of a wide range of ages and tested the inversion effect in 2- to 4- years old children. In specific, by using a picture book to investigate face recognition, it was found that the group aged 2-4 years did not show an inversion effect but an inverted inversion effect: response times for inverted trials were significantly faster than for upright trials overall (Brace et al., 2001). The explanation provided for this finding was that responses to inverted faces are faster as these faces are processed only according to their piecemeal features. This explanation, therefore, simply pinpoints a much earlier age for the acquisition of configural processing abilities and suggests that performance is adversely affected whilst this configural processing strategy is being perfected (Brace et al., 2001).

2.4.4. Holistic processing in childhood

For decades, it has been claimed that holistic information is the most important type of information contained in facial stimuli. Farah et al. (1998) defined holistic processing of faces as the simultaneous integration of the multiple features of a face in a single perceptual representation (a gestalt). Although featural processing plays a great role in the recognition of faces, holistic processing has received greater attention in the literature. One assumption that has caused a great deal of debate between researchers is the notion that face expertise in adulthood is achieved because of holistic processing of faces (see later section 2.4.6).

There has been a debate concerning whether children as young as 6 years old process faces holistically or whether children show holistic processing after the age of 10 years. Carey & Diamond (1977) proposed the ‘encoding switch’ hypothesis of holistic processing according to which 6 year olds use a featural encoding strategy for processing faces, while at the age of 10 years, children switch to processing faces holistically. Evidence for the above suggestion came from Carey & Diamond’s (1977) studies on inversion. When children were asked to identify upright and inverted faces in an old/new paradigm, 6 year olds recognised the inverted faces equally well as they did upright faces. In contrast, 8 and 10 year olds, like adults, recognised faces better in the upright condition. Therefore, it was claimed that children initially processed faces according to their parts and then by the age of 10 switch from a piecemeal encoding approach to a holistic approach (Carey & Diamond, 1977).

The ‘encoding switch’ hypothesis was challenged by Tanaka & Farah (1993) and Tanaka et al. (1998) who proposed the holistic hypothesis according to which normal, upright faces are processed holistically whereas inverted faces are processed featurally. In fact, Tanaka et al (1998) used the part-whole paradigm and showed that by the age of 6 years children are encoding faces holistically because they recognised face parts better in the whole face conditions rather than in isolation. Surprisingly, this holistic advantage remained relatively stable from age 6 to age 10. In addition, while the older children performed better than the younger children in both the isolated-part and whole-face test conditions, the relative difference between the two conditions did not vary with age (Tanaka et al., 1998). Therefore, the authors concluded that the “results fail to support the claim that children switch from a featural encoding strategy to a holistic strategy as they grow older. Instead, it appears that, early on, children process faces holistically and the holistic advantage is maintained through adulthood” (p.491).

This finding confirmed those of Carey & Diamond (1994), who used composite faces to test face processing skills in 6- and 10-years old children. Similar to the previously mentioned study, they found that the composite effect was independent of age. Thus, the expertise effects found in adults were not the result of an increased reliance on holistic encoding. The question which arises at that point is: why, then, do children perform worse on face recognition tasks than do adults? Both children and adults process faces holistically. What therefore, accounts for these differences in performance? According to Carey & Diamond (1994), “it is possible that the age x orientation (upright vs. inverted faces) interaction that marks increasing expertise at face encoding reflects a fuller specification of the shared configuration of the face, so that the young child’s configural encoding involves many fewer features than does the 10-year-old’s or the adult’s”. They conclude, “In this case only, it is likely that expertise reflects increasing reliance on configural distinguishing features of the face” (Carey & Diamond, 1994, p. 272).

More recently, de Heering et al (2007) also demonstrated a holistic processing strategy in young children. Specifically, it was shown that when 4 - years old children are tested on the composite face effect, they perform as well as 6 year olds and adults. Therefore, it was concluded that holistic face processing was mature at 4 years of age and possibly even earlier than this (de Heering et al, 2007).

2.4.5. Configural processing in childhood

Since Carey & Diamond’s (1994) suggestion that face expertise reflects increasing reliance on configural information, research has been more focused on the differences between configural and featural processing and the circumstances under which people use the one or the other strategy when presented with faces. This kind of research was based on assumptions such as that our skills at distinguishing large numbers of faces require another type of information in addition to, or instead of, componential information (Searcy & Bartlett, 1996).

This non-componential information has been defined in several different ways, all of which implicated (directly or indirectly) the configural information contained in faces.

For instance, Sergent (1984) referred to the particular combination or conjunction of components that make up individual faces, Benson & Perret (1994) referred to the spatial deviation of faces from average or norm faces, and Bartlett & Searcy (1993) referred to the spatial configuration formed by the positioning of facial components. In the study by Searcy & Bartlett (1996), it was concluded that the processing of componential information in faces can indeed involve different operations from the processing of spatial relational information. In fact, although both configural and feature-based information are involved in face recognition and are presumably both part of the holistic representation, configural information in faces is not processed in a holistic way (Leder & Carbon, 2004).

In order to directly test the operation of featural vs. configural processing, the facial stimuli that were used avoided the confounding of local with configural information. In fact, such stimuli involved several versions of a single face stimuli, either differing in the features (eyes, mouth) or the configurations between the features (distance between eyes or between nose and mouth). When such a design was used to test adults' face processing skills, it was concluded that the critical information that is used in face recognition, and that is disrupted by inversion, consists of relations between single features (Leder & Bruce, 2000). In other words, it is the reliance on configuration that is essential for adults' expertise in processing upright faces. However, the work of Schwaninger, Ryf & Hofer (2003) demonstrated that whereas people are very sensitive in detecting configural differences, configural information is not perceived veridically, but is instead overestimated by 11-41 per cent. In fact, inversion strongly impairs configural processing in detection and recognition tasks, but the perception of configural information is much less orientation-sensitive

(Schwaninger, Ryf & Hofer, 2003). Thus, the methodology used in different studies needs always to be considered when evaluating findings.

Mondloch, Le Grand & Maurer (2002) applied the design used by Leder & Bruce (2000) in children aged 6-, 8- and 10-years old. They revealed evidence of configural processing in 6-year olds (as did previous studies). The processing, however, appeared to lag behind the development of featural processing (which appeared to be fully developed). The authors concluded that children's relatively poor performance in identifying faces is due largely to poor configural processing; an ability that develops more slowly than the processing of individual features (Mondloch, Le Grand, Maurer, 2002). Supporting evidence comes from a follow-up study by Mondloch et al. (2003) who also used faces that differed in emotional expression, head orientation, lip reading and identity. They found that the slow development of sensitivity to configural information affected children's ability to match facial identity through changes in head orientation. In contrast, emotional expression and lip reading did not appear to have an effect on children's performance that did as well as adults on these tasks (Mondloch et al., 2003).

Limited evidence exists on the processing skills of children aged 4- to 6-years. However, one noteworthy study is that of Freire & Lee (2001). They used several versions of one face differing on either the features, or configurations between the features or paraphernalia (hat on or off), to examine 4- to 7-year olds' performance. Interestingly, in conrast to the findings of Mondloch et al. (2003), Friere & Lee provided direct evidence that, children as young as 4-years of age can process both configural and featural information from an unfamiliar face and that either type of cue can be used for recognition. In addition, as far as paraphernalia information (i.e. visual information extraneous to faces, such as a hat) is concerned, paraphernalia items cause problems of identification which are stronger for configural information among the younger children (Freire & Lee, 2001; Mondloch et al., 2003).

2.4.6. Configural vs. Holistic processing

In the last few years, the distinction between configural and holistic information in faces has been challenged and reviewed (see Rossion, 2008). This is due to the fact that the definition of holistic processing of faces has been challenged and that some have questioned whether this differs from second-order configural processing. In fact, for a long time, researchers have used the two terms interchangeably, which has caused great debates as to what the two types of information represent in faces and which of the two is responsible for face expertise observed in children older than 10 years, and in adults. Developmental studies provided evidence of holistic processing in young children (Tanaka et al., 1998), whose recognition of faces improved with age (they were not experts and therefore holistic processing did not account for face expertise).

Maurer et al. (2002) have proposed a different distinction between the three types of information in faces and how these are represented. Specifically it was suggested that there are two types of information contained in faces. These are, featural (as defined before) and configural information. According to the authors, configural information represents three types of information: a) first order configural information (the basic arrangement of features in the face), b) holistic information (when the face is processed as template or Gestalt), and c) second-order configural information (the specific metric relations between the features of the face). The processing of these three types of information in a face occurs in a functional and neural order in such a way so that in order to detect each type of information individuals go through all three types until they achieve the face expertise with second-order information processing. According to Maurer et al (2002) holistic processing is the second stage after first-order processing and before second-order processing. “However, none of the existing data rules out the possibility that the three types of configural processing operate largely in parallel, or that under some conditions, a higher level can operate expertly in the absence of processing at the other levels” (Maurer et al., 2002, p.260).

The difficulty in distinguishing between holistic and configural processing is also evident in the operationalisation of holistic processing and how this is tested. As discussed in section 2.3, the paradigms used to test holistic processing are mainly the part-whole paradigm and composite faces paradigm. Although, the two paradigms are the most widely used to test the holistic hypothesis of processing faces, the extent to which they are an actual measure of this, and not configural processing is still questionable. It is arguable that by using these types of paradigms, then the definition we give to holistic processing is very similar to the definition of configural processing, if not the same. As discussed earlier, in both types of paradigms, configural information should be important since components of faces are recognised either in a whole or part of a face (which inevitably includes distances/configurations between features or parts of faces). Adding to this, the inversion effect found in both paradigms provides further support for configural encoding (since inversion disrupts configural processing). With regards to these conclusions, Carey & Diamond (1994) argue that a minimal reliance on relational features is all that is required for holistic encoding, whereas expertise at face encoding requires greater reliance on such features. This argument is logical especially when considering developmental aspects of face processing. As discussed in sections 2.4.4 and 2.4.5 , empirical evidence has shown that holistic encoding does not account for adult expertise in processing faces since children process faces holistically (Carey & Diamond, 1994) although their overall performances are not adult-like, whereas configural processing develops slowly (Mondloch et al., 2002) and becomes adult-like after the age of 10 years.

To clarify this, Leder & Carbon (2004) tested participants on the part-whole paradigm in which faces not only differed in features but also in the specific metric relations between features (second-order configural processing). It was found that the holistic advantage in the part-whole paradigm appeared in both features and configurations. They concluded that second-order configural and holistic processing are different types of processing which produce differential whole-to-parts effects and which can be studied when both sorts of information are systematically separated (Leder & Carbon, 2004).

Despite increasing research evidence suggesting that configural information in faces accounts for the face expertise found in children and adults, very recently a different hypothesis has been proposed in order to explain humans' performance in recognising faces. Rossion (2009), based on extensive investigations of the face inversion effect, proposed the perceptual field hypothesis in face processing. According to this hypothesis, the major cause of face inversion on face recognition is the disruption of a perceptual process in which the observer sees the multiple features of a whole individual upright face at once. The perceptual process is holistic because it is driven by a holistic face representation (Rossion, 2009). An inverted face cannot be perceived holistically because each feature is processed independently. Also, as previous evidence has suggested, with inverted faces it is particularly difficult to perceive the distances between facial features (configural information). According to Rossion (2009), this difficulty is a consequence of face inversion, due to a loss of holistic perception.

This argument and the importance of holistic representation of faces are also demonstrated in a recent study of a prosopagnosic patient by Van Belle, De Graef, Verfaillie, Busigny and Rossion (2010). This patient showed an inability to recognise faces following brain damage. In that study it was found that the context of a whole face assisted face recognition even if facial features were masked in typical controls but not in the patient with prosopagnosia. The authors concluded that expertise in face recognition does not rest on the ability to analyse local features sequentially but rather on the ability to see individual features of a face all at once (Van Belle, et al, 2010), thus supporting the view that faces are processed holistically.

2.4.7. Face Processing and brain activity

In order to gain a better understanding of face recognition and the underlying processes involved, the neurological evidence that has been investigated should also be considered. Research on this specific area proposes that there is a distinct pattern of brain activity when people are presented with faces. However, according to Farah (1996), for face recognition to be special it would require “functionally and anatomically distinct mechanisms from those required for other kinds of pattern recognition”. Where hemispheric asymmetry occurs, the right rather than the left hemisphere is implicated in face processing. The middle part of the right fusiform gyrus shows activation in all reported studies and has been named the 'Fusiform Face Area' (FFA) (Elgar & Campbell, 2001). Also, behavioural studies using unilateral presentation of face images generally demonstrated a right hemisphere (left visual field) superiority in face recognition.

The distinct brain activity that research refers to, along with face processing skills has an impressive start in early infancy. Evidence for this assertion comes from a study by Valenza et al. (1996) in which the authors investigated the controversial issues concerning the preference for face-like patterns in newborns, and they concluded that even nine minutes after birth, newborns prefer faces to other visual patterns. However, the specific study revealed additional findings regarding brain activity and face processing in newborns. Interestingly, the face-like pattern was fixated significantly longer in the left visual field, whereas the nonface-like pattern was fixated longer in the right visual field (Valenza et al., 1996). Valenza et al. (1996) interpreted these results in a way that suggested that this difference between the two visual fields proposes an early right-hemisphere specialisation for processing face-like patterns. This assumption is very interesting and should be taken into consideration since it argues (although without significant evidence) for a specificity of cortical processing of faces in newborns, nine minutes after birth. Furthermore, it proposes that face recognition is at least in some ways different from recognition of other types of stimuli.

This is an aspect that has been extensively investigated with the purpose of finding differences in brain activity between face and object recognition. Many such studies have included prosopagnosic patients and their behaviour towards face and object recognition. Prosopagnosia refers to the failure to recognise previously known faces, while the capacity of individuals with prosopagnosia to recognise nonface objects often appears intact (Gauthier, Berhmann & Tarr, 1999). Farah (1996) reviewed several studies with prosopagnosic individuals to determine the extent to which face processing is special. It was concluded that the systems specialised for face and object recognition are functionally independent. Put more precisely, “there is one system that is more important for face recognition than for nonface object recognition, and another system that is more important for nonface object recognition than for face recognition, and they are arranged in parallel” (Farah, 1996, p.187). Evidence for this assertion came from studies that investigated the face inversion effect (a prosopagnosic patient showed impaired face recognition but great accuracy with inverted faces) (Farah, Wilson, Drain and Tanaka, 1995), and also studies in which individuals had to learn face and nonface objects (in this type of methodology, a prosopagnostic patient was found to be very accurate with recognition of sheep faces but not human faces) (McNeil and Warrington, 1993).

On the other hand however, Gauthier, Behrmann & Tarr (1999) criticised the findings on prosopagnosic patients and raised questions regarding the modularity of face recognition as well as its theoretical and methodological foundations. In a series of studies with two prosopagnostic patients Gauthier, Behrmann & Tarr (1999) investigated specifically the response times, accuracy, the effect of the different levels of categorisation of the stimuli, etc. Considering these conditions, no significant differences were found in the behaviour of the individuals when face or nonface objects were presented to them, and therefore it was assumed that there is no sufficient evidence to propose that faces are special and their processing involves a distinct activity in human brain.

In a similar line of research, more recently Halit et al. (2004) argued that, while evidence from behavioural studies has been useful in testing hypotheses about the typical and atypical development of face processing, issues related to neural specialisation can most directly be addressed through functional neuroimaging. In other words, only by studying and recording event-related potentials (ERPs) someone is able to determine the specificity or otherwise of cortical processing of faces. Halit et al. (2004) investigated and recorded the ERPs in both adults and 3-month-old infants while they watched faces and matched visual noise stimuli. Interestingly, it was concluded that "the present results when taken together with previous ERP results comparing faces to objects, establishes conclusively that by 3 months there is some degree of specialisation of cortical processing of faces" (Halit et al., 2004). This specialisation develops over the years and it appears to be the case that in both infants and children face processing activates a greater extent of cortical tissue than in adults.

To further support this evidence, researchers have used functional magnetic resonance imaging (fMRI) to identify the exact brain area in which face processing is thought to take place (e.g. Kanwisher et al., 1997; Yovel & Kanwisher, 2004). Kanwisher et al. (1997) argued that imaging studies that have reported regions of the fusiform gyrus and other areas that were more active during face than object viewing, although they are an important start, they do not establish that these cortical regions are selectively involved in face perception. That is because "each of these findings is consistent with several alternative interpretations of the mental processes underlying the observed activations" (Kanwisher et al., 1997). Based on this assumption, Kanwisher et al. (1997) used functional magnetic resonance imaging to run multiple tests applied to the same cortical region within individual subjects to search for discrete regions of cortex specialised for face perception. Strong evidence was found that a region in the fusiform gyrus in 12 of 15 subjects responded significantly more strongly during passive viewing of face than object stimuli. More importantly it was found that this region does not respond to animal or human images or body parts, and it generalises to respond to images of faces taken from a different viewpoint

In contradiction to all the above studies, a study by Gauthier et al. (1999) provided strong evidence against the modularity of face processing. These authors demonstrated that the right fusiform gyrus is not a face-area; instead it is an expertise area (and since adults are experts in face recognition this area in the brain is activated). In specific, the authors used functional magnetic resonance imaging and measured changes associated with increasing expertise in brain areas selected for their face preference. Individual subjects were trained to recognise different families of objects called 'greebles', and then were asked to recognise them (along with face stimuli) in both upright and inverted conditions. Findings were surprising, suggesting that activation in face-specific areas can increase with expertise for novel objects. In fact, when upright greebles were compared to inverted greebles, an effect was obtained in the right hemisphere 'face areas', which was larger in the right middle fusiform gyrus (Gauthier et al., 1999). Adding to that, according to the authors, expertise is not the only factor to contribute to the specialisation of the middle fusiform gyrus for face processing. Apparently, with faces there is a categorisation process that takes place (they are recognised in a very specific level – e.g. Tom versus

Jim) which does not take place with objects. Thus, it is possible that level of categorisation accounts for a coarse specialisation in the middle fusiform gyrus and that expertise with subordinate-level recognition tasks builds on this, leading to further specialisation and to more focused activation (Gauthier et al., 1999).

At this point, the question which arises is whether then, face processing skills are an innate ability or experience-based. The findings by Gauthier et al. (1999) just described propose that face processing is experience-based and develops throughout the years, whereas all the previously mentioned studies propose the opposite; that face processing is an innate ability. Le Grand et al (2003) tested this hypothesis by comparing visually normal individuals to patients for whom visual input had been restricted mainly to one hemisphere during infancy. In this behavioural study it was found that not all face processing abilities require early visual experience. For instance, featural and contour face processing can develop normally even when visual input is absent during early infancy (Le Grand et al., 2003). On the other hand however, second-order relational (configural) processing is unique – it continues to improve long after other face processing skills are adult-like, but only if its development is initiated by visual input to the right hemisphere during early infancy (Le Grand et al., 2003). Thus, it can be assumed that, since face recognition is mostly based on configural processing and this configural processing is based on experience during early infancy, then face recognition is experience-based and not an innate mechanism in humans.

2.4.8. Development of face processing: A summary and conclusions

In summary, evidence from studies with newborn infants suggests that faces act as very special class of stimuli and there is a preference towards them (Schwarzer et al, 2003). Evidence suggests that by 5 months of age, infants can detect the first-order and second-order configural information in faces. However, the mechanisms applied are not the same observed in adults (Bhatt, et al., 2005). Configural processing undergoes development in the first decade of life, although 2 year olds can process faces configurally (Brace et al, 2001). It appears that until the age of 4 years, the way children process faces is predominately based on the featural information (Schwarzer, 2002). After the age of 4, evidence of holistic face processing is observed which is very similar to that of adults (Carey & Diamond, 1977; Tanaka et al., 1998; Tanaka & Farah, 1993; Carey & Diamond, 1994), and this holistic advantage is maintained through adulthood. However, children's performances on face tasks is still not adult-like. Research has demonstrated that this is due to configural processing not being fully developed before the age of 10 years (Mondloch et al, 2002; Carey & Diamond, 1994; Freire & Lee, 2001). And as Leder & Bruce have demonstrated it is the reliance on configurations that is essential for adult's expertise at processing upright faces.

Although these conclusions are quite well supported, problems still exist regarding the operational definitions of terms such as 'configural processing', and 'holistic processing'. Rakover (2002) suggests that while the operational definition allows researchers to get on with the job, it is not based on so solid a connection between theoretical concepts and observations.

As far as face processing and brain activation is concerned, the evidence seems to be contradictory. Research appears to be more focused on the assumption that this 'Fusiform Face Area' exists and is activated only when face stimuli are presented to individuals, and that is mainly due to three reasons outlined in the literature : first it is clear that face recognition is observed as early as a few hours after birth, second, there is support for the right hemisphere bias in processing faces, and third, there are some data to suggest that early damage to the regions of the brain that would normally subserve face recognition results in a long-term impairment, suggesting a lack of plasticity in this system (Nelson, 2001).

2.5. Face processing in ASD

"…I often get into embarrassing situations because I do not remember faces unless I have seen the people many times or they have a very distinct facial feature, such as a big beard, thick glasses, or a strange hairstyle…" (Grandin, 2006, p.69).

One of the salient characteristics of autism spectrum disorders is a failure to remember and recognise faces, as Temple Grandin's observation illustrates. Difficulties with recognising faces in individuals with autism spectrum disorders have been documented not only in the personal writings of those individuals diagnosed with the disorder (i.e. Grandin, 2006) but also in the cognitive and developmental literature.

Face processing in autism has received a great deal of attention in the last two decades, but although research evidence has been very informative at the same time evidence and conclusions appear to be controversial.

Early evidence regarding the face processing abilities of individuals with autism provided support for the hypothesis that this population is dealing with faces in an atypical / different way than typically developing individuals (Langdell, 1978). Specifically, children with autism seemed to pay greater attention to the lower half of the face (mouth section) than the upper half (eyes) that seemed to draw the attention of comparison groups (Langdell, 1978). In addition, children with autism were found not to be affected by inversion when asked to recognise faces. In fact, their performance improved when they were asked to identify inverted faces, while in the comparison group performance dropped (Langdell, 1978; Hobson, Ouston & Lee, 1988). Because of this unusual finding, it was concluded that individuals with autism employ feature-based strategies when processing faces, rather than holistic / configural strategies. Others have also argued for a general perceptual disorder, whereby children with autism may be unable to make use of configural information in faces, which leads to reduced expertise in all aspects of face perception, even emotion recognition (Davies, Bishop, Manstead & Tantam, 1994).

In later studies investigating the part-whole paradigm – in which performances in identifying face features (eyes, mouth) either in the context of the whole face or in isolation, are compared - in individuals with autism findings were not as straightforward and clear. Both Joseph & Tanaka (2003) and Lopez, Donelly, Hadwin & Leekam (2004) found evidence of holistic processing in participants with autism, although under certain conditions. Recognition by participants with autism was mainly based on the lower half of the face for holistic processing (Joseph & Tanaka, 2003) or they performed similar to comparison groups in the part-whole paradigm only when they were cued to the relevant face feature for matching (Lopez, et al, 2004). However, it was argued that based on these findings the notion of holistic processing impairment does not fully explain the processing abnormalities in autistic face recognition (Joseph & Tanaka, 2003). Rather, what is needed is a distinction between holistic, featural and configural information since intact encoding of the whole stimulus does not mean intact face expertise, and impaired face recognition does not mean dependence on parts-based analysis (Rouw & de Gelder, 2002).

Research investigating whether individuals with autism can make use of second-order configural information in faces (specific metric relations between the features) has led to conflicting conclusions. There are studies to suggest that individuals with autism are able to employ second-order configural processing when presented with face stimuli in different face processing paradigms. So, in Teunisse & de Gelder' s (2003) study, participants with autism showed the typical inversion effect when processing faces, and in a study by Rouse, Donelly, Hadwin & Brown (2004), which tested participants' performance on the Thatcher illusion, both participants with autism and typical participants were equally sensitive to the illusion and therefore had the ability to compute second-order relations among the features of a face. Adding to that, a recent study by Nishimura, Rutherford & Maurer (2008) provided strong evidence that adults with ASD show the normal composite face effect and are able to identify faces based only on second-order configural information ("Jane task" by Mondloch, Le Grand & Maurer, 2002).

On the other hand, there are studies that suggest atypicalitites in the processing of faces by individuals with ASD. Following early evidence that suggested that individuals with autism process faces in a more feature-based manner (Langdell, 1978), studies investigating second-order configural processing drew similar conclusions and in fact, suggested that it is this type of processing that accounts for the difficulties observed in autism when individuals are asked to make identity judgements.

Evidence for this notion is provided by Deruelle and her colleagues over the last few years on face processing and spatial frequencies. Different spatial frequencies convey different information about the appearance of a stimulus. High spatial frequencies represent abrupt spatial changes in the image, such as edges, and generally correspond to fine detail. Low spatial frequencies, on the other hand, represent global information about the shape, such as general orientation and proportions. Deruelle, Rondan, Gepner & Tardif (2004) found that when identification of faces was dependent on spatial frequencies, low spatial frequencies require second-order configural processing whereas high spatial frequencies require featural processing, children with autism perform better in the high spatial frequencies condition, and therefore use a feature-based strategy for processing faces. Their findings were replicated in a later study (Deruelle, Rondan, Salle-Collemiche, Bastard-Rosset and Da Fonseca, 2008) in which children had to match hybrid faces and high / low-pass filtered faces on identity, emotion or gender. The study found evidence of atypicalities in children with ASD, since the children seemed to rely more on local facial elements than did typically developing children (Deruelle, et al., 2008). Similar conclusions were reached by Wallace, Coleman and Bailey (2008). In their study, holistic processing and second-order configural processing were investigated. Holistic processing was tested by asking participants to match different faces (or cars), while configural processing was assessed by asking participants to match faces (or houses) that differed either in configurations only or in features only. Wallace et al. (2008) found an impairment in both aspects of face processing (holistic and configural) but intact object processing. Therefore, it was suggested that the consistently poor performance shown by ASD individuals represented a comprehensive cognitive impairment in face processing.

Other authors have added to this work by focusing on the precise nature of visual gaze during face processing. The study of gaze behaviour has long been used to investigate how stimuli are processed (i.e. when a person fixates at an object, its image falls on the part of the retina specialised for detailed visual processing). In the study of autism, eye-tracking studies have suggested that participants with autism spend a greater proportion of their inspection time viewing non-feature areas and less time examining core features, especially the eyes (Klin et al., 2002; Pelphrey et al., 2002; Speer et al., 2007; Spetzio et al., 2008). However, there are also studies which suggest that individuals with autism scan faces in the same way as typically developing individuals (Van der Geest et al, 2002; Bar-Haim et al, 2006). Interestingly, the type of facial stimuli that participants with autism seem to have most difficulties in is social-dynamic facial stimuli (Speer et al., 2007).

2.5.1. Neuropsychological studies of face processing in ASD

As we have discussed earlier in this chapter, research on face processing and brain activity in typical individuals has concluded that there is a specific area in the brain that is activated when individuals are presented with face stimuli (Farah, 1996; Elgar & Campbell, 2001; Halit et al., 2004). It is well established that when hemispheric asymmetry for face processing is observed, the right rather than the left hemisphere is implicated in face processing, and specifically the middle part of the right fusiform gyrus shows activation and has been named ‘Fusiform Face Area’ (FFA) (Elgar & Campbell, 2001) (See Chapter 2 for details). What about individuals with autism though? Do they show similar activation in those brain areas when presented with face stimuli? As in behavioural studies, findings across studies investigating brain activity and face processing in ASD populations are contradictory and inconsistent.

Using fMRI, Schultz et al. (2000) found no activation of the FFA in ASD individuals. Instead it was found that ASD individuals used their inferior temporal gyri (ITG) more than controls did when they processed faces, which this area (ITG) was most strongly associated with object-specific perceptual discriminations among the controls (Schultz et al., 2000). Similarly, Pierce et al. (2001) tested seven male adults with autism and eight typically developing comparison participants on face and shape perception tasks and recorded their brain activity using fMRI. In contrast to previous fMRI studies of face processing in typically developed humans, it was found that in participants with autism there was either abnormally weak or no activation in the FFA in response to the human face. However, the most surprising finding of this study was that, although there was no activation of the FFA during the tasks, participants with autism were not significantly different from typical comparison participants in terms of accuracy and response times on either the face or shape perception tasks (Pierce et al., 2001). It was concluded that as compared with typical individuals, individuals with autism ‘see’ faces utilizing different neural systems, doing so via a unique neural circuity (Pierce et al., 2001). Further to this, ventral visual cortex appears to be organised differently in individuals with autism, at least for face-specific regions, although subtle differences may also exist for other categories (Humphreys et al., 2008).

In support of fMRI studies which suggested an atypicality of brain responses to faces in autism, come studies which recorded event-related potentials to images of faces, inverted faces and objects from individuals with ASD. Both McPartland et al. (2004) and more recently Webb, Dawson, Bernier & Panagiotides (2006) found ERP evidence of atypical face processing in autism. McPartland et al. (2004) showed that, whereas in typical individuals differences in brain activity were obvious when upright vs. inverted face stimuli were presented, in autistic individuals there was no such difference, indicating less sensitivity to alteration in the configural properties of faces. Similarly, in the study by Webb et al., (2006) it was shown that 3-4 year old children with autism had slower electrical brain responses to faces (i.e. the brain responded slower than the typical 170ms – the N170 component – found in typically developing individuals) and a larger amplitude response to objects compared to children with typical development and developmental delay. Adding to that, abnormal brain activity seems to appear when familiar vs. unfamiliar face stimuli are presented to individuals with ASD. Dawson et al. (2002) argued that children with autism do not show a differential brain electrical response to their mother's vs. an unfamiliar face, but in fact, they do show that differential brain electrical response to an unfamiliar object as compared with a favourite object in the same way typical children show it.

Overall, it has been suggested that these atypical patterns reflect abnormal cortical specialisation (McPartland et al., 2004; Webb et al., 2006). Also, findings suggest that individuals with autism exhibit abnormal temporal processing of faces (McPartland et al., 2004), and that specifically, the perceptual processing of faces in autism spectrum conditions is more like the perceptual processing of objects in normal populations (Schultz et al., 2000).

Various explanations have been put forward for these findings. One explanation, which most of the research supports, is that it is likely that individuals with ASD process faces in a different manner than typical individuals, relying more on feature-based than configural analysis (Langdell, 1978; Hobson, et al, 1988; Schultz et al., 2000). Since the Fusiform Face Area is specialised for configural processing in typically developing individuals (Gauthier et al., 1999) and in individuals with ASD that area appears not to be activated, then ASD individuals might not process faces configurally. Another explanation could be the fact that children with autism are face inexperienced and therefore the FFA does not develop normally and does not appear activated when they are presented with facial stimuli. In other words, if we accept that a genetically determined specialised system for face processing exists, then autism involves a genetic abnormality that affects this system (Dawson, et al., 2002). An alternative explanation could implicate the structure and function of the amygdala. Pierce et al. (2001) confirmed previous evidence for abnormal amygdala function and structure in ASD and argued that, since during normal development the amygdala plays a key role in establishing the social significance of a face, then an absence of normal amygdala functioning would prevent many of the normal social perceptual activities of a newborn and young child. Further to that, amygdala defects probably prevent effective afferent and efferent connections with other neural regions in particular the fusiform gyrus –Fusiform Face Area (Pierce et al., 2001).

Since it has been proposed that not attending to faces and generally not been interested in faces in ASD, may explain the atypical brain function observed in this population, studies became more focused on increasing attention and motivation when presenting face stimuli. Hadjikhani et al. (2004) found an activation of the FFA and other brain areas normally involved in face processing in individuals with ASD when presented with facial stimuli compared to non-face stimuli. This finding is in contrast to previous research (e.g. Pierce et al., 2001; Schultz et al., 2000), but the authors provided explanations for this. First of all, according to Hadjikhani et al. (2004) there were technical differences between the studies and in fact, they maximised the likelihood to detect fMRI signal in the visual cortex and in the FFA. Secondly, there were differences in the stimuli and the tasks that were used. Hadjikhani et al. (2004) claimed that in previous studies, participants performed the task for faces without attending to the central features of the face. Evidence for this assertion comes form the study by Klin et al. (2002) in which it was shown that in a naturalistic social situation, individuals with autism attended either to the mouth section of a face or to the surrounding objects. According to Davidson & Dalton (2003), FFA activation to faces in children with autism is positively correlated with the amount of time spent attending to eye region of the faces. In the study by Hadjikhani et al. (2004) it was ensured that participants were attending to the inner features of the face by introducing a fixation cross at the centre of the stimuli and by emphasising that fixation on this cross should be maintained, and thus, activation in the FFA was found. Arguably, the fixation cross introduced in faces in that study could be an element of criticism since the activation might simply be the result of looking at faces with crosses in the middle of them.

Pierce, Haist, Sedaghat & Courchesne (2004) provided evidence for typical FFA activation in a group of adults with autism by presenting not only faces of strangers but also personally meaningful faces, such as mother and co-worker and therefore increasing attention and motivation. It has been suggested that dysfunction in the FFA found in other studies of autism may reflect defects in systems that modulate the FFA, rather than the FFA itself (Pierce et al., 2004).

2.6. General aims of the thesis

The literature on face processing in autism, although developed, is inconsistent. (for a review of the literature see Dawson, et al, 2005; Sasson, 2006; Bowler, 2007). Some evidence suggests that it is the processing of second-order configural properties of faces that is atypical in autism. But, further evidence is needed to confirm this idea. In addition, holistic processing needs to be investigated more systematically since this could account for some of the face processing difficulties that individuals with autism encounter.

Chapters 3 to 6, therefore, set out a series of experiments in which face processing in high-functioning children with and without autism is studied systematically. The studies focus on second-order configural processing since the majority of the research evidence suggests that this is an area of difficulty for individuals with autism. The aim is to contribute to the debate regarding the specificity of impairment in face processing in children with autism and to identify the source of such difficulties where they occur.

CHAPTER 3

EXPERIMENT 1: CONFIGURAL FACE PROCESSING IN ASD

3.1. Introduction

The aim of Experiment 1 is to investigate the specific strategies that children with autism adopt when processing static faces. Research evidence to date has not been conclusive and questions still remain about whether or not individuals with autism experience difficulties when they are asked to make identity judgements about faces. Additional issues include the underlying source of face processing impairment, and more specifically, the type of information individuals with autism attend to in faces (configural, featural or contour). This chapter addresses these issues.

3.1.1. Typical development

As discussed in Chapter 2, adult-like expertise in processing faces is not achieved in childhood before the age of 10 years (Mondloch, et al., 2002). The main reason for this is the slowness in the development of processing of configural properties in faces compared to featural processing (Mondloch et al., 2002; Leder & Bruce, 2000). Although this view has been challenged by studies that have found evidence of configural processing in children as young as 4 years of age (Friere & Lee, 2001), young children still appear to show difficulties in face processing because configural processing continually improves long after face processing skills are adult-like (Le Grand et al., 2003).

3.1.2. Face processing in ASD

Early evidence for atypical processing of faces by ASD individuals comes from Langdell (1978) who asked children with ASD, typically developing children and children with moderate learning difficulties to identify familiar peers from photographs. Participants were matched on chronological age and full scale IQ (WISC). Younger children with autism were found to be less proficient than typically developing children at judging the identity on the basis of a person's eyebrows, but both older and younger ASD children were significantly more able to identify the lower parts of the faces than were children in the comparison group (Langdell, 1978). In addition, inverted faces were also presented to the participants. In the inverted faces condition, ASD children were significantly more accurate than their matched comparison participants (Langdell, 1978). For this reason, and because it is usually expected that participants will perform worse on inverted faces because of the disruption of the configurations in a face, it was assumed that ASD children would process faces in a feature-based way. Also, the atypicality observed in their face processing skills was confirmed by the fact that the responses of children with ASD appeared to be based more on the lower part of the face (mouth section), contrary to comparison children whose responses were more based on the upper half (eyes section) (Langdell, 1978).

Hobson, Ouston & Lee (1988) attempted to replicate Langdell's findings and extend them by examining children's performance on facial emotion recognition tasks. These tasks asked participants to recognise the same emotions across different face stimuli and to recognise faces across different emotions with the aim of shedding light to the relation between identity and emotion recognition in adults with autism. In the case of inverted faces, Langdell's (1978) findings were confirmed and it was concluded that, whatever the psychological processes underlying upside-down face recognition, it appears that children with autism are employing processes or strategies that are different either in kind or in efficiency from those used by children in the comparison group (Hobson et al, 1988). However, the advantage of the mouth section in face processing found by Langdell's (1978) study was not confirmed. Hobson et al (1988) found that participants with autism relied on both the mouth and eyes section when they were to recognise a face. The most interesting finding of all, was that participants with autism appeared to have problems in emotion (when cues were reduced they suffered a decline in performance) and gender recognition (individuals with autism failed to categorise people into males and females according to their facial features). Hobson, et al (1988) argued that "autistic individuals probably recognise something about another person's identity, but we cannot with confidence say how far they comprehend the sex of the person. Most importantly, we can state reasons for doubting whether autistic individuals fully grasp the feelings that a person's face may express" (p. 451).

Similar conclusions have been drawn by other studies, such as that of Tantam, Monaghan, Nicholson, & Stirling (1989) and Davies, Bishop, Manstead, & Tantam (1994). Davies et al. (1994) extended those conclusions by arguing for a general perceptual disorder, whereby children with autism may be unable to make use of configural information in faces, which leads to reduced expertise in all aspects of face perception (even emotion recognition). Possible explanations for autistic individuals' face processing abnormalities were investigated by Boucher & Lewis (1992). They used two tasks in which children were initially asked to look at pictures of unfamiliar faces which they later had to remember among a series of foils. In their second experiment, pictures of buildings were also used. In the experiment, three hypotheses were tested. The first hypothesis was that impaired face recognition is caused by discrimination difficulties. This was not supported by the findings. The second hypothesis tested whether impaired face recognition was caused by abnormalities of looking, or by an overall inattention to faces as a distinct class of stimuli. However, this hypothesis was not confirmed either. Finally, the third hypothesis argued for an unspecified deficit in processes related to memory as a cause for autistic children's impaired face recognition. As this was not supported by the findings either, Boucher & Lewis (1992) proposed that the immediate source of the face recognition deficit may lie within the area of memory. Overall, because some children with autism performed well on the face recognition tests, but at the same time their scores correlated with fixation times (this was not the case in the comparison group), it was concluded that children with autism encode facial information using a different strategy from children without autism (Boucher & Lewis, 1992).

Similarly, Deruelle et al. (2004) confirmed these findings by showing that children with autism performed worse than comparison children on matching faces according to emotional expression, gender, lip-reading, and gaze discrimination but that they performed very similarly to comparison children on the identity-matching condition. Although this demonstrates that children with autism make use of configural information, Deruelle et al. (2004) argued that it was possible that comparison children and children with autism used different strategies despite a similar level of performance. Even though identity matching usually involves a configural analysis in typically developing children, one cannot reject the idea that children with autism could resolve the task by relying on facial components only (Deruelle et al., 2004). These authors strongly argued that children with autism use a feature-based processing for faces. The method used in their study differed from previous studies in that it manipulated low- and high-spatial frequency information in face recognition tasks. Based on the fact that configural properties of a face are better represented at a low spatial frequency level and facial features are better represented at a high spatial frequency level (Costen, Parker & Craw, 1994; Goffaux, et al., 2005), the authors showed that, whereas typical controls performed better in the low spatial frequencies condition (configurations), children with autism performed better in the high spatial frequencies condition (features). It was concluded that individuals with autism do not attend to the same information within faces as normally developing children, but nevertheless the use of different strategy does not preclude good performance in facial identity recognition (Deruelle et al., 2004).

Neuropsychological evidence has provided support for the above since in a number of studies investigating the activation of Fusiform Face Area, no typical activation has been found in participants with autism (Schultz, Gauthier, Klin, Fulbright, Anderson, Volkmar, Skudlarski, Lacadie, Cohen & Gore, 2000; McPartland, Dawson, Webb, Panagiotides, & Carver, 2004; Webb, Dawson, Bernier & Panagiotides, 2006; Humphreys, Hasson, Avidan, Minshew & Behrmann, 2008). As discussed in Chapter 2, individuals with autism seemed to activate object-specific perceptual brain areas when presented with face stimuli (Schultz et al, 2000), while when looking at differences between upright and inverted faces, the typical difference found in the brain activation of typical participants was not found in participants with autism, indicating less sensitivity to alteration in the configural properties of faces (McPartland et al., 2004). Interestingly, in a study by Pierce, Muller, Ambrose, Allen, Courchesne (2001) it has also been found that although participants with autism did not show behavioural differences in their performance on the face tasks compared to comparison group, no activation of the FFA was found. It was concluded that compared to typical individuals, individuals with autism 'see' faces utilising different neural systems, using a unique neural circuity (Pierce et al., 2001).

Configural processing of faces has also been investigated in ASD using the paradigms applied to typically developing populations. For instance, Teunisse & de Gelder (2003) tested adolescents with autism on inverted and composite faces, which are both techniques that tap configural processing (if the effect appears in the performance of the participants). In their first experiment Teunisse & de Gelder (2003) tested the autism group on the inversion effect with a task with reduced memory demands. By contrast with previous research (Hobson, et al, 1988; Langdell, 1978; Tantam et al., 1989), which argued that people with autism show no inversion effect for faces, Teunisse & de Gelder (2003) showed that adolescents with autism recognised upright faces more accurately and faster than inverted faces. Furthermore, for the individuals with autism there was a larger inversion effect for faces than for objects (shoes). However, what is noteable is the finding that the inversion effect was obtained only in those individuals with autism with high social intelligence scores (as measured by WAIS-Picture Arrangement and the Social Interpretation Test). Therefore, there were still some individuals with autism who performed relatively poorly with upright presentations (Teunisse & de Gelder, 2003). In the second experiment, the authors tested the same adolescents with autism on a composite task and interestingly the results were in line with the hypothesis that individuals with autism make less use of the configural information of a face, which is not in accordance with the results on the inversion task. Teunisse & de Gelder (2003) discussed those findings by arguing that the composite faces task is perception-based as it involves a visual search of the composite faces. Individuals with autism did not show the composite effect, suggesting that their visual search strategies are influenced to a much lesser degree by the embedding context (Teunisse & de Gelder, 2003). In other words, it was concluded that most adolescents with autism do not have an inability to form a configuration-based face representation but that they are less prone to use contextual information in a perceptual task (Teunisse & de Gelder, 2003).

The assumption that individuals with autism do not have an inability to process faces configurally was also supported by Rouse, Donnelly, Hadwin, & Brown, (2004). By testing typically developing children and children with autism on the Thatcher illusion, they found that both groups were equally sensitive to the illusion and, therefore, had the ability to compute second-order (configural) relations between the features of a face (Rouse et al., 2004).

In support of this, Nishimura, et al. (2008) provided strong evidence for typical processing of faces by adults with ASD. In a series of studies investigating holistic processing (composite faces task) and configural processing ("Jane task" by Mondloch et al., 2002) Nishimura and colleagues (2008) showed that adults with ASD demonstrated normal holistic processing and normal sensitivity to second-order relations in both upright and inverted faces, thus providing evidence of configural processing of unfamiliar faces.

Such findings are also supported by studies investigating brain activity when participants are performing face tasks. It has been found, that when participants with autism are cued to attend to the inner features of the face or when generally attention and motivation are increased then typical activation of the Fusiform Face Area is observed, which therefore suggests that faces are processed in a typical manner by individuals with ASD (Hadjikhani, Joseph, Snyder, Chabris, Clark, Steele, McGrath, Vangel, Aharon, Feczko, Harris & Tager-Flusberg, 2004; Pierce, Haist, Sedaghat & Courchesne, 2004)

Recently, Wallace, et al. (2008) published a well-controlled study investigating second-order configural and holistic processing of faces and objects in a group of adults with autism. The two types of processing were studied separately with the use of two different computerised tasks. In addition, the Benton Test of Facial Recognition (BTFR) (Benton et al., 1983) was administered to compare group performance on a standardised neuropsychological measure of face processing and so that correlations between BTFR score and accuracy on the two computerised tasks could be calculated, thereby validating the tasks' use in future neuropsychological studies (Wallace et al., 2008). In the study of holistic processing, participants had to decide if two faces or cars (presented sequentially with the first stimulus presented only for 40 msecs) were the same or different. In the study of second-order configural processing, pictures of faces and houses were altered in terms of the second-order configural and feature properties and participants had to make same / different judgements about two stimuli presented sequentially. Performance accuracy on all three tests correlated with each other suggesting that although the three face tasks differed in design, they assessed related skills (Wallace et al., 2008). The findings revealed that adults with autism performed significantly worse than the comparison group on both holistic and second-order configural tasks, as well as on the BTFR and Wallace et al. (2008) concluded that the consistently poor performance shown by the clinical group represented a comprehensive cognitive impairment in face processing. However, what needs to be pointed out is that the noticeable heterogeneity in face superiority amongst individuals with ASD found in the study possibly suggests that face processing is impaired in some individuals with ASD but not all (Wallace et al., 2008). Alternatively, some higher functioning individuals with ASD may be more flexible and will have developed strategies to cope with difficulties in processing faces.

Interestingly, the assumption that individuals with autism might use different strategies for face recognition, was supported by Deruelle et al. (2008) who investigated face categorisation strategies in children with ASD. Children had to match hybrid faces and high and low – pass filtered faces on either identity, emotion or gender, and findings revealed efficient face processing abilities in children with ASD, although there were underlying atypical processing strategies observed in the clinical group. In particular, children with ASD were found to rely more on local elements of the face than were typically developing individuals (Deruelle et al., 2008). In addition, Deruelle et al., (2008) highlighted evidence for flexibility in the use of different indices depending on the task, because, for identity and emotion categorisation, children with ASD relied more on features rather than configurations but for gender categorisation they relied on configurations in the same way that typical controls did.

A slightly different approach was adopted by Lahaie, Mottron, Arguin, Berthiaume, Jemel & Saunuer (2006) who argued that individuals with ASD do not have any problems processing configural information in faces. However, they prefer to process features when they are presented with face stimuli. The authors studied the inversion effect (which was found to be normal in all groups) and the priming paradigm (which showed similar results). However, in the second experiment participants with autism showed a superior effect of a single natural facial part on recognition relative to typically developing control participants. Therefore, it was concluded that people with ASD show an enhanced local processing of faces - which explained previous findings of featural processing in autism (Hobson et al, 1988; Deruelle et al, 2004), but without an impairment in configural processing (Lahaie et al, 2006).

To sum up, evidence from behavioural as well as neuropsychological studies seems to be quite contradictory rather than conclusive. Some of the findings across different studies seem to suggest that individuals with ASD are characterised by an impairment in processing second-order configural information from faces, an ability essential for the development of face expertise (Deruelle et al., 2004; Wallace et al., 2008; Deruelle et al., 2008; Pierce et al., 2001; Humphreys et al., 2008; McPartland et al., 2004; Webb et al., 2006). On the other hand, there is also evidence to suggest that individuals with ASD are not faced by any kind of impairment and their face processing abilities are very similar to those of typically developing groups (Rouse et al., 2004; Nishimura et al., 2007; Hadjikhani et al., 2004; Pierce et al., 2004). Therefore, the question still remains. Are individuals with autism characterised by an impairment in processing faces? What seems to be the case is that there is definitely a difference in processing style (if not impairment), however, the nature and source of this different processing style of faces in autism have not been defined yet. Is it second-order configural information that individuals with autism fail to process? Or is it just their preference for processing featural information as Lahaie et al., (2006) proposed? Further evidence is needed to establish this.

3.1.3. Experiment 1

In the current experiment, a new paradigm which has previously been administered to typically developing children by Mondloch, Le Grand, and Maurer (2002), will be administered to children with autism. According to Mondloch et al. (2002), this paradigm is differentially sensitive to featural versus configural processing, and is, therefore, ideally suited to answer the question of what kind of processing style children with autism use for faces.

Children’s ages in the current experiment range between 6.5 and 12.3 years. The specific age range has been chosen because most of the research evidence suggests that by the age of 6 years, children show evidence of configural and holistic face processing (Mondloch et al., 2003; Tanaka & Farah, 1993; Tanaka et al., 1998; Freire & Lee, 2001). Specifically, as it has been seen in Chapter 2 (sections 2.4.4 and 2.4.5), the work by Tanaka and his collegues has suggested that 6 year olds show the holistic advantage in the part-whole paradigm, as opposed to the work of Carey & Diamond (1977) who proposed the encoding switch hypothesis of holistic processing taking place at the age of 10 years. Similarly, although Mondloch et al. (2003) suggested that configural processing is evident in 6 year olds and is adult-like after the age of 8 years, the work of Freire & Lee (2001) has shown that even at the age of 4 years children are capable of processing the configural properties of faces similarly to the featural ones. The ages of our children therefore are correctly chosen in terms of the processing type (i.e. configural) that is tested by the current experiment.

Given that in Langdell (1978) and later studies such as Lahaie, et al (2006) participants with autism performed better in featural processing, it is hypothesised that children with ASD will show superior performance when processing of faces is based on features in the current experiment. When configural properties are altered, we would predict worse performance and no inversion effect (which is expected to be found in typically developing children). Finally, no predictions can be made for the faces in which the contour is changed as the processing of those faces involves both featural and configural information to be processed, although not central to the face (features: chin, forehead, etc; configurations: distance between mouth and face outline, etc).

3.2. Method

3.2.1. Participants

Two groups of children were recruited. Twenty children (all boys, mean chronological age = 9.4 years, age range = 7.3 – 12.3 years, SD = 1.4) with high-functioning autism were recruited through specialised schools for autism spectrum disorders in London. Diagnosis was confirmed by teachers' records of children's statements. The comparison group consisted of 20 children (all boys) all in mainstream school, and without any recorded developmental disorders (according to parental report). Both groups were matched for chronological age, Verbal Mental Age (based on the British Picture Vocabulary Scale - Dunn, Dunn, Whetton & Burley, 1997), Verbal IQ (BPVS) and raw scores on Raven's Standard Progressive Matrices (Ravens, 1958) (Table 3.1 presents demographic information). Participants were recruited through various schools in London, and both the head of the school and the parent/carer formally consented to the child's participation in the study (see Appendix 1 for sample information letter and consent form and Appendix 2 for participants' overlap across experiments). The study was approved by City University's Ethics Committee.

Table 3.1. Participants' chronological age (CA) in years and months, verbal mental age (VMA), VIQ scores, and Raven's Progressive Matrices*.

	Autism (n=20)			Comparison (n=20)		
	M	(SD)	Range	M	(SD)	Range
Chronological Age	9.4	(1.4)	7.3-12.3	8.9	(1.2)	6.5-10.5
Verbal Mental Age (BPVS)	9.4	(2.7)	5.4-14.8	9.4	(2.5)	5.1-13.6
Verbal IQ (BPVS)	99.1	(15.1)	71-120	103.2	(13.9)	79-123
RSPM (raw score)	24.2	(10.5)	6-45	28.9	(8.6)	13-42

* Analysis revealed no significant differences between the two groups in the different measures (**CA**: t= 1.12, df=38, p= 0.26; **VMA**: t= -0.08, df= 38, p= 0.93; **VIQ**: t= -0.8, df= 38, p= 0.37; **RSPM**: t= -1.55, df= 38, p= 0.12)

3.2.2. Stimuli and apparatus

Faces were created according to the procedure used by Mondloch et al. (2002). A grey-scale photograph of a female face (model face) was taken with an electronic camera, which was then modified with the graphics software program Adobe Photoshop 8.0 in order to create twelve different versions. To encourage processing of the internal portion of the face and to discourage reliance on non-face features, the model did not wear any jewellery or glasses, and a surgical cap covered the hair and ears. A single face was used, and the first four different versions of it were created. The newly created photographs (featural set – Figure 3.2) differed from the model face by eyes and mouth. Specifically, the four faces in the featural set were created by replacing the model's eyes and mouth with ones of very similar in shape and size taken from photographs of other females. Similar shape features were chosen because we wanted to avoid any changes in the spacing among features. The same model face was modified to create the second set of four faces which differed according to the spacing between the features (spacing/configural set – Figure 3.1). In each created face, eyes were moved closer together or farther apart, by 4mm relative to the original face, and the mouth was moved up or down by 2mm. In the original study by Mondloch et al. (2002) the same distances were used; they reported that by increasing the distances, the inversion effect is eliminated. Anthropometric norms, also support these alterations (Farkas, 1981, cited in Mondloch et al., 2002) Finally, the four faces in the contour set were created by pasting the internal portion of the original face within the outer contour of four different females. Therefore, features and internal spacing between the features remained constant (Figure 3.3). The control stimuli consisted of the original face and three different faces that differed from the original in features, spacing and outer contour. The stimuli were presented on a Toshiba Tecra A2 Lap Top with 17” monitor.

Figure 3.1. Faces in the configural / spacing set

Figure 3.2. Faces in the featural set

Figure 3.3. Faces in the contour set

3.2.3. Procedure

Participants were tested individually, during school times, in a separate quiet room. On the first visit, children were assessed on the BPVS while on a second visit the Raven’s Standard Progressive Matrices was administered. On all visits, short breaks were offered between the tests as well as praise and rewards for children’s work, appropriate to maintaining their motivation. On the third visit the face processing task was administered.

In order to make the task more interesting to the children, they were told that the task was a game. They were shown the photograph of the target face on the laptop monitor and told that her name was ‘Jane’. Following this, children were presented with the modified faces and were told that these were ‘Jane’s sisters’, who look very much like Jane but they are not exactly the same. According to the story, Jane and her sisters are playing games with people and try to confuse them in terms of who is who. The children’s task was to make sure that Jane and her sisters do not confuse them, and they can always tell if the sisters that appear on the screen are the same or different by clicking on the appropriate button on the mouse (left button for SAME and right button for DIFFERENT).

Prior to the face task, participants were given 12 practice trials. During each trial of the practice task, children were presented with either two identical faces or two radically different versions of a face (e.g. a face with eyes rotated 45^{o} clockwise paired with the same face with the eyes rotated counterclockwise) on the laptop monitor. They had to indicate whether the two face stimuli were same or different by clicking on the appropriate button on the mouse. Each of the first three pairs of faces was presented side-by-side and feedback was provided on the participant's response.

All participants were presented with 90 upright trials followed by 90 inverted trials. The 90 trials were divided into three, 30-trial blocks: configural, featural, and external contour (one 30-trial block each visit). Trials were blocked to encourage participants to use specific face processing strategies. Therefore, at each visit, participants completed one 30-trial block of upright faces, and one 30-trial block of inverted faces (60 trials per visit, all of them either on configural, featural or external contour). For each participant, the order in which blocks were presented was the same for upright and inverted trials. Three orders were used: configural-featural-contour, featural-contour-configural, and contour-configural-featural. Within each block the correct response was 'same' for half of the trials. At the end of each session, the control trials were administered in order to ensure that children are attending and they are still 'playing the game'.

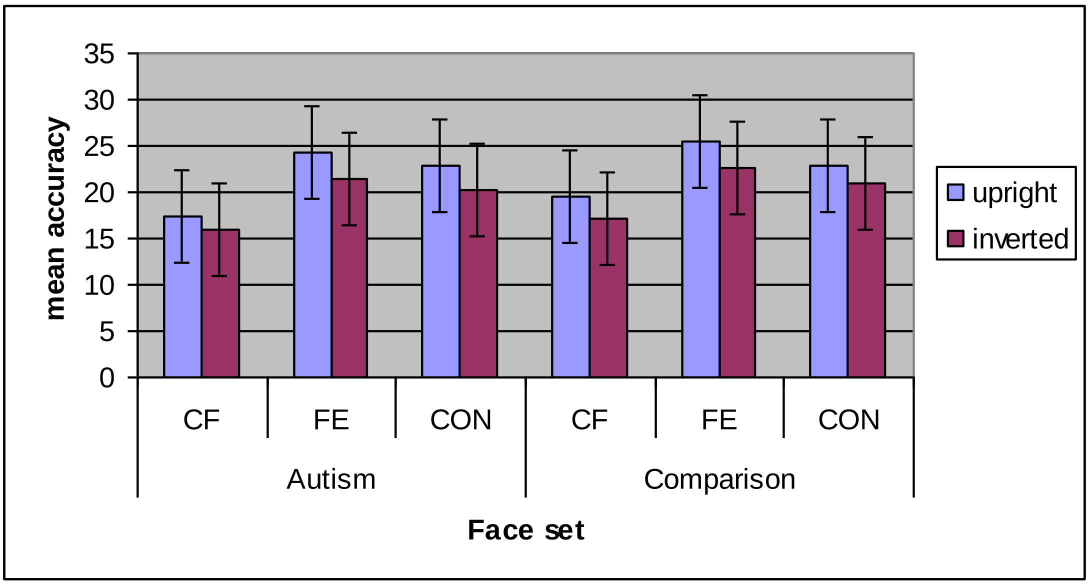
During each trial the model face appeared for 900 msec. After an interstimulus interval of 300 msec, the test face appeared on the screen until the participant gave a response. Participants were warned that faces would appear on the screen for a short period of time, so they had to look carefully. The participant had to click on the 'same' button (right click on the mouse) if he thought that the second face (test face) was the same as the one that appeared before, or the 'different' button (left click on the mouse) if he thought that the two faces were different. Pilot testing determined the duration of presentation and confirmed that the presentation time was sufficient to allow the child to form an initial impression of the face.

3.3. Results

Correlations were calculated between the dependent variables (performance on configural, featural, contour, configural inverted, featural inverted and contour inverted) and participants' mental age (MA), VIQ (verbal IQ) and score on Raven's. The analysis revealed one significant correlation between MA and performance on the contour set ($r = .40$, $N= 40$, $p< .01$). The remaining correlations were not significant (max $r = .31$, min $p= .052$). Therefore, MA, VIQ and Raven's scores were not included as covariates in the following analyses.

Mean accuracies of the autism and comparison group are illustrated in Figure 3.4.

Figure 3.4. Mean recognition accuracy scores of participants in the Autism and Comparison group in the three face sets (CF: configural, FE: featural, CON: contour) for the upright and inverted conditions



3.3.1. Overall Accuracy

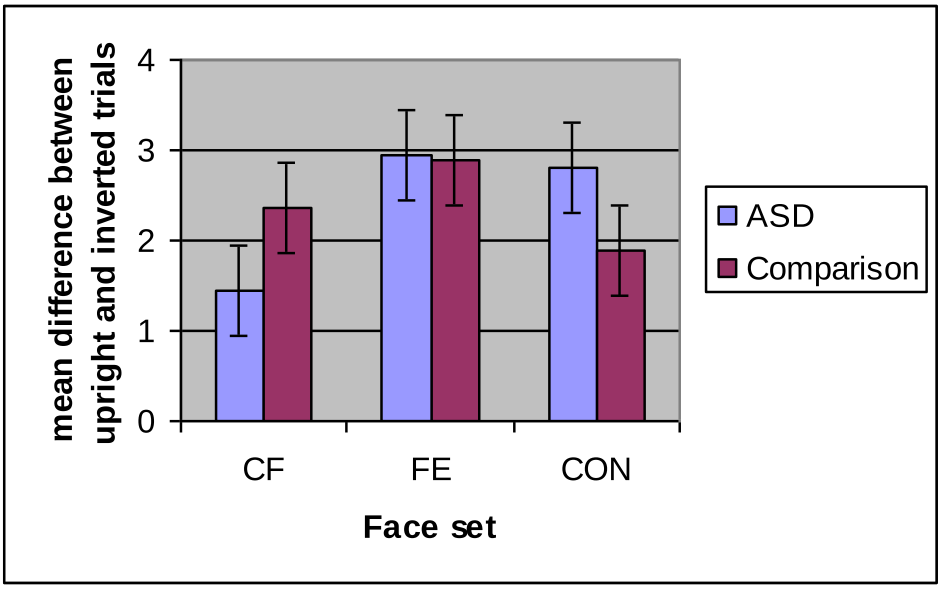
For overall accuracy a 2 (group) x 3 (face set) x 2 (orientation) mixed ANOVA was carried out, with group as the between-subjects variable (autism vs. comparison group) and within-subjects variables, face set (configural, featural and contour) and orientation (upright vs. inverted). There was a significant main effect of face set ($F(2, 38) = 73.03$, $p < .01$). Participants in both groups performed better in the featural than the configural and contour set. There was a significant main effect of orientation ($F(1, 38) = 63.95$, $p < .01$), with participants performing better in the upright than the inverted condition, as predicted. The main effect of group was not significant ($F(1, 38) = 1.62$, $p = .21$). No significant interactions were found (max $F = .85$, min $p = .43$).

Since our main question was whether high-functioning children with autism are characterised by a difficulty in processing configural information in faces, we examined whether the two groups differed in their performance only on upright faces that differed in second-order configurations. The independent *t*-test on participants' accuracy revealed a significant difference between groups with the comparison group performing better in making same / different judgements when faces differed in second-order configurations ($t(38) = -2.06$, $p = .046$). However, this should be interpreted with caution since the main analysis did not reveal any statistically significant interaction.

3.3.2. Inversion effect

In order to examine the inversion effect, the difference between upright and inverted trials for each set was calculated and a mixed 2 x 3 ANOVA was conducted with group as a between-subjects factor and face set as a within-subjects factor (configural, featural, contour). The analysis found no significant main effect of group (F (1,38) = .001, p= .97) or face set (F (2,76)= .83, p= .44). No statistically significant interaction was found (F (2,76)= .63, p= .53) (see Figure 3.5).

Figure 3.5. The face inversion effect (difference between upright and inverted trials) in each face set (CF: configural, FE: featural, CON: contour)



Power Analysis: A post-hoc power analysis was carried out in order to determine the power of the test used. The program used to make the necessary calculations was GPOWER (Erdfelder, Faul & Buchner, 1996). The number of participants in our experiment was 40, and the number of IVs was 6. We inserted the means for each IV in GPOWER which automatically calculated an effect size of .61. According to Cohen (1988), any effect size between 0.5 and 0.8 is condidered medium. Overall, the power of the test was calculated to be .96.

3.4. Discussion

The present study aimed to investigate the specific face processing strategies adopted by children with autism and whether these differed from the strategies used by typically developing children. A second specific aim was to examine second-order configural processing and whether children with autism show atypicalities when they are asked to make identity judgements when based on this criterion, as previous studies have indicated. For this purpose, a paradigm that has been found to be differentially sensitive to featural versus configural processing (Mondloch et al., 2002) was administered. Three sets of faces were created (by manipulating a single face), these being a) spacing / configural set in which faces differed only in the distances between the eyes and nose-mouth and therefore any identity decision is based in the processing of second-order configural information; b) featural set in which faces differed only in the eyes and mouth and therefore featural processing is required when asked to make identity decisions; and c) contour set in which faces differed only in the face contour. In the last case we assume that processing of these faces should be based more on processing external features / distances of faces rather than internal (central to the face). Face stimuli in all sets were presented in both upright and inverted orientation so that we are able to establish the size of inversion effect (evidence of second-order configural processing).

Overall, no statistically significant difference between the two groups was found in terms of recognition accuracy: high-functioning children with autism appeared to perform similarly to typically developing children without any signs of atypical face processing abilities.

One issue that needs to be addressed before we attempt to explain our findings in relation to findings from previous studies, is the possibility of our participants performing at chance level, especially in the ‘configural’ set of faces. As it can be seen from Figure 3.4, participants’ performance in the ‘configural’ set is just above chance (chance level would be defined by a mean accuracy of 15 since 30 is the maximum correct response), which could be interpreted as showing that this was a very difficult condition for both groups of participants. This is a possibility which could be due to the participants being slightly too young to be able to process the configural properties of faces, despite the fact that some studies suggest that configural processing is evident even in 4 year olds (Freire & Lee, 2001). Overall, the level of responding reported here suggests that findings should be interpreted cautiously when compared to those of previous studies.

Performance of the comparison group children in upright trials confirmed previous findings (Mondloch et al., 2002), with the best performance appearing in the featural set, followed by the contour set, then the spacing / configural set. This is consistent with evidence suggesting that the development of second-order configural processing is slower than the development of featural processing (Mondloch et al., 2002). Six-year olds can make identity judgements about faces based on features, but it is only after the age of 10 years that children can make face identity judgements based on the second-order configurations.

The best performance of the high-functioning children with autism was observed in the featural set, followed by the contour set. Their worst performance occurred in the spacing / configural set. At this stage we need to point out that the planned analysis that was conducted to test the simple hypothesis that children with autism will be impaired in their processing of second-order configural information revealed a significant result supporting this hypothesis. However, because of non significant interactions found by the analysis of variance, direct and clear conclusions cannot be drawn regarding second-order configural processing in high-functioning children with autism. This finding can only be explained indirectly and by putting forward several possibilities. It could be argued that, although overall, children with autism do not appear to have any apparent impairment in processing second-order configurations in faces, possibly the development of this ability is even slower in this population compared to typically developing children in this study. In other words, we cannot argue for an impairment in processing second-order configural information of faces in autism, but rather for a slower development of this ability which ends up as being typical-like at a later age. Such a claim can also be supported by the typical performance of children with autism in the contour set. This is an indication of some form of second-order configural processing since identification of these stimuli depends on the processing of external configural information (distance between eye and face outline, or mouth and face ouline). Finally, it is possible that high-functioning children with autism in this study do actually have difficulties with processing second-order configural information in faces but they have developed strategies to cope with such difficulties and overcome them, at least to a certain extent. As Deruelle et al. (2004) have suggested, individuals with autism might not attend to the same information within faces as typically developing individuals do, but nevertheless the use of different strategy does not preclude good performance in facial identity recognition. Generally, our findings suggest that children with autism cannot only make identity judgments based on the features of faces (featural processing) but they can also identify faces based on second-order configural information, which is in accordance with previous findings (Teunisse & de Gelder, 2003; Rouse et al., 2004; Nishimura et al., 2007).

Regarding the inversion effect analysis in this experiment, previous evidence for second-order configural processing comes from studies that investigated evidence from inverted faces (inversion effect) and which have established that since inverted faces are processed featurally (because second-order configural information is disrupted) the larger inversion effect should appear in faces that require second-order configural processing (and smaller effect when recognition relies on features).

In the current study, a slightly different pattern of results was found in both groups of participants (high-functioning autism and typical development) although none of the differences was significant and no interactions were found. As far as the comparison group children was concerned, the inversion effect (calculation of the difference in accuracy between upright and inverted test trials for each participant) did not differ between the three face sets. Part of this finding can be explained by the age of our participants in this study. Typically developing children in our study had a mean chronological age of approximately 9 years. They are quite young to demonstrate the adult-like expertise in face processing and the large inversion effect in the spacing / configural set observed in children aged 10- to 14-years of age (Mondloch et al., 2002; 2003). The unusual finding was the considerable inversion effect in the featural set since previous studies have demonstrated that the smallest inversion effect (or no effect at all) is found for this kind of stimulus (Freire et al., 2000; Leder & Bruce, 2000; Mondloch et al., 2002). However various explanations may account for this finding. First, as Mondloch et al. (2002) have suggested, the current paradigm applied in the present study may have introduced a baseline inversion effect for all face sets (including the featural set), similar to that reported previously for other mono-oriented stimuli, including houses and airplanes (Diamond & Carey, 1986). Possibly the different features used in our study introduced configural changes, too and therefore when faces were inverted participants' performance and processing style was disrupted.

Second, in children with high-functioning autism (mean chronological age 112 months – approximately 9-years-old) in this study, the inversion effect for the featural set and contour set was quite similar while the smallest inversion effect was found for the spacing / configural set, although again differences were not significant. This confirms our previous argument that children with autism in this study appear to have difficulties in processing second-order configural information in faces but since this is not statistically significant, direct conclusions cannot be drawn. Again, it is possible that children with autism have adopted a coping strategy that allows a certain extent of second-order configural processing to take place.

In conclusion, our findings for the high-functioning children with autism and their face processing strategies contradict previous evidence from both behavioural and neuropsychological studies that argued for an impairment in face processing in autism related to the processing of second-order configural information (Deruelle et al., 2004; Wallace et al., 2008; Deruelle et al., 2008; Webb et al., 2006). Findings from this study provide further support to these studies that have demonstrated typical performance in face processing tasks by individuals with autism and which have particularly showed intact second-order processing of information in faces and, therefore, normal activation of the brain's fusiform face area (Rouse et al., 2004; Nishimura et al., 2007; Hadjikhani et al., 2004; Pierce et al., 2004). However, it is possible (due to the children's average VIQ scores) that children with autism in the present study have adopted strategies to cope with face recognition. In fact, because the functioning level of this group of children was average, we should be cautious when generalising conclusions to children that fall along other parts of the spectrum (such as children with lower IQ scores).

The current study did not examine holistic face processing. However, this type of processing of faces has received considerable attention in the face processing literature (i.e. Farah et al. 1998; Sergent, 1984; Tanaka & Sengco, 1997), to the extent that it has been claimed that holistic processing is responsible for face expertise (Carey & Diamond, 1977). Although this view has been challenged in many ways, holistic processing remains as a very important aspect of face recognition which has got a lot to offer in our understanding of the nature of a possible face processing impairment in children with autism.

The following chapter investigates holistic face processing in autism with the aim of establishing the nature of face processing skills in children with autism.

CHAPTER 4

EXPERIMENT 2: HOLISTIC FACE PROCESSING IN ASD

4.1. Introduction

In Chapter 3, configural and featural face processing in children with ASD was investigated. Overall analysis revealed that children with ASD performed similarly to the comparison group and, therefore, showed typical configural face processing. However, planned analysis showed that the ASD group was not as efficient as the comparison group in its use of configural strategies in matching faces. Because configural processing is considered as the type of face processing slowest to develop (Mondloch et al., 2002) and also the one responsible for face expertise (Leder and Bruce, 2000), we need investigate other types of face processing in ASD that may develop earlier. Holistic face processing is the type of information that needs to be investigated as a stage before other more advanced processing strategies are considered in more detail.

Farah et al. (1998) defined holistic processing of faces as the simultaneous integration of the multiple features of a face in a single perceptual representation (a gestalt). As discussed in Chapter 2, over the years the above definition has been challenged in many ways. Specifically, the definition of holistic processing of faces has been challenged to the extent that great confusion has been created as to how this differs from second-order configural processing. Researchers have used the two terms interchangeably, which has caused great debates as to what the two types of information represent in faces and which of the two is responsible for face expertise observed in adults.

Another issue relates to its importance with regards to face processing in general. Developmental studies provided evidence of holistic processing in young children (Tanaka et al., 1998) who however kept improving in their recognition of faces with age (they were not experts and therefore holistic processing did not account for face expertise). A solution to the problem of defining holistic processing and determining its contribution to face expertise was proposed by Maurer et al. (2002) who argued that there are two types of information contained in faces. These are, featural (as defined before) and configural information. According to these authors, configural information represents three types of information: a) first order configural information (the basic arrangement of features in the face), b) holistic information (when the face is processed as template or Gestalt), and c) second-order configural information (the specific metric relations between the features of the face). For the purpose of this chapter, holistic face processing is defined according to Farah et al. (1998) and is considered as a separate mechanism from configural face processing.

As discussed in Chapter 2, holistic face processing has been tested in various ways. The two main paradigms cited in the literature are the part-whole paradigm and the composite face paradigm. In the part-whole paradigm participants are asked to recognise individual facial features either when these are presented in isolation or in the context of a face. In this paradigm participants always perform better in the 'whole face' condition (Tanaka & farah, 1993; Tanaka et al., 1998). Consequently, it has been claimed that faces are processed holistically rather than featurally (Tanaka et al., 1998). The composite face paradigm is an illusion in which identical top halves of faces are perceived as being slightly different if they are aligned with different bottom parts of faces, even when the bottom parts are irrelevant and not attended to (Young et al. 1987). This face composite illusion is a particularly clear demonstration that the features of a face cannot be perceived in isolation. That is, the perception of the attended top part depends on the identity of the bottom part and its position. This observation is generally interpreted as a deficit in the integration of the facial features into a Gestalt (holistic representation) (Freire & Lee, 2003).

The inversion effect has also been considered as an illustration of holistic face processing. Based on evidence which showed that inversion disproportionately impairs the recognition of faces more than the recognition of objects (i.e. Yin, 1969), it was concluded that face recognition was special compared to object recognition because of holistic processing (as opposed to featural processing of objects). Further evidence also suggested that face inversion does not affect featural processing but greatly affects holistic processing (Farah et al, 1998; Sergent, 1984; Tanaka & Sengco, 1997).

4.1.2. Holistic face processing in Autism Spectrum Disorders

Studies of autism and holistic face processing are contradictory. On the one hand, there are studies that claim that individuals with autism show a-typicalities when processing faces, i.e. they adopt featural encoding strategies (Langdell, 1978; Hobson, Ouston & Lee, 1988; Joseph & Tanaka, 2003). This is also supported by neurological evidence (Pierce et al, 2001; Schultz et al, 2000). On the other hand, there is evidence to suggest that individuals with autism process faces in the same way as comparison participants (Davies et al, 1994; Teunisse & de Gelder, 1994, Nishimura et al, 2007).

As Sasson (2006) argues, it is difficult to conclude why some studies have found face processing deficits in autism while others have not. However, it is possible that differences in experimental tasks, participants' ages and control group criteria contribute to the ambiguity created (Sasson, 2006). Furthermore, as Klin (1999) has suggested, it is quite possible that some individuals with the disorder, especially older and higher functioning individuals, have developed strategies to overcome their difficulties. These could be alternative face strategies which are quite effective and make them appear typical in their face processing skills.

The literature on face processing in autism lacks longitudinal research and, therefore, it is difficult to speak with certainty about the development of specific face processing strategies (i.e. holistic, featural or second-order configural) in this population. However, certain assumptions can be made based on evidence from studies looking at different age groups separately.

Pascalis et al (2002) claimed that face processing becomes increasingly species-specific during typical infant development due to an experientially driven perceptual narrowing effect (i.e. interest in human faces which develops throughout infancy). Also, Le Grand et al (2001) and Geldart et al (2002) indicated that the sophisticated face processing abilities of typical adults are experientially tied to normal levels of visual input during infancy. Based on these assumptions and on evidence that suggests that infants with autism differ from typically developing infants in the manner and frequency with they engage in face processing (Osterling & Dawson, 1994; Osterling et al., 2002), it is arguable that holistic face processing skills, which are observed in typical 4 year olds (de Heering et al, 2007) may not be developed effectively in children with autism.

The encoding switch hypothesis, discussed earlier, proposes that young children switch from a featural encoding strategy to a holistic processing of faces at around the age of 10 years. Based on this, it seems that unlike typically developing individuals, individuals with autism may not shift from a bias for featural face elements to a more holistic processing style. Featural-based processing of faces in autism was shown in one of the first studies on face processing in autism by Langdell (1978). Also, Weeks & Hobson (1987) showed that children and young adults with autism tend to categorise a series of facial photographs according to paraphernalia (i.e. hats) while typical controls use a more holistic attribute (facial expression). More recently, Wallace, Coleman & Bailey (2008) investigated autistic adults' holistic face processing skills by asking them to match faces based on identity (same / different task). Specifically, a face was presented for a short while (study phase) and then another face was presented at which point participants had to decide whether the second face matched the first face or not. The same procedure was followed for control stimuli (cars). Participants with autism were less accurate on tasks of face recognition and it was argued that this was due to either impaired or absent use of holistic processing strategies (Wallace, Coleman & Bailey, 2008).

One study which directly investigated autistic children and their holistic face processing skills (Joseph & Tanaka, 2003) used the part-whole paradigm. It found that children with autism did exhibit the typical pattern of enhanced recognition accuracy when viewing wholes of upright faces, but this pattern was present only for the mouth region. It was significantly reduced for the eyes region. Also, children with autism demonstrated a strong effect of orientation when whole-face recognition depended on the mouth, with 70% accuracy in the upright condition as compared to 47% accuracy in the inverted condition (Joseph & Tanaka, 2003). As predicted, typically developing children showed a significant inversion effect when whole-face recognition depended on the eyes. Because of these unusual findings the authors concluded that the notion of holistic processing impairment does not fully explain the processing abnormalities in autistic face recognition and, therefore, the question of whether there are holistic face processing atypicalities in autism remains an open one.

Based on the findings by Joseph & Tanaka (2003), Lopez et al (2004) repeated the part-whole paradigm with adolescents with autism, with a small variation in the procedure. Specifically, in the study phase, participants were cued to the specific feature of the face that they were to be tested in the test phase. This change in the procedure appeared to have a positive effect on the performance of participants with autism. The results of the cued condition demonstrated that both groups showed better performance on the whole face rather than in the part-face condition. Therefore, individuals with autism were able to recognise faces using holistic information but only under certain cued conditions. As far as the un-cued condition is concerned, participants with autism did not show a mouth advantage as previously demonstrated by Joseph & Tanaka (2003). Instead, participants' performance on the eyes and mouth conditions were the same. Also, the study failed to replicate the local bias (featural face processing) that previous studies have demonstrated (i.e. Langdell, 1978). Overall, it was concluded that individuals with autism process faces holistically in the presence of cues, however, they do not do so in the absence of cues (Lopez et al., 2004).

As it can be seen so far, evidence from studies applying the part-whole paradigm in autism has provided us with mixed conclusions as to whether individuals with the diagnosis use holistic processing when encoding facial stimuli. Joseph & Tanaka (2003) found a holistic advantage only for the mouth region of faces, while Lopez et al (2004) found evidence of holistic processing only when the autistic participants were cued to the to the feature that they were to be tested on each time. Apart from the apparent methodological difference, one main difference between the two studies is the age of participants. In the Joseph & Tanaka (2003) study participants were younger (children) and it is possible that face processing abilities (i.e. holistic) were not fully developed yet, whereas in the Lopez et al. (2004) study participants were older and either holistic face processing skills were better developed or other compensatory face processing strategies were applied. Overall, however, evidence is inconclusive.

Quite a few studies have focused on the composite face effect (discussed in section 2.4.2.) and whether individuals with autism are prone to it. However, again findings are controversial. Teunisse & de Gelder (2003) tested adolescents with autism on both the inversion effect and the composite face effect. Interestingly, participants with autism showed a typical inversion effect which was larger for faces than for shoes and which provided evidence for holistic face processing. But when the same participants were tested on the composite face effect, the typical effect found in control participants, it was never apparent in individuals with autism. The authors concluded that although participants with autism do not appear to suffer from an inability to form a configuration-based face representation, they are less prone to use contextual information which in typical individuals activates a holistic processing of the stimulus (Teunisse & de Gelder, 2003).

Similar findings were reported by Gauthier, Klaiman & Schultz (2009) whose adolescent ASD participants showed no composite effects in face recognition and, therefore, no holistic face processing. But, as opposed to the above, Nishimura, Rutherford & Maurer (2008) supported the notion of typical holistic face processing in autism since they found typical performance in adults with autism on the composite face effect.

4.1.3. The current study

The part-whole paradigm has been extensively used in the face processing literature as a good measure of holistic vs. featural processing. Findings have shown that individuals perform better when asked to recognise a whole face rather than parts of faces (holistic processing). This ability seems to develop at an early age and specifically before the development of second-order configural processing.

In ASD, existing findings from studies that have used this specific paradigm (Joseph & Tanaka, 2002) have showed that children with autism appear to use second-order configural processing (or holistic as it is assumed) only in the lower part of the face (i.e. mouth), while children without autism perform better in the trials involving the eyes. This finding (mouth advantage) has not been replicated while similar studies have provided contradictory findings (i.e. Lopez et al., 2004).

In the present study the part-whole paradigm is administered with the aim of establishing whether children with autism are using holistic face processing when looking at face stimuli. This study differs from the two main existing studies that used the part-whole paradigm in faces in individuals with ASD in two ways. First of all, the presentation time of the 'study' face is set to 900 msec which is less than that used in the study by Joseph & Tanaka (2002) (3.5 sec) and more than that in Lopez et al. (2004) (500msec). This avoids a long exposure time which might allow participants with ASD to focus on specific features. It was also necessary to provide our participants with sufficient time to study the faces; pilot testing suggested that 900 msec was sufficient for children with ASD in our study. Secondly, no cues were provided, as it was the case in the study by Lopez et al (2004), during which participants were cued to specific features.

4.2. Method

4.2.1. Participants

Participants in the autism group were 15 children with high-functioning autism and Asperger's Syndrome. They were all recruited through specialised schools for autism spectrum disorders in London and Essex and diagnosis was confirmed by teachers' records of children's statements. The comparison group consisted of 15 children (all boys) in mainstream education without any recorded developmental disorders. The two groups were matched on gender, chronological age, Verbal Mental Age (based on the British Picture Vocabulary Scale - Dunn, et al., 1997), Verbal IQ (BPVS) and raw scores on Raven's Standard Progressive Matrices (Ravens, 1958). The Benton Facial Recognition test (Benton, 1983) was also administered. Both the head of the school and the parent/carer formally agreed in the childrens' participation in the study (see Appendix 1 for sample information letter and consent form and Appendix 2 for participants' overlap across experiments). The study was approved by City University's Ethics Committee.

Table 4.1 below shows the participants' performance in each of those tests.

Table 4.1. Participants' chronological age (CA) in years, verbal mental age (VMA), IQ scores, Raven's Standard Progressive Matrices and Benton Facial Recognition Test scores*

	Autism (n=15)			Comparison (n=15)		
	M	(SD)	Range	M	(SD)	Range
Chronological Age	9.4	(0.9)	8.06-11.1	9.5	(0.9)	8.04-11
Verbal Mental Age (BPVS)	9.7	(2)	5.06-13.07	9.9	(1.8)	6.02-13.01
Verbal IQ (BPVS)	102	(13.1)	69-122	102.4	(12.6)	63-116
RSPM (raw score)	31.4	(11.5)	12-54	31.8	(9.8)	18-47
Benton Facial Recognition	38.3	(5.2)	28-46	42.6	(3)	38-49

* Analysis for CA, VMA, VIQ and RSPM revealed no significant differences between the two groups (**CA**: t= -0.15, df= 28, p= 0.87; **VMA**: t= -0.3, df= 28, p= 0.72; **VIQ**: t= -0.08, df= 28, p= 0.93; **RSPM**: t= -0.11, df= 28, p= 0.90). Analysis of the BFRT showed a significant difference between the two groups (t = -2.7, df = 28, p < .05).

4.2.2. Stimuli and apparatus

Face stimuli for this experiment were kindly provided by Wallace et al (2008). A set of seven, grey-scale 15cm x 15cm photographs of female face portraits were used in this experiment (see Figure 4.1). Face images had a neutral expression. Faces were modified using the graphics software program Adobe Photoshop. The first set of seven faces was modified in order to create two more sets of faces; one (7 faces – see Figure 4.2) consisted of faces that differed from the initial set only in the eyes, and a second set (7 faces – see Figure 4.3) consisted of faces that differed only in the mouth (14 faces in total). The rest of the features remained the same.

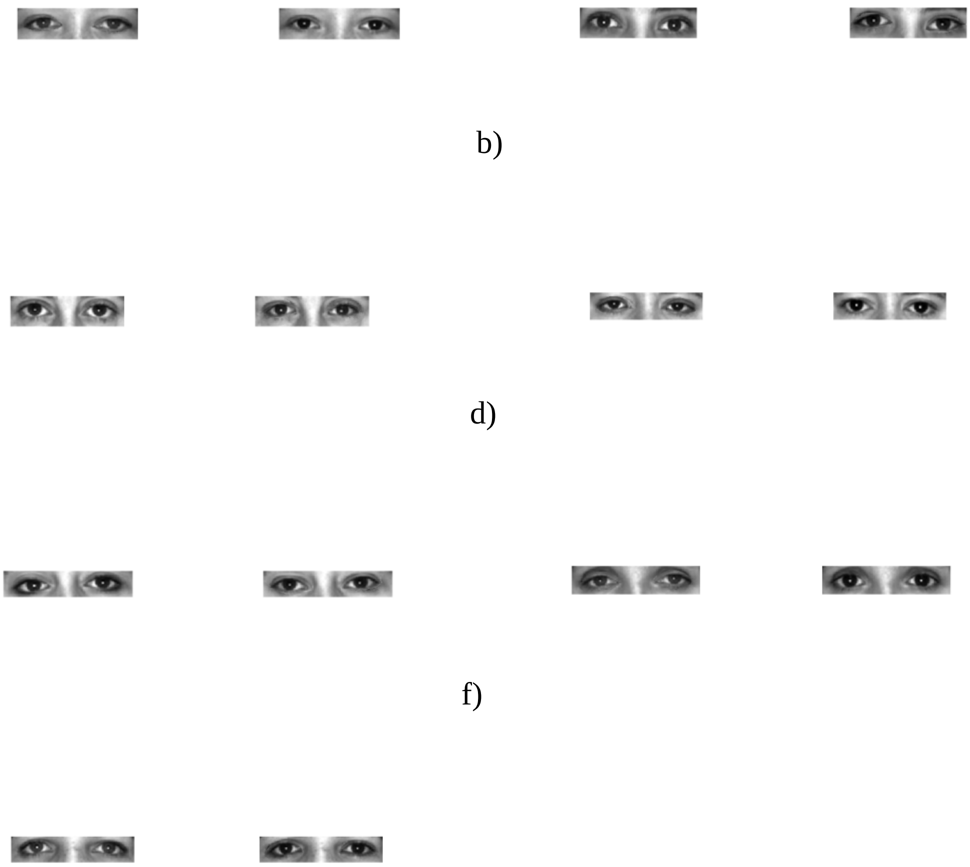
Faces for the featural conditions were created by cropping either the eyes of each of those faces (7 eyes – see Figure 4.4) or the mouths (7 mouths – see Figure 4.5) using the rectangular marquee tool thereby eliminating the remainder of the face stimulus and maintaining the original position of the feature (e.g. mouth towards the bottom). Faces were presented both upright and inverted (simply inverting the original face image).

The same procedure for stimulus construction was used for stimuli in practice trials. The only difference was that instead of replacing the eyes or mouth in the practice trials images, we rotated the eyes or mouth in different directions (images from the practice trials of study one were used).

Figure 4.1. Initial face set

Figure 4.2. ‘Eyes’ face set

Figure 4.3. ‘Mouth’ set of faces



a) b)

c) d)

e) f)

g)

Figure 4.4. ‘Eyes’ face parts

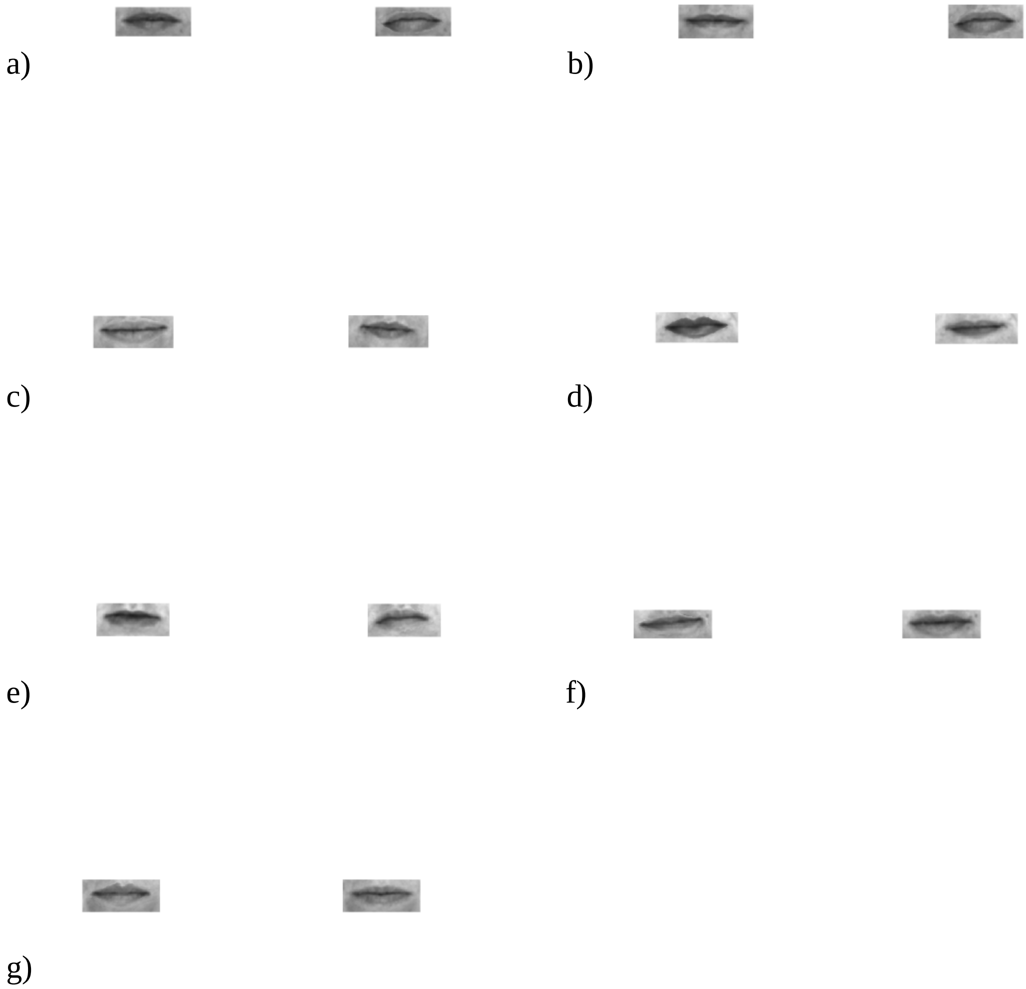


Figure 4.5. ‘Mouth’ face parts

4.2.3. Procedure

Participants were tested individually in a quiet room in the school, during school times. Stimuli were presented on a Toshiba lap top and the presentation was programmed using SuperLab Pro 2.0 software.

Participants sat comfortably in front of a 17” monitor and were instructed to look at the screen carefully. They were given the following instructions: “Please, look at the screen carefully because a face will appear for a short time (very quickly) and then two more faces will appear and you have to decide which of the two faces matches the one you saw before. If you think it is the face on the right hand side of the screen, you have to press ‘m’ and if you think it is the face on the left hand side then press ‘z’”.

Participants were given 12 practice trials during which participants received feedback on their performance (six practice trials in every condition). The only difference between the practice and the experimental trials was that the initial face was presented for longer in the practice trials (1,200 msec instead of 900 msec in the actual experiment).

Before each face appeared on the screen, a cross appeared in the middle of the screen for 2000 msec. This enabled participants to concentrate on the stimuli and to look at the middle of the screen when each face of the initial set appeared. Each face from the initial set appeared on the screen for 900 msec and then was followed by two faces on the screen (one matching the initial face and one differing either in the eyes or mouth). At this stage, participants decided which one of the two faces matched the one presented previously. Since we had created 7 faces differing in the eyes and 7 in the mouth, the total number of trials was 14 (eyes and mouths trials were randomised). The same procedure was followed for the inverted condition (14 randomised trials).

In the conditions tapping featural processing, a very similar procedure was followed. A cross appeared on the screen for 2000 msec, followed by one of our initial faces for 900 msec. After this, two features appeared (either two sets of eyes or two mouths, one of the initial face and one different one) and the participant had to decide which of the two belonged to the face he/she saw before (14 trials randomised). The same procedure was followed for the inverted condition.

Overall, participants completed four conditions: One with upright whole faces, one with inverted whole faces, one with upright features and one with inverted features. Order of presentation of conditions was counterbalanced. Sufficient breaks were provided between each condition.

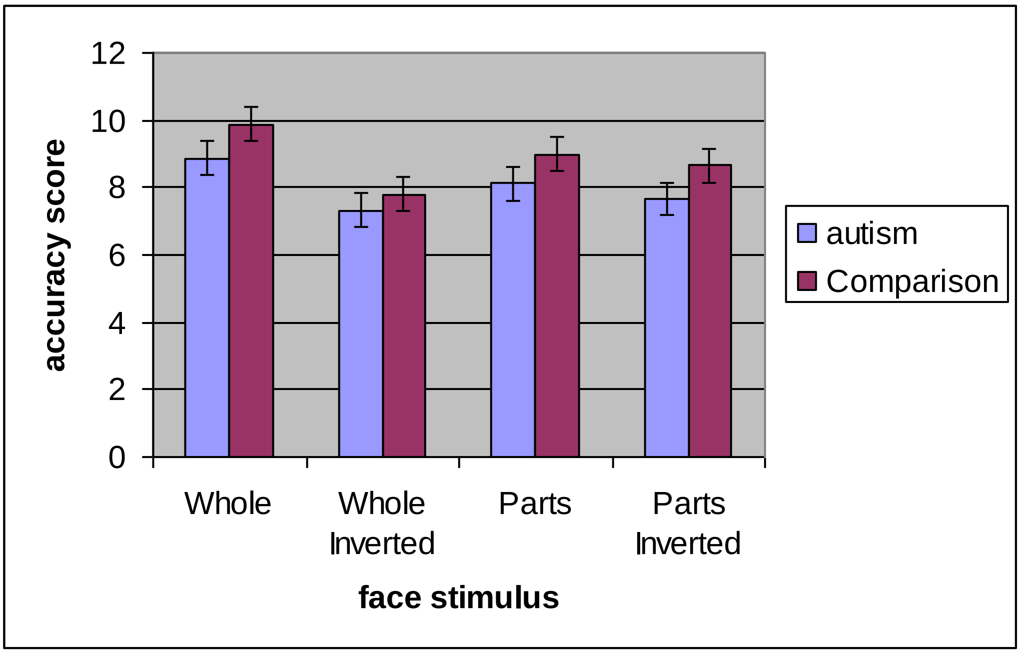
4.3. Results

Before any analysis on the data, the dependent variables (performance on whole faces, parts of faces, eyes in whole faces, mouth in whole faces, eyes in parts of faces, mouth in part of faces, all in both upright and inverted conditions) and participants' mental age (MA), VIQ (verbal IQ) and score on Raven's were subjected to a correlational analysis. The analysis revealed one significant correlation between Ravens raw score and eyes' recognition in inverted parts of faces ($r = .40$, $N = 30$, $p < .05$). The remaining correlations were not significant (max $r = .35$, min $p = .054$). Therefore, MA, VIQ and Raven's scores were not included as covariates in the following analyses.

4.3.1. Overall Accuracy

In order to analyse participants' accuracy on whole faces and parts of faces , a mixed 2 x 2 x 2 ANOVA was employed, with face stimulus (wholes vs. parts) and orientation (upright vs. inverted trials) as the within-subjects factors and group (comparison vs. autism) as the between subjects factor. Analysis revealed a significant main effect of orientation, $F(1,28)=7.97$, $p<.001$, with both groups performing better in the upright conditions. There was also a trend for a significant interaction between face stimulus and orientation, $F(1,28)=3.72$, $p=.06$. Analysis of simple effects revealed that both groups of participants performed better in upright whole faces ($F(1,28) = 14.5$, $p < .01$). The main effect of face stimulus was not significant, $F(1,28) = .06$, $p = .79$. The main effect of group was not significant ($F(1,28) = 2.1$, $p = .15$) The other group interactions were not significant (max $F = 0.06$, min $p = .64$). Figure 4.6 illustrates these findings.

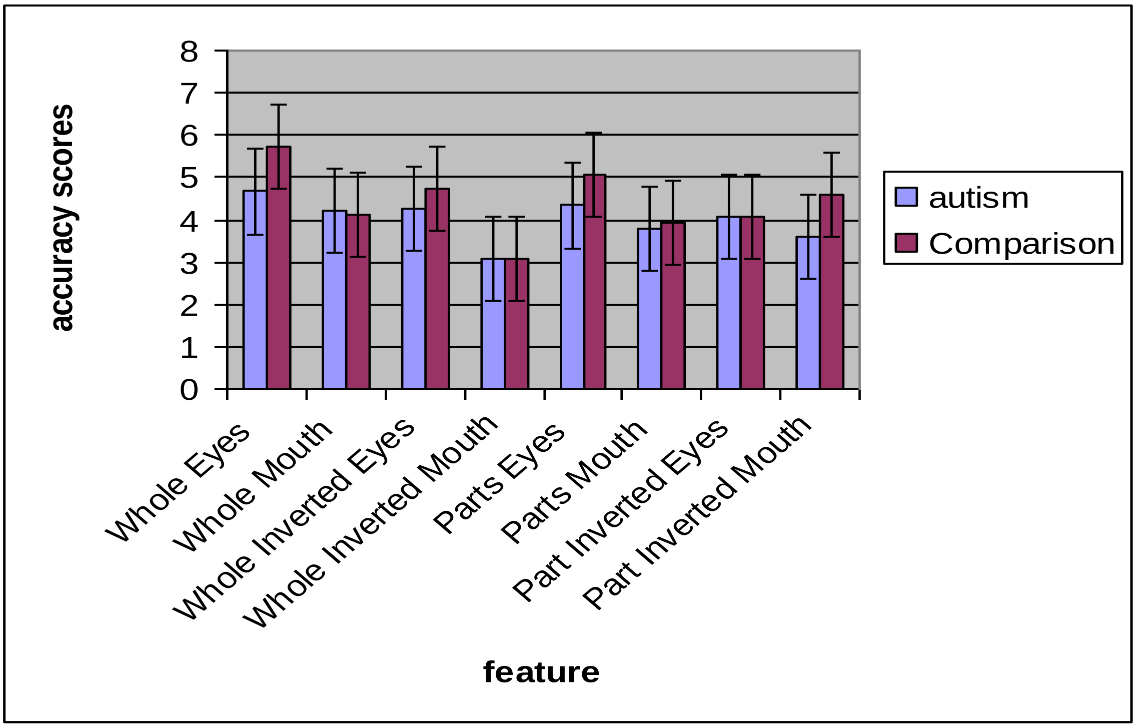
Figure 4.6. Participants' mean accuracy in whole faces and parts of faces in the upright and inverted conditions.



4.3.2. Eyes vs. mouths

In order to analyse participants' accuracy scores on the 'eyes' and 'mouth' section of the face, a mixed 2 x 2 x 2 x 2 ANOVA was employed with feature (eyes vs. mouth), orientation (upright vs. inverted) and face stimulus (whole vs. parts) as within subjects factors and group (comparison vs. autism) as the between subjects factor. This revealed a significant main effect of feature, F(1,28)=25.9, p<.001, with both groups performing better in the eyes than mouth condition and a significant main effect of orientation, F(1,28)=7.97, p<.001, with both groups performing better in upright conditions. The main effect of face stimulus was not significant (F (1,28)= .69, p= .79). There was also a significant interaction between face stimulus and feature, F(1,28)=5.91, p<.05, with both groups performing better in eyes in the whole face conditions, a trend for a significant interaction between face stimuli and orientation, F(1,28)=3.72, p=.06, with both groups performing better in upright, whole conditions, a trend for a significant interaction between feature, orientation and group, F(1,28)=3.5, p=.07, with comparison group performing better on the eyes condition with upright faces, and a significant interaction between face stimuli, feature and orientation, F(1,28)=6.97, p<.05, with both groups performing better in upright, whole eyes. The other main effects and interactions were not significant (max F= 2.1, min p= .15). Figure 4.7 below illustrates these findings.

Figure 4.7. Participants' mean accuracy scores on 'eyes' and 'mouth' trials for whole faces and parts in upright and inverted conditions

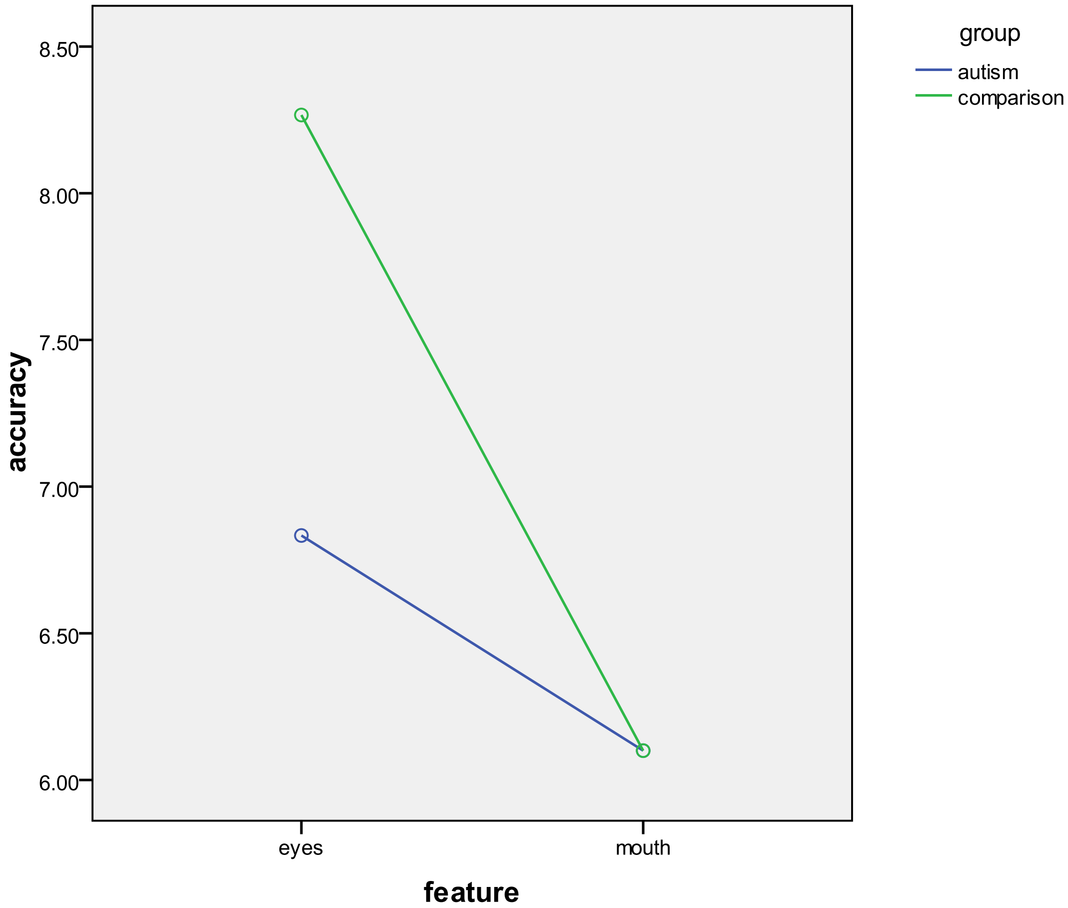


Because of the trend for a significant three-way interaction between group, feature and orientation, we carried out separate ANOVAS for the upright and inverted conditions. Since face stimulus had no effect, we computed four new variables: 1) eyes in upright conditions (eyes in upright whole faces + eyes in upright parts), 2) mouth in upright conditions (mouth in upright whole faces + mouth in upright parts), 3) eyes in inverted conditions (eyes in inverted whole faces + eyes in inverted parts), and 4) mouth in inverted conditions (mouth in inverted whole faces + mouth in inverted parts).

A 2 x 2 ANOVA was carried out for upright conditions with feature (upright eyes vs. upright mouth) as witnin subjcts factor and group (autism vs. comparison) as a between subjects factor. Analysis revealed a significant main effect of feature with both groups performing better in eyes conditons ($F (1,28) = 19.7$, $p< .01$) and a significant interaction between group and feature with the comparison group performing better than the autism group in upright eyes ($F (1,28) = 4.8$, $p< .05$).

The interaction is illustrated in Figure 4.8.

Figure 4.8. Participants' mean accuracy in the 'eyes' and 'mouths' conditions in upright face stimuli (performance scores for whole faces and parts of faces are added)



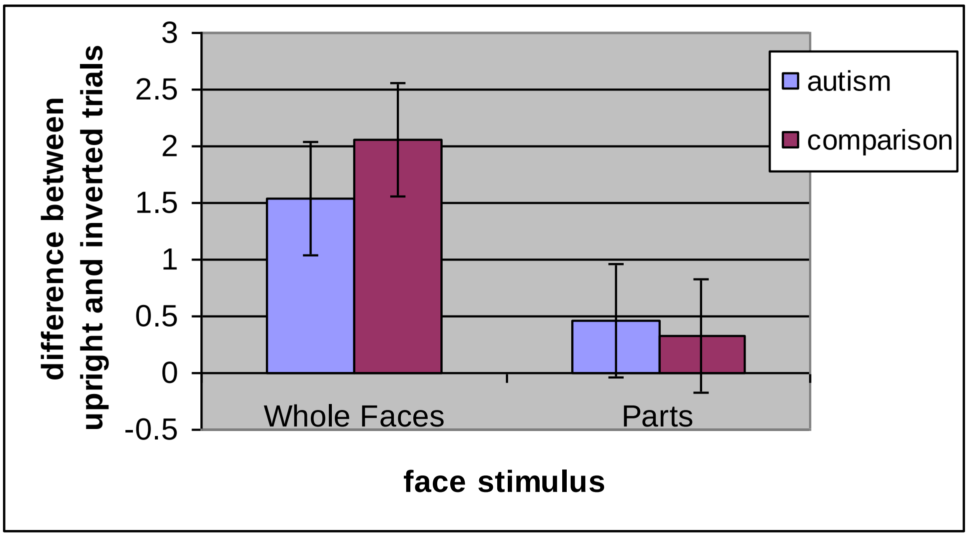
A 2 x 2 ANOVA was carried out for inverted conditions with feature (inverted eyes vs. inverted mouth) as witnin subjcts factor and group (autism vs. comparison) as a between subjects factor. Analysis revealed a significant main effect of feature with both groups performing better in eyes conditons (F (1,28) = 17.02, p< .01). The interaction between group and feature was not significant (F (1,28) = .002, p= .96).

4.3.3. Inversion effect

In order to investigate the inversion effect we calculated the difference between upright and inverted trials in each condition.

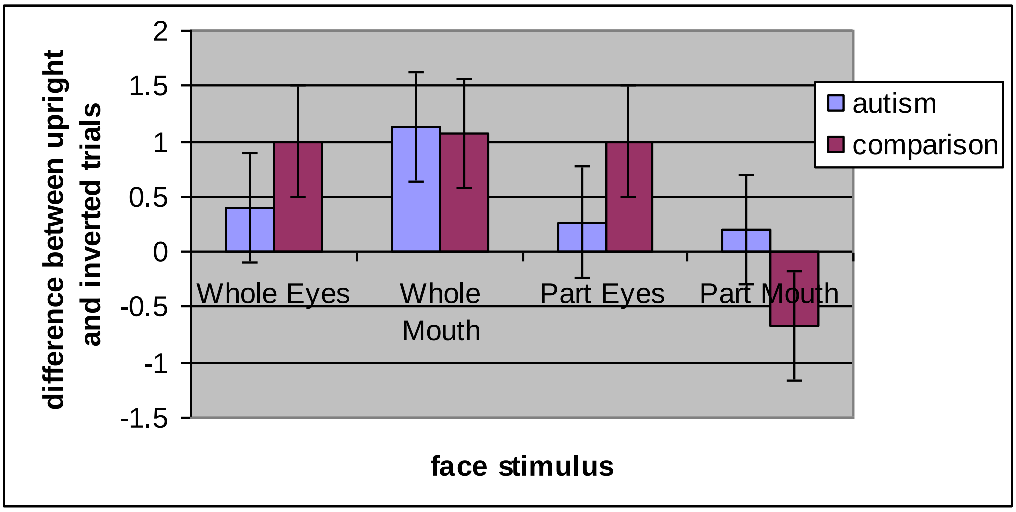
Whole faces vs. Parts: In order to analyse the size of the inversion effect in whole faces and parts of faces, a mixed 2 x 2 ANOVA was employed with face stimulus (inversion effect for whole faces vs. inversion effect for parts of faces) as a within subjects factor and group (control vs. autism) as a between subjects factor. Analysis revealed a trend for a significant main effect of face stimuli, $F(1,28) = 3.72$, $p = .06$, with both groups showing a greater inversion effect for whole faces. There was no significant interaction, $F(1, 28) = .21$, $p = .64$. The main effect of group was not significant ($F(1, 28) = .06$, $p = .79$). Figure 4.9 below illustrates these findings.

Figure 4.9. Participants' face inversion effect (difference between upright and inverted trials) in whole faces and parts of faces.



Eyes vs. mouth: In order to analyse the size of the inversion effect for eyes and mouths, a mixed 2 x 2 x 2 ANOVA was employed with face stimulus (inversion effect for eyes/mouths in whole faces vs. inversion effect for eyes/mouths in parts of faces) and feature (eyes vs. mouth) as within subjects factor and group (control vs. autism) as a between subjects factor. Analysis revealed a trend for a significant main effect of face stimulus, $F(1,28) = 3.72$, $p = .06$, with both groups showing a greater inversion effect for features in whole faces, a trend for a significant interaction between face stimulus and group, $F(1,28) = 3.51$, $p = .07$, according to which, there was a trend for the comparison group to show a greater inversion effect for features in whole faces, and a significant interaction between face stimuli and feature, $F(1,28) = 6.97$, $p < .05$, with both groups showing a greater inversion effect for mouth in whole faces. The other main effects and interaction were not significant (max $F= .94$, min $p= .33$). Figure 4.10 below illustrates these findings.

Figure 4.10. The inversion effect (difference between upright and inverted trials) in the 'eyes' and 'mouth' conditions



In order to investigate the exact nature of the interaction between group and face stimulus we carried out separate paired and independent t-tests for each condition. A significant difference was found for the comparison group for the mouth section between whole faces and parts, $t = 3.0$, df = 14, $p < .01$.

Power Analysis: A post-hoc power analysis was carried out in order to determine the power of the test used. The number of participants in this experiment was 30 and the number of IDs was 4, therefore by inserting the mean for each ID into the GPOWER program (Erdfelder et al, 1996), the calculated effect size was .50 (a moderate effect according to Cohen's (1988) tables). The power of the test was calculated to be .76.

4.4. Discussion

This experiment investigated holistic face processing in children with and without autism. The paradigm that was used was the well-known part-whole paradigm in which participants were asked to match either whole faces differing in features to whole faces or parts of faces (eyes or mouths) to whole faces. The aim of this study was to establish the nature of a possible holistic processing impairment of faces in autism highlighted in previous studies but not found by others.

In terms of accuracy, our participants (both the comparison and autism group) performed better with whole faces rather than parts of faces, therefore demonstrating a holistic processing advantage. This holistic advantage was demonstrated by the inversion effects observed: both of our groups of participants were greatly affected by stimulus inversion but only in the condition of whole faces. This inversion effect is evidence of holistic processing since as it was demonstrated in previous studies inversion does not affect the processing of parts but only the processing of holistic / configural information in faces (Farah et al., 1995; and Tanaka & Farah, 1991).

We also analysed participants' accuracy separately for 'eyes' and 'mouth' manipulations in whole faces and parts of faces. The reason for this was because previous studies have demonstrated an advantage for individuals with autism when asked to match faces depending on the 'mouth' section, while typical individuals normally show an advantage for the 'eyes' section of the face (Langdell, 1978; Joseph & Tanaka, 2003). Our study provided similar findings: our comparison group (typically developing children) showed the eyes advantage in their accuracy for the 'eyes' section, which however, was not the case for the autism group. Our participants with autism did not show the eyes advantage to the same extent as the typically developing participants but neither did they show an advantage for mouth (as demonstrated in other studies, i.e. Langdell, 1978). As for the inversion effect separately for eyes and mouths, participants' accuracy was affected more by inversion when they were matching the features in whole faces rather than parts. There was also a trend for the comparison group to show a greater inversion effect for features in whole faces (although the difference was not statistically significant). Specifically, the comparison group showed a greater inversion effect for mouths in whole faces that in parts of faces.

Overall, this study demonstrated a holistic advantage for the processing of faces for both typically developing children as well as children with autism. Our findings support the findings by the study of Lopez et al (2004) who showed that adolescents with autism performed similarly to comparison participants in the part-whole paradigm when participants were cued to the specific feature to be recognised either in the 'whole' or 'parts' conditions of the experiment. In the present experiment participants were not cued, but produced the same findings: better performance with whole faces and a greater inversion effect for whole faces. The methodology used was the same as the one by Joseph & Tanaka (2003), which showed that participants with autism showed a holistic advantage for the processing of faces only for mouth manipulations. This is in contrast to our findings since although children with autism did not show the eyes advantage that typically developing children did, they did not show a mouth advantage in their accuracy either.

The special aspect of this study that make it stand out from previous ones is that even with short exposure times of the 'study' faces (900 msec as opposed to 3.5 sec in Joseph & Tanaka, (2002)) children with ASD could process faces holistically. Children with autism did not focus more on the 'eyes' section as typically developing children did but nevertheless were able to process the face as a whole entity and this argues against the proposition that individuals with autism use feature-based strategies when processing faces.

The current study provided evidence for holistic processing of faces in autism although without paying any special attention to specific parts of faces (eyes or mouths), whereas typically developing children show a holistic advantage and better performances in the eyes section of the face. The existing literature only allows us to assume that children with autism can process faces holistically but whether configural processing is also involved cannot be said with certainty. Current theories on this specific issue can only allow us to make hypotheses.

According to the model proposed by Maurer et al. (2002) holistic information in a face is one of the three types of configural information (first-order configural information and second-order configural information are the other two). The processing of these three types of information in a face occurs in a functional and neural order in such a way so that in order to detect each type of information individuals go through all three types until they achieve the face expertise with second-order information processing. According to Maurer et al (2002), holistic processing is the second stage after first-order processing and before second-order processing. Therefore, based on this model and the findings from the current study, we can assume that our participants with autism show some kind of configural processing of faces since they show typical performance with holistic processing. Following this model then, our participants with autism have reached at least the second stage of face expertise (second-order information processing was not tested in this experiment).

On the other hand, Rossion (2009) has provided a different explanation for the relationship between holistic and configural information which may also explain our findings. By investigating the inversion effect, Rossion (2009) proposed the perceptual field hypothesis and suggested that an upright face is always perceived holistically and so the cause of the inversion effect is the loss of this holistic perception. However, the consequence of this loss of holistic perception is a great impairment to process the configural information in a face. Therefore, with regards to our findings, our participants with autism process faces holistically but this is also evidence of configural processing because when faces are inverted the processing of the configural information is also disrupted.

To sum up, the present study investigated the holistic processing of faces in autism with the use of the part-whole paradigm. The findings supported previous studies that demonstrated typical performance in individuals with autism in the holistic and configural processing of faces (Davies et al, 1994; Teunisse & de Gelder, 1994; Lopez et al., 2004; Nishimura et al, 2007). However, our participants with ASD did not show the 'eyes' advantage to the same extent as it was shown by the comparison group and overall treated the eyes and mouth sections of faces in the same way, which goes against previous findings that individuals with ASD show a preference for the mouth section when processing faces (Langdell, 1978; Joseph & Tanaka, 2002).

As it was highlighted before, the relationship between holistic and configural processing of faces has not been clarified. As a result, no clear conclusions can be drawn about the exact face processing strategies of children with ASD in the current study.

The next chapter will attempt to clarify the relationship between holistic and configural processing of faces, with the aim of establishing whether any of the two accounts for the face processing differences observed between children with ASD and typically developing children.

CHAPTER 5

EXPERIMENTS 3 & 4: THE DISTINCTIVENESS EFFECT OF FACES IN ASD

5.1. Introduction

In Chapter 4 holistic and featural processing of faces were investigated in typically developing children and children with ASD. However, a limitation was identified with regards to the assumptions of holistic face processing in general. Specifically, it was highlighted that definitions of configural and holistic processing in face processing overlap and therefore no clear conclusions can be drawn from the current paradigms used to test holistic processing as to what processing strategy is applied by participants.

As discussed in Chapters 2 and 4, for decades, psychologists have struggled to provide concrete definitions of the different types of information contained in faces. Unfortunately, although there has been an increasing interest in the face processing skills of infants, children and adults over the last 20 years, still terms and definitions of the types of information in faces overlap across different studies. As a result, conclusions drawn from research have led to uncertainty as to which type of information is more important in a face, or why adults are experts in processing and recognising faces, or even why certain clinical populations (i.e. ASD) show a difficulty with face processing. In the pages to follow we will review the literature focusing on theoretical aspects, while at the same time highlighting any theoretical or methodological problems that may arise.

5.1.1. Current definitions of configural and holistic face processing

As we have seen in Chapter 2, configural or relational information refers to the spatial interrelationship of facial features (Schwaninger, Carbon & Leder, 2003). Two types of configural information have been identified: a) first-order relational information for the basic arrangement of the parts (eyes above nose and nose above mouth), and b) second-order relational information that refers to the specific metric relations between features (Diamond & Carey, 1986) (Although there is that distinction, in research when people talk about configural information, they refer to second-order relations, and that applies for the present review). Contrary to the featural hypothesis, the configural hypothesis holds that we perceive and remember faces by means of two kinds of information namely featural and configural. However, the importance of the latter is conceived of as greater than of the former (Diamond & Carey, 1986; Rhodes et al., 1993). Some ways of testing configural processing include jumbled faces (changing the place of facial features which results in substantial changes in the spatial relations of the facial features), spacing (changing the distances between the features on a target face so that to create a new face that differs from the target only in terms of the distances between the eyes or nose and mouth, etc) and most importantly, inversion. By inversion, the entire face is inverted and this technique is based on the assumption that although no manipulations are added in any other information in the face (features or spacing) it has a great effect on the processing of distances between features. Generally, configural information in a face is very important and has a significant impact on perception. In fact, it is the reliance on configuration that is essential for adults' expertise at processing upright faces (Leder & Bruce, 2000).

The term 'holistic information' has been used to describe the fact that faces are stored as unparsed perceptual wholes in which individual parts (components) are not explicitly represented (Farah et al., 1995; Tanaka & Farah, 1993). The holistic hypothesis then proposes that the recognition and perception of faces is based on the two kinds of information – featural and configural – where these kinds are perceived as a single entity, the whole face. This perceptual wholeness is difficult to break down into its parts without seriously harming perception and remembering a face and its parts (Rakover, 2002). The problematic aspect of this hypothesis regards the relationship between featural and configural information in holistic processing, and that is highlighted in two different views.

The first view is the accessibility interpretation (Rakover, 2002) which supports that faces are not represented in terms of the identities of the parts (eyes, nose mouth) but rather in terms of a template-like representation of the whole (Tanaka & Farah, 1993; Farah et al., 1998). This holistic encoding has been tested by using the part-whole paradigm. This paradigm is based on the assumption that individual parts presented in isolation should be more difficult to recognise than when the same parts are presented in the context of the whole face, and indeed this is what Tanaka & Farah (1993) found. It was also found that this effect was sensitive to orientation, and specifically it disappeared when faces were turned upside down. The second view of holistic encoding state that in holistic representations the spatial relations among the parts is more important in specifying an individual object than are the representations of the individual parts. However, this seems remarkably similar to the definition of configural processing. Indeed, under this characterisation the distinction between holistic representations and configural representations becomes blurred to the point of disappearing (Carey & Diamond, 1994). And therefore this is where the problem lies: what is the relationship between configural and holistic processing? What are the differences between the two perceptual modes?

5.1.2. Paradigms that test holistic processing and their limitations

As was mentioned in Chapter 2, one way that holistic encoding is tested is the part-whole paradigm. As was explained in the previous paragraph, according to this paradigm, features are presented either in isolation or in the context of the already known face (i.e. Bob's face, Bob's nose, etc). However, the question then arises: when presenting a feature in the context of the face rather than in isolation, doesn't that add configural information? We propose that yes, configural is indeed added since the feature is viewed in relation to other features in the face and also in relation to the face contour. And since all these involve distances among the features and the face outline, then again configural information is more important for those who recognise the feature in the context of the whole face.

Another way of testing the holistic hypothesis was developed by Young et al. (1987) and is known as the composite face effect that we discussed in Chapter 2. In this task, the top and bottom halves of two familiar face images are used to create a new face. The two halves are either aligned or misaligned horizontally and the task is to name the person who is depicted in the top half of the image. The aligned condition is actually more difficult for adults than the misaligned condition, ostensibly because a novel holistic configuration emerges when the two face halves are aligned (Freire & Lee, 2003). Therefore, in this case too, configural information appears to play a greater role in processing these types of faces.

Overall, since these two paradigms are the most cited ones as testing the holistic hypothesis of processing faces, the extent to which they are an actual measure of that and not configural processing is still questionable. Or, by using these types of paradigms, then the definition we give to holistic processing is very similar to the definition of configural processing, if not the same. Adding to this, the inversion effect found in both paradigms provides further support for configural encoding (since inversion disrupts configural processing). With regards to these conclusions, Carey & Diamond (1994) argue that a minimal reliance on relational features is all that is required for holistic encoding, whereas expertise at face encoding requires greater reliance on such features. This argument sounds logical also especially when considering developmental aspects of face processing. Developmental studies have shown that holistic encoding does not account for adult expertise in processing faces since children process faces holistically (Carey & Diamond, 1994) although their overall performance is not adult-like, whereas configural processing develops slowly (Mondloch et al., 2002) and becomes adult-like after the age of 10 years.

5.1.3. Proposal

Based on the above, what is proposed in this chapter is, first of all that holistic representations involve template-like representations which also include a minimal reliance on configurations. However, this assumption needs to be tested. Further to this, we assume that holistic encoding and configural encoding, although they both require some level of configural processing, because that level differs between them (Carey & Diamond, 1994 – minimal reliance on configurations for holistic encoding, greater reliance for configural encoding), then these are two different perceptual modes of one higher level mechanism. And this is what needs to be established.

In fact, this assumption takes us back to Maurer, Le Grand & Mondloch (2002) who argued that there are two types of information contained in faces. These are, featural (as it was defined by past research) and configural. According to these authors, there are three types of configural information: a) sensitivity to first-order relations – identifying that a stimulus is a face because its features are arranged with two eyes above the nose, which is above a mouth; b) holistic processing – glueing together the features into a gestalt; and c) sensitivity to second-order relations – perceiving the distances among features. In other words, instead of identifying three ways of processing faces (featurally, holistically and configurally) Maurer et al. (2002) argue for two perceptual modes – featural and configural – whereas holistic is a type of configural processing, which makes sense since it had already been established that holistic processing requires at least some processing of relational features.

Maurer et al. (2002) additionally propose that the three types of configural processing operate in a functional and neural order: detection of the face based on first-order relations being a necessary first step before holistic processing and detection of second-order relations. And we propose that this is how expertise in processing and recognising faces is achieved. However, that too remains to be tested, and although such a test is fairly easy and straightforward for featural, first-order relations and second-order relations, testing and operationalising the term of holistic processing as it has been defined here (template-like representations with minimal reliance on configurations) could be tricky. That is because all the already mentioned paradigms (part-whole, composite face, inversion) mainly tap the processing of second-order relations. Therefore, how can we test holistic processing without manipulating second-order relations in the face? This is the question we will attempt to answer in the next section.

5.1.3.1. The idea of overall similarity and norm-based encoding in faces

Schwarzer (2000) goes back to Garner's (1974) definition of holistic processing in nonfacial visual research which refers to holistic processing in terms of the overall similarity relations of the stimuli. Drawing from Schwarzer's (2000) proposal, this notion of overall similarity is very similar to Farah's et al. (1998) and Tanaka & Farah's (1993) conceptualisation in terms of, first, the emphasis on holistic template-like representations, and second, the contrast of holistic with analytic processing. On the other hand, the difference between the two theories is that configurations or spatial relations among individual features do not play any role in the conceptualisation of holistic processing in terms of overall similarity (Schwarzer, 2000). Based on this assumption Schwarzer (2000) studied analytic and holistic processing in facial stimuli by using a category learning task (categorising schematic faces into children's or adults' faces for holistic, or categorising faces focusing on a single facial attribute for featural processing).

This idea of overall similarity overlaps with the norm-based hypothesis for processing faces (Rakover, 2002). According to the (prototype) norm hypothesis, all facial information, featural and configural, is presented in a cognitive system as deviations from the norm, as distances from the abstract prototype face (Rakover, 2002). This prototype face is created in a cognitive system as a result of extensive exposure to and interaction with a very large number of faces. The idea of the norm-based hypothesis stems from the way that caricatures are made, which was developed by Brennan

(1985). In general terms, caricatures are created by enlargement of the distances between the target face and the norm, and anti-caricatures by reducing these distances. One would then assume that caricatures sharpen and highlight the configuration characteristics of a given face. In actual fact, there is evidence for this hypothesis (e.g. Carey, 1992; Rhodes, 1996, etc). Most importantly however, there is also evidence that casts doubt on this hypothesis. Rhodes & Tremewan (1994) tested whether holistic inversion impairs the perception of caricatures and hypothesised that if caricatures changed configural information, then inversion will impair recognition of caricatures. Their results did not support this hypothesis. It is possible therefore, that the effects of caricatures arise from their distinctiveness, which results from the distortions that caricatures create in a face (Rakover, 2002).

Valentine (1991) studied the effect of distinctiveness of faces and published a series of experiments with a quite detailed and informative analysis of norm-based encoding of faces. Specifically, Valentine proposed a multidimensional space framework in face recognition, which is summarised as such:

"The origin of the multidimensional space is defined as the central tendency of the dimensions. It is assumed that the values of the feature dimensions of the population of faces experienced will vary normally around the central tendency. Therefore by definition, typical faces (close to the central tendency) will be seen more often than distinctive faces (distant from the central tendency). Thus, the density of points (i.e. the number of previously seen faces) will decrease as the distance from the central tendency increases. The population of points will include familiar faces in addition to many points representing faces that have been seen previously but would not necessarily be 'familiar' in the sense that they could be identified. Thus, an implicit knowledge derived from a lifetime's experience with faces contributes to the normal distribution of faces within the multidimensional space" (Valentine, 1991, p.166).

Valentine (1991) also identified two specific models within the framework. The first one is the norm-based coding model which assumes that faces are encoded in terms of their deviation from a single general face norm or prototype located at the origin of the space (i.e. the central tendency). The second is the exemplar-based model which is similar to the norm-based coding model, except that it is more appropriate to consider faces as being encoded as points rather than vectors – in other words, there is no extracted norm or prototype (Valentine, 1991). In a series of experiments Valentine (1991) did not discriminate between the two models, however findings in terms of face recognition were very interesting. First of all, both models showed a greater effect of inversion for typical faces than for distinctive faces. On the assumption that typical faces are closer to the norm and thus that more subtle relational features are required to distinguish among them, typical faces will place higher demands on the norm-based coding mechanism that is disrupted by inversion (Carey & Diamond, 1994). Valentine (1991) also, tried to explain this finding in terms of the types of information contained in faces. He assumed that recognition of distinctive faces may be less affected by inversion because distinctive faces can be more easily encoded in terms of featural information. However, this begs the question of the basis of distinctive information in faces (Valentine, 1991). The multidimensional space framework is neutral in respect to the issue of whether distinctive information is conveyed predominantly by featural or configural information (Valentine, 1991).

Similar findings about the two models were reported by Rhodes, Carey, Byatt & Proffitt (1998). Therefore, faces judged as distinctive are more easily remembered than faces judged as typical (Chang, Levine & Benson, 2002) and this advantage is referred to as the distinctiveness effect. For adults the effect has been found for both familiar and unfamiliar faces (Bartlett, Hurry & Thorley, 1984) and also, distinctive faces are remembered better after long details than are typical faces (Shepherd, Gibling & Ellis, 1991).

To date, there are only a few studies that have compared children's recognition of distinctive versus typical faces. Johnston & Ellis (1995) tested 5 to 13 year-olds and found that 5 year-olds did not show a recognition advantage for distinctive faces over typical faces. Instead the advantage for processing distinctive faces began to emerge at age 7 and was adult-like at age 9. Similar findings were obtained by Ellis (1992). However, Chang, Levine & Benson (2002) found that 6, 8, 11 year-olds and adults all perceived caricatures as the most distinctive versions of a faces (and anti-caricatures as the least distinctive) although the effect was smallest for 6 year-olds. More evidence is needed to establish developmental aspects of processing distinctive faces.

5.1.3.2. Conclusion

For the purpose of this chapter, we support Maurer et al.'s (2002) proposal that, instead of three types of information in faces (featural, configural and holistic), there are two types of information: featural and configural. According to the authors, there are three types of configural information: first-order configural information (eyes above nose and nose above mouth), holistic information, and second-order configural information (the specific metric relations among the features). We argue therefore, that holistic information is a type of configural information and can be defined as the processing of template-like representation (prototype) of a face, which requires a minimal reliance on configurations. Furthermore, we propose that a possibly good measure of this kind of holistic processing could be the distinctiveness effect, since the definition of the former overlaps with the assumptions of the latter. We propose that holistic processing involves template-like representations (norms/prototypes) that might also require minimal reliance on configural information. An inversion effect should not occur. However, if it does occur, then the effect should be small. In actual fact, research has established this phenomenon in distinctive faces – there is a smaller inversion effect for these than for typical faces (Valentine, 1991; Rhodes & Tremewan, 1994). It is known that holistic processing and the distinctiveness effect are based on template-like representations. Finally, considering the development of holistic processing, there is evidence of that in young children (Carey & Diamond, 1994), which is also the case with the distinctiveness effect (Chang, Levine & Benson, 2002).

5.1.4. Holistic vs. Configural processing in ASD

As we have already discussed in previous chapters, most of the research literature on autism and face processing has focused on the issue of featural vs. configural processing. However, while these are important research findings they are not consistent and fail to answer questions that still arise regarding the deficit that characterises face processing in individuals with ASD. Before we move into proposing a different approach in studying face processing in autism, let us first summarise some of the most important research findings so far.

As we have seen in Chapter 2, section 2.5, one of the very first studies was conducted by Langdell (1978), who asked children with ASD to identify photographs of faces of their classmates in both upright and inverted conditions and with parts masked off (upper or lower half). It was found that recognition of faces by children with ASD was based on the mouth section (whereas typically developing children were mainly based on the eyes section). In addition, the well-known inversion effect was not found in the ASD group. Similar findings were reported by others (Hobson, Ouston & Lee, 1988; Tantam, Monaghan, Nicholson & Stirling, 1989; Boucher & Lewis, 1992), who all supported the argument that individuals with ASD adopt a feature based strategy for processing faces instead of a holistic strategy that is adopted by typically developing individuals. This argument was directly tested by Joseph & Tanaka (2003) who applied the part-whole paradigm in children with ASD. Their findings confirmed past research in that, the mouth section appeared to be processed holistically by children with autism while no such effect was found for the eyes. In fact, the greater reliance on the mouth section of the face by ASD children was highlighted by the inversion effect found particularly for that area of the face. Joseph & Tanaka (2003) concluded that face recognition abnormalities in autism are not fully explained by a difficulty in holistic face processing and that there is an unusual significance accorded to the mouth section when children with autism process information from people's faces.

Although later studies also supported the impaired face processing skills of individuals with ASD (e.g. Deruelle, Rondan, Gepner & Tardif, 2004), there was also evidence that challenged this argument. Teunisse & de Gelder (2003) tested the inversion and composite face effect in tasks with reduced demands and since both effects were found in the ASD group as well as in the comparison groups it was concluded that individuals with autism can, in fact, process faces configurally, while previous findings were a result of task difficulty rather than face processing difficulties. Similarly, Rouse, Donnelly, Hadwin & Brown (2004) found that children with ASD were susceptible to the Thatcher illusion and therefore could process configurations in the face in the same manner that comparison groups could.

Overall, what appears to be the case is that individuals with ASD can process faces holistically and configurally, but appear to show a preference for focusing on particular regions of the face, especially the mouth region (see Bowler, 2007). Or in other words, as Jemel, Mottron & Dawson (2006) argued, "although the superior processing of local aspects of faces was previously thought to derive from a deficit in the perception of global and configural information, recent findings suggest and enhanced low-level perceptual processing with absence of global perceptual impairments". On the other hand, apart from the methodological issues that need to be taken into consideration, what we need to look into more detail is what we mean by holistic/configural processing and how we test that.

The issue of defining and operationalising holistic information in faces, as well as its relationship to configural information, was discussed in the previous section of this chapter. It was concluded that holistic information is a type of configural information that is contained in faces (Maurer et al., 2002), rather than a separate type of information as it was proposed by Farah et al. (1995) and Tanaka & Farah (1993). That is due to the fact that holistic processing of faces appears to involve some reliance (minimal) on configurations (Carey & Diamond), whereas at the same time, involves the processing of template-like representations. This definition of holistic processing cannot be tested with the existing paradigms (part-whole, composite face, inversion) since these seem to tap configural processing, and therefore it was proposed that the distinctiveness effect is an ideal measure of holistic processing. The distinctiveness effect is based on the norm (prototype) hypothesis which argues that all facial information is presented in the cognitive system as deviations from the norm, as distances from the abstract prototype face (Rakover, 2002), and can be measured with caricature faces (Brennan, 1985; Stevenage, 1995; Lewis & Johnston, 1999). Caricatures are created by enlargement of the distances between the target face and the norm, however their recognition is not impaired by inversion (Rhodes & Tremewan, 1994) and so, configural information does not play a role. Developmental studies have concluded that distinctive faces are remembered more easily than typical faces by 8 and 11 year-olds and adults (Chang, Levine & Benson, 2002; Bartlett, Hurry & Thorley, 1984), while there is no such effect found in 5- and 6-years-old children (Johnston & Ellis, 1995; Ellis, 1992).

To date there are no studies investigating the distinctiveness effect of faces in autism. That is because most of the research so far has focused on the issue of feature vs. configural or holistic processing, which has produced conflicting evidence. It would be very interesting therefore to look at the distinctiveness effect of faces and if individuals with autism are susceptible to it. However, the kind of predictions to be made are unknown since, as it was mentioned above, there is no past research on which to base them.

5.1.4.1. Prototype formation in ASD

On the other hand though, past research literature on concept and prototype formation in autism, would lead us to predict difficulty in processing distinctive faces. These two areas of research overlap, since according to the prototype-based account, categories are represented by an idealised instance involving the abstraction of information from specific exemplars (Posner & Keele, 1968; Rosch, 1978).

Early research on concept formation and understanding in autism has provided evidence for intact categorisation abilities. So, for example, Ungerer & Sigman (1987) showed that children with ASD were able to distinguish between simple perceptual categories and also between members of natural kind and artefact categories. Also, Tager-Flusberg (1985) found that participants with ASD were able to recognise semantic relationships among pictures and words as well as comparison groups. In contrast to these studies, Shulman, Yirmiya and Greenbaum (1995) suggested that people with ASD show abnormal responses to categorisation since fewer accurate classifications or representative objects were made by that group. In addition, in the area of memory research, individuals with autism and Asperger syndrome failed to aid their free recall memory by grouping exemplar information into categories (Tager-Flusberg, 1991; Bowler, Matthews & Gardiner, 1997). Finally, in a recent study by Gastgeb, Strauss & Minshew (2006) it was found that both individuals with autism and typically developing individuals showed improvement in their categorisation abilities throughout the lifespan for all levels of typicality. On the other hand, a later study by Gastgeb, Rump, Best, Minshew & Strauss (2009) showed atypical categorisation and prototype formation skills. In that study participants were familiarized to a series of faces depicting subtle variations in the spatial distance of facial features, and were then given a forced choice familiarity test between the mean prototype and the mode prototype. Individuals with autism were significantly less likely to select the mean prototype face. This provided evidence that individuals with autism have difficulty abstracting subtle spatial information that is necessary not only for categorizing faces and objects, but also for the formation of a mean prototype (Gastgeb, et al., 2009).

As far as prototype formation in autism is concerned, there are only a few studies to date that have investigated this effect. Dunn, Gomes & Sebastian (1996) found that children with autism produced a lower proportion of prototypical responses than comparison groups in word fluency tasks. Klinger & Dawson (2001) also found a difficulty in prototype formation since participants with autism performed at chance in selecting the prototype in categorisation tasks. As opposed to these studies, Molesworth, Bowler & Hampton (2005) provided evidence for a full prototype effect in recognition tests. This discrepancy could be attributable to methodological differences between studies. So for example, in the Klinger & Dawson (2001) study participants were lower functioning children with autism whereas in Molesworth et al. (2005) participants were high-functioning children with autism. Further studies by Molesworth, Bowler & Hampton (2008) confirmed that high-functioning children with autism show intact prototype effects.

Overall, similar to the literature on face processing, literature on concept and prototype formation produces conflicting evidence. No straightforward conclusions can be drawn and therefore our predictions about the processing of caricatures and their outcomes will be twofold. Thus, a difficulty in processing caricatures, will lead us to assume that individuals with autism have difficulties with holistic processing, which is the second stage in developing expertise according to Maurer et al. (2002). In the case of normal processing of caricatures we would assume that individuals with autism can actually process faces holistically and therefore their difficulties appear in the third stage of achieving expertise, which requires the processing of second-order relations among the features (Maurer et al, 2002).

5.2. Experiment 3

5.2.1. Method

The present experiment is based on the study conducted by Johnston & Ellis (1995), which looked at the age effects in the processing of typical and distinctive faces. Parts of the methodology are changed so that memory demands of the task are decreased for children with autism. So for example, the number of 'study' faces was decreased to 7 (from 9 in each condition in the original study) and 'test' faces to 14 (from 18). Adding to this, in the current experiment, typical and distinctive faces were presented in separate conditions. This was for two reasons: first because by this way memory demands are decreased (fewer trials in each condition), and second, because we wanted to avoid children focusing on distinctive faces simply because they stand out from typical faces in the list.

5.2.1.1. Participants

Participants in the autism group were 16 children with high-functioning autism (all boys). The children's diagnosis was confirmed by the school staff who kept records of their diagnostic reports. The comparison group consisted of 16 children (all boys) in mainstream education without any reported developmental disorders. The two groups were matched on gender, chronological age, Verbal Mental Age (based on the British Picture Vocabulary Scale – Dunn, et al., 1997), Verbal IQ (BPVS) and raw scores on Raven's Standard Progressive Matrices (Ravens, 1958). Participants were recruited through various schools in London and Essex, while both the head of the school and the parent/carer formally agreed for the children to participate in the study (see Appendix 1 for sample information letter and consent form and Appendix 2 for participants' overlap across experiments). The study was approved by City University's Ethics Committee.

Table 5.1. Participants' chronological age (CA) in years, verbal mental age (VMA), IQ scores and Ravens Progressive Matrices raw scores*.

	Autism (n=16)			Comparison (n=16)		
	M	(SD)	Range	M	(SD)	Range
Chronological Age	9.6	(1.5)	7.3-12.3	9.4	(1.4)	6.8-11.2
Verbal Mental Age (BPVS)	10.3	(2.6)	6.5-14.8	10.3	(2.3)	6.5-13.8
Verbal IQ (BPVS)	104.4	(12)	86-120	105.5	(10.9)	84-119
RSPM (raw score)	29.3	(11.3)	13-49	33.2	(12.2)	14-56

* Analysis for CA, VMA, VIQ and RSPM revealed no significant differences between the two groups (**CA**: t= -0.55, df= 30, p= 0.58; **VMA**: t= 0.03, df= 30, p= 0.97; **VIQ**: t= -0.27, df= 30, p= 0.78; **RSPM**: t= -0.94, df= 30, p= 0.35).

5.2.1.2. Stimuli and Apparatus

The materials used were 28 digitised grey-scale photos of adult faces, which were unfamiliar to all participants. All the faces were female and were presented in full-frontal pose exhibiting a neutral expression. Also, hair and ears were covered by the use of a surgical cap so that participants' attention was drawn to internal features only. None of the faces had any distinctive features such as glasses.

The 28 pictures of faces had been separated into one group of 14 pictures of typical faces, and a second group of 14 pictures which were the distinctive / caricature version of each of the typical faces in the first group. Distinctive faces were created with the use of a programme designed to create caricature versions of faces, called FaceFun. Specifically, in order to create the distinctive faces, each typical face was altered in forehead (height increased by 60%), eyes (width increased by 60% and height increased by 100%), nose (width increased by 60%), mouth (width increased by 40% and height increased by 20%) and chin (width increased by 30%).

In order to confirm the extent of typicality or distinctiveness of each face, faces were rated by adults who were unfamiliar with the purpose of our experiment. Our adults / judges (N = 14, Mean Age = 33.2, 6 males, 8 females) were told to rate each face on a scale of 1-7, where a rating of 7 should be designated to a very distinctive face and a rating of 1 should be designated to a very typical face (procedure adopted by Johnston & Ellis, 1995). The mean distinctiveness rating of the faces in the distinctive group was 5.51, whereas for the faces in the typical group was 2.71. The ranges of each group did not overlap (distinctive: 4.50-6.50, typical: 1.64-4.29). A related t-test confirmed that the typical and distinctive faces differed significantly in their distinctiveness, $t(13) = 10.16$, $p=.000$.

Faces were presented on a 17” computer monitor (Toshiba Tecra A2)

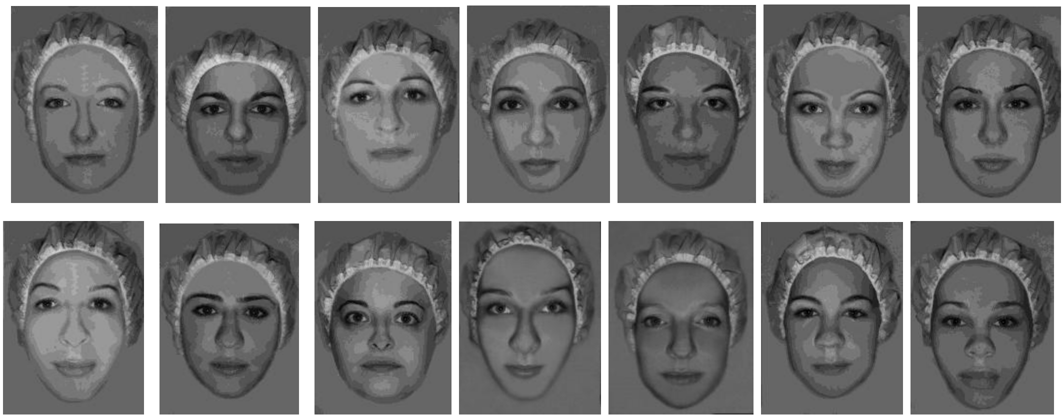


Figure 5.1. Typical Faces

Figure 5.2. Distinctive faces

5.2.1.3. Procedure

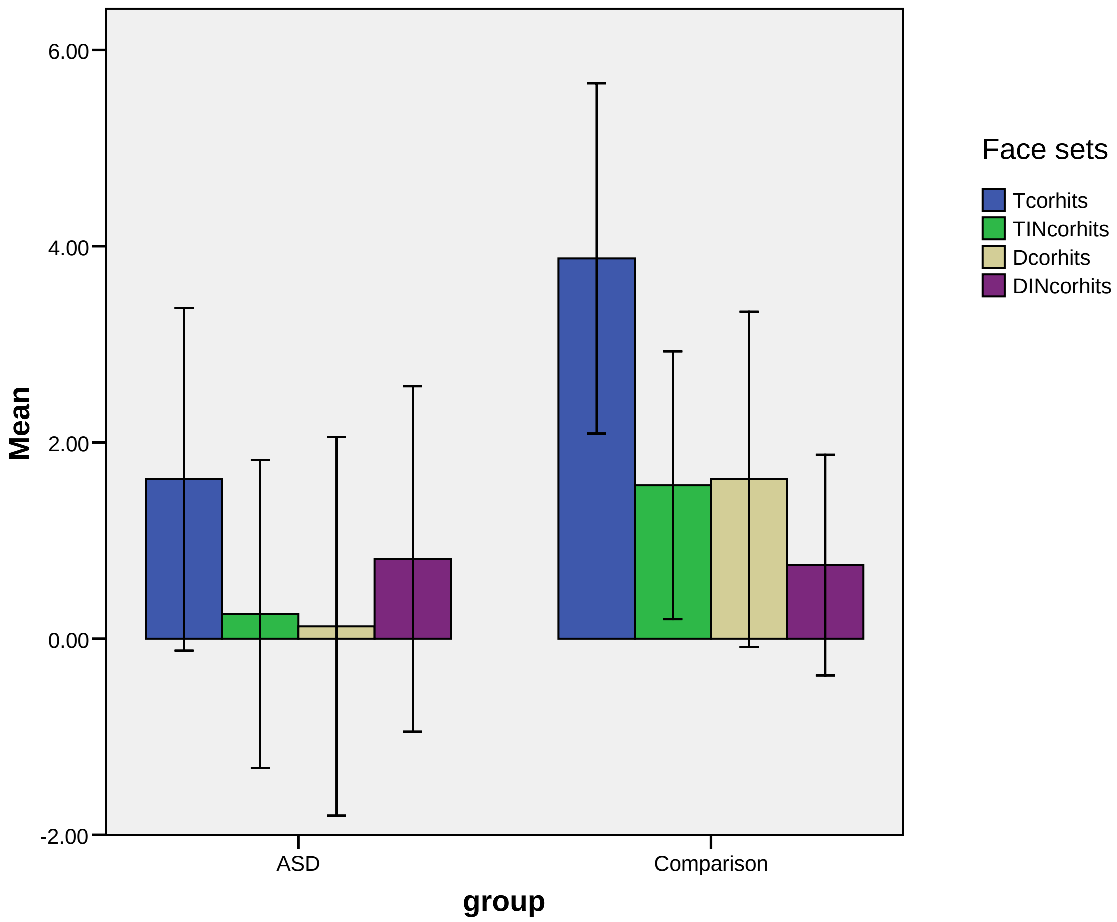
All participants were tested individually, in a quiet room during school times. They were told that they would be shown a sequence of faces and that they should look carefully at each one as they would later be asked to pick these out of a larger set of faces. The relevant computer keys had been labelled with a sticker marked with the words “YES” (for having seen the face before) and “NO” (for not having seen the face before).

After a practice trial, each participant was shown a sequence of 7 typical faces. Each face was viewed for 3 sec and there was a 2 sec interstimulus interval. The participant was then immediately shown the test sequence of 14 faces, which included the original 7 and a new set of 7 faces similar in type. In the test phase the participant had to indicate whether or not each presented face was one of the ones seen earlier. The same procedure was repeated for the set of distinctive faces. Also, the inverted condition of both typical and distinctive faces was carried out using the same procedure.

5.2.2. Results

For each participant, we calculated and analysed the corrected hits and false positives. Corrected hits were calculated by subtracting the false positives from the hits for each participant. These two measures were chosen to be analysed because they both provide evidence for better recognition (i.e. more corrected hits and fewer false positives shows that the stimuli are better recognised). Figures 5.3 and 5.7 present the means for the above measures.

Figure 5.3. Corrected hits in the different conditions (Tcorhits: typical faces corrected hits, TINcorhits: typical inverted faces corrected hits, Dcorhits: distinctive faces corrected hits, DINcorhits: distinctive inverted faces corrected hits) for the ASD and comparison group



Before any analysis on the data, the dependent variables (corrected hits and false alarms in upright and inverted typical and distinctive faces) and participants' mental age (MA), VIQ (verbal IQ) and score on Raven's were subjected to a correlational analysis. The analysis revealed no significant correlations (max r = .34, min p= .051). Therefore, MA, VIQ and Raven's scores were not included as covariates in the following analyses.

5.2.2.1. Corrected hits

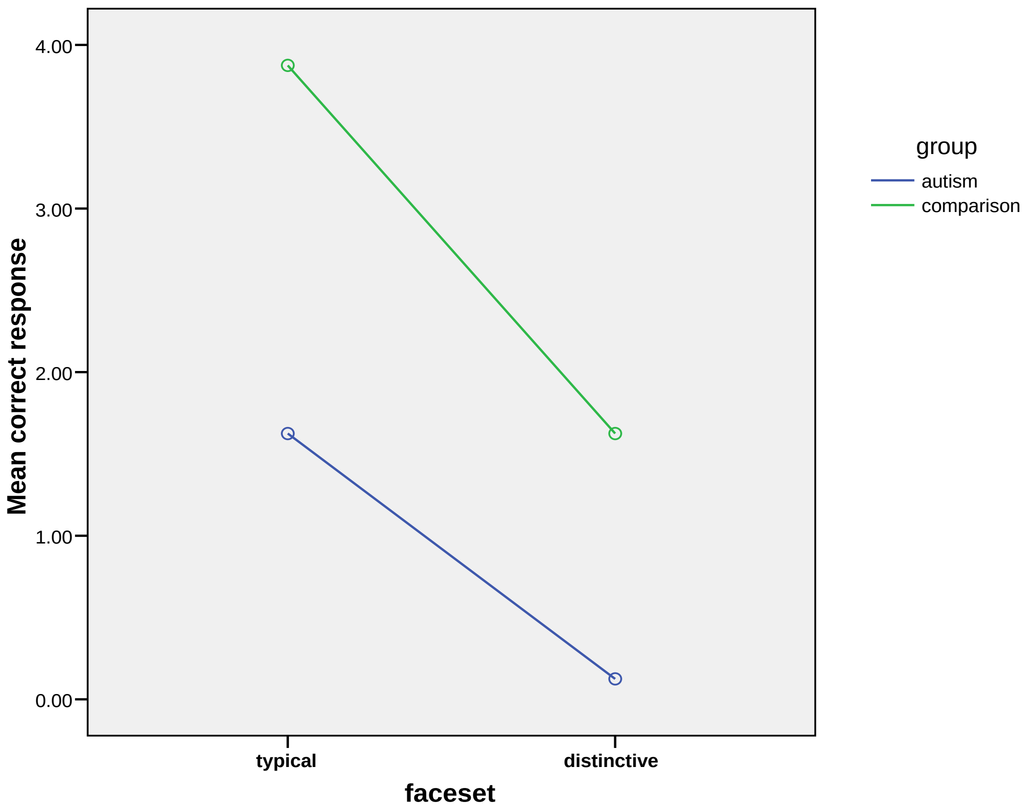
Corrected hits were subjected to a 2 x 2 x 2 mixed ANOVA to investigate the effects of face type (typical and distinctive), orientation (upright and inverted) and group (autism and comparison group).

There was a significant main effect of group, F (1,30) = 12.9, p<001, with the comparison group performing better that the autism group. The main effect of face type was significant, F (1,30) = 15.6, p<.001 (participants performed better in typical faces). There was also a significant main effect of orientation, F (1,30) = 10.3, p<.005 (participants performed better in upright faces). The interaction between face type and orientation was also significant, F (1,30) = 12.41, p<.001 (participants performed better in upright typical faces). The interaction between orientation and group was significant, F (1,30) = 12.5, p<.05 (the comparison group performed better in upright sets than the autism group), as well as the interaction between face type and group, F (1,30) = 4.4, p<.05 (the comparison group performed better than the autism group in typical faces). Finally, the three way interaction between face type, orientation and group was not significant (F (1,30)= .39, p= .53).

Since there was a significant interaction between face type and orientation, it was decided to analyse upright trials separately from inverted trials. Therefore a two-way ANOVA was used to analyse upright trials of typical and distinctive faces with group as a between subjects factor. A separate two-way ANOVA was used for inverted trials of typical and distinctive faces with group as a between subjects factor.

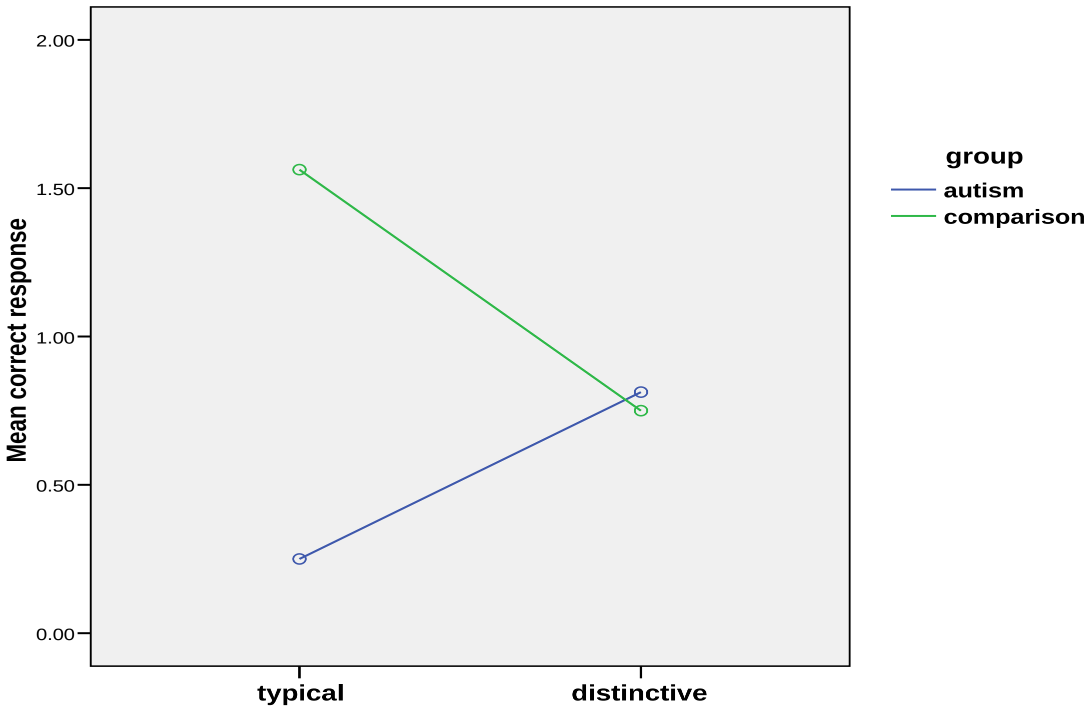
Upright trials: Analysis of upright trials showed a significant main effect of face type, F (1,30) = 23.2, p<.001, with participants performing better in typical than distinctive faces. The interaction between face type and group was not significant (F (1,30)= .93, p= .34).

Figure 5.4. Corrected hits in upright typical and distinctive faces for the autism and comparison group.



Inverted trials: Analysis of inverted trials revealed no significant main effect of face type ($F(1,30)= .15$, $p= .69$). However, it showed a significant interaction between face type and group, $F(1,30) = 4.7$, $p< .05$. This is illustrated in Figure 5.5 and shows that the comparison group performs better in typical faces than the ASD group but in distinctive faces the two groups show no differences.

Figure 5.5. Corrected hits in inverted typical and distinctive faces for the autism and comparison group.



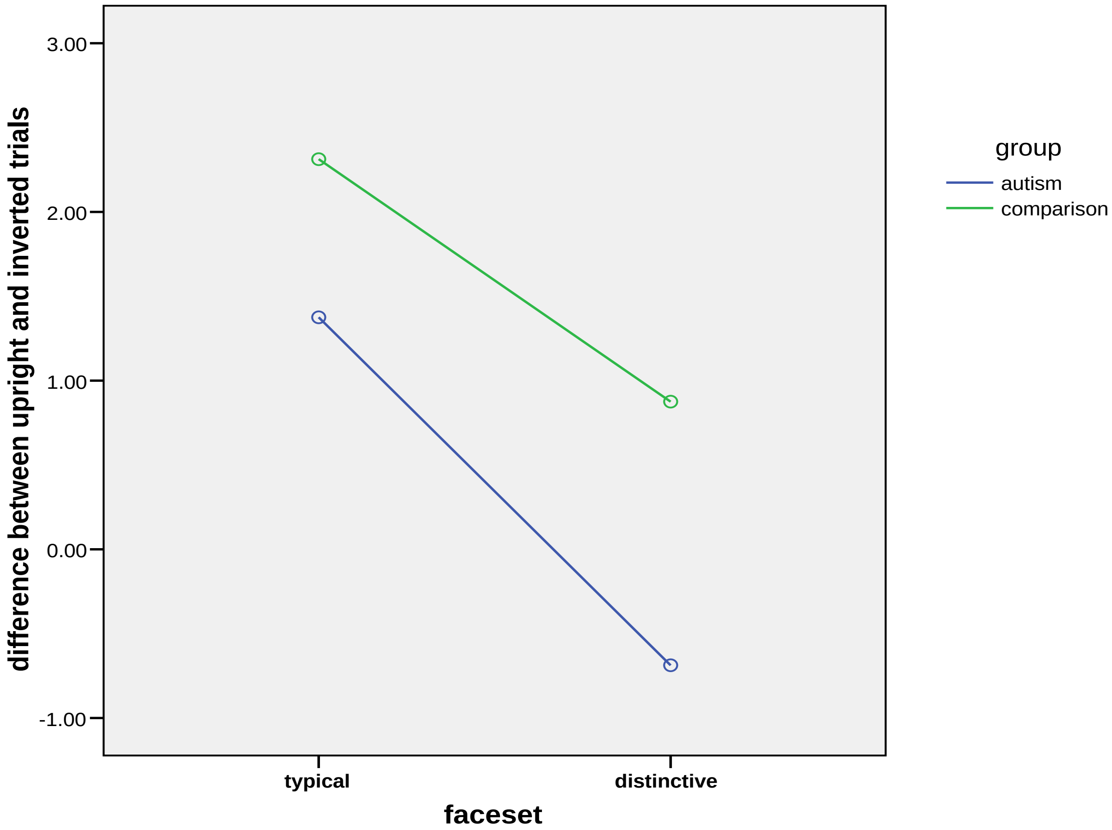
Analysis of simple effects on participants' performances in inverted trials showed significant differences between typical and distinctive trials in both groups (comparison group: $t = 11.22$, $df = 15$, $p<.001$, autism group: $t = 6.07$, $df = 15$, p<.001). A significant difference was also found between the autism and comparison group in the typical inverted faces ($t = 2.52$, $df = 30$, $p < .05$), while the difference between the two groups in the distinctive inverted faces was not significant ($t = 0.12$, $df = 30$, $p = .9$).

5.2.2.2. Inversion Effect

In order to analyse the inversion effect in more detail we calculated the differences between participants' performance in upright trials and inverted trials (upright trials minus inverted trials) and then applied a two-way ANOVA on these difference scores with group as a between subjects factor.

This analysis revealed a significant main effect of face type, $F(1,30) = 12.4$, $p < .001$, but no significant interaction between face type and group ($F(1,30) = .39$, $p = .53$).

Figure 5.6. Inversion effect (difference between upright and inverted trials for typical and distinctive faces) of corrected hits for typical and distinctive faces in the autism and comparison group.



5.2.2.3. False Alarms

False alarms were subjected to a 2 x 2 x 2 mixed ANOVA to investigate the effects of face type (typical and distinctive), orientation (upright and inverted) and group (autism and comparison group).

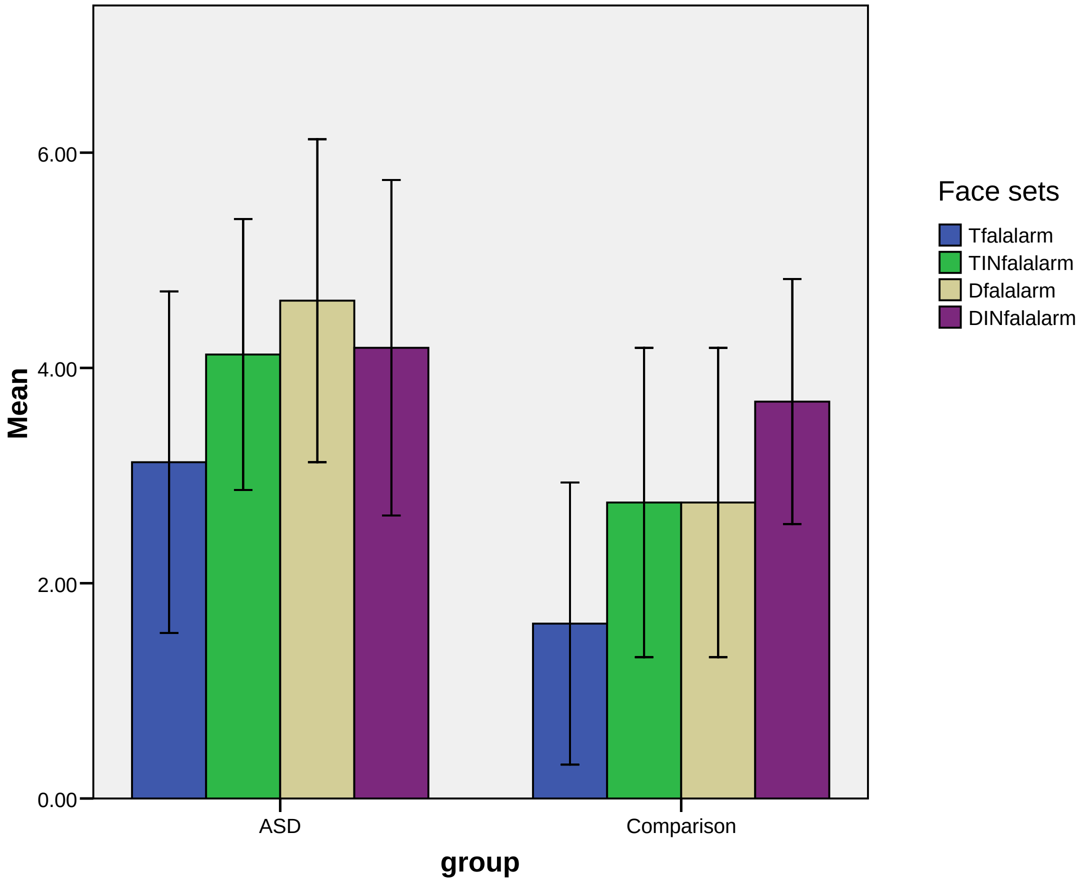
There was a significant main effect of group (F (1,30) = 14.7, p<.001), with the autism group showing more false alarms than the comparison group. There were also significant main effects of face type (F (1,30) = 18, p<.001) and orientation (F (1,30)

= 8.2, p<.01). There was a greater number of false alarms when faces were distinctive and when they were inverted. However, there was a significant interaction between face type and orientation (F (1,30) = 4.7, p<.05). The three way interaction between face type, orientation and group was not significant (F (1,30)= 2.8, p= .10). Table 5.2 and Figure 5.7 summarise these findings

Table 5.2. Participants' false alarms in upright and inverted conditions

	Autism (n=16) M (SD)	Comparison (n=16) M (SD)
Typical Faces	3.1 (1.5)	1.6 (1.3)
Typical Faces Inverted	4.1 (1.2)	2.7 (1.4)
Distinctive Faces	4.6 (1.5)	2.7 (1.4)
Distinctive Faces Inverted	4.1 (1.5)	3.6 (1.1)

Figure 5.7. False alarms in the different conditions (Tfalalarm: typical faces false alarms, TINfalalarm: typical inverted faces false alarms, Dfalalarm: distinctive faces false alarms, DINfalalarm: distinctive inverted faces false alarms) for the ASD and comparison group



Since there was a significant interaction between face type and orientation, it was decided to analyse upright trials separately from inverted trials. Therefore, a two-way ANOVA was used to analyse upright trials of typical and distinctive faces with group as a between subjects factor. A separate two-way ANOVA was used for inverted trials of typical and distinctive faces with group as a between subjects factor.

Analysis of upright trials revealed a significant main effect of face type ($F(1,30) = 21.8$, $p < .01$ – participants showed more false alarms in distinctive faces) and no significant face type by group interaction (F (1,30)= .44, p= .51). The main effect of group was also significant (F (1,30)= 15.1, p<.01). The analysis of inverted trial revealed neither significant main effects (F (1,30)= 3.08, p= .08) nor significant interactions (F (1,30)= 2.3, p= .13). However, the main effect of group was significant (F (1,30)= 5.8, p< .05), which showed that children in the autism group had more false alarms when faces were inverted. Figures 5.8 and 5.9 illustrate the findings.

Figure 5.8. False alarms in upright trials for typical and distinctive faces

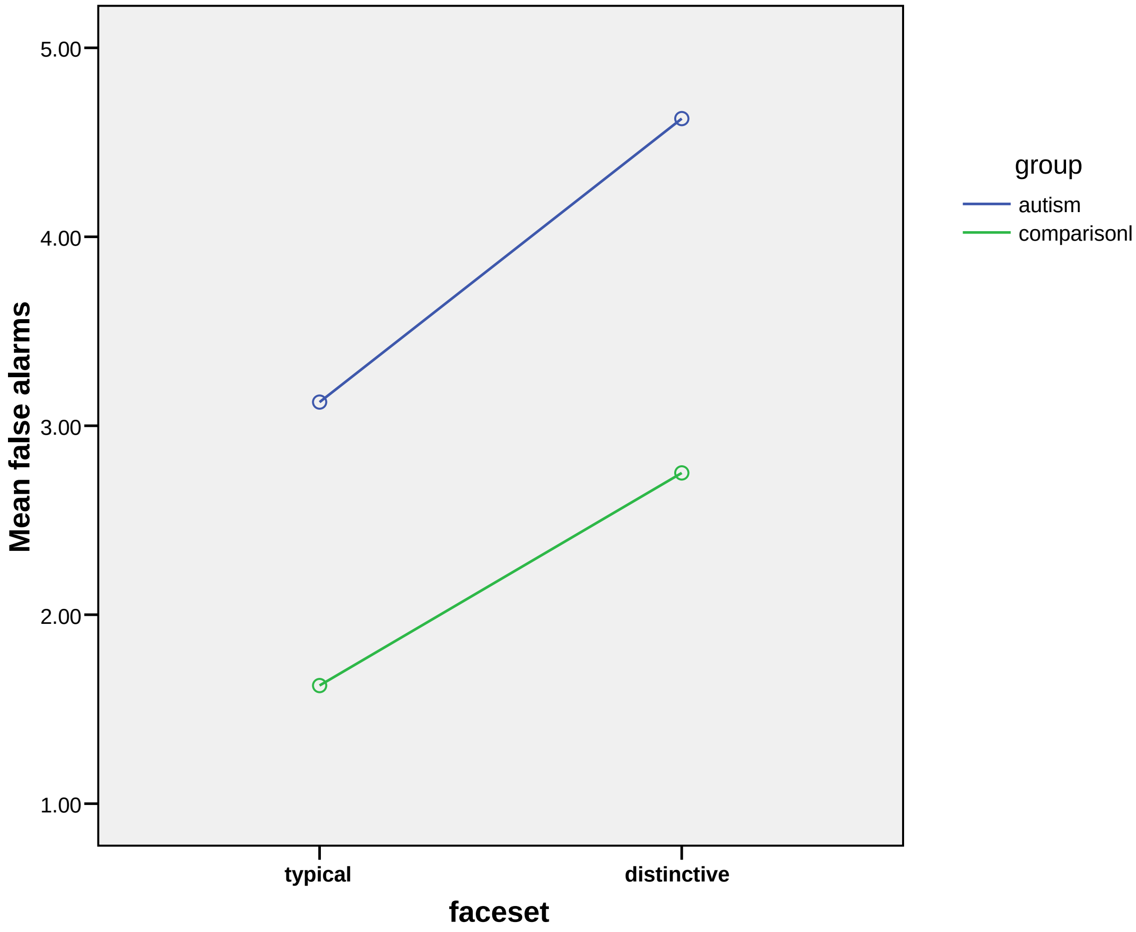
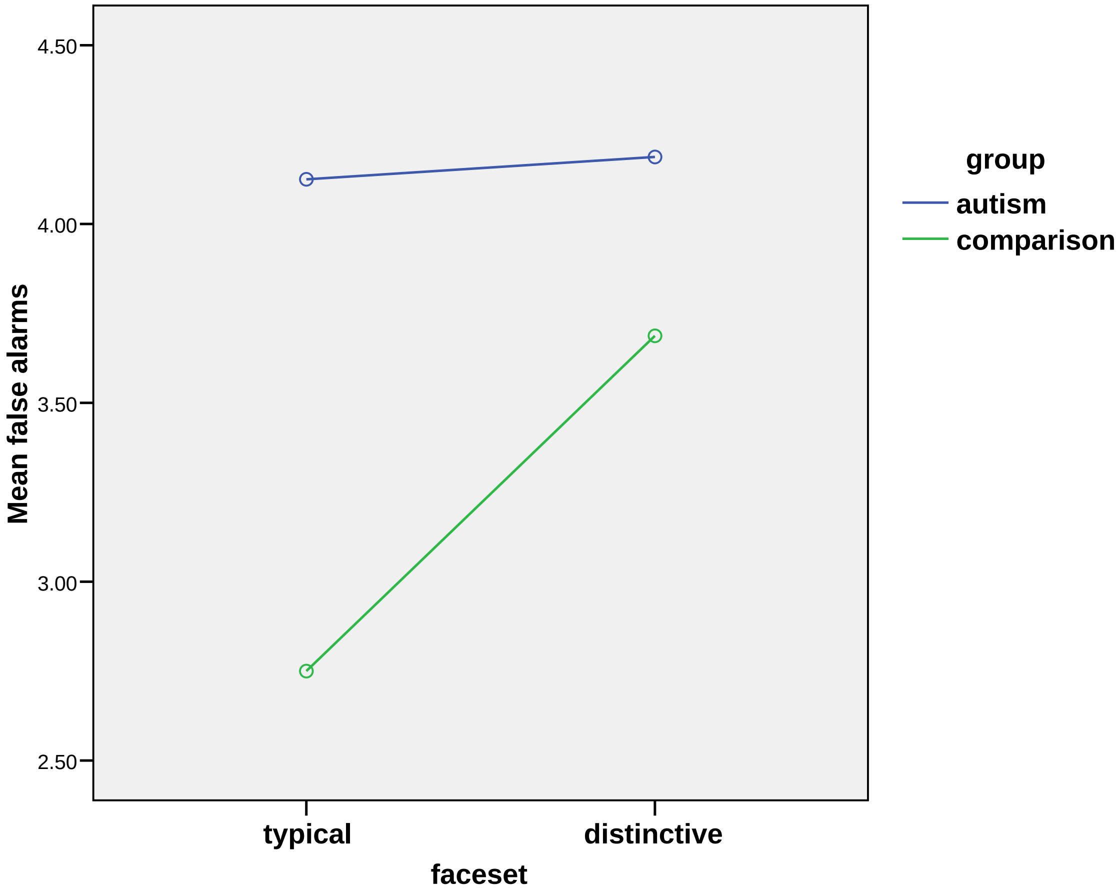


Figure 5.9. False alarms in inverted trials for typical and distinctive faces



5.2.2.4. Inversion Effect

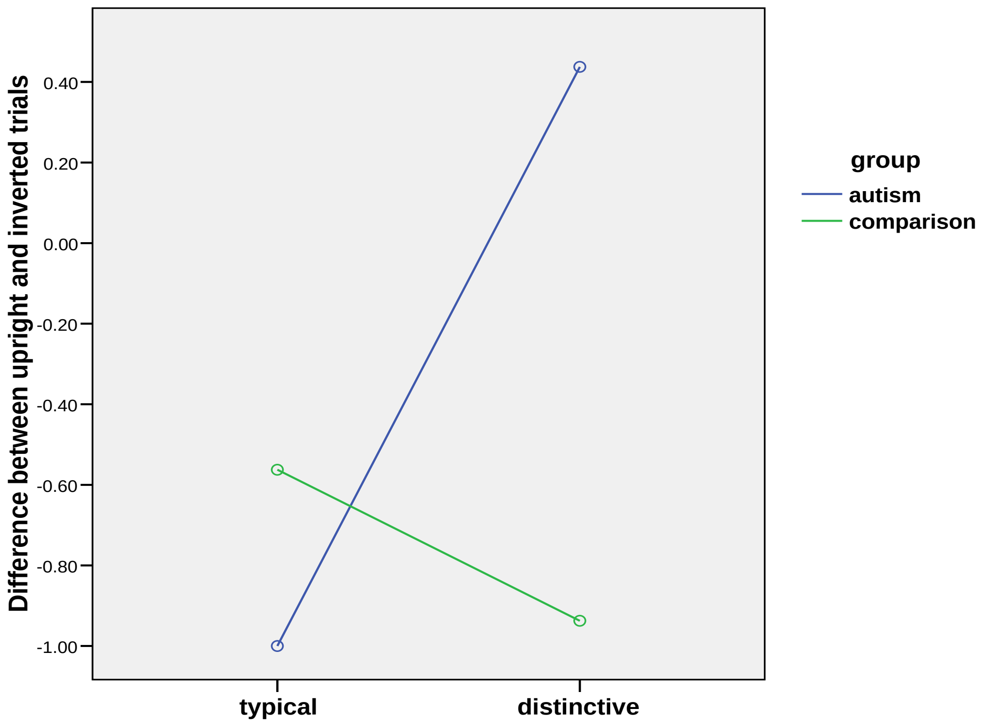
In order to analyse the inversion effect of false alarms in more detail we calculated the differences between participants' performances in upright trials and inverted trials (upright trials minus inverted trials) and then applied a two-way ANOVA on these scores with group as a between subjects factor.

The main effect of group was significant, $F(1,30) = 14.7$, $p<.001$. There was no significant main effect of face type but there was a marginally significant interaction between face type and group ($F(1,30) = 4.07$, $p = .053$), with the autism group showing more false alarms when distinctive faces are presented. Table 5.3 summarises the means for each condition in each group and Figure 5.10 illustrates the interaction.

Table 5.3. Mean difference between upright and inverted trials (inversion effect) in false alarms for typical and distinctive faces

	Autism (n=16) M (SD)	Comparison (n=16) M (SD)
Typical Faces	-1 (1.8)	-.5 (2.2)
Distinctive Faces	.4 (1.4)	-.9 (1.4)
Total	-.3 (1.6)	-1.4 (1.8)

Figure 5.10. Inversion effect of false alarms for typical and distinctive faces in the autism and comparison group



Analysis of simple effects on the inversion effect of false alarms revealed a significant difference between typical and distinctive faces in the autism group ($t = 2.46$, $df = 15$, $p<.05$), while in the comparison group differences were not significant ($t = .55$, $df = 15$, $p = .59$). Also, a significant difference was found between the autism and comparison group in distinctive faces ($t = 2.64$, $df = 30$, $p<.05$), whereas in typical faces the difference was not significant ($t = .6$, $df = 30$, $p = .55$). This shows that face inversion affects the autism group's false alarms more when faces are distinctive indicating more false alarms in the recognition of upright distinctive faces (since inversion = upright trials – inverted trials).

Power Analysis: As in previous experiments, GPOWER (Erdfelder et al., 1996) was used to calculate power. With number of participants being 32 and number of independent variables being 8, the effect size calculated was .50 (a moderate effect according to Cohen's (1988) tables). The post-hoc power analysis revealed the power of the test to be .79.

5.2.3. Discussion

In this experiment we analysed corrected hits and false alarms. Corrected hits' results showed that both groups of children (autism and comparison) performed better in the typical rather than distinctive faces, which goes against our initial hypotheses and does not confirm the distinctiveness effect. However, the comparison group performed significantly better on typical faces than did the autism group. It was also found that there was a greater inversion effect in typical faces, which confirmed our prediction that distinctive faces (caricatures) are processed with minimal reliance on second-order configurations, which explained the smaller inversion effect. When faces are inverted, comparison children perform better with typical faces and worse with distinctive ones. However, children with autism appear to treat inverted faces differently since they do better when faces are distinctive and worse when they are typical (the exact opposite of the comparison group).

False alarms analysis revealed that both groups of participants had more false alarms in the distinctive faces conditions, and while in the distinctive faces they appear to have more false alarms in the upright trials, in the typical faces there are more false alarms in the inverted trials. Also, there was a slightly greater inversion effect on false alarms in typical faces than in distinctive ones. As for children with autism, they appear to show a greater inversion effect of false alarms in distinctive faces than in typical faces.

Obviously, it could be argued that our task was slightly difficult for our participants with autism since they had to remember 14 faces overall and distinguish them from among 28, which also involves memory. It would be interesting to see, how our participants would perform if memory factors were reduced and trials of typical faces were combined with trials of distinctive faces. Would the typicality effect still be the case? This is what our next experiment aims to investigate.

5.3. Experiment 4

5.3.1. Introduction

In Experiment 3 we did not manage to replicate the distinctiveness effect, since our participants performed better with typical faces. Specifically, findings from upright trials revealed that both children with autism and children without autism recognise typical faces better than distinctive ones (the picture is slightly different for inverted faces), which provides evidence of second-order configural processing in both groups of participants.

In the two main studies that have investigated the distinctiveness effect and its implications for face recognition, by Valentine (1991) and Johnston & Ellis (1995) a few methodological differences are worth noting: the first relates to how typical and distinctive faces were presented. In the study by Valentine (1991), typical and distinctive faces were presented in separate conditions / blocks, while Johnston & Ellis (1995) presented the two groups of facial stimuli in one block (i.e. mixed). Adding to this, Valentine (1991) used different presentation times for typical and distinctive faces (longer for distinctive faces) while Johnston & Ellis (1995) had a group of participants that studied faces for 2 sec and another that viewed faces for 6 sec. Finally, one study had children as participants with the aim of investigating the developmental effects of face distinctiveness (Johnston & Ellis, 1995), while Valentine's (1991) participants were adults.

The effect of the different exposure times of faces on the distinctiveness effect has not been investigated and although both of the above mentioned studies provided similar results (superior performance for distinctive faces), participants' ages between studies differed and therefore clear conclusions cannot be drawn. Similarly, with regards to length of time for which faces were presented, Johnston & Ellis (1995) did not provide clear findings. Longer exposure times appeared to increase the recognition of distinctive faces but this was not the case for the shorter durations.

The current experiment is a follow-up of Experiment 3. In Experiment 3 participants underwent separate conditions for typical and distinctive faces in counterbalanced order. Typical and distinctive faces were still presented in different blocks. So, is it possible that there was an element of learning and getting used to distinctive faces, to the point that they lose their level of distinctiveness? In other words, is it possible if we mix our typical and distinctive faces and present them together, that distinctive faces will appear more distinctive, and therefore our participants might show the distinctiveness effect? If that happens, then not only can we replicate the distinctiveness effect, which will tell us a great deal about our participants' face processing skills, but also we can provide evidence for habituation to facial stimuli in autism. Another methodological difference between the two experiments is that faces in the 'study' phase of Experiment 4 will be presented to participants for shorter duration (2000msec in Experiment 4 instead of 3000msec in Experiment 3) to investigate the effect of presentation time in the two groups of children. These are the aims investigated in the present experiment.

5.3.2. Method

5.3.2.1. Participants

Participants in the autism group were 12 children with high-functioning autism. Children's diagnosis was confirmed by the school staff who kept records of their diagnostic reports. The comparison group consisted of 12 typically developing children in mainstream education. The two groups were matched on chronological age, Verbal Mental Age (based on the British Picture Vocabulary Scale – Dunn, et al., 1997), Verbal IQ (BPVS), raw scores on Raven's Standard Progressive Matrices (Ravens, 1958). The Benton Facial Recognition test (Benton, et al., 1983) was also carried out with all of our participants (Table 5.4 presents demographic information). Participants were recruited through various schools in London, while both the head of the school and the parent/carer formally agreed for the children to participate in the study (see Appendix 1 for sample information letter and consent form, and Appendix 2 for participants' overlap across experiments).

Table 5.4. Participants' chronological age (CA) in years, verbal mental age (VMA), IQ scores**,** Ravens progressive Matrices raw score and Benton Facial Recognition test scores.

	Autism (n=12)			Comparison (n=12)		
	M	(SD)	Range	M	(SD)	Range
Chronological Age	8.9	(1.2)	7.02-11	9.1	(1.3)	7.04-11
Verbal Mental Age (BPVS)	9.3	(2.1)	6-13.08	9.4	(2)	6-13.01
Verbal IQ (BPVS)	99.7	(15.6)	61-123	100	(14.1)	61-116
RSPM (raw score)	31.4	(7)	23-45	28.2	(9.2)	16-42
Benton Facial Recognition	37.6	(5.4)	28-47	42.1	(3.1)	38-49

* Analysis for CA, VMA, VIQ and RSPM revealed no significant differences between the two groups (**CA**: t= -0.28, df= 22, p= 0.77; **VMA**: t= -0.18, df= 22, p= 0.85; **VIQ**: t= -0.05, df= 22, p= 0.95; **RSPM**: t= -0.94, df= 22, p= 0.35). Analysis of the BFRT showed a significant difference between the two groups (t=-2.4, df=22, p<.05).

5.3.2.2. Stimuli and apparatus

Stimuli are the same as these employed in Experiment 3. The only difference is that instead of 7 study faces in each of the two conditions (7 typical and 7 distinctive) and 14 faces in the test phase, we now have one condition with 10 study faces (5 typical and 5 distinctive faces) and 20 tests faces for the test phase (this included the 10 faces in the study phase and 10 new faces). Also, just like in Experiment 3 participants were exposed to an inverted faces condition, too.

5.3.2.3. Procedure

The procedure is the same as in Experiment 3. Participants were instructed to look at the screen and study very carefully each face that appeared because later on they would be asked to recognise them in a larger list of faces. So, in this study phase, participants looked at 10 faces (5 typical and 5 distinctive faces the order of which was randomised). Before each face, a cross appeared in the middle of the screen (to help participants concentrate) for 2000 msec and then each face appeared on the screen for 2000 msec. When participants were ready we moved to the test phase during which a face appeared on the screen and participants had to indicate if they saw the face before or not (click on the ‘YES’ button if they have seen the face before or the ‘NO’ button if they haven’t). The same procedure was followed for the inverted faces condition. The two conditions were counterbalanced between participants.

5.3.3 Results

For each participant, we calculated and analysed the corrected hits and false positives. Corrected hits were calculated by subtracting the false positives from the hits for each participant. These two measures were chosen because they both provide evidence for better recognition (i.e. more corrected hits and fewer false positives shows that the stimuli are better recognised).

5.3.3.1. Corrected hits

Corrected hits were subjected to a 2 x 2 x 2 mixed ANOVA to investigate the effects of face type (typical and distinctive), orientation (upright and inverted) as within subjects factors and group (autism and comparison group) as a between subjects factor.

No significant main effects or interactions were found in this analysis (max $F = 2.8$, min $p = .10$). The table below summarises the means for each condition.

Table 5.5. Mean accuracy in typical and distinctive faces for the ASD and comparison group

	Autism (n=12) M (SD)	Comparison (n=12) M (SD)
Typical faces	.5 (2.3)	1.3 (2.1)
Typical faces inverted	.2 (1.4)	.6 (2.1)
Distinctive faces	.3 (2)	1.5 (1.5)
Distinctive faces inverted	1 (1)	.1 (1.1)

5.3.3.2. Inversion Effect

In order to analyse the inversion effect in more detail we calculated the differences between participants' performances in upright trials and inverted trials (upright trials minus inverted trials) and then applied a one-way ANOVA on these difference scores with group as a between subjects factor.

Analysis revealed no significant main effects or significant interactions (max F= 2.8, min p= .10). The table below summarises the means for each condition.

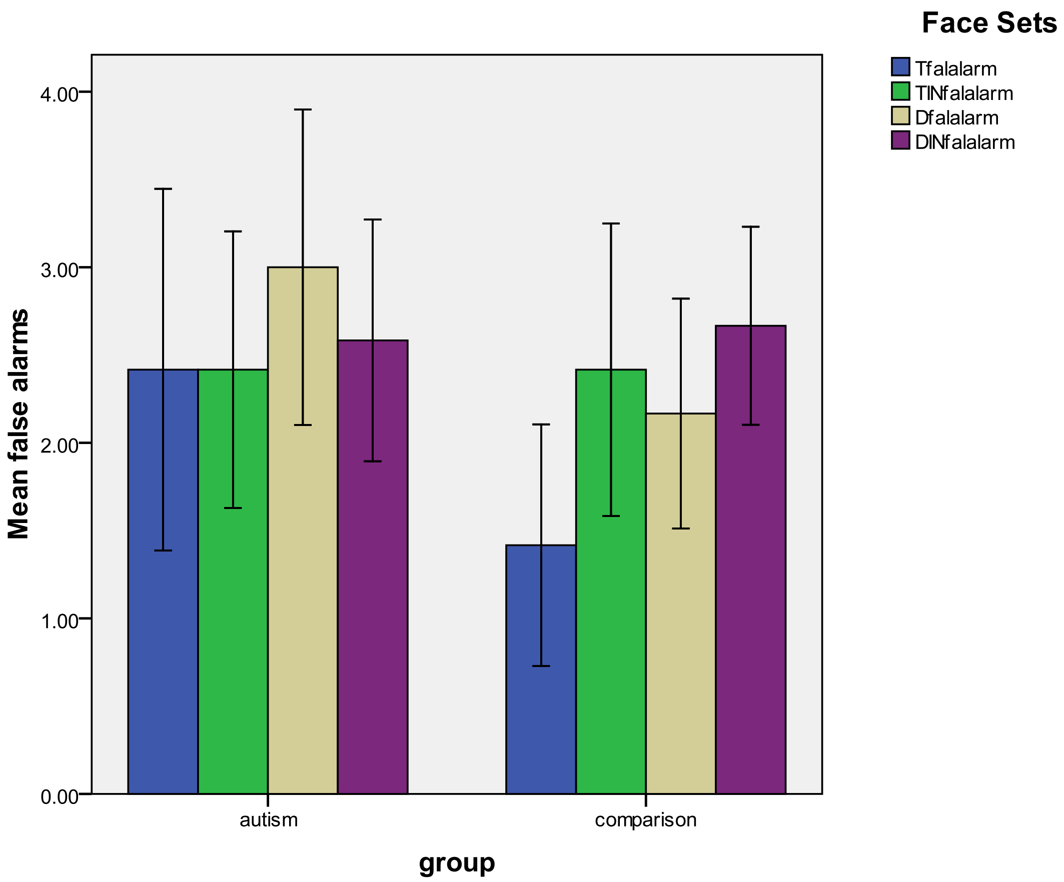
Table 5.6. The inversion effect in typical and distinctive faces for the ASD and comparison group

	Autism (n=12) M (SD)	Comparison (n=12) M (SD)
Typical faces	.3 (2.4)	.6 (2.3)
Distinctive faces	-.6 (2.1)	1.3 (2.4)

5.3.3.3. False Alarms

False alarms were subjected to a 2 x 2 x 2 mixed ANOVA to investigate the effects of face type (typical and distinctive), orientation (upright and inverted) and group (autism and comparison group). The means are presented in Figure 5.11 below.

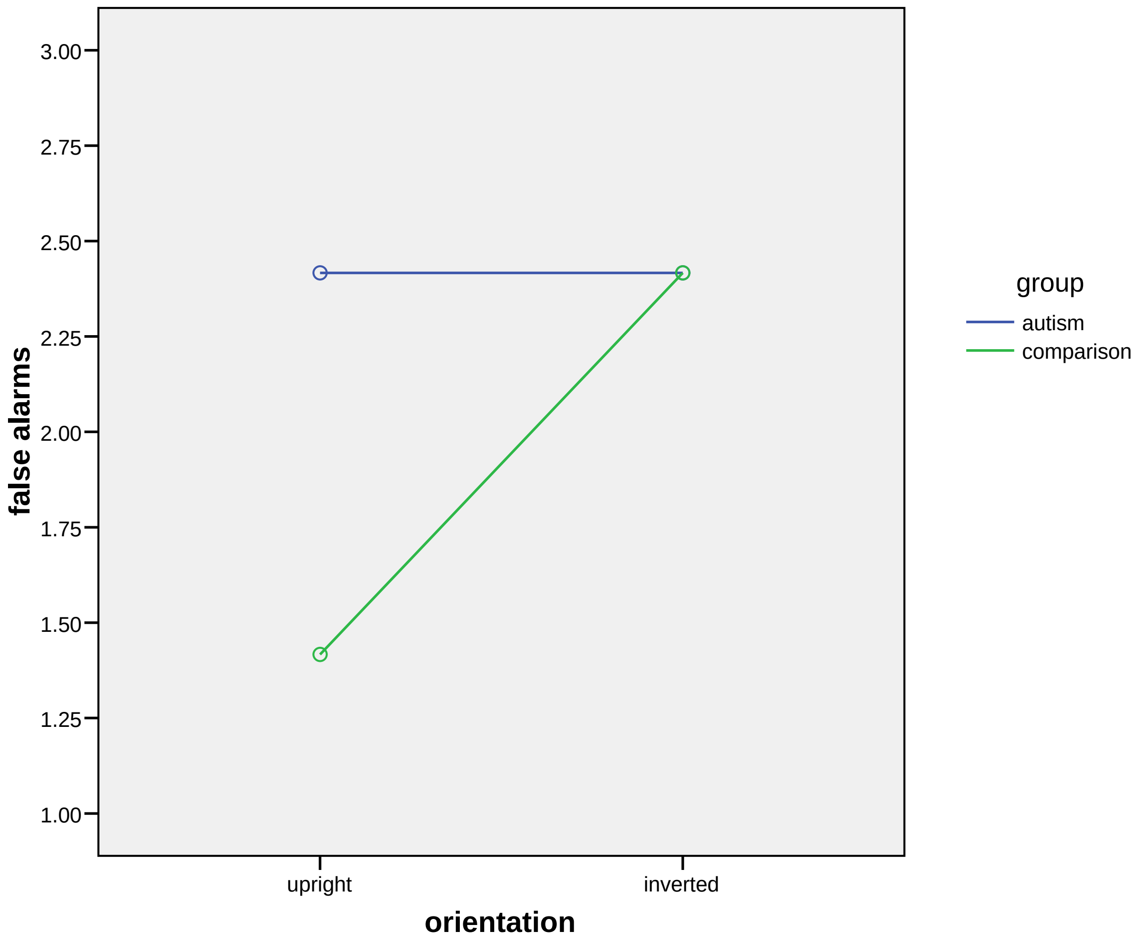
Figure 5.11. False alarms in the different conditions (Tfalalarm: typical faces false alarms, TINfalalarm: typical inverted faces false alarms, Dfalalarm: distinctive faces false alarms, DINfalalarm: distinctive inverted faces false alarms).



There was a significant interaction between group and orientation (F (1,22)=4.5, p<.05), with the autism group showing more false alarms in upright trials. There was also a trend for a significant main effect of face type, (F (1,22)=3.8, p=.06), with participants showing more false alarms when asked to remember distinctive faces.

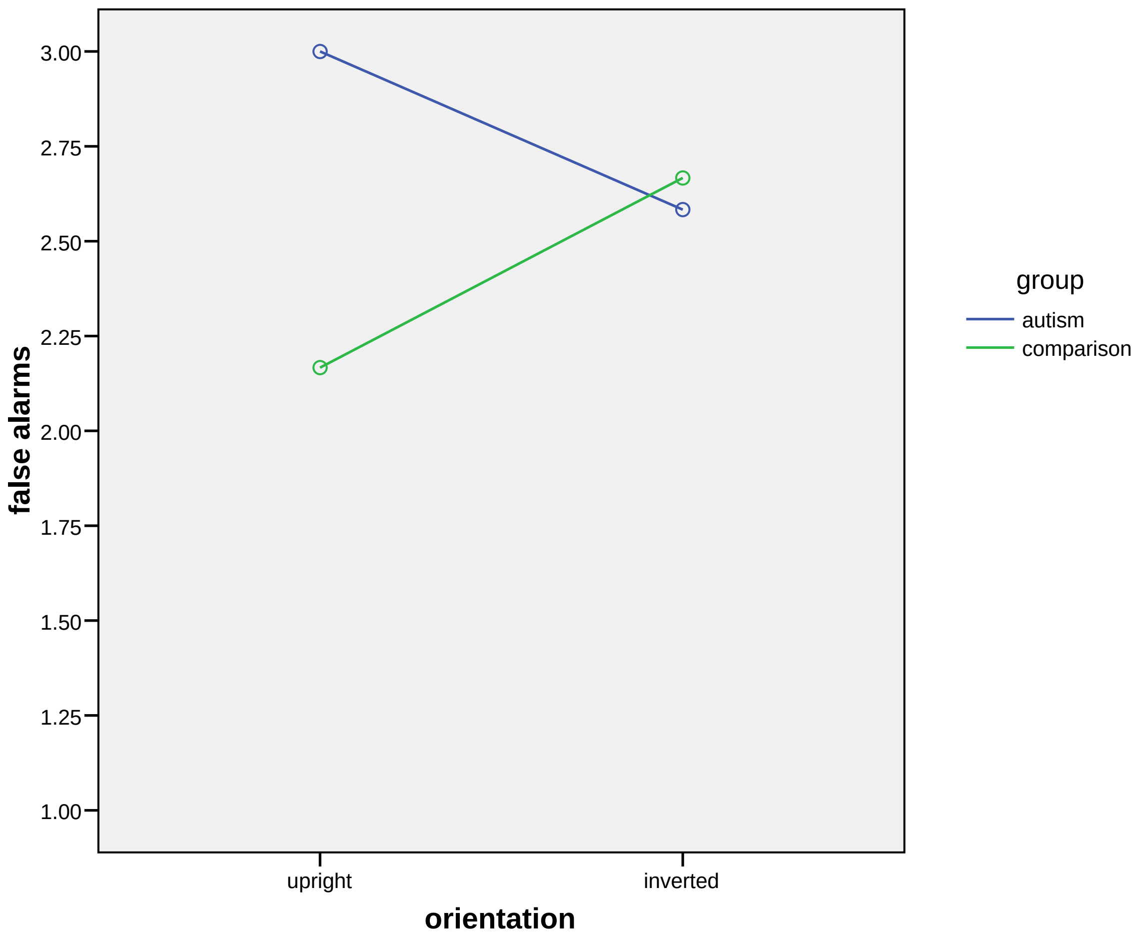
The remaining main effects and interactions were not significant (max F= 1.9, min p= .18). Figure 5.12 illustrate these findings.

Figure 5.12. False alarms in upright and inverted typical faces for the autism and comparison group



Analysis of simple effects showed a significant difference between upright and inverted trials for the comparison group in typical faces, t=-2.2, df=11, p<.05, but not for our participants with autism.

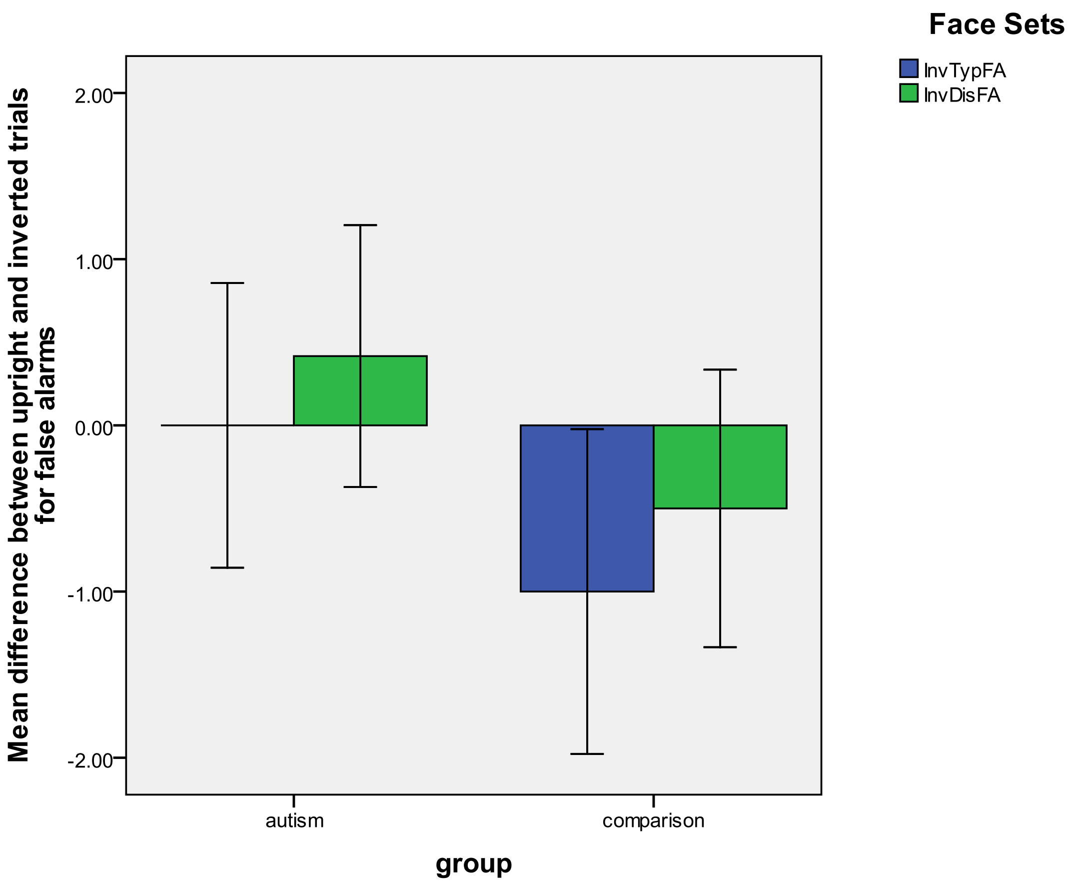
Figure 5.13. False alarms in upright and inverted distinctive faces for the autism and comparison group.



5.3.3.4. Inversion Effect

In order to analyse the inversion effect in more detail we calculated the differences between participants' performance in upright trials and inverted trials (upright trials minus inverted trials) and then applied a two-way ANOVA on these scores with group as a between subjects factor. Means are presented in Figure 5.14.

Figure 5.14. The inversion effect in participants' false alarms in typical and distinctive faces (InvTypFA: inversion effect in the false alarms of typical faces, InvDisFA: inversion effect in the false alarms of distinctive faces)



The main effect of group was significant ($F(1,22)= 4.5$, $p<.05$). The remaining main effects or interactions were not significant (max $F= 1.9$, min $p= .18$.)

5.3.4. Discussion

The current experiment was a follow-up of Experiment 3 in which the distinctiveness effect in faces was investigated. The reason for exploring the distinctiveness effect further was because of a number of methodological issues identified in the literature. These methodological issues relate to the way distinctive and typical faces are presented as well as their exposure times. In the current experiment distinctive and typical faces were presented within one block of trials, as opposed to the previous experiment when they were presented in separate blocks of trials, and face presentation time was reduced to 2sec as opposed to 3sec in the previous study. The aim was to investigate the effect of type of presentation and exposure time on our participants' corrected hits and false alarms when asked to remember typical and distinctive faces, and whether there will be any difference in the performance of children with autism. In other words, since the distinctiveness effect was not replicated in Experiment 3, will distinctive faces appear more distinctive when they are presented within a list of typical faces, and also since evidence about exposure times time has been inconclusive so far (Johnston and Ellis, 1995), further investigations are needed to establish any effects.

Overall, the analysis of corrected hits showed that when typical and distinctive faces are presented in one block of trials, participants show neither the distinctiveness effect (distinctive faces remembered better) nor the typicality effect (typical faces remembered better). As far as false alarms is concerned, there was a non-significant trend for both groups of our participants to show more false alarms with distinctive faces. Finally, participants with autism appeared to have more false alarms in upright trials than typically developing children, who had significantly more false alarms than the ASD group in inverted trials for both typical and distinctive faces. None of the inversion effects analyses produced any significant main effects or interactions.

5.4. General Discussion

In this chapter two experiments were carried out with the aim of investigating holistic face processing in children with autism and children without a diagnosis of autism. Holistic processing is this study was tested with the use of distinctive faces (caricatures) and that was based on the assumption that holistic information in faces refers to template-like representations of a face which are processed with only minimal reliance on configurations. The literature on the distinctiveness effect shares the same assumption and mainly proposes that distinctive faces are recognised better than typical faces. If distinctive faces in our study are better recognised than typical ones then we can conclude that our participants engage in holistic processing, which according to Maurer et al. (2002), is the second in the order of information processed in faces just before we reach expertise (with second-order configural processing).

In both Experiments 3 and 4 we analysed corrected hits and false alarms.

5.4.1. Experiment 3

In Experiment 3 corrected hits' results showed that both groups of children (autism and comparison) performed better in the typical rather than distinctive faces, which goes against our initial hypotheses and does not confirm the distinctiveness effect. Although both goups of participants performed better on typical faces compared to the distinctive ones, the comparison group performed significantly better than the autism group on typical faces, which indicates that the autism group was experiencing configural processing difficulties. It was also found that there was a greater inversion effect in typical faces, which confirms our prediction that distinctive faces (caricatures) are processed with minimal reliance on second-order configurations.

Interestingly, this inversion effect seems to be greater for the comparison group in the typical faces condition.

More specifically, we performed separate analyses for upright and inverted stimuli. For the upright stimuli, we only found a significant main effect of face type with both groups of children performing better when asked to recognise typical faces. Analysis of inverted trials showed a different pattern of results. There was no significant main effect of face type. However, the interaction between face type and group (autism vs. comparison) was significant, with comparison children in the inverted condition performing better with typical than distinctive faces., The picture is slightly different for children with a diagnosis of autism who appear to treat inverted faces differently since they do better when faces are distinctive and worse when they are typical faces (the exact opposite of comparison group, see Figure 5.5).

Overall, when we calculated the inversion effect (upright trials performance minus inverted trials' performance) no group interaction was found, but rather once more both groups of children showed a greater inversion effect in typical faces.

Part of our analysis also included analysing participants' false alarms. Overall there were significant main effects of face type (typical vs. distinctive) and orientation (upright vs. inverted), a significant interaction between face type and orientation, whereas the group interaction was not significant. In other words, both groups of participants appeared to have more false alarms in the distinctive faces conditions, and while in the distinctive faces they appear to have more false alarms in the upright trials, in the typical faces there are more false alarms in the inverted trials.

Separate analyses for upright and inverted trials showed that both groups had more false alarms in the upright distinctive faces condition, while in the inverted trials condition both groups of children had more false alarms in the inverted trials conditions.

Overall, when we calculated the inversion effect (upright trials performance minus inverted trials' performance), no significant main effect of face type was found, but a marginally significant group interaction was found. Specifically, in the comparison group, there was a slightly greater inversion effect on false alarms in typical faces than in distinctive ones. As for children with autism, they appear to show a greater inversion effect of false alarms in distinctive faces than in typical faces (see Figure 5.12).

But what do all these findings mean in terms of the face processing strategies our two groups of children use? Recognition memory paradigms have long been used as a tool for studying the way we represent faces. In the usual kind of experiment, just like the one used in the current study, the participant observes a set of target faces and later decides which faces from among a set of distractors were part of the target set. Responses are elicited as either old/new judgements, or as particular choices from a set of alternatives. One of the most consistent findings in this type of experiment is that distinctive faces (those that are rated as "easy to spot in the crowd") are correctly recognised more frequently than typical faces. This distinctiveness effect is robust and has been widely reported in the literature (e.g. Bartlett, Hurry & Thorley, 1984; Shepherd, Gibling & Ellis, 1991; Johnston & Ellis, 1995). In all of these studies, distinctive faces produce more corrected hits and fewer false alarms (incorrect detection) than typical faces. This difference is often interpreted to mean that distinctive faces are better remembered than typical faces.

5.4.2. Distinctiveness Effect

One of our most important findings that contradicts these previous research findings regarding the recognition advantage for distinctive faces, is that none of our two groups of children showed this distinctiveness advantage. In fact, as it was mentioned before, both children with autism as well as children without the diagnosis recognised typical faces better than distinctive ones, as illustrated by the analysis of corrected hits. This finding is also supported by the false alarms analysis which showed more false alarms in the distinctive faces. Generally, our participants found distinctive faces harder to recognise and remember. At this point, questions related to our methodology and specifically the way we created faces, arise. It might be suggested that the distinctive faces used in our study might not be distinctive enough. However, the faces used in this study were first rated by adults who were blind to the aims of this study, and analysis of these ratings provided us with significant differences between the two sets of faces (typical and distinctive). Also, all distinctive faces were caricature versions of the same typical faces, and the caricatures were made in exactly the same way for all our faces. So, our experimental stimuli were very well controlled.

Although the above assumption (well controlled stimuli) is regarded as an advantage for our study, there is also evidence to suggest that this can serve as a disadvantage for the purpose of our study. In a study that used face silhouettes, Davidenko and Ramscar (2005) showed that in fact, distinctiveness effects in face memory vanish with well controlled distractors. Specifically, those well controlled distractors were created according to the multidimensional space framework in face recognition (face space) proposed by Valentine ("The origin of the multidimensional space is defined as the central tendency of the dimensions. It is assumed that the values of the feature dimensions of the population of faces experienced will vary normally around the central tendency. Therefore by definition, typical faces (close to the central tendency) will be seen more often than distinctive faces (distant from the central tendency). Thus, the density of points (i.e. the number of previously seen faces) will decrease as the distance from the central tendency increases. The population of points will include familiar faces in addition to many points representing faces that have been seen previously but would not necessarily be 'familiar' in the sense that they could be identified. Thus, an implicit knowledge derived from a lifetime's experience with faces contributes to the normal distribution of faces within the multidimensional space" - Valentine, 1991, p.166). In the Davidenko and Ramscar (2005) study the set of distinctive silhouettes was identical to the set of typical silhouettes, except that it was centered in a different location of the space, still within the realm of normal looking silhouettes. With this technique the authors showed that typical faces were recognised with better accuracy, which they called the 'typicality effect' (Davidenko and Ramscar, 2005).

Obviously, this 'typicality effect' is what was replicated in our study, too. Although our distinctive faces were clearly distinctive (as rated by an independent group of adult judges), they were not recognised more accurately because distinctive faces were identical to typical faces but centered in a different location of the 'face space' (as proposed by Valentine in 1991).

However, the aim of the two experiments was not only to investigate the distinctiveness effect in face recognition but also to look into the underlying face processing strategies that children use when asked to identify typical vs. distinctive faces. Because our distinctive faces were in fact distinctive and typical faces were typical (as rated by the group of independent judges), many conclusions can be drawn regarding children's face processing techniques (i.e. holistic face processing vs. second order configural processing), especially because in our experiment we included upright as well as inverted conditions.

First of all, in Experiment 3 it was found that both groups of children recognised upright typical faces more correctly than upright distinctive faces, and clearly this provides evidence for second order configural processing in both groups of participants. This is also supported by findings coming from the analysis of the inversion effect (upright trials performance minus inverted trials' performance), which revealed a greater inversion effect for typical faces (again in both groups of children). This finding goes along with our prediction that when we compare performance between typical and distinctive faces, because of the kind of information contained in distinctive faces (template representations with minimal reliance in second order configurations), the inversion effect should be smaller in distinctive faces, which in turn provides evidence for holistic processing. Therefore, our participants engaged in second order configural processing, which is demonstrated in their better performance with typical faces and the greater inversion effect observed in this set of faces. Similarly, poorer performance in distinctive faces and the smaller inversion effect provide evidence for holistic processing (as defined in the current studie - template representations with minimal reliance in second order configurations). This finding confirms previous findings that suggest that the extent of inversion is the best measure of second order configural processing in faces (Searcy and Bartlett 1996; Murray et al, 2000; Boutsen and Humphreys, 2003), which in turn is evidence of face expertise (Leder & Bruce, 2000).

However, despite the fact that our participants with autism showed evidence of configural processing, this was not at the same level as in the comparison group. In fact, our participants with autism performed significantly worse than the comparison group in their recognition of typical faces thus demonstrating difficulties with configural processing. So, there is a very interesting finding here: our participants with autism are capable of face configural processing and they perform better in this than in holistic processing, but when this configural processing is compared to that of comparison children, then it appears that it is not as effective and therefore difficulties are apparent. In some ways this finding provides support both for studies that have found evidence of configural processing in autism (Teunisse & de Gelder, 2003; Rouse et al., 2004; Nishimura et al., 2007; Rouse et al., 2004; Nishimura et al., 2007; Hadjikhani et al., 2004; Pierce et al., 2004), as well as those that have found impairments in this type of face processing (Deruelle, Rondan, Gepner & Tardif, 2004; Deruelle, Rondan, Salle-Collemiche, Bastard-Rosset and Da Fonseca, 2008; Wallace et al., 2008). A close look at the other results of this experiment might provide explanations for the current finding.

Although so far we have some evidence for second order configural processing in both groups of children, it is also interesting to look at our findings separately for upright and inverted trials. In the previous sections we discussed the upright trials and the fact that both our groups performed better in recognition trials for the typical faces, which is evidence for second-order configural processing. However, previous evidence from inverted faces tasks has suggested that the processing of upside down faces is based on featural information (Tanaka and Farah, 1991; Farah, Tanaka and Drain, 1995), which explains poorer performance when participants are asked to recognise them. One interesting finding of Experiment 3 was that (in the analysis of corrected hits) when analysing inverted trials, our comparison group (children without autism) performed better with typical faces and worse with distinctive ones, whereas children with autism appeared to perform better when faces were distinctive and worse when they were typical faces (the exact opposite of the comparison group). Therefore, it seems that our two groups of children treat inverted faces in different ways. But what does this tell us in relation to face processing strategies?

The finding that our comparison group does better with typical inverted faces than distinctive inverted faces, suggests that the difficulty presented in the distinctive faces is due to the holistic processing strategy required, whereas in typical faces second order configural information is required. In other words, this finding confirms our previous finding that participants in the comparison group process the second order configural information in typical faces, which is more effective (better performance) than holistic processing is because it shows face processing expertise. However, the picture is different for the group of children with autism. Children with autism performed differently and actually recognised inverted distinctive faces more correctly than they did typical inverted faces. Based on what it was mentioned above, this finding suggests that children with autism show a preference for holistic processing in inverted trials, which reflects their better performance in the distinctive faces.

Generally, these conclusions receive further support from the analysis of false alarms, too. So, in upright trials it has been shown that both groups of participants present more false alarms in the recognition of distinctive faces which provides support for the 'typicality effect' discussed earlier. Distinctive faces are harder to recognise, possibly due to the holistic processing required, and therefore participants make more false alarms.

Regarding inverted trials, again both groups seem to produce more false alarms to the distinctive faces. However, as it can be seen in Figure 5.5 in the autism group this difference between typical and distinctive faces is much smaller (although not significantly so). This supports the previous finding from corrected hits in which children with autism performed better in inverted distinctive trials, while children in the comparison group performed better in inverted typical trials. So, once more this is evidence for holistic processing in autism and second-order configural processing in children without autism.

More interestingly the analysis of the inversion effect on false alarms showed that in the comparison group, there was a slightly greater inversion effect on false alarms in typical than in distinctive faces. As for children with autism, they appear to show a greater inversion effect for false alarms in distinctive faces than in typical faces.

Specifically, in the comparison group the differences are always negative which means that, as expected, more false alarms are observed in the inverted trials conditions (in both typical and distinctive sets of faces).

In children with autism, there seems to be a greater difference between upright and inverted trials' false alarms in distinctive faces, as demonstrated by the large positive inversion effect in distinctive faces. Since previously we demonstrated that children with autism, similarly to our comparison group, show more false alarms in distinctive rather than typical upright faces, the large positive inversion effect in distinctive faces demonstrates that the big difference in false alarms between upright and inverted trials in distinctive faces is due to very few false alarms in the inverted trials of distinctive faces. This supports our previous finding that inverted trials of distinctive faces are treated differently in autism, possibly due to holistic processing being involved.

To sum up, the findings from Experiment 3 revealed a series of interesting facts. First of all, in contrast to what it was initially hypothesised, the distinctiveness effect was not confirmed. Rather, because of our well controlled stimuli in our experiment we replicated the 'typicality effect' which was first proposed by Davidenko and Ramscar (2005). That means that both participants with autism and participants without autism correctly recognised more typical than distinctive faces, which in turn suggests that our participants used second order configural processing in their recognition of faces. That is because, as it was explained in our review of the literature, typical faces are processed based on second order relations, while caricature faces (distinctive faces) are processed holistically. In the review, it has been suggested that so far, existing literature has not been able to clearly distinguish between holistic and configural (second order configural) information, and that existing paradigms that have attempted to test these parameters have not been conclusive. As a result we have ended up either using those two terms (holistic vs. configural) interchangeably or suggesting that the two terms overlap. However, because this tends to be rather confusing and clearly conclusions regarding face processing in general as well as in special populations (i.e. autism spectrum disorders) cannot be drawn, Experiment 3 attempted to define the terms more specifically. So, based on the distinctiveness effect in faces, we proposed that holistic information involves template-like representations which also include a minimal reliance on configurations. Further to this, we assume that holistic encoding and configural encoding, although they both require some level of configural processing, because that level differs between them (Carey & Diamond, 1994 – minimal reliance on configurations for holistic encoding, greater reliance for configural encoding), then these are two different perceptual modes of one higher level mechanism.

In fact, this argument takes us back to Maurer, Le Grand & Mondloch (2002) who argued that there are two types of information contained in faces: featural and configural. To recap briefly, these authors argue that there are three types of configural information: a) sensitivity to first-order relations, i.e., the identification of a stimulus as a face because its features are arranged with two eyes above the nose, which is above a mouth; b) holistic processing, i.e., bringing together the features of the face into a gestalt; and c) sensitivity to second-order relations, i.e., perceiving the specific distances between the features of the face.

Therefore, based on this analysis, it is reasonable to conclude that our participants engaged in second-order configural processing when accurately recognising typical faces (this also shows a level of expertise in face recognition). However, the story is not so straightforward in the case of our group of children with autism. Although children with autism performed better on typical than on distinctive faces, this second-order configural processing that takes place when recognising typical faces is not as effective as that demonstrated by the comparison group. In addition, there are differences when looking at the inverted trials conditions of the experiment. Here, children with autism were using a different kind of processing as demonstrated by both their corrected hits and false alarms. Specifically, in the case of inverted faces, children with autism performed better when the faces were distinctive. It is as if, when presented with inverted distinctive faces, children with autism preferred / found easier to engage in holistic processing.

5.4.3. Experiment 3 vs. Experiment 4

In Experiment 3, the distinctiveness effect found in previous studies (Valentine, 1991; Johnston & Ellis, 1995) was not replicated, but instead, we replicated the typicality effect (Davidenko and Ramscar, 2005). Both groups of participants showed more corrected hits and fewer false alarms in their recognition of upright typical faces, and also showed a larger inversion effect for typical faces. This led us to conclude that children in Experiment 3 (both typically developing children and children with autism) process upright typical faces configurally although this configural processing is not of the same quality as the one demonstrated by the comparison group. Also, children with autism in Experiment 3 showed some differences in the way they recognise and process distinctive faces. Specifically, when distinctive faces were inverted, children with autism performed better than the comparison group who instead did better with inverted typical faces. Also, with regards to false alarms, participants with autism in Experiment 3 appeared to show a greater inversion effect of false alarms in distinctive faces than in typical faces, as opposed to the comparison group who showed a greater inversion effect for false alarms for typical faces. As discussed previously, this finding from false alarms supports findings from performance on corrected hits were participants with autism did better with inverted distinctive faces. As it was explained this was possibly due to a different processing strategy from children with autism based on a holistic representation of distinctive faces.

In Experiment 4, the first and main finding of Experiment 3 was not replicated. Analysis of the corrected hits in Experiment 4 did not replicate the typicality effect found in Experiment 3 (no superior performance in typical faces or a larger inversion effect for this type for typical faces). Both our groups of participants performed equally well on both typical and distinctive faces. However, the analysis of false alarms showed that our participants made more mistakes in distinctive faces (not a significant difference but a clear trend). As for children with autism, they show more false alarms for upright trials than typically developing children but no differences between upright and inverted trials, as shown by the comparison group (more false alarms for inverted than upright typical faces).

Although analyses of corrected hits and inversion effects from Experiment 4 did not replicate findings from corrected hits in Experiment 3, false alarms analysis in Experiment 4 did replicate the typicality effect found in Experiment 3. Participants made more false alarms to distinctive faces, which therefore means that they found this group of stimuli harder to remember compared to typical faces, which were associated with fewer false alarms. In addition, typically developing children showed significantly more false alarms for inverted trials than upright trials of typical faces. Both these findings suggest that at least typically developing children recognise typical faces better because they process them based on configural information. As for our participants with autism although they show more false alarms for distinctive faces too, they show equally high false alarms for upright and inverted trials of typical faces (see Figure 5.13), suggesting that they find typical faces easier to remember in comparison to distinctive faces but that they treat upright and inverted typical faces in the same way. It can be hypothesised that in this study children with autism have found effective strategies to process typical faces compared to distinctive faces but these strategies are not effective enough in distinguishing between upright and inverted stimuli. This lack of difference between upright and inverted faces abolishes the inversion effect for this group, which rules out the possibility that the children with autism might use configurally based strategies when processing typical faces. We also rule out the possibility of featural processing since none of the stimuli used in this study were manipulated on the basis of their featural properties. Rather, it is possible that the strategy used by the children with autism was more holistically based, since as it was discussed in the previous chapter, a lack of inversion effect will possibly demonstrate holistic processing of typical faces.

In relation to the methodological changes from Experiment 3, it is difficult to interpret our findings with certainty or to determine which change accounts for which finding in Experiment 4. Because of manipulations in both presentation procedure (i.e. mixing typical and distinctive faces in one block of trials in Experiment 4 rather separate ones as in Experiment 3) and exposure times (2000 msec in Experiment 4 instead of 3000 msec in Experiment 3) the following interpretation of the findings is made with caution.

So, with respect to the methodological differences between Experiments 3 and 4, it seems that the mixed presentation of faces and shorter time of exposure of faces affected participants' corrected hits. Participants did not seem to perceive distinctive faces as more distinctive when these were presented within the same block as typical faces, as predicted. Adding to this, the shorter exposure time of study faces did not allow for typical faces to be processed in such an effective way so that to produce better corrected hits as demonstrated in Experiment 3. Therefore it appears that the longer exposure times in Experiment 3 increased the recognition of typical faces as opposed to distinctive faces. At a glance, this finding contrasts with what Johnston & Ellis (1995) found in their study, i.e. that longer exposure times increased the recognition of distinctive faces. However, a closer look at our findings and those by Johnston & Ellis (1995) actually suggests that longer exposure times for faces increases the recognition of the type of face that appears more salient to participants. In other words, in Johnston & Ellis (1995) there was evidence that distinctive faces were better recognised (distinctiveness effect) whereas in our study (Experiment 3) typical faces were better recognised (typicality effect) and as a result, longer exposure times increased participants' performance on faces that were easier to remember in the first place.

On the other hand, the methodological manipulations of Experiment 4 had no effect on typical children's false alarm rate (findings were very similar to Experiment 3). The effects of the methodological manipulations were more apparent on the false alarms of children with autism in the current study and specifically on the way they processed upright and inverted typical faces. So, in Experiment 4 children's with autism false alarms were equivalent for inverted faces (see Figure 5.11) while in Experiment 3 the only difference between the two groups was observed in the inversion effect for false alarms, which showed that autistic children's false alarms were greatly affected by the inversion of distinctive faces. The reasons why the manipulations in Experiment 4 affected the performance of children with autism in such a way are not clear.

Since there is no previous research on the processing of distinctive faces in autism, we will attempt to explain our findings drawing on the findings of similar and more general research conducted on autism and face processing.

Research on face processing in autism has mainly focused on featural vs. configural processing, however findings have been inconsistent and so the research world at the moment is divided between three conflicting suggestions. The first and most traditional one proposes that individuals with autism show a difficulty in the processing of second order configural information in faces, show intact featural processing, and therefore do not appear to have this level of expertise that neurotypical individuals have in processing faces (Langdell, 1978; Hobson, Ouston & Lee, 1988; Tantam, Monaghan, Nicholson & Stirling, 1989; Boucher & Lewis, 1992). The second suggestion supports findings that show that individuals with autism can actually process second-order configurations in faces and that the opposite finding is due to mainly task difficulty (Rouse, Donnelly, Hadwin & Brown, 2004; Teunisse & de Gelder, 2003). The third and more interesting suggestion is the one proposed by Jemel, Mottron & Dawson (2006) who argued for an enhanced low level perceptual processing in autism, but with absence of global perceptual difficulties.

The findings of the current experiments seem partly to support the third suggestion, which proposes no global perceptual difficulties (as demonstrated by good recognition of upright typical faces in our experiments, although this was not as efficient as in the comparison group), but with a preference for a lower level perceptual processing strategy (holistic processing of inverted distinctive faces). It is proposed that this holistic processing strategy is a lower level perceptual processing based on the assumption by Maurer, Le Grand & Mondloch (2002) that holistic face processing comes as a second stage before we reach the expertise level with second-order configural processing. Therefore, our participants with autism are capable of some type of second-order configural processing when faces are upright but when the task is harder (as with inverted distinctive faces) they employ a lower level perceptual processing. This finding taken together with the finding that second-order configural processing in autism is not as efficient as in the comparison group, shows that in autism, the ability to process the specific metric relations between the features in faces (i.e., face expertise) has either not developed yet, or is not purely configural but rather a non-configural compensatory strategy.

This finding could be explained by the participants' characteristics. This group, because of their high level of functioning (VIQ of 104), may have developed strategies to overcome difficulties caused by their diagnosis. These strategies (not necessarily second order configural processing) were easily developed because upright faces are the most commonly experienced orientation of face. Since inverted faces are not usually experienced in everyday life, our participants with autism could not develop the same strategies for inverted faces as they have for upright faces. Therefore, their difficulties with face processing were apparent.

Further studies are needed in order to establish the nature of the distinctiveness and typicality effects of faces in autism and how these can inform us about face processing skills in autism. One interesting finding of the current experiments was that our participants with autism show atypicalities when processing inverted faces (Experiments 3 and 4) which are not apparent in the processing of upright faces. For this reason, in the next chapter the inversion effect in the processing of faces in autism will be further explored.

CHAPTER 6

EXPERIMENT 5: THE FACE INVERSION EFFECT IN ASD

6.1. Introduction

In the previous chapter the need for further investigation of the face inversion effect in autism was highlighted. Evidence was found to suggest that although upright faces in autism are processed typically, this is not the case with inverted faces. In the current chapter therefore, the face inversion effect will be further investigated in relation to the specific face processing strategies it encompasses.

Typical individuals are experts in recognising and processing faces since they have the ability to remember hundreds of different faces despite the fact that these do not significantly differ in their physical arrangement. However, when faces are inverted, this expertise that humans have is lost and therefore any information extracted from faces is disrupted. This has been called the ‘face inversion effect’.

6.1.1. Faces vs. Objects

It has been suggested that the inversion effect is specific to face stimuli rather than non-face stimuli. This is explained by the way the two types of stimuli (faces vs. objects) differ in their processing and which type of information is most important in each of these stimuli. Diamond and Carey (1986) addressed this issue and suggested that when processing faces the most important type of information is second-order relational information, i.e. the specific metric relations between features. Specifically, they suggested that with experience people develop a finely tuned face prototype, according to which they can encode the second-order relational information in faces. This ability underlies this expertise, which is also evident in the recognition of objects with prototypical spatial configurations. On the other hand, in common object recognition it is the processing of first-order relational information that is essential. First-order relational information refers to the basic arrangement of components. Diamond and Carey (1986) carried an experiment in order to test this expertise hypothesis. They demonstrated that dog experts show an inversion effect in their recognition of dogs' faces, comparable in magnitude to the face inversion effect, whereas non-expert participants who had developed prototypes for human but not for dogs' faces showed an inversion effect for human faces only. However, what does this tell us about the underlying processes in face and object recognition?

Tanaka and Farah (1991) and Farah, Tanaka and Drain (1995) investigated this by comparing participants' performance on the recognition of dot patterns and faces in upright and inverted conditions. It was concluded that the degree to which people encoded a pattern in terms of parts affected the degree of inversion effect in recognising the pattern (Farah, et al., 1995). Face recognition (and the inversion effect), therefore appears to differ from other types of pattern recognition (and inversion) in its use of relatively holistic, undecomposed representations. This conclusion supported previous findings by Tanaka and Farah (1993) which revealed that when the recognition of faces and objects (houses) is compared, participants show an impairment when recognising parts of faces as opposed to parts of objects. Overall, it appears that the recognition of objects relies on featural processing, which is not sensitive to inversion because inverted patterns are processed featurally, whereas the recognition of faces relies on undecomposed presentations that are sensitive to inversion.

The inversion effect for faces has also been investigated in studies that have focused on how the human brain responds when these two types of stimuli are presented. The most robust difference in activity between faces and objects has been described in the lateral middle fusiform gyrus, bilaterally but often stronger in the right hemisphere (Gauthier et al, 1999; Kanwisher et al, 1997). This region has been referred to as the "Fusiform Face Area" (FFA). On the other hand, "object-selective" areas include a medial area, joining part of the ventral occipital lobe to the parahippocampal gyrus (Epstein and Kanwisher, 1998; Haxby et al, 1999). But what is the case with inverted faces? Following behavioural evidence which suggests that inverted faces are processed featurally, in the same way that objects are, we would expect that brain activation for inverted faces would be different to that for upright faces, but may be similar to that for objects. This is what Haxby et al (1999) found, i.e. a face inversion superiority in regions more active for houses than faces. Generally, studies have shown a decrease for face inversion in FFA (Gauthier et al, 1999; Kanwisher et al, 1997). These findings reinforce suggestions that inverted faces are processed differently and it is very possible that their processing shares similarities with object processing.

6.1.2. Information in inverted faces

During the last two decades research on the inversion effect has been focused on what exactly type of facial information is affected by inversion. The debate involves mainly the question of whether the facial information affected by inversion is holistic, configural or featural.

The causes of the face inversion effect have been investigated for years and up to now there is no clear conclusion as to why this occurs. One of the first studies that looked into the face inversion effect was the study by Yin (1969). Yin interpreted the face inversion effect to mean that inverting a face affects recognition accuracy. Typically, recognition accuracy decreases about 20-30% (Yin, 1969) when inverted faces are used. Therefore, faces are processed more efficiently in the upright orientation than upside-down. So, according to Yin (1969), faces might be processed qualitatively differently in different orientations. Early studies (Valentine, 1988, 1991) on face inversion suggested that inversion adds noise to the encoding process and affects configural and featural information equally. This suggestion was recently supported by groups of researchers who found equal inversion effects for configural/holistic and featural information in faces (Riesenhuber, Jarudi, Gilad & Sinha, 2004; Yovel and Kanwisher, 2004; Sekuler, Gaspar, Gold and Bennet, 2004). It was concluded that "there is no difference between featurally and configurally transformed faces in terms of inversion effect" (Riesenhuber et al, 2004, p.448). However, in a review paper Rossion (2008) highlighted the methodological limitations of these studies which led to these unexpected findings. In addition, such a view was soon challenged since evidence is growing that inversion affects face perception qualitatively.

Therefore, the debate moved on to consider which type of information is mostly affected by inversion: holistic or configural? As highlighted in previous chapters, the definitions of these two types of face information overlap and there is great confusion in the literature as to what each of these two types of information represent. Unsurprisingly, the confusion has continued in inversion studies with groups of researchers supporting the effect that inversion has on holistic processing, with others supporting the effect that inversion has on configural information.

Farah et al., (1995), and Tanaka & Farah (1991) suggested that the type of information affected by face inversion and which results in participants' poorer performance with recognising inverted faces, is holistic information. In two experiments that manipulated dot patterns and faces, Farah et al., (1995) concluded that the inversion effect was associated with holistic pattern perception, whether or not the pattern was a face. Therefore, face recognition is orientation-sensitive because face perception is holistic and the perception of holistically represented complex patterns is orientation sensitive (Farah et al, 1995). These authors argued that a possible explanation for this involves capacity limitations of the orientation normalisation process. "If orientation invariance in pattern recognition is achieved through a normalisation process and that process operates on units of shape, be they parts or undecomposed wholes, then complex, holistically represented stimuli will be the most taxing for the normalisation process. If this process has a limited capacity, then such stimuli might exceed the capacity for normalisation altogether" (Farah, et al., 1995, p.633).

The importance of holistic information was also supported by Schwarzer (2000) who used a categorisation task to investigate the face inversion effect in children and adults. The way the experimenters constructed the face categories enabled participants to categorise faces either analytically (featurally) or holistically (overall similarity). Schwarzer's results showed a developmental trend from analytic to holistic processing and an effect of face inversion with increasing age. In fact, adults showed a marked effect of inversion in categorising faces in that they mainly processed upright faces holistically and inverted faces analytically. Therefore, it was holistic processing that was affected by inversion (Schwarzer, 2000). Later studies investigating the specifics of holistic face processing and the inversion effect showed that holistic face processing is preserved up until 60 degrees of rotation of the face stimulus, after which, (between 60 and 90 degrees), it is severely disrupted (Rossion and Boremanse, 2008).

Despite this evidence, and on the other side of the debate, there are scientists who argue that inverted faces are harder to recognise because the processing of configural information is disrupted. Searcy and Bartlett (1996) conducted a series of experiments with faces that differed either in features only or in the distances between features (configurations). Participants took part in a grotesqueness rating task and also in tasks that required to state if two simultaneously presented faces were the same or different (in both upright and inverted conditions). Two main findings emerged from these experiments. First, that the spatially distorted faces were perceived as less grotesque when inverted than when upright, whereas the component distortions and unaltered items were not (Searcy and Bartlett, 1996). Secondly, it was found that in the comparison task participants became much slower in making a judgement when faces were inverted and especially when the pair of faces differed in the configurations between the features. The authors confirmed that inversion affects the processing of configurations in a face rather than the processing of features. In addition it was suggested that "the inversion effect occurs in the perceptual encoding of faces, as opposed to consolidation of representations in memory, retention of such representations in memory, retention of such representations over time or subsequent retrieval" (Searcy and Bartlett, 1996, p.913).

Leder and Bruce (2000) claimed that the study by Searcy and Bartlett (1996) although providing evidence for the effect of inversion on configural processing, did not really distinguish the configural from the holistic position. In a series of experiments Leder and Bruce (2000) tested the position that configural and holistic information are separate types of information in faces that are affected by inversion in different ways. Similar to the Searcy and Bartlett (1996) study, Leder and Bruce (2000) used sets of faces that differed in terms of featural, configural or both sorts of information. Participants learned the identities of a small set of faces which they later had to recognise in complete or part versions, in upright or inverted orientation. In order to test the holistic vs. configural debate, Leder and Bruce (2000) used faces that differed only in configurations and then tested participants' ability to recognise relational features either in isolation or in the context of a face. They found that participants were able to recognise isolated relational information but that there was no significant increase in accuracy when the information was placed in the context of a face (holistic information). This ability was sensitive to orientation, too. Overall, it was found that faces which differed in configurations and those that differed in both configurations and features produced greater inversion effects than those that differed in features only. It was concluded that local and configural information may both contribute to upright face processing but inversion only significantly affected configural information (Leder and Bruce, 2000).

The effect of inversion on configural information has also been investigated with the use of Thatcherised faces. As we have seen in Chapter 2 (p. 41), the Thatcher illusion (Thomson, 1980) is an orientation-sensitive face illusion. It is a face in which the eyes and mouth are inverted relative to the rest of the face, and that looks grotesque when it is shown upright but not when shown inverted. This is because of the configural information that is disrupted when the face is upside down, which is what happens with Thatcherised faces. Boutsen and Humphreys (2003) investigated the effects of inversion in Thatcherised faces, but in addition to this, they also introduced the terms of 'local' and 'global' configural information in faces. In a series of experiments these two authors investigated the effects of local and global configural information with normal and Thatcherised faces, parts and whole faces, and same identity or different identity face pairs. The manipulation of same-person vs. different-person pairs was used to induce different matching strategies in participants. It was hypothesised that matching same-person pairs would induce a feature-based strategy, while matching different-person pairs would be more likely to rely relatively more strongly on configuration-based information (Boutsen and Humphreys, 2003). The authors found a larger inversion effect for face parts of faces of different identity compared to the face parts of faces of the same identity which did not produce consistent inversion effects. This was interpreted as evidence of the effect of local configural information (different identity face parts). With whole faces, Boutsen and Humphreys (2003) found that the context of the face influenced the inversion effect of same-identity face pairs, which was again interpreted as evidence of local configural information (same identity, whole face pairs). As for the effect of face context addition in the different identity pairs, this was not significant, which meant that different identity face pairs, either parts of whole faces produce similar inversion effects because their processing relies on configural information. This finding provided evidence against the holistic processing approach since if this was the case we would expect larger inversion effects with the addition of a face context in both same-identity as well as different-identity pairs (Boutsen and Humphreys, 2003). The authors concluded the results of the study favour a local, rather than global, version of the proposal that face inversion and thatcherisation disrupt the encoding of configural information.

In support of the above studies, Murray, Yong and Rhodes (2000) attempted to investigate the inversion effect by looking at the exact orientation that results in significant inversion effects. They presented Thatcherised faces (configural), featurally altered faces, spatially altered faces and unaltered faces and asked participants to rate faces' bizarreness in eight orientations from 0 to 180 degrees. It was found that, for Thatcherised and spatially altered faces, a discontinuity in the function relating orientation and bizarreness occured. This apparent shift in processing mode occurred between 90 and 120 degrees. Murray et al (2000) concluded that the "encoding of spatial-relational information is disproportionately impaired as the orientation of a face deviates from upright, reflecting a qualitative difference in the processing of upright and inverted faces" (p. 496).

One interesting finding with regards to the processing of face configurations and the extent to which these are affected by inversion, is that vertical configurations are more affected by inversion than horizontal ones. Goffaux and Rossion (2007) conducted a series of experiments with faces that differed in features, vertical configurations and horizontal configurations. They asked participants to make same/different judgements on pairs of faces presented sequentially in three orientations (upright, 90 degrees and inverted). It was found that face inversion disrupts configural processes more than featural and this is mostly due to vertical relations between features no longer being perceived when a face is inverted (Goffaux and Rossion, 2007). In fact, the effect of inversion on the processing of horizontal relations was moderate and equal to what was observed for the processing of features. Finally, this inversion effect for vertical relations continued to hold when faces were tilted at 90 degrees. The authors suggest that critical factors in getting large effects of inversion may also be the presence of a dominant vertical axis of elongation and the presence of internal features arranged mainly along the vertical axis (Goffaux and Rossion, 2007).

The holistic vs. configural information debate is ongoing and clear empirical evidence has not conclusively established either which is more important in face recognition or what is the role of these two types of facial information in the face inversion effect. It seems that even though these types of information have been distinguished at a conceptual level, it may in fact be very difficult to dissociate the two empirically (Rossion and Boremanse, 2008). However, recently, Rossion (2009) has proposed the perceptual field hypothesis. Rossion's hypothesis is based on the assumption that faces are both perceived and represented holistically, in other words holistic processing refers to a perceptual process. When a face is inverted it cannot be perceived holistically (as demonstrated by previous studies), but rather featurally, which then means that the perceptual field of the observer becomes smaller. According to Rossion (2009), when participants' performance is compared when they are viewing inverted faces differing in configurations and when they are viewing faces differing in features, participants do worse on inverted faces with altered configurations because in this case the perceptual field required to perceive these faces is larger than that required for faces with featural alterations. And this is problematic because in inverted faces the perceptual field is restricted and therefore it is easier to perceive the featural alterations. Rossion (2009) maintains that "all diagnostic face cues are indeed incorporated in the same holistic face representation. However, in general, inversion affects the perception of relative distances between features more than local features simply because the perception of relative distances between features depends on holistic processing relatively more than the perception of local features. Hence the cause of the face inversion effect is the disruption of holistic perception, or the constriction of the perceptual field, and a consequence is a massive impairment of the perception of all diagnostic face cues, in particular those that involve multiple elements over a wide visual space (configurations)" (p. 307).

6.1.3. Developmental evidence

With regards to developmental evidence, several studies have suggested that children younger than the age of 10 years do not show the face recognition expertise that is observed in adults (Carey et al., 1980; Bruce et al., 2000; Mondloch et al., 2002). As discussed in Chapter 2, it seems that although many face processing skills are present in infancy, children do not perform as well as adults when they are asked to remember and recognise faces. Once more, in order to identify the nature of these difficulties that young children are faced with, scientists have looked into holistic and configural processing as opposed to featural processing in young populations.

Itier and Taylor (2004) carried out an experiment in order to investigate the developmental changes in the face inversion effect, with participants aged 8-16 years old and adults. The paradigm they used was a non-traditional one since apart from upright and inverted faces, they also used photo negatives as a measure of configural processing. The authors analysed hits, false alarms and response times in a memory task. Findings from all these measures revealed an improvement in performance with age, i.e. better and faster recognition for upright, inverted and negative faces. This demonstrates that similar to upright faces, whatever is processed in inverted and negative faces develops until adulthood (Itier and Taylor, 2004). The authors concluded that configural processing is present from the age of 8 years since the inversion effect and processing of photo negatives were present in all age groups. The improvement observed was due to general working memory and attentional improvements with age, continuing after the age of 16 years. Therefore, instead of the expertise hypothesis (Diamond and Carey, 1986), Itier and Taylor (2004) proposed a quantitative improvement of face recognition skills, at least from 8 years on. Configural processing is most critical for face recognition, yet both featural and configural processing appear to be utilised similarly for face recognition from 8 year-olds to adults (Itier and Taylor, 2004).

Developmental studies exploring holistic processing in children have mainly used the composite face effect or part-whole paradigm. Children as young as 6 years old performed better when composite faces were misaligned or inverted (Carey and Diamond, 1994) and when facial features were presented in the context of a whole face (Tanaka and Farah, 1993). Their performance was the same as those of adults and therefore it was concluded that holistic processing appears to be mature by 6 years of age and cannot account for developmental changes in face processing after that age (Mondloch et al., 2002). For this reason and because evidence emerged on the significant role that configural information has on face perception, studies moved into investigating the role of spatial information in faces by children.

Based on the paradigm by Friere et al. (2000), Mondloch et al. (2002) created three sets of faces (out of one single face) – one set in which faces differed in local features only, one in which faces differed in the configurations between features and one in which faces differed in the facial contour. Children aged 6, 8 and 10 years and adults were tested in a same/different task in both upright and inverted conditions. It was found that across all age groups, the effect of featural and face contour manipulations were the same. However, with configural manipulations 6 year olds made more mistakes. In addition, 6 year olds did not show the large inversion effect for the configural set that 10 year olds and adults showed. In fact, the size of the inversion effect did not vary between face sets for 6 and 8 year olds, a result indicating that they were less able to take advantage of configural information in the upright spacing set (Mondloch et al., 2002). The authors concluded that adult expertise in configural processing is especially slow to develop compared to their expertise in featural processing.

Because most of the developmental evidence for configural processing and the inversion effect comes from children aged 6 years onwards, Brace, Hole, Kemp, Pike, Van Duuren and Norgate (2001) decided to develop a paradigm that would be appropriate for testing younger populations on the inversion effect. Therefore, with a use of a picture book and a story that involved upright and inverted faces, the authors investigated the effects of face inversion in children as young as 2 years of age. Their findings with children aged 6 years old replicated previous findings showing configural processing of faces. However, findings from younger children were different. The authors claimed that children aged 2-4 years show the inverted inversion effect in their response times. In other words, instead of becoming slower with inverted faces, children as young as 2 years old become faster when asked to recognise upside down faces. As the authors suggest, one explanation for this could be the featural processing that children employed in order to recognise inverted faces which is easier and therefore makes them faster. Which then means that the encoding switch hypothesis (Diamond and Carey, 1986) is partly true because it occurs but at an earlier age that was initially suggested (Brace et al, 2001).

6.1.4. The Face Inversion Effect in Autism

As discussed in Chapter 2, section, 2.5, studies that investigated the face inversion effect in individuals with autism have reported a different pattern of performance than this observed in typical participants. Overall, it appears that children and adults with an autism diagnosis perform better with inverted faces than typical controls (Langdell, 1978; Hobson et al, 1988). It has been suggested that this is due to general face processing impairments in autism that relate mainly to difficulties processing the configural information in faces (Davies et al., 1994; Wallace et al, 2008). Since featural processing of faces has been found to operate at a 'normal' level in autism, and as demonstrated above, inverted faces are processed in a piecemeal manner, individuals with autism perform better than typical individuals when asked to recognise upside-down faces, and worse when the same faces are upright.

The first study to examine the face processing abilities of autistic individuals and the face inversion effect in particular, was that of Langdell (1978). In this study, Langdell asked participants with and without autism to recognise familiar upright and inverted faces with some of their features masked. Participants with autism recognised the features of the faces better than controls when these were inverted. Similarly, an early study by Hobson, Ouston and Lee (1988), found that participants with autism were better at matching the identity and emotion in upside-down faces. Hobson et al., (1988) concluded that “whatever the psychological processes underlying inverted face recognition, it appears that autistic participants are employing processes or strategies that were different either in kind or efficiency from those used by the non-autistic participants” (p.451). This conclusion was also confirmed by Tantam, Monaghan, Nicholson and Stirling (1988) who showed that participants with autism performed equally well on inverted faces with participants without autism but worse when they had to find the odd person out and the odd facial expression out of faces presented upright.

Atypicalities in processing inverted faces in autism have also been demonstrated in studies of brain function, specifically event-related potentials. In a study by McPartland, Dawson, Webb, Panagiotides and Carver (2004) it was shown that individuals with autism exhibit abnormal temporal processing of faces. Interestingly, in contrast to typical individuals who showed robust differences, individuals with autism showed minimal differences in latencies to upright versus inverted faces, indicating less sensitivity to alteration in the configural properties of faces (McPartland et al., 2004).

Despite early evidence showing differences in the recognition of inverted faces between individuals with and without autism, later studies produced mixed findings.

Teunisse and de Gelder (2003) investigated the inversion effect in autism with a reduced-memory face recognition task (increased presentation time of target face) and found the typical inversion effect observed in the comparison group. Therefore, autistic participants' performances with inverted faces were worse and slower than that for upright faces. In addition to this, for the individuals with autism the inversion effect was larger for faces than for shoes. In a similar type of paradigm, Lahaie, et al., (2006) showed that participants with autism are affected by face inversion in the same way participants without autism are. More specifically, both autistic and non-autistic participants showed an inversion effect in response times by becoming significantly slower when faces (and greebles) were presented upside-down. In terms of accuracy findings were unexpected since only autistic participants (and not typical controls) showed the typical face inversion effect demonstrated in previous face processing studies. The authors suggested that configural processing in autism was intact (Lahaie et al., 2006).

A study that directly tested the processing of configural information in faces and whether this was affected by inversion in individuals with autism was that of Nishimura, Rutherford and Maurer (2008). The authors replicated the study by Mondloch et al (2002) in which one face was manipulated in order to create sets of faces differing either in features, configurations or facial contour. Participants had to match faces that were presented either upright or inverted. Nishimura et al. (2008) found that not only were participants with autism able to detect the configural changes in faces, but they also demonstrated a large inversion effect for these sets of faces similar to comparison participants matched on chronological age and full-scale IQ. Also, although previous studies had reported superior featural processing in individuals with autism (Hobson et al., 1988) this was not observed in the study by Nishimura et al. (2008), which was also supported by the absence of any superior inverted facial featural processing.

The face inversion effect in autism has also been investigated in terms of the eyes and mouth region of the face. Because of early evidence that individuals with autism may attend to the mouth region more than to the eyes region of a face as opposed to typical comparison participants who prefer the eyes region (Langdell, 1978; Joseph and Tanaka, 2003), Rutherford, Clements and Sekuler (2007) manipulated faces in either the eyes region or the mouth and compared participants performance on upright and inverted trials. It was found that both participants with autism and typical controls showed the mouth inversion effect but that they extracted information from the eye region of the face first, and only made use of information around the mouth if exposure time permited (Rutherford et al., 2007).

Because of the discrepancy in the findings between earlier and more recent studies on the face inversion effect in autism, scientists have also looked at the face scanning strategies of individuals with autism with the aim of defining the nature of their face processing difficulties in autism. Van der Geest et al (2002) found that when shown inverted faces, typically developing children but not children with autism, looked less at the face. The authors suggested that this finding reflected poor configural processing in autism. However, on the other hand, Falck-Ytter (2008) showed that both children with autism and typical comparison participants looked less at the face and eye areas during inversion, which was then interpreted as evidence of configural processing in children with autism.

6.1.5. Present study

The aim of this study is to investigate second –order configural processing in faces with the use of the inversion effect, in children with and without autism spectrum disorders.

To date, the inversion effect has been investigated in same/different recognition tasks, with configurally or featurally manipulated faces or non-manipulated faces (simple 'holistic' inversion). In most of these studies, in the inverted conditions, it has been observed that face stimuli are presented inverted in both the 'study' and 'test' phase (either sequentially or simultaneously). Although this procedure has its benefits and has proven to be effective in tapping second-order configural processing, there is also a criticism which relates to the different information contained in faces. As mentioned before, Boutsen and Humphreys (2003) introduced the notions of global configural information and local configural information when people are asked to match faces of different identity. In the current study, it is proposed that these two types of configural processing in faces can be tested by manipulating the presentation of faces when studying inversion. It is suggested that when two faces are inverted and participants are asked to match them, they are more likely to rely on local configurations. However, when one face is upright and the other inverted, then participants are more likely to rely on global configural information when asked to match these two faces. This should demonstrate a 'pure' inversion effect since our experience with faces is based on upright presentations and therefore the best measure of the inversion effect is sustained only by matching an upright to an inverted face.

In the current study, participants' accuracy in matching two upright faces, one upright to an inverted face, and two inverted faces, all presented simultaneously, are compared. We are interested in differences between these three conditions and whether they are affected by type of stimulus (faces vs. houses) or face manipulation (configural vs. featural). We are also interested in whether children with autism are affected by inversion when faces differ in second-order configurations or features and if object recognition (with the use of houses) shows a different pattern of performances.

Overall, it is hypothesised that the comparison group of children, will perform better in upright faces, followed by the inverted faces condition, followed by the 'one upright – one inverted' condition as global second-order configural processing will be the most difficult condition to complete. It would be interesting to see if performances from children with autism will be similar since difficulties and atypicalities have been observed in the inversion effect and face processing in general.

6.2. Method

6.2.1. Participants

Two groups of children were tested. Participants in the autism group were 12 children with high-functioning autism (Mean age = 9.2 years, SD = 1.2). The children's diagnosis was confirmed by the school staff who kept records of their diagnostic reports.The comparison group consisted of 12 children in mainstream school without any recorded developmental disorders. The two groups were matched on chronological age, Verbal Mental Age (based on the British Picture Vocabulary Scale – Dunn, et al., 1997)), Verbal IQ (BPVS) and raw scores on Raven's Standard Progressive Matrices (Ravens, 1958) (Table 6.1 presents demographic information). Participants were also tested on the Benton Facial Recognition test (Benton et al, 1983).

Participants were recruited through various schools in London and Essex while both the head of the school and the parent/carer formally agreed for the children to participate in the study (see Appendix 1 for information letter and consent form and Appendix 2 for participants' overlap across studies). The study was approved by City University's Ethics Committee.

Table 6.1. Participants' chronological age (CA) in years, verbal mental age (VMA), IQ scores, Ravens Progressive Matrices and Benton Facial Recognition test scores*.

	Autism (n=12)			Comparison (n=12)		
	M	(SD)	Range	M	(SD)	Range
Chronological Age	9.2	(1.2)	7.07-11.1	9.2	(1.2)	7.07-11
Verbal Mental Age (BPVS)	9.6	(2.7)	6-15.06	9.6	(2.1)	6-13.01
Verbal IQ (BPVS)	100	(19.6)	69-122	99.9	(14.3)	63-116
RSPM (raw score)	34.5	(8.9)	23-52	29.4	(10.4)	18-47
Benton Facial Recognition	39.3	(6.4)	28-50	42.1	(3.2)	38-49

* Analysis revealed no significant differences between the two groups in the different measures (**CA**: t= -0.12, df= 22, p= 0.90; **VMA**: t= -0.009, df= 22, p= 0.99; **VIQ**: t= 0.14, df= 22, p= 0.88; **RSPM**: t= 1.30, df= 22, p= 0.20; **BFRT**: t = -1.36, df = 22, p= 0.18).

6.2.2. Stimuli and apparatus

Photos of faces for this experiment were kindly provided by Wallace et al (2008). Stimuli were a set of 10 grey-scale photos of faces (5 male and 5 female) which were modified to create two more sets of faces. Faces in the one set differed from the original faces in second order configurations. So, eyes were either closer together or further apart by 2mm and mouth was up or down by 2 mm. Faces in the second set differed from the original faces in features (eyes and mouth were replaced with different ones).

In addition to faces, we also used pictures of houses as stimuli. The procedure of modifying the original set of 10 houses was exactly the same as for the face stimuli. For example, for the second-order configural set, windows and doors were moved further apart or closer together and in the featural set windows and doors were replaced with new ones.

Both face and house stimuli were 6cm x 6cm in size.

Twelve conditions were created from these sets of stimuli; 6 with faces and 6 with houses. In the three face conditions, faces that differed in second-order configurations were paired (20 trials; 10 same and 10 different); one where both faces were upright, one where both faces were inverted and one where one face was upright and one inverted. In the other three face conditions, faces that differed in features were paired (20 trials; 10 same and 10 different); one where both faces were upright, one with both faces inverted and one where one face was upright and one inverted. In the three conditions with houses, houses that differed in second-order configurations were paired (20 trials; 10 same and 10 different); one where both houses were upright, one where both houses were inverted and one where one house was upright and one inverted. Finally, in the other three house conditions, houses that differed in features were paired (20 trials; 10 same and 10 different); one where both houses were upright, one where both houses were inverted and one where one house was upright and one inverted.

Stimuli were presented on a 17” computer monitor (Toshiba Tecra A2).

6.2.3. Procedure

Children were tested individually, in a quiet room, during school times. They were told that they would play a game during which they would look at pictures of faces and houses have to indicate if these were same or different (mouse buttons were labelled). Before each condition, participants went through 10 practice trials so that they familiarise themselves with the task.

Each condition consisted of 20 trials (10 same and 10 different). Before each trial a cross appeared on the screen for 2000 msec and then two faces or houses appeared on the screen simultaneously. At this point, participants had to make a decision whether the two stimuli were the same or different. The left mouse button was labelled as ‘SAME’ while the right was labelled as ‘DIFFERENT’.

Order and presentation of conditions was counterbalanced.

Figure 6.1. Faces in the configural set presented upright

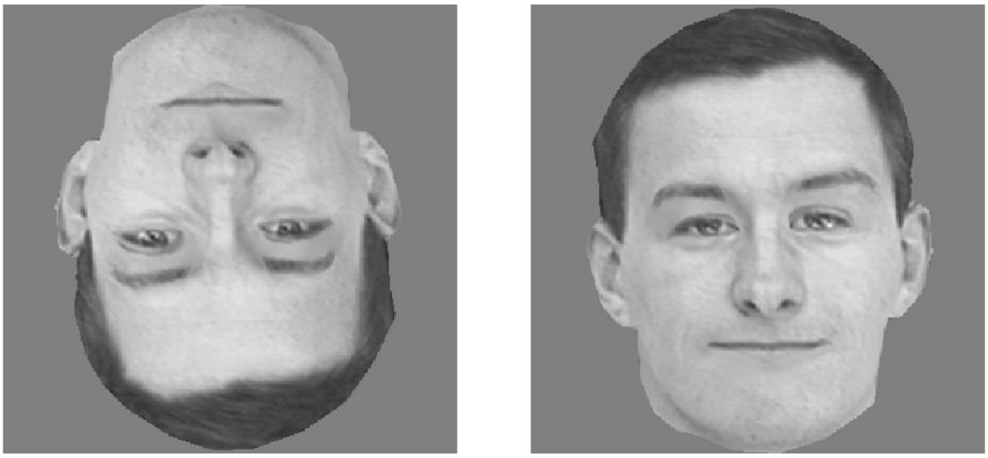


Figure 6.2. Faces in the configural set presented in different orientation

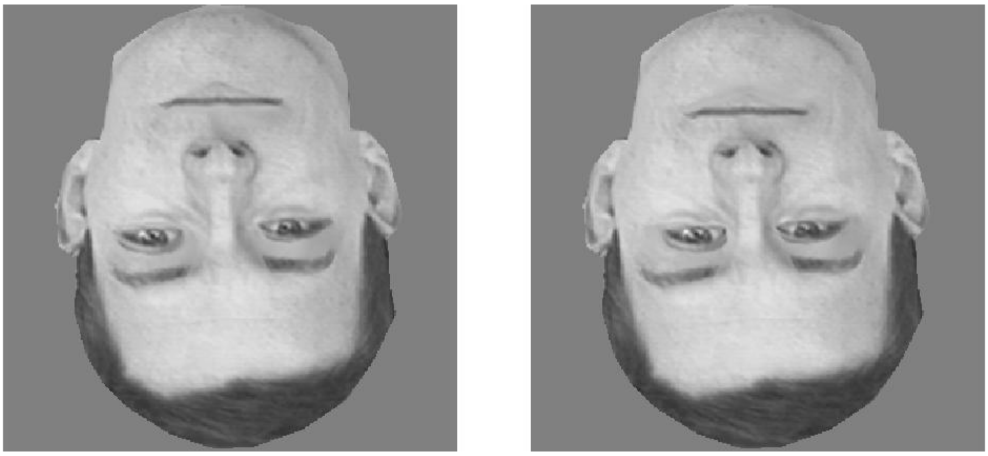


Figure 6.3. Faces in the configural set presented inverted

Figure 6.4. Faces in the featural set presented upright

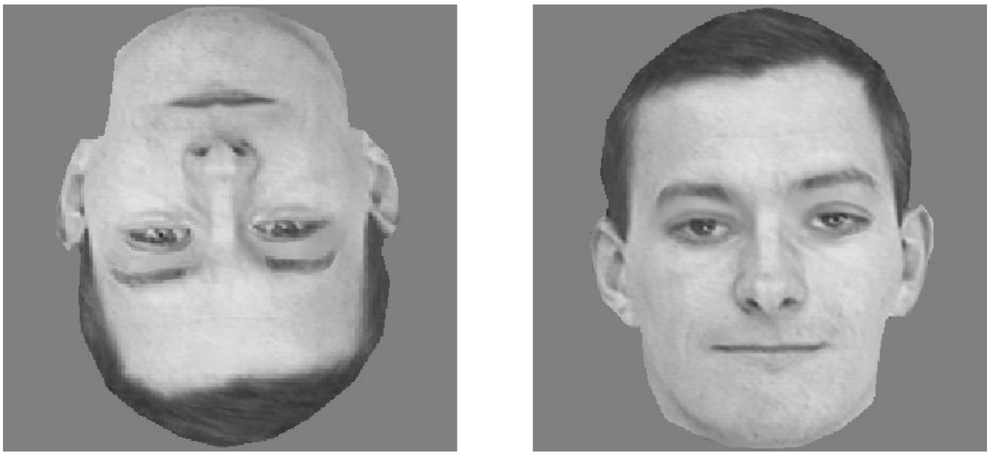


Figure 6.5. Faces in the featural set presented in different orientation

Figure 6.6. Faces in the featural set presented inverted

Figure 6.7. Houses in the configural set presented upright

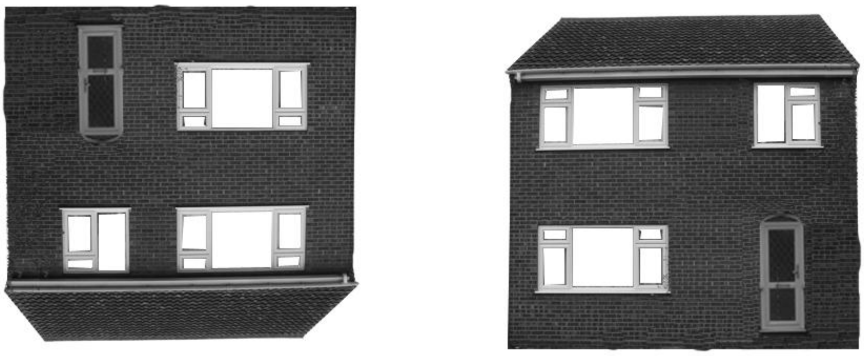


Figure 6.8. Houses in the configural set presented in different orientation

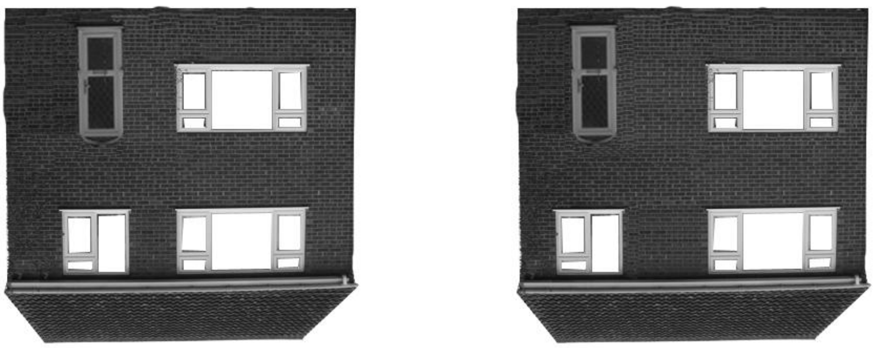


Figure 6.9. Houses in the configural set presented inverted

Figure 6.10. Houses in the featural set presented upright

Figure 6.11. Houses in the featural set presented in different orientation

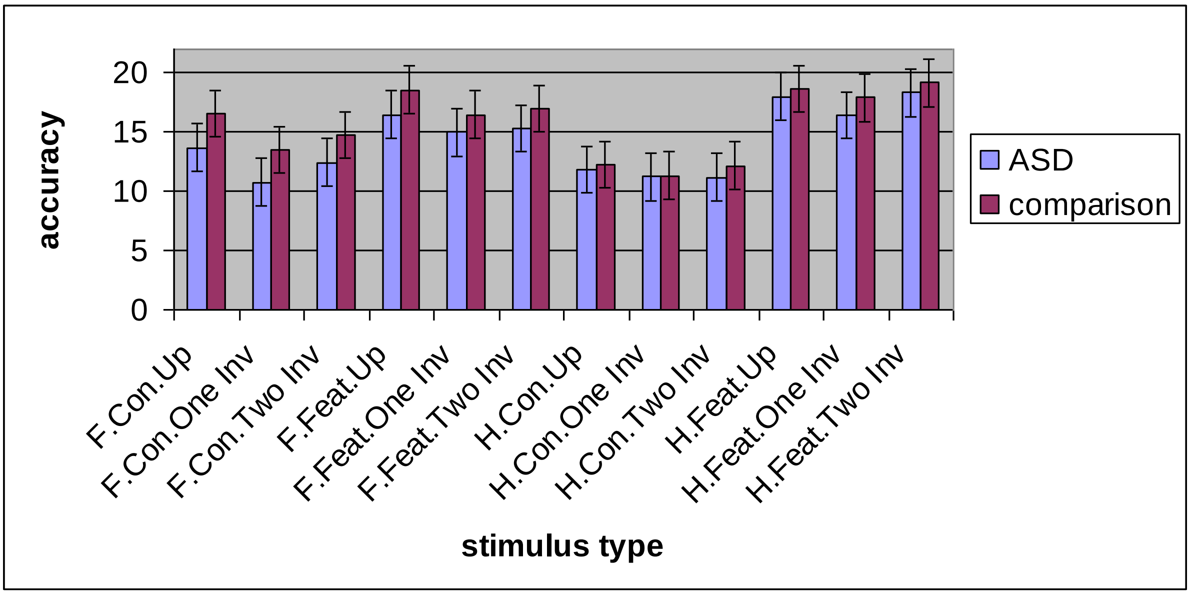
Figure 6.12. Houses in the featural set presented inverted

6.3. Results

Table 6.2. Mean accuracy in all conditions for the ASD and comparison group.

		Autism (n=12) M (SD)	Comparison (n=12) M (SD)
Faces	upright configural	14.7 (3.9)	15.5 (3.2)
	upright featural	17.2 (2.6)	17.8 (2.9)
	one inverted configural	10.6 (3.8)	13.5 (3.8)
	one inverted featural	15.3 (1.8)	16.1 (2.7)
	two inverted configural	12.7 (3.4)	14.4 (3.3)
	two inverted featural	15.5 (2.4)	16.8 (2.6)
Houses	upright configural	11.7 (2.4)	12.3 (3.1)
	upright featural	18.5 (2.7)	18.1 (2.3)
	one inverted configural	10.9 (2.1)	11.6 (2.8)
	one inverted featural	17.6 (2.4)	16.6 (4.0)
	two inverted configural	11.2 (2.3)	12.0 (4.2)
	two inverted featural	19.2 (0.7)	18.2 (3.5)

Figure 6.13.Mean accuracy for face and house stimuli across the different conditions in the ASD and comparison group.

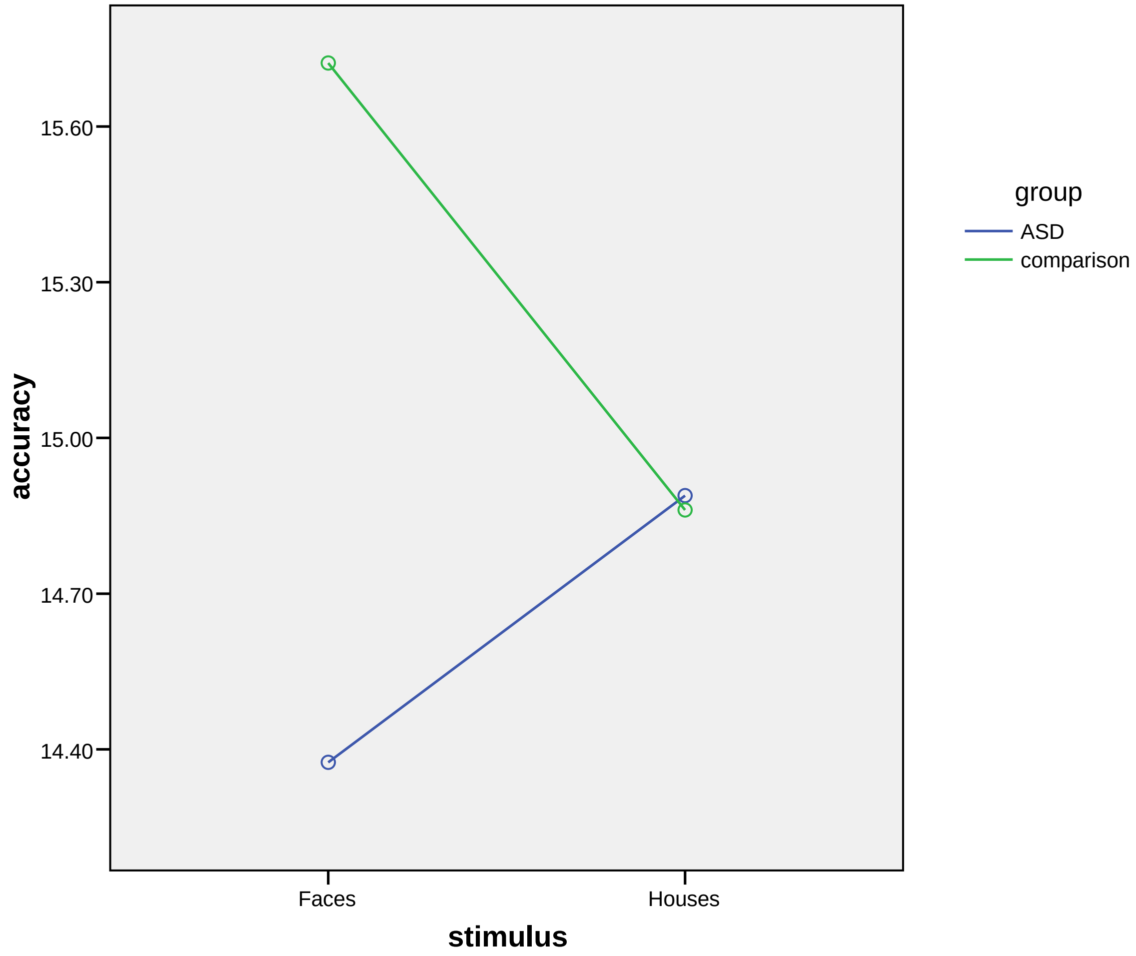


6.3.1. Overall Analysis

In order to analyse participants' accuracy across the different conditions of the experiment, a mixed 2 x 2 x 3 x 2 ANOVA was carried out with stimulus (faces vs. houses), manipulation (configurations vs. features), and orientation (upright, one inverted, two inverted) as within-subjects factors and group (autism vs. control) as a between-subjects factors.

The analysis revealed a significant main effect of orientation, $F(2,44)=19.9$, $p<.01$, indicating higher accuracy for the upright rather than inverted faces. There was also a significant main effect of manipulation, $F(1,22)=110.5$, $p<.01$ with both groups of participants performing better when faces and houses differed in features. The interaction between stimulus and orientation was significant ($F(2,44)=5.03$, $p<.05$) as was the interaction between stimulus and manipulation ($F(1,22)=16.9$, $p<.01$) where participants performed better when houses differed in features. There was also a trend for a significant interaction between stimulus and group ($F(1,22)=3.1$, $p=.08$) reflecting a trend for the comparison group to perform better than the autism group in faces. Figure 6.14 below illustrates this interaction. The remaining main effects and interactions were not significant (max $F= 1.7$, min $p= .19$).

Figure 6.14. Overall accuracy in the face and house conditions (summary score of the three presentation conditions) in the ASD and comparison group.



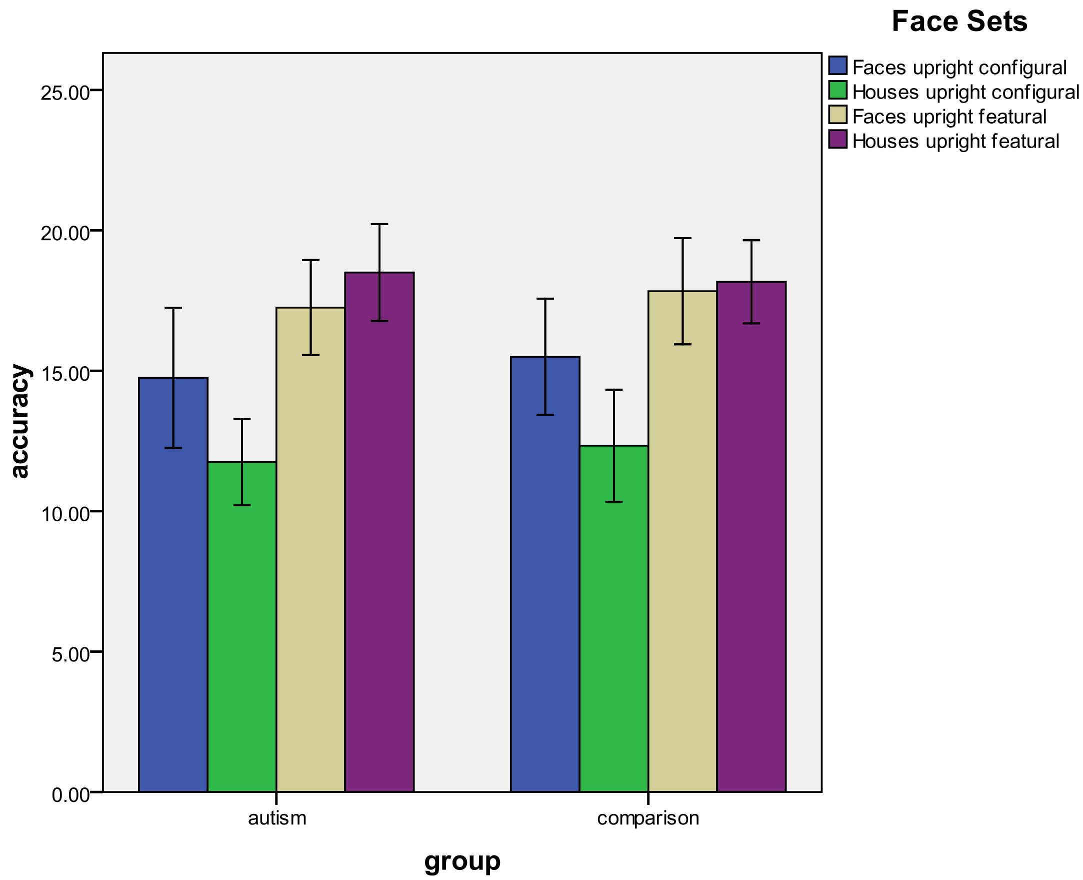
Analysis of simple effects showed no significant differences within or between groups.

6.3.2. Orientation Analysis

Because one of the main aims of this study was to investigate the effects of the different types of stimulus presentation (i.e. orientation) on the processing of faces and houses, we carried out three separate analyses for each type of stimulus presentation.

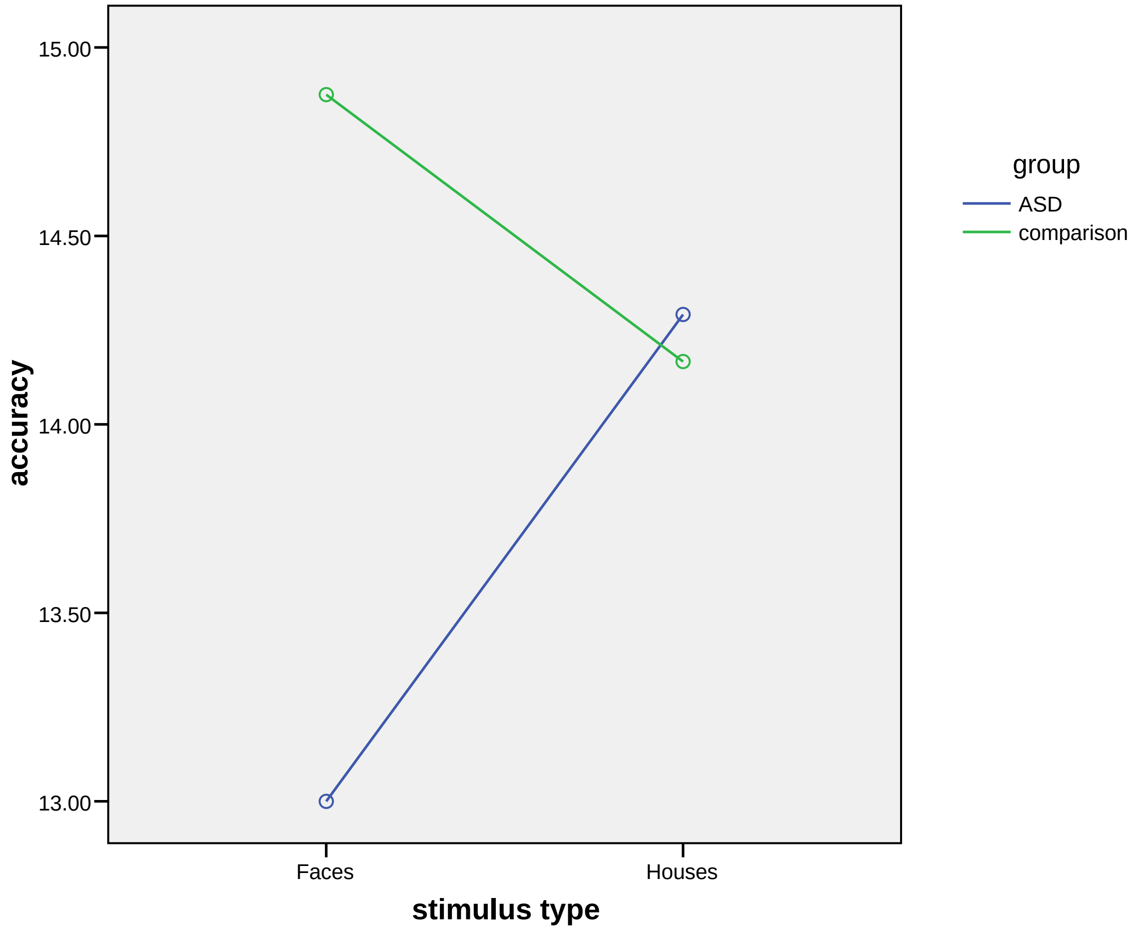
<u>Upright condition:</u> We carried out a mixed 2 x 2 x 2 ANOVA with stimulus (faces vs. houses) and manipulation (configurations vs. features) as within-subjects factors and group (autism vs. control) as a between subjects factor. We found a significant main effect of stimulus, $F(1,22) = 5.7$, $p < .05$, showing better performance in faces, a significant main effect of manipulation, $F(1,22) = 54.4$, $p < .01$ showing better performance with featural manipulations, and a significant interaction between stimulus and manipulation, $F(1,22) = 16.0$, $p < .01$, indicating better performance in houses that differed in features. Interactions involving the group factor were not significant (max $F= .31$, min $p= .57$). Means are presented in Table 6.2, while the graph below illustrates the interaction.

Figure 6.15. Mean accuracy in upright trials for faces and houses with configural and featural manipulations



One Inverted: We carried out a mixed 2 x 2 x 2 ANOVA with stimulus (faces vs. houses) and manipulation (configurations vs. features) as within-subjects factors and group (autism vs. control) as a between subjects factor. We found a significant main effect of manipulation, $F(1,22)=57.0$, $p<.01$ (better performance with featural manipulations – see means in Table 6.2) and a marginally significant interaction between stimulus and group, $F(1,22)=3.8$, $p=.06$. Figure 6.16 illustrates this interaction. The remaining main effects and interactions were not significant (max F= 3.3, min p= .08).

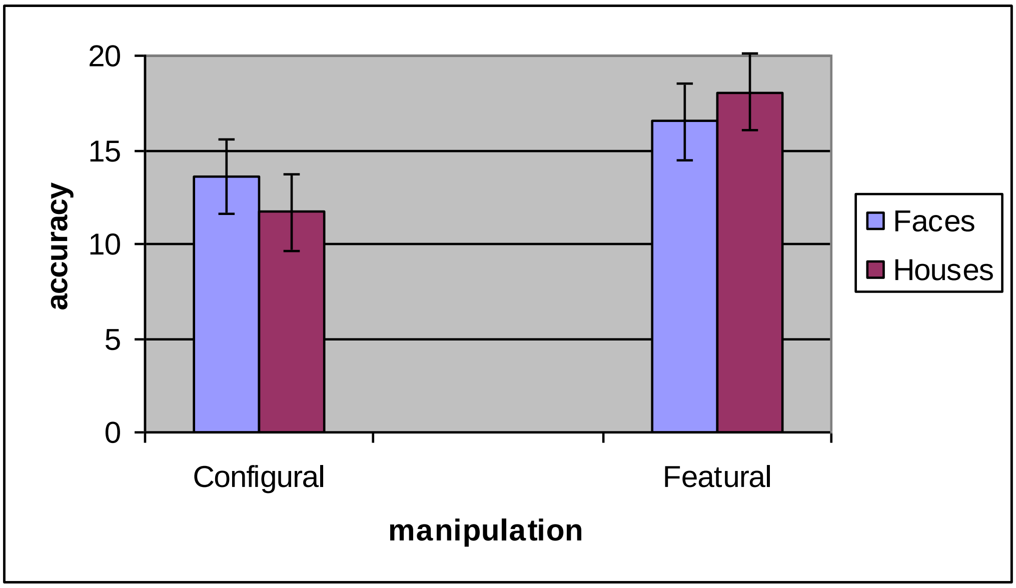
Figure 6.16. Mean accuracy in face and house stimuli for the ASD and comparison group when faces are presented in different orientation (one upright, one inverted)



In order to find the precise cause of the interaction between group and stimulus (simple effects), we carried out four t-tests (two within subjects and two between subjects). The only difference which was approaching significance was the one between the two groups in face stimuli (t= -1.7, df = 22, p = .09).

Two Inverted: We carried out a mixed 2 x 2 x 2 ANOVA with stimulus (faces vs. houses) and manipulation (configurations vs. features) as within-subjects factors and group (autism vs. comparison) as a between subjects factor. We found a significant main effect of manipulation, $F(1,22)=83.7$, $p<.000$ (better performance with featural manipulations), and a significant interaction between stimulus and manipulation, $F(1,22)=19.6$, $p<.000$ (better performance for houses that differed in features) Interactions involving the group factor were not significant (max F= 2.5, min p= .12). The graph below summarises these findings.

Figure 6.17. Participants' performance (ASD scores plus comparison group scores) in faces and houses differing in features and configurations.



6.3.3. Stimulus Analysis

In order to analyse the effect of stimulus we carried out two separate ANOVAs for the two types of stimuli (faces vs. houses), with manipulation (configurations vs. features) and orientation (upright, one inverted, two inverted) as within-subjects factors and group (autism vs. comparison) as a between-subjects factor.

Faces: The analysis for faces only revealed a significant main effect of manipulation, $F(1,22)=53.2$, $p<.000$ (participants performed better in featural sets) and a significant main effect of orientation, $F(2,44)=15.9$, $p<.000$ (both groups of participants performed better with upright faces). Group interactions and the manipulation x orientation interaction were not significant (max F= 1.19, min p= .28).

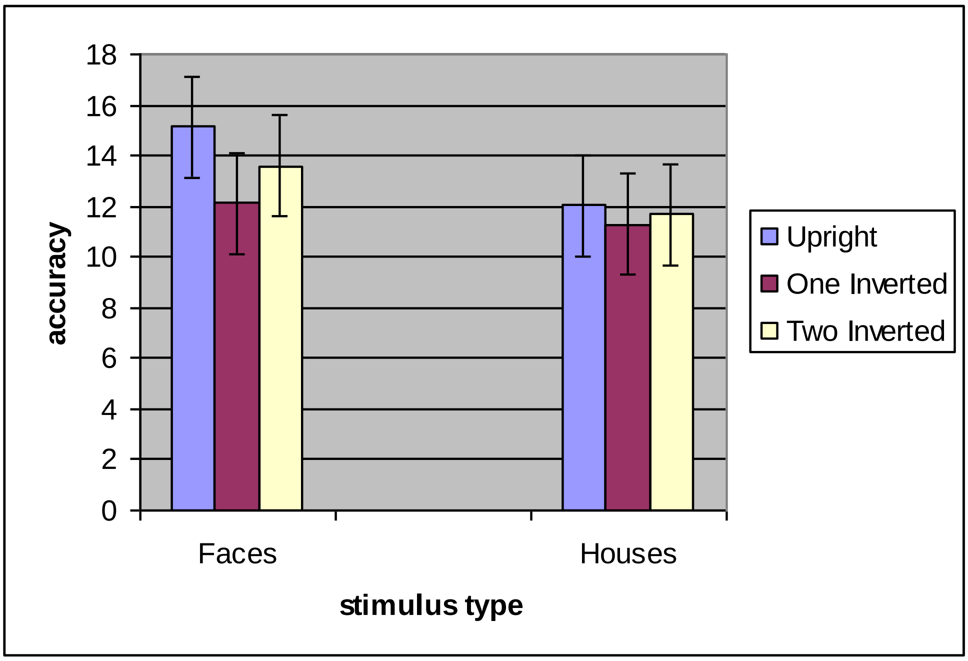
Houses: The analysis for houses only revealed a significant main effect of manipulation, $F(1,22)=68.0$, $p<.01$ (both groups of participants performed better in featural sets) and a significant main effect of orientation, $F(2,44)=6.2$, $p<.01$ (both groups of participants performed better in upright trials). Group interactions and the manipulation x orientation interaction were not significant (max F= 1.17, min p= .31).

6.3.4. Manipulations Analysis

In order to analyse the effect of manipulations we carried out two separate ANOVAs for the two types of manipulations (configurations vs. features), with stimulus (faces vs. houses) and orientation (upright, one inverted, two inverted) as within-subjects factors and group (autism vs. comparison) as a between-subjects factor.

Configurations: The analysis revealed a significant main effect of orientation, $F(2,44)=7.7$, $p<.01$, a significant main effect of stimulus, $F(1,22)=8.3$, $p<.01$ and a significant interaction between orientation and stimulus, $F(2,44)=4.3$, $p<.05$. Group interactions were not significant (max F= .88, min p= .41). The Figure 6.18 below illustrates these findings.

Figure 6.18. Participants' performance (ASD score plus comparison group score) in faces and houses differing in configurations in the three different orientations



<u>Features:</u> The analysis revealed a significant main effect of orientation, $F(2,44)=8.4$, $p<.01$ and a significant main effect of stimulus, $F(1,22)=11.8$, $p<.01$. Also, there was a trend for a significant interaction between stimulus and group, $F(1,22)=3.3$, $p=.08$ and a trend for a significant interaction between orientation and stimulus, $F(2,44)=2.7$, $p=.07$. The remaining main effects or interactions were not significant (max F= .43, min p= .65). Figures 6.19 and 6.20 illustrate the interactions.

Figure 6.19. Participants' performance (ASD scores plus comparison group scores) on faces and houses differing in features in the three different orientations

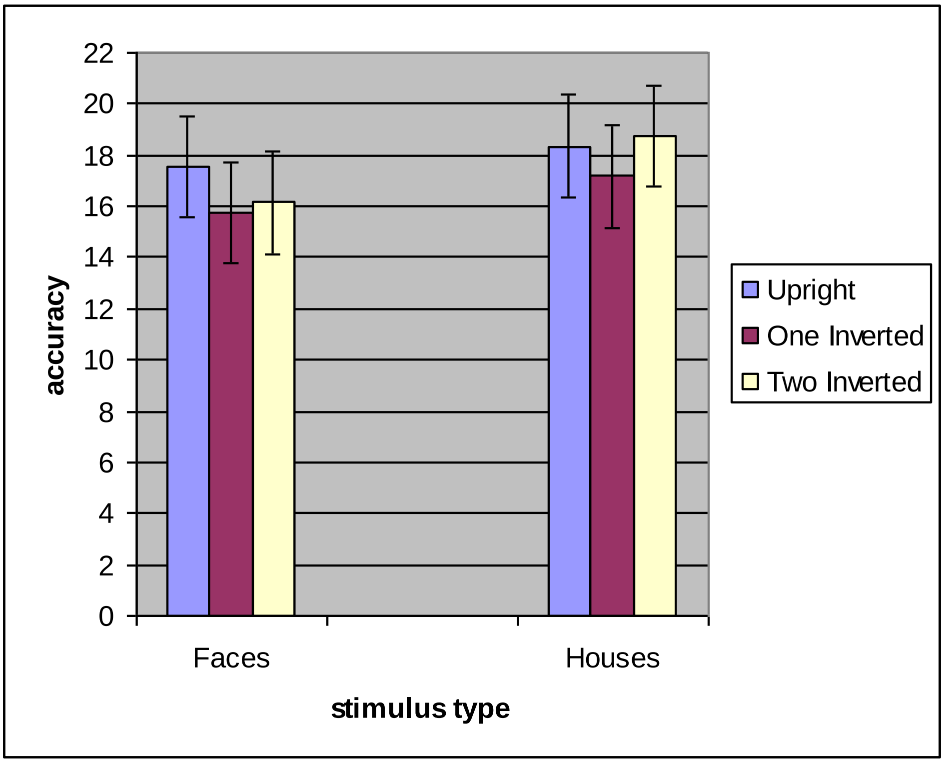
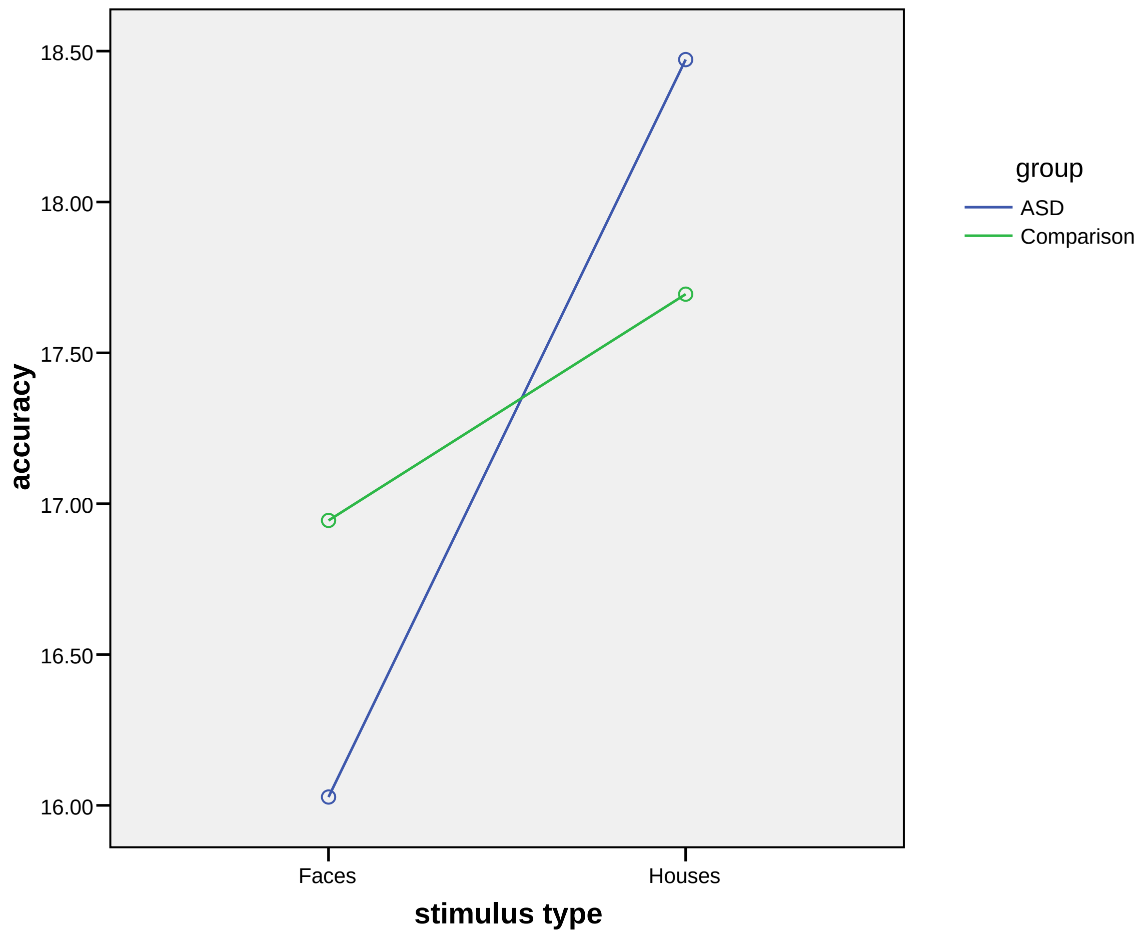


Figure 6.20 Mean accuracy in face and house stimuli (summary score of the three orientation presentations) differing in features in the ASD and comparison group.



In order to investigate the exact nature of the interaction, within and between subjects t-tests were carried out. There was a significant difference between faces and houses stimuli differing in features for the ASD group ($t= -3.9$, $df= 11$, $p< .01$). Also, there was a marginally significant difference between the two groups in houses that differed in features (t= .79, df=22, p= .07).

6.3.5. Inversion effects

In order to investigate the inversion effect of each condition we calculated the difference between upright trials and 'one inverted' (i.e. up minus one inv. - upone) trials and the difference between upright trials and 'two inverted' trials (i.e. up minus two inv. - uptwo). These scores were then subjected to a repeated measures ANOVA with orientation difference (upone vs. uptwo), stimulus (face vs. house) and manipulation (configurations vs. features) as within-subjects factors and group (autism vs. control) as a between subjects factor.

Table 6.3. Difference between upright trial conditions and 'one inverted' condition ('UpOne') and 'two inverted' condition ('UpTwo') in the ASD and Comparison group.

		Autism (n=12) M (SD)	Comparison (n=12) M (SD)
Faces Configural	UpOne	4.0 (4.4)	1.9 (3.0)
	UpTwo	2.0 (3.2)	1.0 (3.3)
Featural	UpOne	1.9 (2.8)	1.6 (2.8)
	UpTwo	1.7 (2.7)	1.0 (2.0)
Houses Configural	UpOne	.8 (2.3)	.6 (2.1)
	UpTwo	.5 (2.5)	.2 (1.7)
Featural	UpOne	.8 (3.5)	1.5 (2.6)
	UpTwo	-.7 (3.0)	-.8 (2.1)

The results revealed a significant main effect of stimulus, $F(1,22)=9.6$, $p<.01$, a significant main effect of orientation difference, $F(1,22)=22.7$, $p<.01$ and a trend for significant interaction between stimulus, manipulation and orientation difference, $F(1,22)=3.5$, $p=.07$. Neither the main effect nor any group interactions were significant (max $F= 1.78$, min $p= .19$). Means are presented in Table 6.3.

6.3.6. Orientation Analysis

Because of the marginally significant three-way interaction between orientation, stimulus and manipulation, and because one of the main aims of this study was to investigate the effects of the different types of stimulus presentation (i.e. orientation) on the processing of faces and houses, we carried out two separate analyses for each type of stimulus presentation.

UpOne: We carried out a repeated measures ANOVA with stimulus (faces vs. houses) and manipulation (configurations vs. features) as within-subjects factors and group (autism vs. control) as a between subjects factor. We found a significant main effect of stimulus, $F(1,22)=6.6$, $p<.05$, with both groups of participants showing a greater inversion effect for faces. The remaining main effects and interactions were not significant (max $F= 2.1$, min $p= .15$). Means are presented in Table 6.3.

UpTwo: We carried out a repeated measures ANOVA with stimulus (faces vs. houses) and manipulation (configurations vs. features) as within-subjects factors and group (autism vs. control) as a between subjects factor. We found a significant main effect of stimulus, $F(1,22)=8.2$, $p<.01$, with both groups of participants showing a greater inversion effect for faces. The remaining main effects and interactions were not significant (max $F= 1.02$, min $p= .32$). Means are presented in Table 6.3.

Power Analysis: GPOWER (Erdfelder et al., 1996) was once again used to calculate the power of the test used. The number of participants was 24 and number of independent variables was 12. Therefore, considering the means for each ID, GPOWER calculated an effect size of .40, which according to Cohen's (1988) tables is a low effect. The post-hoc power analysis revealed the power of the test to be .50.

6.4. Discussion

The current study employed a new paradigm for the study of the face inversion effect. No studies up to now have compared the effects of the different orientation of the 'study' and 'test' faces in face inversion and how this differs to when both faces are presented inverted. In addition, except for the study by Boutsen and Humphreys (2003), no other studies have investigated the idea of local and global configural information in faces. In this study it was proposed that when two inverted faces are compared, participants with or without ASD rely more on local configural information and match the faces according to this. However, when one face is upright and the other inverted, the processing of global configural information is essential for matching these two faces.

This study aimed to investigate the face inversion effect in autism by manipulating featural and configural information in faces and houses in a same/different task. Stimuli were presented in three different orientation combinations simultaneously, i.e. both upright, one upright and one inverted and both inverted. It was suggested that faces that are inverted at presentation require local configural information when required to be matched, while when one face is inverted and the other upright it is global configural information that is required. We were interested in identifying if children with autism show a face recognition impairment and what is the exact nature of it in relation to the face inversion effect.

Overall, it was found that both groups of participants performed better when stimuli (both faces and houses) differed in features. There was also a trend for the comparison group to perform better than the autism group on faces, while no differences were found between the two groups when they were asked to match house stimuli (see Figure 6.14).

With regards to the three different orientation presentations, when stimuli were presented upright no group interactions were significant. In fact, overall our participants performed better with face stimuli and when stimuli differed in features. However, there was a significant interaction between stimuli and manipulation in that participants did not show any difference in accuracy when asked to recognise faces and houses that differed in features, but showed a significant difference between the two types of stimuli when these differed in configurations, i.e. we found better performance for faces differing in configurations than houses differing in configurations. Despite the fact that participants' performance on the house stimuli might be due to chance (i.e. participants found this condition very difficult) it is arguable that this finding confirms earlier ones showing that faces are processed configurally while houses are processed featurally.

When each stimulus in the studied pair was presented in a different orientation, i.e. one upright and one inverted, analysis showed a slightly different pattern of results. Once more all participants were more accurate when stimuli differed in features. However, there was also a marginally significant interaction between participant group and the type of stimuli, in that the comparison group were more accurate than children with autism, when asked to match faces and especially when the faces differed in configurations.

When both stimuli were inverted, no group differences were significant. All participants showed higher performance when houses differed on features than when they differed on configurations'.

In order to test the effect of having one or two items inverted we calculated the difference between upright trials and 'one inverted' (i.e. up minus one inv. – 'upone') trials and the difference between upright trials and 'two inverted' trials (i.e. up minus two inv. – 'uptwo'). Analysis of these data revealed greater inversion effects for faces that differed in configurations and when these faces were presented in mixed orientation (one upright and one inverted). This finding illustrates that the most difficult condition of this study was when faces were presented in different orientation and therefore when global configural processing is required.

The current experiment was successful in tapping these two types of information processing in that participants were less accurate when asked to match an upright to an inverted face (and vice versa). This was the hardest condition of the experiment because global configural processing was required. One would suggest that this was due to additional cognitive processes involved unrelated to face processing strategies because of the different orientation of the stimuli. However, in our experiment this specific condition was the most difficult one (as illustrated both by accuracy and the inversion effect) in the case of faces that differed in configural information only. The 'one upright – one inverted' condition did not have any effect, either in the case of houses that differed in either features or configurations, nor when faces differed in features. Therefore, since it is well-established that faces are processed according to the specific metric-relations between the features (configural information) which is a skill greatly affected by inversion, the fact that the ‘one upright – one inverted’ condition had an effect only for faces that differed in configurations shows that the processes involved are face-specific and relate to global configural information. This is in contrast to the ‘both inverted’ condition which produced similar inversion effects for faces that differed in features and configurations. This lack of greater inversion effects for faces differing in configurations and presented as ‘both inverted’ possibly suggests local configural processing which is less affected by inversion.

The current paradigm was also successful in replicating findings by previous studies that showed that objects are processed based on their features (Diamond and Carey, 1986; Tanaka and Farah, 1993). We found that across all conditions houses that differed in features were matched more accurately by our participants as opposed to houses that differed in configurations, which was the least accurate condition for our participants. This is also confirmed by the small inversion effects observed in the processing of houses and enhances the idea that the degree to which people encode a pattern in terms of parts affects the degree of inversion effect in recognising the pattern (Farah, et al., 1995). Finally, with regards to faces vs. houses, our findings support those of Tanaka and Farah (1993) which revealed that when face and object (house) recognition are compared, participants show ‘an impairment’ when recognising parts of faces as opposed to parts of objects. Indeed, this is what was found in the current study: participants were more accurate when asked to match houses based on their features than when asked to match faces based on their features (see Figure 6.19).

As far as our findings from children with autism is concerned, to a great extent these support findings from previous studies. First of all, our analysis revealed a tendency for children with autism to perform less accurately with faces compared to children without autism. Such a difference was not observed in the house stimuli, and although this difference for faces did not reach significance, it can be argued that with a larger group of participants significance might have been reached. Overall, this finding shows that children with autism found matching faces harder than the comparison group, which in turn suggests that a specific face impairment could be present. This confirms findings from previous studies which proposed a face processing impairment in autism (i.e. Langdell, 1978; Hobson, et al, 1988; Tantam, et al., 1988; McPartland, et al., 2004), but it comes in contrast to other studies which found no face processing impairments in autism (Teunisse and de Gelder, 2003; Nishimura et al., 2008). Methodological issues however, cannot account for this discrepancy between studies. The current design was very simple and did not raise any memory demands. Stimuli were presented simultaneously and no time limit was set. Participants took their time and studied both stimuli on the computer screen for as long they needed before they gave a response. Also, the instructions were clear and the task involved a simple 'same' or 'different' response. Therefore, the difference between the present study and others could be due to other reasons. First of all, in the studies by Teunisse and de Gelder, (2003) and Nishimura et al. (2008) participants were adolescents and adults with autism respectively; as opposed to participants of the current study who were children (mean age 9 years old). It is very possible that this difference between the studies accounts for the contrasting findings since the developmental nature of face processing in autism is not known yet due to lack of research in this area. It is possible that in some groups of children with autism, typical face processing skills are indeed developing but in a slower manner and therefore typical face processing is achieved in adulthood (rather than early adolescence or even childhood like in typical populations). A crucial difference between the face inversion task in the current study and the one by Teunisse and de Gelder, (2003) is that in our study participants were matching faces of the same identity that differed either in featural information or configural information whereas in Teunisse and de Gelder (2003), participants were matching faces of different identity, which suggests that participants with autism possibly relied on external face information too. Also, it is possible that different face tasks produce different results in autism. This was highlighted in the study by Teunisse and de Gelder, (2003) in which the same group of participants showed a different pattern of results in the face inversion task and in the composite task. Although the authors claimed that this was due to different face information processing between the two tasks (configural vs. contextual information in faces), overall the two tasks provide evidence of configural processing in typical populations. Therefore, it seems that depending on the face task, individuals with autism develop strategies and manage to overcome their difficulties to a certain extent. The exact nature of this impairment in relation to the current study of the face inversion effect is discussed below.

With regards to the face inversion effect, our separate analyses for the different orientation of face presentations, found no differences between the two groups for faces presented both upright and both inverted. However, a difference was observed when participants were asked to match faces presented in different orientation (one upright and one inverted). Specifically, participants with autism were less accurate than the comparison group with faces that differed in configurations when these were presented in different orientation. This is a very interesting finding, since according to our suggestion faces matched in different orientations require the processing of global configural information. Therefore it seems that our participants with autism have difficulties with the processing of this type of information although they present no difficulties with the processing of local configural information, as illustrated by their performances in matching two inverted faces. Obviously the degree of difficulty involved in processing these two types of information (local configural vs. global configural) differs and that is because as it is suggested in this study, with the processing of global configural information face expertise is achieved (as illustrated by the performance of our comparison group). Local configural information also contributes to the development of face expertise possibly as a stage before this is fully achieved (with global configural processing) and at this stage participants with autism appear to perform in a typical way. Overall, it can be argued that participants with autism in the current study show some ability to process faces configurally but this ability is not fully developed because it relies on matching local properties of the face which include configural information, as opposed to global face properties which include configurations.

As mentioned previously, the face inversion effect as measured by the calculated difference between our ‘upright trials’ and ‘both inverted’ or ‘one upright-one inverted’, produced no group differences while both groups showed greater inversion effects for faces. Although this is evidence of configural processing of faces for both children with autism and typically developing children in this study, it can be argued that in the case of children with autism this calculated difference between conditions might not be relevant because as shown by their overall performance they tend to perform worse in faces. So this absolute difference reflects the extent to which their performance is affected between conditions, which appears to be similar to comparison participants, but within conditions this is worse overall.

To sum up, the current study investigated the face inversion effect with respect to local and global configural information. Participants with autism performed similarly to typically developing children in this with respects to local configural information. However, differences were found between the two groups when faces presented in different orientations had to be matched. Children with autism found this condition very difficult especially when faces differed in configural information. We take this as constituting evidence for an impairment in the processing of global configural information.

However, the notions of global and local configural processing are fairly new and the design used in this study has not been applied before. Further exploration is required in typically developing populations as to what are the effects of these two types of information in face processing and how these develop in children and adults. Adding to this, we acknowledge that the number of participants in our groups was small and possibly a replication of the study is required with larger groups of participants in order to establish our findings. Despite these limitations, this study has provided some evidence for a different type of face processing by children with autism, which needs to be further explored in relation to the face inversion effect.

CHAPTER 7

GENERAL DISCUSSION

7. General Discussion

7.1. Aim and summary of findings

This thesis aimed to investigate the face processing abilities of children with autism. For this purpose, five experiments were conducted in which configural, holistic and featural processing of faces in children with autism and typically developing children were investigated. What follows is a brief summary of the main findings of each experiment prior to discussion of the overall implications.

7.1.1. Experiment 1

In Experiment 1, the 'Jane task' (Mondloch et al., 2002) was replicated with the aim of investigating second-order configural processing and whether children with autism show atypicalities when they are asked to make identity judgements when based on this kind of processing, as previous studies have indicated. In this paradigm a single face was manipulated in order to create three sets of faces: a) spacing / configural set in which faces differed only in the distances between the eyes and nose-mouth and therefore any identity decision is based in the processing of second-order configural information; b) featural set in which faces differed only in the eyes and mouth and therefore featural processing is required when asked to make identity decisions; and c) contour set in which faces differed only in the face contour. In the last case we assume that processing of these faces should be based more on the processing of external features / distances of faces rather than internal (central to the face). Face stimuli in all sets were presented in both upright and inverted orientation so that we are able to establish the size of inversion effect (evidence of second-order configural processing).

Overall, the findings from this study showed no differences between the two groups and therefore it was concluded that children with autism show second-order configural processing of faces in the way that typically developing children do. However, because one of the aims of this experiment was to specifically investigate configural face processing in autism, a planned analysis was carried out to investigate any differences between our groups of participants in the configural set of faces. This revealed that typically developing children performed better than children with autism when asked to match faces that differed in the configurations (i.e. specific metric relations) between the features (see Figure 3.4). This suggests that there may be some impairment in processing the configural properties of faces by children with ASD.

7.1.2. Experiment 2

In Experiment 2, holistic face processing in children with and without autism was investigated. The paradigm that was used was the well-known part-whole paradigm, in which face parts are matched either in the context of a whole face or in isolation. Participants' accuracy was analysed in this experiment, the aim of which was to establish the nature of a possible holistic processing impairment of faces in autism highlighted in some, but not all, previous studies.

Our participants (both the comparison and autism group) performed better with whole faces rather than parts of faces, therefore demonstrating a holistic processing advantage. This holistic advantage was also demonstrated by the inversion effects observed: our groups of participants were greatly affected by stimulus inversion but only in the condition of whole faces. It was concluded that children with autism show the typical holistic face processing advantage as demonstrated both by their accuracy with upright whole faces as well as their inversion effect in whole faces.

In Experiment 2 we also analysed participants' accuracy separately for 'eyes' and 'mouth' manipulations in whole faces and parts of faces. Typically developing children showed the eyes advantage in their accuracy for the 'eyes' section, which however, was not the case for the autism group. Our participants with autism did not show the eyes advantage to the same extent as the typically developing participants did but neither did they show an advantage for mouth (see Figure 4.6).

7.1.3. Experiments 3 and 4

In Experiment 3 and 4, holistic face processing was again investigated. Holistic processing in that experiment was tested with the use of distinctive faces (caricatures) and was based on the assumption that holistic information in faces refers to template-like representations of a face which are processed with only minimal reliance on configurations. The literature on the distinctiveness effect shares the same assumption and mainly proposes that distinctive faces are recognised better than typical faces. However, because of holistic processing of distinctive faces and also minimal reliance on configurations, we did not expect an inversion effect for these types of faces. It was hypothesised that if distinctive faces are better recognised than typical ones then our participants engage in holistic processing, which according to Maurer et al. (2002), comes second in the order in which information is processed in faces just before we reach expertise (with second-order configural processing).

In these two experiments we analysed corrected hits and false alarms. The corrected hits results in Experiment 3 showed that both groups of children (autism and comparison) performed better in the typical rather than distinctive faces condition, which was against our initial hypotheses and did not confirm the distinctiveness effect (see Figure 5.3). However, children with autism did not perform as well as the comparison group in their recognition of typical faces. It was also found that there was a greater inversion effect for typical faces, which confirmed our prediction that distinctive faces (caricatures) are processed with minimal reliance on second-order configurations, which explained the smaller inversion effect (see Figure 5.7). We also found that when faces are inverted, comparison children perform better with typical and worse with distinctive faces. However, children with autism appear to treat inverted faces differently since they do better when faces are distinctive and worse when they are typical (the exact opposite of what occurs in the comparison group, see Figure 5.6).

False alarms analysis in Experiment 3 revealed that both groups of participants had more false alarms in the distinctive faces conditions, and while in the distinctive faces condition they appear to have more false alarms for upright trials, in the typical faces condition there are more false alarms for the inverted trials (see Table 5.2). Also, there was a slightly greater inversion effect on false alarms for typical than for distinctive faces. As for children with autism, they appear to show a greater inversion effect of false alarms in distinctive faces than in typical faces (see Figure 5.12).

In Experiment 4 we explored the distinctiveness effect further since a number of methodological issues were identified in the literature on distinctiveness. These methodological issues relate to the way distinctive and typical faces are presented as well as their exposure times. In Experiment 4, distinctive and typical faces were presented in the same block of trials, as opposed to Experiment 3, where they were presented in separate blocks of trials. Face presentation time was also reduced to 2sec as opposed to 3sec in the previous study. That was in order to investigate the effects of exposure time in the recognition of typical and distinctive faces.

Overall, the analysis of corrected hits showed that when typical and distinctive faces are presented in one block of trials, participants showed neither the distinctiveness effect (distinctive faces remembered better) nor the typicality effect (typical faces remembered better) (see Table 5.5). As far as false alarms is concerned, there was a non-significant trend for all our participants to show more false alarms with distinctive faces (see Table 5.6). Finally, participants with autism appeared to have more false alarms in upright trials than typically developing children, who had significantly more false alarms in inverted trials for both typical and distinctive faces (see Figure 5.13).

7.1.4. Experiment 5

In Experiment 5 the face inversion effect was investigated by manipulating featural and configural information in faces and houses in a same/different task. Stimuli were presented in three different orientation combinations simultaneously, i.e. both upright, one upright and one inverted and both inverted. It was suggested that faces that are presented inverted require local configural information when asked to be matched while when one face is inverted and the other upright it is global configural information that is required. We were interested in identifying whether children with autism show a face recognition impairment and what is the exact nature of it in relation to the face inversion effect.

It was found that both groups of participants performed better when stimuli (both faces and houses) differed in features. There was also a trend for the comparison group to perform better than the autism group in faces, while no differences occurred between the two groups when they were asked to match house stimuli (see Figure 6.14).

With regards to the three different orientation presentations, when stimuli were presented upright no differences were found between the two groups of participants. In fact, overall our participants performed better with face stimuli and when stimuli differed in features. Although, participants did not show any difference in accuracy when asked to recognise faces and houses that differed in features, they showed a significant difference between the two types of stimuli when these differed in configurations, i.e. we found better performance for faces differing in configurations than houses differing in configurations. When stimuli were presented in different orientation, i.e. one upright and one inverted, analysis showed that our participants were more accurate when stimuli differed in features. However, the comparison group was more accurate than children with autism, when asked to match faces and especially when the faces differed in configurations (see Figure 6.16). When both stimuli were inverted, no group differences were significant. Participants were more accurate when houses differed in features and less accurate when houses differed in configurations.

In order to investigate the inversion effect of each condition we calculated the difference between upright trials and 'one inverted' (i.e. up minus one inv. – 'upone') trials and the difference between upright trials and 'two inverted' trials (i.e. up minus two inv. – 'uptwo'). Analysis revealed greater inversion effects for faces that differed in configurations and when these faces were presented in different orientation (one upright and one inverted) (see Table 6.3). This finding illustrates that the most difficult condition of this study was when faces were presented in a different orientation and therefore when global configural processing is required.

7.2. Findings in relation to face processing strategies

In summary, with regards to the specific types of processing of faces (i.e. featural, holistic, configural), findings from all five experiments revealed that children with autism show intact featural processing. Our participants with autism performed consistently equally well to typically developing children across all experiments in conditions that tested featural processing.

Holistic face processing was investigated in Chapters 4 and 5 across three experiments (Experiments 2, 3 and 4). At a first glance, findings from these studies revealed that children with autism process faces holistically. In the part-whole paradigm (Experiment 2) they performed better when asked to match whole faces than features to whole faces and also showed a greater inversion effect for whole faces. Also, in the distinctiveness effect experiments (Experiments 3 and 4) participants with autism performed similarly to participants without autism with upright trials. However, a closer look at the findings of these studies reveals a few atypicalities in holistic face processing in autism. These atypicalities occur when face stimuli are inverted. For example, in the part-whole paradigm our participants with autism did not show the eyes advantage that normally seen in typically developing children. In addition, in the distinctiveness effect, participants with autism show more false alarms when distinctive faces are inverted. Together these findings suggest that when faces are inverted, participants with autism experience difficulties when holistic processing is required for the correct matching of these faces (Experiments 2, 3 and 4).

With regards to configural processing, this type of face processing was investigated in Experiments 1 and 5 of this thesis. Experiment 1 provided conflicting evidence, since in the overall analysis children with autism performed equally well as typically developing children, but the planned analysis showed worse performance in faces that differed in configurations. In Experiment 5, we distinguished between global and local configural processing and therefore it was demonstrated that children with autism show no impairment in local configural processing but are presented with difficulties in global configural processing.

Overall, it appears that when faces are upright children with autism show normal face processing abilities. However, when faces are inverted they show differences that affect their holistic as well as their configural processing of faces.

7.3. Findings from this thesis vs. previous findings

But how do these findings inform us in relation to the face processing literature in autism? Unfortunately, because of the nature of the studies in this thesis, developmental aspects of face processing in autism cannot be discussed. However, there is quite a bit of existing evidence on the face processing abilities of children with autism aged 9 to 10 years old. This is an important age for children because existing research findings have demonstrated that face processing expertise is achieved at around this time of a child's life (i.e. Mondloch et al., 2003).

Findings from the current thesis on the featural processing of faces in autism confirm previous studies, which suggested that this type of processing in autism is intact (Langdell, 1978; Hobson, et al., 1988; Joseph & Tanaka, 2003).

With regards to our findings on holistic face processing, evidence from the part-whole paradigm (Experiment 2) suggested that children with autism benefit from the context of a whole face when they are asked to match facial features, therefore showing holistic face processing abilities. However, they are showing equal performance for the 'eyes' and 'mouth' sections of the face, while typically developing children show an advantage in processing the eyes. These findings only partly support those of Joseph & Tanaka (2003) and Lopez et al. (2004) who also looked at the part-whole paradigm in autism. Joseph & Tanaka (2003) found that children with autism show holistic face processing skills only for the 'mouth' section of faces, while Lopez et al. (2004) showed that individuals with autism perform as well as the comparison group in the part-whole paradigm under the condition where they are cued to the specific feature that they have to make a judgement upon. Findings from Experiment 2 contradict Joseph & Tanaka's study because an overall holistic advantage was found in children with autism who relied equally on both eyes and mouth sections of the face, as opposed to Joseph & Tanaka (2003) who found holistic face processing only for the mouth section in autism. This finding confirms evidence from Lopez et al.'s

(2004) study which showed typical holistic processing of faces in autism. However, in our study participants were not cued to the feature to be matched and therefore our findings expand on existing evidence that holistic face processing in autism is intact without the need to make any task manipulations to divert children's attention to specific features. As Boutet, Gentes-Hawn & Chaudhuri (2002) have shown, holistic encoding is one aspect of face processing that should occur equally well with or without specific instructions on where to attend, and this is what was confirmed in Experiment 2 of this thesis.

In Experiments 3 and 4 of this thesis, holistic face processing was investigated again using a different paradigm. Due to difficulties in defining and operationalising the terms of holistic and configural processing, it was decided that the distinctiveness effect could be one measure of holistic processing which would help to distinguish it from configural processing. It was hypothesised that typical faces would be processed configurally and will show a large inversion effect in recognition because of greater reliance in the configural properties of the face. On the other hand, distinctive faces would be processed holistically, as template-like representations with minimal reliance on configurations and therefore a smaller inversion effect should occur (this definition overlaps with definitions of distinctiveness in faces). The two experiments were a replication of Johnston & Ellis (1995), who showed that 5 year-olds did not show a recognition advantage for distinctive faces over typical faces. Instead the advantage for processing distinctive faces began to emerge at age 7 and was adult-like at age 9. Experiments 3 and 4 reported in this thesis did not provide evidence for the distinctiveness effect found in previous work (Valentine, 1991; Chang, Levine & Benson, 2002; Bartlett, Hurry & Thorley, 1984; Johnston & Ellis, 1995; Ellis, 1992).

In contrast, they provide evidence for the newly proposed typicality effect (Davidenko & Ramscar, 2005), which suggests that when distinctive faces are identical to the set of typical faces, except that they are centered in a different location of the face space (Valentine, 1991), still within the realm of normally-appearing faces, then these distinctive faces loose their distinctiveness and typical faces are remembered better. This was how stimuli in our studies were created and what was found (Experiments 3 and 4). Typical faces were recognised better and distinctive faces elicited more false alarms both by typically developing children and children with autism, therefore replicating the typicality effect (Davidenko & Ramscar, 2005).

Despite the fact that the distinctiveness effect was not replicated in Experiments 3 and 4, predictions with regards to how typical and distinctive faces are processed were confirmed. A large inversion effect was found in both groups of participants for typical faces which showed that our participants were responding on the basis of configural properties of typical faces when processing them. A smaller inversion effect was found for distinctive faces and as it was hypothesised this was because participants used holistic processing, which requires minimal reliance on configural information. One important finding of Experiment 3 was that despite the fact that children with autism showed evidence of configural processing when recognising typical faces (they performed better on typical than on distinctive faces), this configural processing was not as effective as that of the comparison group since the comparison group performed significantly better than the autism group.This suggests that our participants with autism may well have problems with configural processing which is either not as developed by the age of 9 years as in typically developing children, or they engage in compensatory strategies when processing faces, strategies that ultimately are not very effective. Another difference between our two groups of participants was the way inverted faces were processed. Children with autism performed better when inverted faces were distinctive and worse when they were typical (the exact opposite of the comparison group). This shows a difference in the way participants with autism treat inverted faces. It seems that in autism, inversion disrupts the processing of face stimuli in ways that are different from those seen in typically developing participants, and this is either due to a different but in some ways, efficient strategy in processing upright faces in the first place or due to treating inverted faces as different type of stimuli from upright faces.

The follow-up study of the distinctiveness effect in this thesis (Experiment 4) manipulated the stimulus presentation (mixed presentation of typical and distinctive faces), and exposure time (shorter exposure time). Although in typically developing children no big differences were found compared to the first study (confirmed the typicality effect in false alarms), children with autism were affected in their processing of typical faces. Specifically, in autism, we found equally high false alarms for upright and inverted trials of typical faces. This finding suggests that our participants with autism find typical faces easier to remember compared to distinctive faces but they treat upright and inverted typical faces in the same way. This lack of difference between upright and inverted trials demonstrates a non-existent inversion effect, which rules out the possibility of this group of autistic children using configurally based strategies in processing typical faces. Rather, it is possible that the strategy used is more holistically based, since as it was discussed before, a lack of inversion effect will possibly demonstrate holistic processing of typical faces. Findings from Experiments 3 and 4 seem to support studies that have demonstrated differences and atypicalities in face processing in autism (Langdell, 1978; Hobson, Ouston & Lee, 1988; Tantam, Monaghan, Nicholson & Stirling, 1989; Boucher & Lewis, 1992, Joseph & Tanaka, 2003). Overall, findings from these two experiments seem to partly support Jemel, Mottron & Dawson's (2006) theory, which proposes an absence of global perceptual difficulties (as demonstrated by good recognition of upright typical faces in our experiment), but with a preference for a lower level perceptual processing strategy (holistic processing of inverted distinctive faces) in autism.

Because of differences in the processing of inverted faces in autism found in Experiments 3 and 4, the final experiment of this thesis (Experiment 5) investigated the inversion effect. This time, two new terms were introduced for configural information in faces: local configural information and global configural processing (Boutsen and Humphreys, 2003). The first evidence that there might be something different in the processing of faces in autism came from the finding that children with autism in that Experiment 5 did not perform as well as typically developing children in matching faces while no differences were apparent when our participants were asked to match house stimuli. Also, it was found that participants with autism performed worse on faces that required global configural processing compared to faces that required local configural processing in which they showed no differences to typically developing children. Experiment 5 was very useful in explaining the findings from Experiment 1 of this thesis according to which children with autism showed no impairment in processing configural information in faces therefore supporting existing evidence that configural processing in autism is intact (Teunisse & de Gelder, 2003; Rouse et al., 2004; Nishimura et al., 2008). The inversion effect in

Experiment 1 was measured by presenting both 'study' and 'test' faces upside-down, which is a condition on which participants with autism performed as well as typically developing children in both Experiments 1 and 5. However, is it possible that because both stimuli were presented in the same orientation it was easier for participants to match faces by treating specific metric distances between features as a 'feature' (local configural information)? Moreover, it was hypothesised that since faces are usually experienced in upright orientation, when the aim is to test the inversion effect the best measure should be illustrated when participants have to match an upright to an inverted face rather than two inverted faces. Because of this, in Experiment 5 a third condition was included in which 'study' and 'test' faces that differed in configurations were presented in different orientations (thereby tapping global configural processing), and this is where participants with autism showed differences in their performance which confirmed previous evidence highlighting an impairment in face processing in autism (i.e. Langdell, 1978; Hobson, et al, 1988; Tantam, et al., 1988; McPartland, et al., 2004).

Overall, this thesis has produced evidence that children with autism aged 9 to 10 years-old can in some ways, process faces configurally and holistically. As opposed to previous studies that have suggested that children with autism employ an exclussively feature-based strategy when processing faces (Langdell, 1978; Hobson et al., 1988; Tantam et al., 1989; Boucher & Lewis, 1992; Davies et al, 1994), and therefore show impairments in face processing, experiments, in this thesis we have found evidence of some sort of configural and holistic processing of faces. However, face inversion seems to affect their performance in ways that are different from those that affect the performance of typically developing children. According to the face processing literature, in inverted faces the processing of configural and/or holistic information is disrupted and this explains why performance of typically developing individuals in recognising inverted faces drops off dramatically (Farah et al., 1995; Tanaka & Farah, 1991; Schwarzer, 2000; Searcy and Bartlett, 1996; Leder and Bruce, 2000; Mondloch et al., 2002; Boutsen and Humphreys, 2003; Rossion, 2009). This thesis has demonstrated that children with autism are able to match two inverted faces (Experiments 1 and 5) even when these differ in configural information. However, because it was suggested that configural information in two inverted faces might be processed in a 'local' manner, we investigated global configural information by presenting one face upright and the other one inverted. And this was where children with autism revealed atypical performance (worse when matching these two faces). In addition, although children with autism showed the typicality effect when asked to remember upright typical and distinctive faces similarly to typically developing children (Experiments 3 and 4), when distinctive faces (which are processed holistically) were inverted they remembered them better than typical faces (the comparison group performed better with typical faces) and showed fewer false alarms. This demonstrates differences in the way holistic processing is taking place in autism and how it is affected by inversion. As mentioned above, previous studies have also demonstrated differences between individuals with autism and typically developing comparison groups of participants, however previous researchers have consistently argued that this was due to a feature-based strategy employed by individuals with autism (Langdell, 1978; Hobson et al., 1988; Tantam et al., 1989; Boucher & Lewis, 1992; Davies et al, 1994).

Evidence in the current thesis does not provide support for the above assumption since findings show that configural and holistic processing are in some ways evident in children with autism. Several explanations can be provided for this discrepancy between findings from previous studies and findings from the studies in the current thesis. First of all, it can be argued that because upright faces are experienced in everyday life to a great extent, high-functioning children with autism in our studies had developed an understanding of faces as socially significant stimuli and had developed the strategies necessary to process them. In addition to the increased experience with upright faces, another factor that contributes to the development of skills is the intensive behavioural interventions that children with autism are going through nowadays from a young age. There is evidence to suggest that these interventions are effective in teaching children with autism social skills, including spending more time looking at faces, identity recognition, emotion recognition, etc (Bauminger, 2002). In fact, very recently, a computerised game was developed and its efficiency in teaching children with autism face recognition skills has been evaluated. In the study by Tanaka, Wolf, Klaiman, Koenig, Cockburn, Herlihy, Brown, Stahl, Kaiser & Schultz (2010), the *Let's Face It!* program (Tanaka et al., 2003), which targets face impairments associated with autism, such as recognition of identity, analytic and holistic face processing and attention to eye region of faces, was provided for 20 hours. After this short-term intervention, results suggested measurable improvements in the face recognition skills of children with autism (Tanaka et al, 2010). Interestingly however, this program only involves faces presented upright and so the question which arises is whether tests with inverted faces would produce similar findings. When a face is inverted, although this is a type of stimulus that is not usually experienced, typically developing individuals have the social understanding and cognitive abilities to still treat it as a 'face stimulus' despite the fact that processing it becomes more difficult. It is quite possible that the strategies that children with autism have developed for processing upright faces, do not allow them (or are not efficient enough) to still see an inverted face as a 'face stimulus'. And because of this confusion, their strategies for processing upright faces are disrupted in a different way when the face is inverted. On the other hand, as Deruelle et al. (2004) have argued, it is possible that typically developing individuals and individuals diagnosed with autism use different strategies despite a similar level of performance. Even though identity matching usually involves a configural analysis in typically developing children, one cannot reject the idea that children with autism can resolve tasks by relying on facial components only (Deruelle et al., 2004). However, this argument does not explain the findings from our tasks that tapped specifically configural processing with no ways to resolve the tasks successfully if relying on feature analysis (Experiments 1, 3, 4 & 5).

Our findings can be explained by a theory proposed by Maurer, et al. (2002), according to which holistic face processing and second-order configural processing are both types of configural processing. As discussed in Chapter 2 (section 2.4.6) according to Maurer et al. (2002) holistic processing is the second stage after first-order processing and before the development of second-order information processing. The atypicalities found in children with autism in Experiment 3 of this thesis might suggest no global perceptual difficulties (as demonstrated by good recognition of upright typical faces in that experiment), but with a preference for a lower level perceptual processing strategy (holistic processing of inverted distinctive faces) in autism. It is proposed that this holistic processing strategy is a lower level perceptual processing based on the assumption by Maurer, et al. (2002) that holistic face processing comes as a second stage before we reach the expertise level with second-order configural processing. Therefore, our participants with autism are capable of second-order configural processing when faces are upright but when the task is harder (as with inverted distinctive faces) they employ a lower level perceptual processing, which shows that the ability to process the specific metric relations between the features in faces (i.e., face expertise) has not developed yet.

7.4. Implications of current findings for broader theories of ASD

In Chapter 1 of this thesis (section 1.3.3), the perception theories of ASD were discussed (WCC, Reduced Generalisation, EPF). Face perception belongs to this greater area of perception theories and has greatly informed us about the nature of ASD. In fact, many of the findings from the face processing literature, both in typically developing individuals as well as in autism have greatly informed theories on perception, and vice versa. This is because the different "Perception" hypotheses proposed, can definitely explain some of the findings on face processing since it is well established that faces can be processed in two ways: either globally (holistic / configural processing) or locally (featural processing).

As discussed in section 1.3.3 one theory that directly relates to face processing is the Weak Central Coherence theory of autism. Initially proposed by Frith (1989), it has been suggested that individuals with ASD show a weak central coherence, meaning that they fail to extract global information and instead show a processing bias for featural or local information. Further research has replicated these findings (e.g. Frith & Happe, 1994), which were also supported by findings from the face processing literature that suggested that individuals with autism fail to process faces globally and rely more on the local features (Langdell, 1978; Hobson et al., 1988; Tantam et al., 1989; Boucher & Lewis, 1992; Davies et al, 1994). However, studies in the current thesis have produced evidence that cannot be explained by the weak central coherence theory. Our participants showed clear evidence of holistic and configural processing at least in upright faces, which goes against claims that individuals with autism fail to extract global information from stimuli (Frith, 1989).

An alternative theory to the one of weak central coherence is the theory of Enhanced Perceptual Functioning (EPF model - Mottron & Burack, 2001). As it was discussed in section 1.3.3, the theory emphasises the principle of locally oriented processing in autism as an enhanced perceptual functioning, with possibly intact global processing. The model has been tested and confirmed in relation to a face processing task by Lahaie, et al. (2006) in which individuals with autism showed typical face inversion effects and an enhanced processing of face features in a priming paradigm using partial or complete faces. The authors suggested that atypical behaviours towards faces during the development of children with autism are not due to a social deficit but to a possible superiority of fine-grained, low-level perception (i.e. enhanced perceptual functioning, Lahaie, et al., 2006). Once more, findings from experiments in the current thesis can only partly be explained by the EPF model. Participants with autism showed typical holistic and configural processing with upright faces which was not, however, confirmed by their performance with inverted faces.

The final theory of perception discussed in section 1.3.3, is the one by Plaisted (2001) which argues that the attentional and perceptual abnormalities in autism are phenomena of reduced generalisation, or a reduced processing of the similarities that hold between stimuli and between situations (theory of Reduced Generalisation and Enhanced Discrimination). Specifically, it has been found that individuals with autism performed better than a comparison group on a difficult discrimination task (i.e. one where stimuli to be discriminated hold many elements in common and each possesses very few unique elements - Plaisted, et al., 1998), but were poorer at a task that requires categorisation of two sets of stimuli (Plaisted, O'Riordan, Aitken, & Killcross, submitted, cited in Plaisted, 2001). The reduced generalisation theory and EPF model share many similar assumptions although one of the main differences between the two theories is that the EPF model proposes no global processing deficits in autism while the reduced generalisation theory suggests definite problems with global processing in autism. Plaisted (2001) has argued that a possible underlying mechanism that could explain these findings is habituation and the differences observed in individuals with autism in this process. It is hypothesised that if processes underlying the habituation of stimulus elements are enhanced in autism, common elements would be preferentially influenced over unique elements, and this explains superior performance on discrimination tasks but with inferior performance on categorisation tasks by individuals with autism (Plaisted, 2001). Evidence for this theory comes mainly from the superior performance of individuals with autism on the Embedded Figures test and variants of the Navon task. No direct evidence exists up to now with regards to social stimuli such as faces. Considering the existing face processing literature in autism, the theory of reduced generalisation and enhanced discrimination may be able to at least partly explain findings from the face processing research, such as, impairment in the processing of holistic and configural information with a preference for featural processing. However, although in some studies a preference for featural information has been demonstrated by participants with autism (Langdell, 1978) no enhanced featural processing has been demonstrated. Moreover, the theory of reduced generalisation and enhanced discrimination cannot explain findings from studies that have found typical face processing skills by individuals with autism (Teunisse & de Gelder, 2003; Rouse et al., 2004; Nishimura et al., 2008).

The findings from the experiments in the current thesis could possibly be explained by the theory of reduced generalisation and enhanced discrimination (Plaisted, 2001). Elements of reduced generalisation might be able to explain our participants' performance in Experiments 3, 4 and 5, where children with autism performed similarly to the comparison group with upright faces but differently with inverted faces and therefore showed some problems with the processing of configural information.

Overall, none of the three main perceptual theories of autism fully explains our findings. The theory of reduced generalisation and enhanced discrimination might possibly explain some of our findings but on the whole it cannot specifically explain why participants with autism in this thesis showed typical performance on upright faces but atypical performance with inverted faces. And no direct evidence of enhanced discrimination has been found in the current series of studies. Thus, the question still remains: How do these findings fit alongside studies of perception in ASD and can perceptual theories provide explanations for specific face processing atypicalities observed in autism?

This question has been considered before and the main hypothesis tested was whether face processing atypicalities are due to a general visual processing impairment in autism or due to the social impairment which is also a diagnostic characteristic of the disorder. The hypothesis that a social impairment is responsible for the face processing difficulties observed in individuals with autism is based on assumptions that individuals with the disorder do not attend to faces and generally do not show the same level of interest in people's faces (Tanaka, et al. 2003; Osterling & Dawson, 1994). In fact, eye contact avoidance is considered as a diagnostic feature for autism spectrum disorders (DSM-IV-TR - APA, 2000) and is observed in both young children and adults, as well as in lower and higher functioning groups and Asperger's Syndrome (Wing, 1981; Swettenham, Baron-Cohen, Charman, Cox, Baird, Drew, Rees & Wheelwright, 1998). At the same time, there is evidence to suggest that early visual input to the right hemisphere plays a significant role in the development of configural processing of faces. Le Grand, et al (2003) tested participants with unilateral congenital cataract to either the left or the right eye, on a face task specifically designed to tap configural processing ('Jane' task by Mondloch et al., 2002). It was found that neural networks in the right hemisphere are not pre-specified for configural processing and therefore, this expert ability will not develop if patterned visual input is missing during early infancy. This was not the case for visual input in the left hemisphere. These findings were specific to the processing of configural information in faces and not for featural or contour information. The authors concluded that "configural processing is unique – it continues to improve long after other face processing skills are adult-like, but only if its development was initiated by visual input to the right hemisphere during early infancy" (p. 1111). Based on this finding and on the fact that individuals with autism do not attend to faces, at least not in a typical way, it can be hypothesised that individuals with autism will show difficulties with the processing of configural information in faces due to decreased visual input from faces since their early years.

On the other hand, the perceptual impairment hypothesis is based on findings of the above mentioned perceptual theories which maintain that individuals with autism are particularly attentive to local details or featural information, with or without a failure to extract the gestalt of the input (weak central coherence, reduced generalisation and enhanced perceptual functioning hypothesis). It is suggested that individuals with autism may be impaired (or biased) to process visual information at a more local level and that the failure to derive more holistic representations is particularly disadvantageous when similar perceptual exemplars must be differentiated, be they faces or not (Behrmann, et al., 2006). However, evidence from both behavioural and neuroimaging studies has produced mixed results as to the face processing skills of individuals with autism (for a review see Sasson, 2006) and therefore existing perceptual theories appear not to apply in the area of face processing in autism. The reason for this is possibly the special nature of faces as stimuli.

7.5. The neuropsychology of Face Processing in ASD

As briefly discussed in Chapter 2, Farah (1996) after reviewing the literature on visual processing and specifically that on face processing, of brain damaged patients (i.e. prosopagnosia and visual agnosia) has concluded that faces are a special class of stimuli. Drawing on evidence from patients with prosopagnosia that showed a selective impairment in face recognition and also a deficit in new face learning, Farah (1996) concluded that there is a specialised system for recognising faces. This system is anatomically distinct, in that it can be selectively damaged and selectively disconnected from medial temporal areas by stroke or head injury, and also it does not elaborate the processing of the object system, but rather it processes stimuli in parallel with it (Farah, 1996). Thus, it was claimed that "face recognition and object recognition appear to depend on different systems, which are anatomically separate, functionally independent, and differ according to the degree of part decomposition used in representing shape" (Farah, 1996, p. 189).

With regards to face recognition, as we have seen in Chapter 2, the specific area in the brain that has been identified is the right fusiform gyrus, which has been referred to as 'Fusiform Face Area' (FFA). There is a great deal evidence to support the notion that this area in the brain is activated when participants are presented with face stimuli, and it is so specific to faces that it will not respond to animal or human images or body parts (Kanwisher et al., 1997; Elgar & Campbell, 2001; Halit et al., 2004; Yovel & Kanwisher, 2004). Despite evidence which suggested that the FFA is not a face area but rather an expertise area (Gauthier et al., 1999), the right fusiform gyrus is still found as the area most activated when humans are presented with facial stimuli (for detailed discussion refer to Chapter 2, section 2.4.7.).

In Chapter 2, section 2.5. it was discussed how neuropsychological evidence of face processing in autism has been controversial. The majority of the studies conducted have found that the FFA is not activated in individuals with autism when they are presented with facial stimuli (Schultz et al., 2000; Pierce et al, 2001; McPartland et al, 2004). In fact, even in cases that participants with autism were able to perform equally well to typical controls on face tasks, their FFA did not show the same activation levels as the one in comparison groups (Pierce et al, 2001). On the other hand, Hadjikhani et al (2004) has found a typical activation of FFA in autism by ensuring that participants with autism were attending to the inner features of the faces.

The current thesis provided only behavioural data on the face processing skills of children with ASD. Therefore, only certain conclusions can be drawn with regards to the neuropsychology of face processing in ASD. Overall, based on our findings that children with ASD did not process inverted faces in the same way as typically developing children (Experiments 3 and 5), therefore showing atypicalities in face processing, it is arguable that there are possible differences in the involvement of FFA, which confirms previous findings (Schultz et al., 2000; Pierce et al, 2001; McPartland et al, 2004).

However, a closer look at the evidence on the neuropsychology of face processing provides a better explanation for the findings from this thesis. First of all, Experiment 3 has shown that children with ASD remembered inverted distinctive faces better than typical faces, whereas the comparison group showed better recognition for inverted typical faces (see Figure 5.4). This finding was confirmed by the false alarms of our participants. In the comparison group, children showed fewer false alarms for inverted typical faces than distinctive ones, while children with ASD showed a similar false alarm rate for both typical and distinctive inverted faces (see Figure 5.9). These findings were interpreted first of all, as a failure of the ASD group to make use of the 'typical' second-order configural processing required for the recognition of typical faces. Secondly, the findings suggest that children with ASD perform better when holistic processing is involved (as in distinctive faces).

In Experiment 5, the main finding was that in the condition that required global configural processing (faces or houses to be matched presented in a different orientation – one inverted and one upright), the comparison group performed better than the ASD group. In fact, in this condition, the comparison group performed better on faces than houses, whereas the ASD group performed better on houses than faces (see Figure 6.16). This finding is interpreted as a failure on the part of the ASD group to make use of the global configural processing required for the processing of faces.

Therefore, taken together, findings from Experiment 3 and 5, suggest that children with ASD are impaired in their recognition of faces when second-order configural processing is required and there is no other strategy to compensate for it (as it was possibly the case in our previous experiments).

7.6. The role of the hippocampus and perirhinal cortex in face processing

As discussed in Chapter 2 (section 2.3), faces are complex visual stimuli since their recognition is mainly based on spatial relations between elements, rather than the elements themselves (Simion et al., 2003). Because of these spatial properties of faces, it is worth considering the contribution of the Medial Temporal Lobe (MTL) and specifically the hippocampus system in face recognition.

There is growing evidence to suggest that the hippocampus mediates a holistic representation of the space in which a participant is situated (Muller, 1996). In fact, a view that has received considerable attention is the one which proposed that the hippocampus mediates a neural representation of physical space, that is, a cognitive map (O'Keefe & Nadel, 1978, cited in Eichenbaum, Dudchenko, Wood, Shapiro & Tanila, 1999). This view is largely based on evidence of the behavioural physiology of hippocampal neurons, which suggested that some cells (called place cells) increased firing rate when a rat was at a particular location in its environment (O'Keefe & Dostrovsky, 1971, cited in Eichenbaum, et al., 1999) Specifically, rat studies have shown that spatial information was encoded within the cellular activity of the very hippocampal structures that are necessary for spatial learning and memory (for a review see Eichenbaum et al, 1999). According to the cognitive mapping view of the hippocampus (O'Keefe & Nadel, 1978, cited in Eichenbaum, et al., 1999), when spatial or nonspatial features are changed in a familiar situation, the entire hippocampal ensemble must act coherently, such that all the place cells either maintain the same firing pattern or all the cells form a new representation (Eichenbaum, et al., 1999). Adding to this, it has been suggested that in recognition memory, the hippocampus is involved in processing information essential to recognition memory concerning the relative familiarity of arrangements of items, as is also needed for episodic memory (Wan, Aggleton and Brown, 1999).

Another structure of the MTL that has received considerable interest is the perirhinal cortex and the way its processes resemble or differ from those of the hippocampus. There is evidence to suggest that the perirhinal cortex is activated significantly more by pictures of novel than of familiar individual objects (Wan et al., 1999). Adding to this, it has been shown that the perirhinal cortex is recruited in tasks that require discrimination of objects with highly overlapping shape features, including faces (O'Neil, Cate and Kohler, 2009). In fact, Murray & Richmond (2001) have suggested that the perirhinal cortex plays a critical role in object recognition: the knowledge that a particular object is one and the same across the different instances in which it is experienced, and a role in associating objects with other objects and with abstractions (Murray & Richmond, 2001). Overall, it appears that the perirhinal cortex may provide a representation of the conjunctions of features or of gestalt characteristics critical when individual shape features are insufficient for unique object identification (Murray & Bussey, 1999; Cate & Kohler, 2006).

Considering the face processing literature and the way faces are processed it seems that the processes involved in the hippocampus relate more to the processing of the second-order configural properties of faces whereas the processes involved in the perirhinal system match the processes involved in the holistic processing of faces (gestalt representations). The way the hippocampus and the perirhinal system are interconnected is a subject of continuous debate. However, there is evidence to suggest that hippocampal lesions in animals have no apparent effect on tests of object recognition, whereas perirhinal damage is far more disruptive than is hippocampal damage (Buckley, 2005). Therefore it seems that in the case of hippocampal damage there are processes which compensate for it and therefore recognition remains intact (recollective recognition but not familiarity based recognition– Aggleton & Brown, 2006). It is possible that these compensatory processes take place in the perirhinal cortex.

In ASD there is increasing evidence, particularly from the episodic memory literature that suggests that there is impaired hippocampal functioning (Bowler, Gardiner & Grice, 2000; Gardiner, Bowler & Grice, 2003; Bowler, Gardiner, Gaigg, 2007), although it is not yet known whether this results from hippocampal differences *per se* or from abnormal interaction between the hippocampus and other structures. If this is the case, then we would expect impairments in face tasks which require the processing of the visual arrangement of objects. In fact this is what we have found in Experiments 3 and 5. Upright face stimuli in these experiments were processed in a typical way by children with ASD thus showing typical configural processing. However, it is arguable that despite any possible hippocampal impairments, our participants with ASD were able to do the task based on processes in the perirhinal system which mediates holistic representations. That is because as it was mentioned before, in the cases of hippocampal lesions in animals there have been no apparent adverse effects on tests of object recognition (Buckley, 2005). However, when face stimuli were inverted the perirhinal cortex could not compensate for the impaired special ability of the hippocampus to re-configure facial elements, and so our participants' face processing impairments became apparent. In other words, it looks like typically developing children in our experiments are using a kind of processing that allows them to combine and recombine facial elements into different configurations (second-order configural processing), whereas children with ASD are using a kind of 'fused' configuration (holistic processing) where the elements cannot be rearranged into a new configuration. These fused configurations are mediated by the perirhinal cortex and our findings therefore suggest that individuals with autism rely on the perirhinal cortex to compensate for diminished hippocampal functionality.

7.7. Methodological issues, and suggestions for further research

These results should be interpreted in light of some possible methodological issues and limitations. One possible limitation of the current thesis is the restricted sample size. Sample size within research is a long and widely debated subject, also, highlighted within research concerning autism (Jarrold & Brock, 2004). While it is important to include adequate numbers of participants within research so as to allow for statistical comparisons to be made between different groups, difficulties with locating, recruiting and testing certain populations (for example because of distractibility – Siegal, 1996) need to be acknowledged. For these reasons, the typical sample size in autism research ranges between 10 to 20 participants, in each group (e.g. Tantam et al, 1989; Rutherford, et al., 2007; Lahaie et al, 2006; Boucher & Lewis, 1992; Behrmann, et al., 2006; Hobson, et al., 1988). In the current thesis, sample sizes across the five experiments varied between 12 and 20 participants in each group, therefore falling within the norm of sample sizes in autism research. Adding to this, post-hoc power analysis was carried out for each of our experiments which depending on sample size, revealed that our tests' power varied between moderate to high (.50 - .96) (Cohen, 1988).

Secondly, the current research focused on the face processing abilities of high-functioning children with autism. The reasons for selecting this group were based purely on the types of experimental tasks administered, which, in order to complete, required the understanding complex instructions. Adding to this, since our comparison group consisted of typically developing children and our matching criteria were chronological and verbal mental age, our group of children with autism needed to also be of average intelligence. However, the face processing abilities of lower functioning individuals with autism have not been investigated, mainly due to difficulties designing appropriate paradigms, controlling for additional co-morbid disorders often found in lower-functioning groups and also testing these individuals, who are characterised by a tendency to avoid interaction. Therefore, because of these problems it is likely they won't be able to complete or understand fully tests which involve high cognitive demands, such as those involved in face processing. Despite these difficulties, in order to confidently generalise findings, both high as well as lower functioning groups of children with autism should be tested and any differences should be highlighted since this informs us about the nature of the disorder. For example, in the study by Teunisse & de Gelder (2003) differences were found between adolescent participants with autism with high and low social intelligence scores (as measured by WAIS-Picture Arrangement and the Social Interpetation Test) in their face processing strategies.

As far as Experiments 3 and 4 is concerned (the face distinctiveness effect as a measure of holistic processing), there is no theoretical model that could support this work since this aspect of face processing in autism has not been investigated extensively and therefore further studies are needed to establish the current findings. The current paradigm should be tested in younger as well as older children with autism. Also, data from adults would be very informative and together these could give us an account of the developmental nature of the face distinctiveness effect in autism. Adding to this, the distinctiveness effect paradigm should be further tested in the face processing literature and especially in relation to configural and holistic face processing. Further studies that manipulate typical and distinctive faces in configural and holistic ways would be able to inform us even better with regards to the role of specific configural and holistic information in faces. Overall, this thesis provided evidence that the distinctiveness effect is potentially an efficient way to operationally distinguish between configural and holistic face processing.

Similarly, Experiment 5 has introduced a new way of looking into configural processing in relation to the face inversion effect. The notions of local and global configural processing should be further investigated and their role in face processing in general should be established. This will later further inform us about possibly specific difficulties observed in ASD.

An important issue that also needs to be further investigated is what other brain areas might be involved in the processing of faces. As discussed in section 7.5 above, apart from the Fusiform Face Area and its contribution which has received a great deal of attention in the face processing literature, other brain areas (e.g. the perirhinal cortex, O'Neil et al, 2009) may also contribute to face processing and recognition. Specifically, the involvement of the hippocampus and the perirhinal cortex should be further explored in relation to configural and holistic face processing. This will possibly shed light to the much debated issue of configural and holistic processing and the distinction between them. And in turn this will further inform us about the development of face processing skills both in typically developing population as well as in ASD.

Regarding face processing strategies in autism, it is vital that the focus of future studies is around the developmental aspects of face processing in autism with the use of neuropsychological and eye-tracking techniques. Such methods not only greatly inform us about the face processing abilities of individuals with ASD at certain ages but also highlight possible differences between participants' behavioural data and neurological function (for example in the study by Pierce et al (2006) participants with autism were equally accurate and fast in face tasks as the comparison group but did so by utilising different neural systems). In this way we will be able to determine and establish the underlying specific strategies used by individuals with autism.

7.8. Conclusion

On balance the research evidence shows that, faces are a very special class of stimuli for humans. This is demonstrated by both behavioural and neuropsychological studies. In autism, it is very difficult to draw clear conclusions as to what extent faces are treated as special stimuli or not. Most of the evidence to date would suggest that faces are not a special class of stimuli for these individuals. Arguably, the important question here is whether what is considered ‘special’ in typically developing populations, will also be ‘special’ for people with autism. How do we define ‘special’? And is there enough evidence to suggest that individuals with autism do not see anything ‘special’ in faces? Behavioural, neuropsychological and eye-tracking evidence definitely suggest that individuals with autism treat faces differently but the exact way that faces are processed by individuals with autism is not yet established. Studies in the current thesis have provided evidence of intact typical configural and holistic processing of faces in higher-functioning children with autism. At the same time certain atypicalities were observed too. Children with autism showed no preference for the eyes section of a face that is usually observed in a typical comparison group. Children with autism also showed differences in inverted faces, which were processed holistically (a test for distinctive faces), and performed worse when matching faces requiring the processing of global configuration (when the study and test faces were presented in different orientations).

It seems that despite the fact that children with ASD process upright faces typically, when faces are inverted the processing strategies of these children are disrupted in a different way from that observed in those in typically developing children. This gives us a way to understand the apparently intact configural processing seen with upright faces. As highlighted in section 7.5 of this chapter, it seems that children with ASD process faces in a 'fused', holistic way (as opposed to configural processing seen in typically developing children). This however is not an efficient strategy when faces are inverted. Current paradigms in the existing face processing literature have not managed to operationalise holistic and configural face processing separately and this may well be the reason for the contradictory findings regarding the face processing skills of individuals with ASD. In the current thesis, holistic and configural processing have been tested separately and the paradigms used (distinctiveness effect, inversion effect – global/local configural processing) were successful in tapping these two face processing types separately. Future studies should expand in this area so that the exact face processing difficulties observed in ASD are established.

Overall, at a first glance this thesis has provided evidence of typical face processing abilities in ASD. However, a closer look into the holistic and configural face processing reveals atypicalities in the ASD group to the extent that further questions arise as to whether configural and holistic processing operate in the same way as in typical populations or that they are simply compensatory strategies. Evidence for this comes from the way individuals with ASD process inverted faces, which appears to differ from what is seen in typically developing individuals. It is concluded that individuals with ASD show subtle impairments with holistic and configural face processing when paradigms used to test those do not allow for other strategies to take place. It is important therefore, when testing the face processing skills of individuals with ASD, to clearly differentiate between holistic and configural information in faces and tap those separately without allowing any reliance on features or any other compensatory strategy.

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Appendices

APPENDIX 1: Sample of information sheet and consent form

CITY UNIVERSITY
LONDON

The Autism Research Group
Department of Psychology
Northampton Square
London, EC1V 0HB

Dear Parent,

I am a Ph.D student at City University, London, supervised by Professor Dermot Bowler and investigating face processing in children with autism. We now know that children with autism have problems in social understanding. One aspect of this is difficulties in face processing. But we do not know why processing of faces is different and my research aims to change this.

I am writing to ask if you would kindly allow me to work with your child as part of this research. Some of the tasks, which I will use, measure the development of your child. During another task, your child will perform a face recognition task, which will involve showing the child pictures of faces on a computer screen and asking them to indicate whether these are novel or familiar faces. Each child will be seen on his/her own and the testing should take no more than about three or four sessions lasting no more than 20 minutes each. In the past, we have found that children quite enjoy tasks like these and treat them as games.

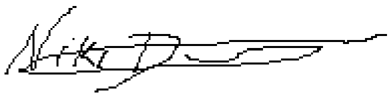
If you would like your child to take part in the study, could you please return the enclosed consent form to the school. If you have any further queries about the project

I would be happy to talk them over with you. My contact details (telephone number & email) are provided below.

I should also add that should you or your child wish to withdraw from the study at any point, you are obviously free to do so without providing reasons. Individual children will not be identified. Individual data are not meaningful and when I describe my findings, I will talk about groups of children only. Finally, feedback of the study will be available upon request.

I greatly appreciate your help in this matter.

Yours sincerely,



Niki Daniel

Autism Research Group

Psychology Department

City University, London

N.Daniel@city.ac.uk

078 6797 3335

Project Title : Face Processing in Children with Autism

Consent form

I agree that my child …………………………………. (full name of child) for whom I am a guardian may take part in the above City University research project. I have read the explanatory statement from Niki Daniel, which I may keep for my records.

I understand that any information………………………………. (full name of child) provides, is confidential and that no information that could lead to the identification of any individual will be disclosed in any reports on the project, or to any other party. No identifiable personal data will be published.

I also understand that……………………..'s (full name of the child) participation is voluntary, that s/he can choose not to participate in any part or all of the project and that s/he or I can withdraw at any stage of the project without being penalised or disadvantaged in any way.

Participant's Name……………………………………………. (print name)

Participant's date of birth…………………….

Parent's/Guardian's Name………………………………………….

Parent's/Guardian's Signature…………………………………………….

APPENDIX 2. Participants' overlap across experiments

ASD Group

Participants	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5
1	X				
2	X				
3	X				
4	X				
5	X				
6	X				
7	X				
8	X				
9	X				
10	X				
11	X				
12	X				
13	X				
14	X				
15	X				
16	X				
17	X				
18	X				
19	X				
20	X				
21		X		X	X
22		X		X	X
23		X		X	X
24		X			X
25		X			X
26		X			
27		X			
28		X			
29		X			
30		X			
31		X			
32		X			
33		X			
34		X			
35		X			
36			X		
37			X		
38			X		
39			X		
40			X		
41			X		
42			X		

43			X		
44			X		
45			X		
46			X		
47			X		
48			X		
49			X		
50			X		
51			X		
52				X	X
53				X	X
54				X	
55				X	
56				X	
57				X	
58				X	
59				X	
60				X	
61					X
62					X
63					X
64					X
65					X

Comparison Group

Participants	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5
1	X				
2	X				
3	X				
4	X				
5	X				
6	X				
7	X				
8	X				
9	X				
10	X				
11	X				
12	X				
13	X				
14	X				
15	X				
16	X				
17	X				
18	X				

19	X				
20	X				
21		X		X	X
22		X		X	X
23		X		X	X
24		X		X	X
25		X		X	X
26		X		X	X
27		X		X	X
28		X		X	X
29		X		X	X
30		X			X
31		X			
32		X			
33		X			
34		X			
35		X			
36			X		
37			X		
38			X		
39			X		
40			X		
41			X		
42			X		
43			X		
44			X		
45			X		
46			X		
47			X		
48			X		
49			X		
50			X		
51			X		
52				X	
53				X	
54				X	
55					X
56					X