

What's in a Face? Exploring Components of Social Perception and Social Cognition in Williams syndrome and Autism

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Abstract

The social profiles seen in Williams syndrome (WS) and autism (ASD) have often been cited as mirror opposites of one another, with hyper-social behaviours seen in Williams syndrome and a disinterest in social engagement evidenced in autism. Studies investigating the social-perceptual abilities of individuals with these neurodevelopmental disorders have found overlapping profiles, with a tendency towards using more featural processing strategies when interpreting information from faces, and deficits in recognising and interpreting the various facial cues that provide social information. It is therefore likely that differences in social approach behaviours in the two groups are driven by a more social-*cognitive* mechanism.

The focus of this thesis was on answering the overarching question: What meaning do faces and socially relevant stimuli have for children with Williams syndrome and autism? Six experiments examined the recognition, attribution, description and understanding of emotions and social cues from faces and socially relevant scenes, amongst WS and ASD individuals relative to their typically developing peers. It was found that the social-perceptual profiles of individuals with the neurodevelopmental disorders were markedly similar, with accuracy for identifying emotions being at non-verbal mental (but not chronological) age level. A tendency towards differences emerged in terms of the *types* of attribution and descriptions that individuals made, with those with ASD focusing more on physical aspects of social and non-social stimuli whilst individuals with WS showed more of an atypicality in the *understanding* of emotions and social contexts.

The lack of any clear differentiation between individuals with ASD and WS in both the social-perceptual and social-cognitive domains is in line with recent research pointing to the extreme heterogeneity seen in these groups. The issue of overlaps and dissociations within such heterogeneous groups provides the theoretical framework for this thesis.

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Introduction

Recognising our friends and family, understanding when they're feeling happy or sad, and knowing how to react to those emotions is something that the majority of us take for granted. Rarely might we question *how* we know: What it is we actually *see* and, perhaps more importantly, *understand* when we look at a face? However, in certain disorders of neuro-development such as Williams syndrome (WS) and the autism spectrum disorders (ASD), the meaning that faces hold and the cues that may be salient appear to be atypical. Therefore the focus of the present thesis is aimed at answering the questions: What atypical meanings do faces have for individuals with these two neuro-developmental disorders, and from where is this meaning derived? In what ways might the very different social behaviours seen in ASD and WS be underpinned by social-perception and/or social-cognition? Finally, how do divides and overlaps in these domains manifest themselves between the two groups, and explain their respective social behaviours?

ASD and WS make particularly interesting points of comparison because of their simultaneously divergent and overlapping profiles. Individuals in both clinical groups appear to be relatively competent at identifying people from faces (Fletcher-Watson, Leekam, Benson, Frank, & Findlay, 2009; Tager-Flusberg, Boshart & Baron-Cohen, 1998) but struggle more in the recognition of emotional expressions (Da Fonseca et al., 2009; García-Villamizar, Rojahn, Zaja, & Jodra, 2010a). However, whilst individuals with ASD appear to be indifferent or nonchalant towards making eye contact and do not actively engage in social interactions (Golarai, Grill-Spector, & Reiss, 2006), those with WS have been labelled as 'hyper-social' (Jones et al., 2000) and tend to seek out social relationships whilst showing prolonged fixations on the face area (Riby & Hancock, 2008). Despite the apparently 'friendly' nature of those with WS, they face the same high levels of social anxiety and difficulties in forming social relationships as do those with ASD (Dodd, Schniering, & Porter, 2009; Dykens, 2003). Therefore the pivotal question of the present PhD research is on *why* the profiles manifest so differently in the social communication domain? What underlying mechanisms may be responsible for this divergence?

The research field of 'face processing' is an incredibly large one, riddled with mixed terminologies, methodologies and conclusions. However, with the development of neurological models has come a clearer framework for understanding how all the different aspects of face processing (from features to spatial relations, taking into account gaze cues and the role of specific emotions) might fit together. This, in turn, allows us to consider where the *dissociations* and *overlaps* within models of face processing might exist in terms of reading the emotional significance of faces, which in turn may inform us of where the fundamental differences might lie in neurodevelopmental groups. Further, the dissociations we need to explore may not only be at the perceptual level but more in terms of the *conceptual* understanding that those with ASD and WS have of faces. The question will therefore be posed here of whether

the deficits found in disorders such as WS and ASD are a product of problems with social *perception* (such as an ability to analyse expressions from faces) or more of a struggle with social *cognition* (such as the ability to actively think about the meaning behind the expression). This issue of what interactions take place, how one component is modulated by another, and where there are dissociations and overlaps is an important area to explore given the heterogeneity seen in these disorders; exploration of the possible divides and overlaps in these areas may shed more light on the core difficulties of individuals with disorders such as WS and ASD.

The following two chapters will provide a summary of the face processing literature in typical development, followed by an examination of the social, cognitive, and behavioural profiles of those with ASD and WS. Chapter 1 will provide a broad overview of the face research literature, with a focus on the *development* of face processing; this emphasis on the role of age and experience in face processing is an essential one when considering whether the difficulties seen in WS and ASD are driven by delay or deficit. Literature on the terminologies, paradigms and models of face processing will first be given, with an overview of both neurological and behavioural evidence.

Chapter 2 will provide an overview of the models and theories of WS and ASD as well as a broad summary of the neurological and behavioural profiles observed in these neuro-developmental disorders in the social and cognitive domains. It will ultimately be argued that, rather than looking to separate components of the face processing system to explain the social difficulties seen in WS and ASD, we should be asking questions about the links and gaps between percepts and concepts and how these underlie, both neurologically and behaviourally, the social cognitive deficits that may be at the core of the divergent phenomenologies of ASD and WS.

Chapter 1: Face Processing in Typical Development

1.1 Fields, terminologies and paradigms

Adult humans have a seemingly expert ability in glancing at a face and immediately knowing whether it's familiar or not and, if it is, who that face belongs to: Their name, how we know them, how they're feeling, etc. But what enables us to do this and at what age does this ability become expert? The face research literature is somewhat mixed in its dissection of the different aspects involved in face processing, and the different types of processing that occur. It is therefore important to elucidate precisely what is meant by each of the key fields, terms and paradigms employed within this literature.

1.1.1 Fields of research

Neurological research has shown that there is something unique about the face that triggers specialised patterns of neural activation in localised areas of the brain (Tong, Nakayama, Moscovitch, Weinrib, & Kanwisher, 2000). The debate in the literature has therefore not been *whether* faces are processed in a specific way neurologically, but *how* they are processed. There are, for example, different levels at which a face can be acknowledged: Simply, if it is familiar or not; what identity it possesses; the role of eye gaze, and what emotional affect is displayed. Evidence of neuropsychological dissociations has been observed from brain imaging investigations between neurodevelopmental groups and typically developing individuals. Different models of face processing (See section 1.4) have typically attempted to pull apart the ways in which one aspect of face processing depends on or is influenced by other components.

Spangler, Schwarzer, Korell, and Maier-Karius, (2010) have used behavioural studies to show, for example, that children and adults alike struggle to ignore facial identity when asked to categorise faces by emotional expression, but are able to selectively focus on identity whilst ignoring expressions. Further, gaze direction in no way interfered with the sorting of facial identity, suggesting complex relationships and dissociations between these components. Gaze has, however, been shown to modulate the recognition of emotional facial expressions (Itier & Batty, 2009), and this relationship appears to be reciprocal; in a study by Lobmaier, Tiddeman, and Perrett (2008), adults were found to be likely to state that happy faces depicted direct gaze, compared to more negative expressions.

The interplay between gaze direction, emotion and identity is an interesting area of research that may lend itself to a better understanding of where possible deficits in neural connectivity might exist in neuro-developmental groups. However, for the purposes of the present PhD study, the emphasis was on the recognition, interpretation and understanding of *emotions* from faces and non-social stimuli. The rationale for an emphasis on the emotional content of faces was that this is the area that causes the most

difficulties in individuals with ASD and WS (Falkmer, Bjällmark, Larsson, & Falkmer, 2011; Järvinen-Pasley, Adolphs, et al., 2010; Rump, Giovannelli, Minshew, & Strauss, 2009), possibly governing the different social approach behaviours in these neuro-developmental groups (Jawaid et al., 2010).

1.1.2 Terminologies

Within the face processing literature, certain terminologies are typically used interchangeably with synonymous meanings. Similarly, certain paradigms designed to tap into these processes may be somewhat confused as to precisely which mechanisms they are cited as being evidence of.

‘Holistic’ processing is a term typically used to refer to the gestalt processing of a face: Rather than decomposing a face into any respective relations between features, holistic processing operates by taking the face as a *whole* (Tanaka & Farah, 1995). The term ‘configural processing’ is concerned with the *organisation* of facial features and has been broken down in various studies into two levels: 1st order configuration is the simple location of features in relation to one another; the mouth lies below the nose and the eyes are positioned above the mouth and nose. Detection of such first order configurations tells us little about the identity of a person but enables us to acknowledge that a face *is* a face, as evidenced by early ERP activity in the Fusiform Face Area [FFA] (Maurer, Grand, & Mondloch, 2002a). That 1st order relations are involved in the recognition of a face as a face rather than any *identification* of that face is generally agreed upon.

It is the role of 2nd order relations that have caused much debate. These are defined as the spatial relations between features: How far apart the eyes are, the distance between the tip of the nose and upper lip, etc. (Maurer et al., 2002a). These cues may play a role in both identification of a face (differences in these subtle relations are one of the differentiating factors in telling one face from another) but also reading facial *expressions*: It is the change in these relations that denotes an upturned mouth as being a smile, or furrowed eyes as making a frown. It is worth noting that ‘configural’ and ‘holistic’ tend to be terms that are used interchangeably in the literature, therefore some studies claiming the presence of face processing using one specific term might actually be referring to the same processes referred to using another term by a different research group. The experiments comprising this PhD research will use the term holistic processing, to mean the piecing together of parts into a whole. None of the experiments cited here manipulated any spatial relations between features therefore any examination of ‘configural processing’ per se was not empirically tested.

Another term frequently used in the literature is ‘featural processing’, which refers to the use of individual features in order to identify a face. Some researchers (Gilad, Meng, & Sinha, 2008) have argued that it is the features themselves that are important when identifying a face, in terms of what each feature looks like (shape, colour, size, etc.) whereas others have argued that features are only important in that they provide

reference ‘landmarks’ for the processing of relations between features (McKone & Yovel, 2009). It has been argued by a number of researchers (Annaz, Karmiloff-Smith, Johnson, & Thomas, 2009; Golarai et al., 2006; Happé, 1999) that those with ASD and WS use a more featural style of processing when identifying faces, and this may be indicative of a developmental delay. For example, Mondloch, Grand and Maurer, (2002) have shown that configural processing develops more slowly than featural processing in children; much debate exists across studies, however, as to precisely at what age configural processing becomes the dominant method, being fully developed. Studies examining this issue are discussed in this chapter.

McKone and Yovel (2009) have, in their review of 17 inversion and 5 part-whole paradigm studies of face processing in the adult typically developing (TD) population (see section below on ‘paradigms’ for a summary of these methods) argued that the features of a face are not as unimportant as recent literature has claimed. In this stringent review of the literature, McKone and Yovel, (2009) concluded that whilst the inversion effect (defined in section 1.1.3) is clearly robust across studies, so is the observation that changes in the *shape* of a feature disrupt the recognition of faces. Specifically they found that, in 5 of the 17 inversion studies, an inversion effect as great as that seen for disruption of spatial relations was found when a *feature* was changed, and that only 35% of the 22 studies found no effect of feature at all. In a more detailed analysis, they concluded that changing feature *colour*, especially in extreme forms, removed any inversion effects whereas *shape* changes did have a significant impact on face recognition. This finding does not necessarily refute the idea that the identity of a face is assessed based on spatial relations but instead suggests a more encompassing holistic view in that the features themselves may dictate where the ‘landmark’ reference points are. Indeed, McKone and Yovel (2009) suggest a model in which many different aspects of the face are classed as features, from which reference points can be formed so that a richer variety of spatial relations are encoded. They go on to suggest that it may also sometimes not be beneficial to encode all of this spatial information and that, sometimes, such as in the case of an extreme colour change, features themselves may be sufficient as a point of recognition.

Neurological evidence for the importance of features in face processing comes from Mercure, Dick and Johnson, (2008) who have found that early ERP activity occurred in response to features, with brain responses to configural information occurring later at N170 (consistently found to be an electrophysiological response to faces, and especially the eyes). They therefore suggest that the processing of features operates as an initial point of identification and then more complex processing of configural information follows; differentiating that something *is* a face and *what* face it is. This offers strong neurological support for McKone and Yovel’s (2009) model in that specific facial features may act as ‘landmark’ reference points for then processing the more spatially related changes. Which features are crucial in encoding faces, what aspects of those features play a key role and to what extent the spatial relations between these features matter, is very much still a topic of debate.

1.1.3 Paradigms

Because of the motivation to pinpoint precisely which processing styles play the critical role in face identification, studies have employed differing paradigms in an effort to isolate and explore the exact processes involved. The **inversion** paradigm has long been cited as evidence for configural processing: When a face is turned upside down, the spatial organisation of features becomes disrupted, and performance for identification drops disproportionately compared to the effect of inverting a non-face object. The premise of the face inversion effect is therefore that disruption of configurations affects accuracy for recognising that face, indicating that configural information must be important (Leder & Bruce, 2000). By systematically manipulating spatial relations and features separately when inverting a face, it is therefore possible to establish which information is sensitive to the inversion effect (Leder & Bruce, 2000). One issue with the inversion paradigm is that, as Maurer, Grand, & Mondloch, (2002b) highlight, it is not clear as to whether 1st or 2nd order configurations are being disrupted. For example, inverting an image of a face so that the mouth appears above the eyes may make the *distances* between features appear differently. On a similar note, in experiments where the features are manipulated (a different set of eyes may be inserted, for example), one might argue that in altering the shape/size of a feature, the spatial relations between this and neighbouring features may also be changed by default. Therefore it is very difficult to pull apart these subtle aspects.

Two other paradigms that have been claimed (Tanaka & Farah, 1993) to tap into evidence of *holistic* rather than featural processing are the **composite** paradigm and the **part-whole** paradigm. Originally devised by Young, Hellawell and Hay (1987), the former method makes use of the alignment of face parts in order to establish whether participants are able to ignore irrelevant information in a face or if holistic processing dominates. The identities of two faces (one top half with one bottom half, typically split through the bridge of the nose) are merged together (See Figure 1.1), either in perfect alignment to form a new face, or with one half offset so that the divide is made explicit. The hypothesis is that, if holistic processing occurs, aligned faces will be much harder to identify from either top or bottom parts because of interference from the rest of the face. This has been consistently found to be the case (Calder, Young, Keane, & Dean, 2000; Durand, Gallay, Seigneiric, Robichon, & Baudouin, 2007). This paradigm has also been used in various studies of *expression* recognition as an argument for holistic processing in this domain as well (Calder et al., 2000a; Durand et al., 2007). However, it should be noted that this paradigm, whilst it can offer support for a holistic view, cannot refute the configural view because spatial relations are still disrupted when two different face parts are merged.

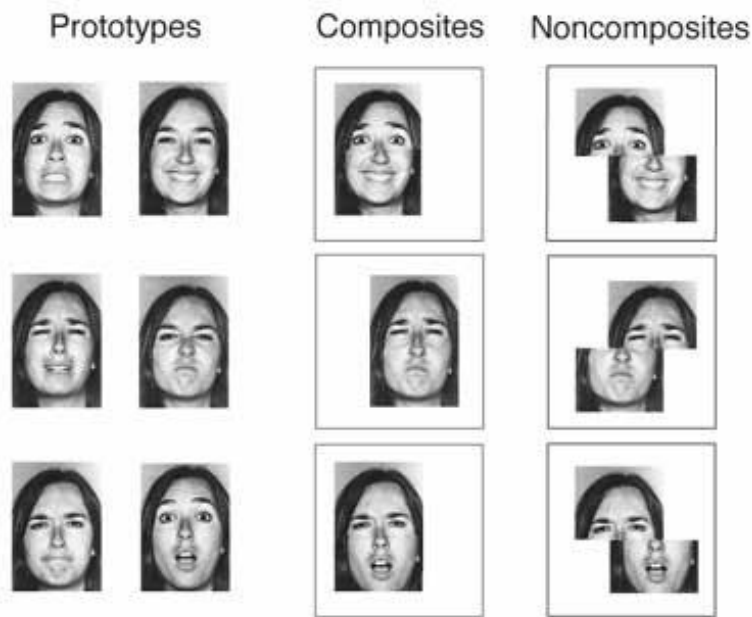


Figure 1.1: Examples of composite faces (Calder et al. 2000a)

The part-whole paradigm, introduced by Tanaka and Farah (1993) is perhaps a more robust test designed to systematically manipulate the presence of features versus configurations in the encoding of faces. Participants are typically presented with an image of a whole face, which they are asked to learn. They are then asked to identify a specific feature of that face (usually the eyes or mouth) when presented either in isolation, in the same whole face configuration, or in a novel configuration. Tanaka and Farah (1993) argue that if holistic processing occurs, it should be the case that identification of isolated features is most difficult, as a gestalt type of face processing requires full face information due to the individual features only being encoded as part of the whole.

In a study using the part-whole paradigm, Tanaka and Sengco (1997) found, as hypothesised, that performance was poorest for isolated features, followed by features presented in new configurations, with the identification of the original configurations showing the most accurate performance. Tanaka and Sengco (1997) posit this as evidence for holistic processing as it shows that whole-face information is most beneficial for the identification of features. This forms a strong argument against the possibility that features may be encoded separately in face processing. However, one may question this interpretation in that, if processing is not at all featural, participants should not be able to identify a face from a feature alone at all. Tanaka and Sengco (1997) also found that original configurations were best recognised in upright faces in an inversion paradigm version of the same task, with no differences between the original or new configurations in the inverted condition, suggesting a lack of sensitivity to configural information when faces are inverted. The same effects were found for non-face (house) images. It is worth noting that when spatial relations are disrupted in neutral faces (as were used in Tanaka and Sengco's study), it is more disturbing as there is no context, whereas we might expect changes in spatial relations between features

that denote a smile or a frown. This could partially explain the detrimental effect of disrupting configurations in this study and it is also worth considering that this might be part of the problem in clinical groups: Do individuals with neuro-developmental disorders struggle to recognise emotions in others because they have no *conceptual* understanding of why spatial relations between facial cues should change?

It is clear that there may be overlap in the methodologies used to pull apart holistic and configural processing, with spatial relations being so difficult to isolate without implicating the appearance of features (or vice versa) that a ‘pure’ measure of one or the other may not be possible. Perhaps use of these terms therefore becomes somewhat academic, if changes to one are so entwined with changes in the other? McKone and Yovel (2009) have highlighted the fact that ‘spatial relations’ in itself is a somewhat unhelpful term in that the particular relations that most studies have explored are somewhat ambiguous, focusing on interocular distances and nose-mouth relations simply because these are the most prominent facial features, and disregarding other possible spatial combinations. For the purposes of the present set of experiments, no manipulations of spatial relations were made; attention to individual features was examined through an analysis of the *types* of descriptive information that participants gave. The focus of this research was therefore not on what types of processing were employed but what *information* from faces participants utilised the most.

1.2 Face Processing in Typical Development

One of the big questions when examining areas of difficulty in neurodevelopmental groups is how their profiles compare to typical children of the same chronological and mental age: Is there evidence of a fundamental deficit or more of a delay? In order to answer this question, it is important to establish what ‘typical’ development within a certain domain looks like. This section will therefore offer a summary of literature examining the *development* of face processing throughout childhood.

As will be discussed in more detail in Chapter 4, there is a great deal of debate in the face processing field as to exactly what age the ability to use competent configural processing is achieved. McKone, Crookes and Kanwisher (2008) have suggested that, from age 4 onwards, the *qualitative* aspects of face processing may not change, with children from this age onwards showing evidence of configural processing across a wide range of studies; however, the *quantitative* aspects might continue to develop, with improvements in accuracy for identifying faces and speed of response seen linearly with age. Specifically, in their review of the literature, McKone et al. (2008) note that no single study has found a type of processing seen in adults that cannot be evidenced in infants as young as 4 years. This may suggest that, at 4, typically developing infants do utilise a configural processing strategy when presented with an image of a face. However, Mondloch et al., (2002) have concluded from their study of featural versus spacing changes that there *is* a developmental trend in the types of processing that are evident throughout childhood.

Mondloch et al. (2002) tested adults and children aged 6, 8 and 10 years (36 participants in each group) on a same/different judgement task. Participants were presented with images of faces in which either the shapes of the eyes/mouth were changed, the spacing between the eyes and mouth were changed, or the shape of the external contour was altered. Examining accuracy for whether or not participants could deduce if two faces differed therefore allowed Mondloch et al. (2002) to establish at what ages children would be able to detect the different types of changes. Whilst adults were not at 100% accuracy on any of the trials, a significant difference was found between the performance of adults and children of all ages when detecting *spacing* changes. The largest inversion effects were also seen for adults. 10 year olds were as accurate as adults at detecting feature changes, and those aged 6 and above were as accurate for detecting changes in the external contours. Taken together, these findings paint a picture of development occurring across age as to the *types* of facial information that children are sensitive to: Children as young as 6 can make use of broad, external contours, whereas 10 year olds are more sensitive to changes in specific features. Sensitivity to more subtle spacing changes perhaps occurs later and, based on the findings of Mondloch et al. (2002) is not at 100% accuracy even in adulthood.

Further support that configural processing is not developed early on in childhood is offered by Mondloch and Thomson (2008); they designed three tasks in which the spacing features of faces were manipulated and children were asked to match identities, rate distinctiveness, or recognise a previously shown face. Eighteen children aged 4 years to 4 years 9 months took part. It was found that the children performed only at chance level or below on all of the tasks, with the exception of the matching task. On this, eight of the 18 children still performed at chance level. Mondloch and Thomson (2008) claim this as evidence that infants aged 4 are *not* sensitive to spacing changes. Unfortunately, no other types of change were manipulated in this study, and it would have been useful to have further examined the possible manipulations that children at this age might be sensitive to. Similarly, it could be the case, as McKone et al. (2008) have noted, that other more general cognitive domains might be underpinning some of the patterns of performance seen in children this age. If attention or memory is poor, that and not necessarily difficulties in detecting spacing changes might still result in performance at chance level. The only way to establish the specificity of the underlying mechanisms would be to manipulate a variety of different types of change.

McKone and Boyer (2006) have examined sensitivity to spacing changes in young children. In their experiment, 20 adults and 20 four year old infants were asked to “choose the most distinctive face” from face pairs. These faces had been manipulated in terms of the appearance of features (such as bushier eyebrows) or in the spacing of features (such as eyes closer together). McKone and Boyer (2006) found that 4 year olds’ choices about which faces were the most distinctive were overall in line with those of adults, and they appeared to be sensitive to both feature and spacing changes. McKone and Boyer (2006) therefore cite this as evidence for a sensitivity to spatial relations that governs judgements about the face in children as young as four years.

The fact that general *accuracy* in McKone and Boyer's (2006) study was not at adult-level amongst the four year olds on either the feature or spacing change conditions may be indicative of a relationship between a more general cognitive domain (such as attention or memory) that may improve with age. McKone and Boyer (2006) argue the case that this, and not under-developed sensitivity to configural information, might underpin differences between children and adults, supported by the fact that overall ratings of distinctiveness correlated significantly with those given by adults and performance was always above chance level, despite the difficulty of the task. However, it is worth considering that *any* changes might make a face appear more novel, and this could perhaps be confounded with 'distinctiveness' per se. How well the results of a study such as McKone and Boyer's (2006) might then generalise to the processes underpinning broader facial *identification* might then be debated.

Going against the argument that the configural processing of faces is something that develops gradually throughout infancy and even into adulthood, Schwarzer and Zauner (2003) have shown that babies as young as 8 months old appear to be able to detect spacing changes in faces. Using a classic habituation paradigm in which babies' (n=97) looking times to two faces were recorded, they then showed the babies either the same habituation face, a completely novel face, or a face in which only the features (and not spatial relations) were changed. There were two conditions in this experiment: Real faces and schematic faces. Interestingly, Schwarzer and Zauner (2003) found that there was an interaction between the type of face presented and the type of change detected (assessed by longer looking times to the changed item). Infants had longer looking times towards the real faces when *spatial* relations were manipulated, compared to longer looking times towards schematic faces in which *features* were altered. Given that the real faces were colour photographs, this may be evidence for the fact that only *real* faces facilitate configural processing; any other type of image is treated as separate featural parts. However, this would go against the findings of Johnson, Dziurawiec, Ellis, and Morton (1991) and their observation that babies will attend to and detect changes in anything with the overall configuration of a face. This issue of the interplay between processing style and image type is one that will be discussed further in Chapter 4.

Following on from Schwarzer and Zauner (2003), Zieber et al. (2013) used a familiarisation looking paradigm, in which 9 month old infants (different groups recruited to three different experiments) were familiarised to a face until they attended to it for 30 seconds; preferences to new faces were then recorded. In two experiments, spacing changes were manipulated on human faces and monkey faces in both upright and inverted conditions. A third experiment presented infants with images of houses matched to the spatial relations and configurations seen in the real faces.

Zieber et al's. (2013) results showed that infants showed preferential looking to both human and monkey faces in the upright conditions but not when inverted. Infants did not show any evidence of detection of spacing changes in the house stimuli. Zieber et al. (2013) conclude that their findings suggest that infants as young as 9 months process configural information, both detecting spacing changes and showing inversion effects,

but this is not finely tuned to be specific to *human* faces, (although is specific to faces and not objects). It is worth noting, however, that monkey and human faces are configurally very similar, therefore it is perhaps not surprising that infants are not sensitive to different types of information from two such similar stimuli. That infants *are* able to detect spacing changes in monkey faces, to which they may have had very little exposure, does point to the possibility that experience is not a requirement for configural processing to develop. On the other hand, it is possible that infants may simply use a blanket strategy when presented with any faces (but not objects). This is an important consideration when examining neurodevelopmental groups.

One theory of face processing which takes experience into account is that of Valentine (1991), who devised a prototype theory of face perception. In his model, an ‘average’ face exists as a prototype and every time a new face is encountered, the prototype is altered accordingly. The more experience with faces one has, the more refined the prototype becomes so that making discriminations between judgements on the identity of race, gender, etc. becomes more effortless with experience. The classic paradigm designed to test for evidence of this involves familiarising participants with faces that vary in elements of features. For example, presenting face stimuli in which the nose/eyes/mouth might have 4 different widths, each manipulated in turn. During the test phase, participants are then shown a previously unseen prototype face (consisting of the average of all the manipulated features), or a face with familiar features, and are asked to choose which one they have seen previously. The logic is that, if we process faces according to a prototype, we will think that we have seen the prototype face before because we have already made a representation of that face ourselves. If this is not the case, then we will simply recognise the previously presented features.

The above research points to the fact that findings are incredibly mixed as to at what age infants are able to detect, and appear to use, spatial and configural changes/cues. One reason for such heterogeneity across different studies may be the types of manipulations that are being made. Baudouin, Gallay, Durand, and Robichon (2010) wanted to examine precisely at what point spacing changes become detectable by children of different ages. In their experiment, between 25 and 28 children were recruited into three different age-groups (8, 10 and 12 years) and compared to 28 adults on a task where participants were asked to state whether the eyes of two faces were the same distance apart or not. Faces were presented in both upright and inverted conditions and inter-ocular distances were manipulated in order to establish at what point changes would be detected in the different age-groups.

The results showed that the spacing needed to detect changes fell in each age-group, from 20 pixels in the youngest children to only 8 pixels in the adult group. Only in adults were there any significant differences in accuracy between upright and inverted faces, indicative of less configural processing in children, teamed with poorer ability to detect more subtle spacing changes. Of most interest was the fact that those individuals who were most sensitive to spacing changes also showed the greatest inversion effects; Baudoin et al. (2010) cite this as evidence of the fact that configural processing governs sensitivity to spatial relations. Whilst the clear linear trend with age in this study points

to a steady ‘fine-tuning’ of configural processing through childhood, it is possible that the results were driven by other cognitive mechanisms, such as improvements in attention. As the only manipulations made were for inter-ocular distances, it is also not possible to deduce whether the same fine-tuning would be seen for other spatial relations. These findings do, however, highlight the importance of considering precisely which manipulations are made in paradigms concerned with examining configural processing.

The literature on the typical development of face processing offers no ultimate consensus as to when configural processing develops. That the detection of spatial changes becomes more fine-tuned with age (both in terms of how subtle the changes can be and in how specific to human faces they are) seems generally accepted, but to what extent featural processing might give way to configural processing, and at what age, is yet to be concluded. It is therefore important to bear this heterogeneity across *typical* development in mind when using typical benchmarks as a comparison for neurodevelopmental groups.

1.3 Recognising Emotions

Research into the processing of emotional expressions from the face is a much murkier field than that of the processing of facial *identity*, in that even defining what constitutes a ‘happy’ or ‘sad’ face has been endlessly debated; even when the six basic emotions (Happy/Sad/Angry/Fearful/Disgusted/Surprised [Ekman & Oster, 1979]) have been clearly defined in terms of very specific muscular configurations. There is a wealth of research (Farran, Branson, & King, 2011) claiming that positive or negative emotions may be processed in different ways, using different cues, depending on different stimuli. The specificity of emotions will be discussed in detail in Chapter 5. The next section will briefly summarise some of the literature focussing on *emotion* recognition in typical adults, again returning to the issue of whether holistic, configural or featural processing seems to be dominant.

The debate as to whether processing of expressions occurs holistically, configurally or featurally is equally active in this field, with Tanaka and Farah (1993) being proponents of the holistic view. Intuitively, it seems unlikely that features alone can determine the recognition of facial expressions: Bob’s eyes may squint when he is angry and be wide open if he’s surprised or scared but they will not change colour or size therefore it must be these subtle *spatial* changes that differentiate between the emotions. Further, it is logical to state that these spatial changes may not always be enough: The fact that wide open eyes could be scared or surprised (or delighted or excited or any number of other emotions) means that some other cues must come into play, such as the mouth. This would then mean that a more holistic appraisal of the entire face is required: What *shape* do the eyes and mouth form in conjunction with one another? This points to the fact that perhaps different emotions might be processed in different ways, depending on what cues are available.

Calder et al. (2000a) set out to explore this very question of what type of processing seems to dominate in the recognition of facial emotions, as well as revisiting the issue of how dissociable identity and expression recognition are. They designed four experiments to test these issues. Using the composite paradigm across all four tasks, they varied the stimuli to tap into the different processes: A classic composite paradigm with facial expressions depicting the six basic emotions (Experiment 1); an inversion task using the same stimuli (Experiment 2); a composite paradigm in which identities but not expressions (both face halves depicted the same expression but comprised of two different identities) were incongruent (Experiment 3) and, finally, manipulation of both expression and identities separately (Experiment 4), as well as a condition in which face halves depicted both a different identity and different expression from one another (always presented in alignment). Calder et al.'s (2000a) hypotheses were that, if facial expressions are processed configurally, the typical composite effect would be found in that reaction times and accuracy to misaligned faces would be faster than those presented in alignment; further, this difference was expected to disappear in inverted faces. Experiments 3 and 4 were designed to dissect whether facial identity and expression are processed separately: If emotional expressions are processed configurally, there should not be any differences between aligned and misaligned faces depicting the same emotion but different identities, as the configurations of each *emotion* should be consistent. Experiment 4, and the manipulation of *both* identity and expression (separately as well as at the same time, under 3 different conditions), was designed to examine precisely which processes are used for both and how interconnected they might be.

Calder et al. (2000a) hypothesised that reaction times would be fastest for *congruent* conditions; therefore, when participants were asked to name the *identities* of faces, this would be fastest when the top and bottom half were the same identity, regardless of incongruence in expression, and vice versa for expression recognition. In other words, the incongruence of the attended to dimension would produce slower reaction times, if identity and expression are processed separately. As a further control to explore whether the same types of processes were at play, reaction times to the bottom halves of faces with incongruent identities *and* expressions were compared to those that had been manipulated separately; it was predicted that, if the same underlying processes were involved, reaction times on these measures would be comparable.

As Calder et al. (2000a) expected, the aligned faces were harder to identify in experiment 1, with slower reaction times and poorer accuracy, suggesting that holistic processing might take place. Interestingly, they found that, when participants were asked to identify emotions from the *bottom* halves of faces, they were faster and more accurate at this overall, suggesting that mouth cues might be the most helpful in emotion recognition. By introducing the inversion task, Calder et al. (2000a) were able to tease apart configural and holistic processing: Whilst the aligned composites were more difficult to recognise overall, an interaction was found whereby there were no longer differences between aligned and misaligned faces in the inverted condition, as predicted. This shows how configural relations are being encoded and, in disrupting these, the classic composite effect disappears. In experiment 3, as predicted, a

composite effect (better performance for misaligned faces) was not found, which Calder et al. (2000a) claimed to be due to the lack of any disruption of configurations between features due to the consistency of the emotional expressions on an emotion judgement task. Experiment 4 also revealed the expected pattern of results: When the face half in which participants were asked to make the judgement on was congruent with the other half (same identities when asked to name the identity, for example), reaction times were found to be faster. Reaction times for identity judgements made when both dimensions were incongruent were comparable to those made when identities were incongruent; the same pattern was seen for expressions, as predicted.

Ultimately, the work of Calder et al. (2000a) shows that we are able to selectively attend to identity or expression when asked to focus on one or the other, and that interference of configural relations does affect the processing of *both* these dimensions. Specifically *which* configural relations are used in the encoding of identity versus expressions is still under debate but their findings do offer strong evidence for the dissociability of expression and identity processing.

Durand et al. (2007) have entered into this debate with their cross-sectional study of development in processing of facial emotions. They make the point that very little has been done to explore developmental change in expression recognition, therefore their design focused on children split into 4 age groups, from 5-12 years (between 24 and 26 children aged 5-6; 7-8; 9-10, and 11-12), as well as an adult group (mean age 22 years, 5 months). Durand et al. (2007) make the claim that the inversion and composite paradigms allow for an examination of what types of changes children may be sensitive to: Is performance affected by disruptions to configural information, as seen when inverting a face, or might more holistic information be used, evidenced by a detriment of alignment on performance in the composite task?

Participants were presented with faces depicting happiness, sadness, anger, disgust and fear, as well as a neutral state in classic inversion and composite paradigms.

Performance was assessed using a method employing signal detection theory, in which discriminability ratings were calculated in order to factor out false alarms in which participants might default to a specific emotion in cases of uncertainty. This is an important point to note in that it means that poorer performance is indicative of difficulty on *certainty* when given a choice, rather than lower ability in *recognising* emotions.

On the inversion task, all emotions and all age groups demonstrated the classic inversion effect, suggesting that configural relations are encoded, even in the youngest groups. This is in line with work by McKone and Boyer (2006), and Ziedler et al. (2013), who have shown that children, and even infants as young as 9 months, are sensitive to spacing changes when processing the identities of faces. In terms of specific emotions, identification of happy and sad showed improvements with age but not to such a great extent that there were significant differences between the age groups overall. Interestingly, the youngest group were poorer at identifying fear, anger and disgust. Baron-Cohen, Wheelwright, Hill, Raste and Plumb (2001) have suggested that recognising more complex emotions requiring more of a 'theory of mind' is something

that develops with age and experience, therefore these findings are in line with this assertion. No interaction was found between emotion type and inversion, suggesting the same strategies employed across all emotions.

In the composite paradigm, all groups performed best for misaligned faces, and this effect disappeared when the stimuli were inverted. Overall, the youngest group were significantly poorer than all other groups on emotion recognition, and differences in performance were also found between those aged 7-8 and 9-10 and those aged 11-12, as well as adults. However, children aged 7-8 were not any less accurate than those aged 9-10; this might be suggestive of a peak and plateau between 7-10 years with further development (perhaps based on more social knowledge) later on.

Durand et al.'s (2007) research is interesting in that it highlights that children as young as 5 do use configural information when processing facial affect (as evidenced by inversion and composite effects) and yet they are less accurate at *identifying* those emotions. This might then suggest that something else is at play beyond configural information. It must be reiterated, however, that the use of discriminability ratings does not suggest that younger children cannot identify emotions per se, but that they find *differentiating* between certain emotions more difficult. These issues of emotion specificity will be addressed in Chapter 5. It is also worth noting that no correlations in performance were found between the two tasks in Durand et al.'s (2007) study, which they suggest may be indicative of different underlying processes facilitated by the two paradigms.

One interesting study to hint that certain emotions are differentially processed even into adulthood is that of Calder et al. (2003). Their participants were split into five age groups ranging from 20 to 75 years, tested on an emotion labelling task and a face morph task. On the face morph task, participants were asked to make judgements as to which of the six basic emotions (happy, sad, anger, fear, surprise and disgust) a face resembled (morphed from two different expressions). The results showed that there was a linear decrease in the recognition of fear from age 40 onwards. This contrasted with *improvements* in the recognition of disgust, with there being a clear significant difference between those aged 20 and 70 years. Recognition of happy remained stable across all age groups, with no significant differences at any stage, consistently demonstrating the best performance.

Because Calder et al.'s (2003) study only required participants to *label* emotions, little can be concluded as to whether or not different emotions might be processed in different ways. However, neurological research (Adolphs & Tranel, 2003) has implicated the amygdala in the detection of fear, whereas the basal ganglia are reputed to be concerned with disgust responses. Could it therefore be that the responsiveness of the amygdala deteriorates with age? It is perhaps unlikely that disgust responses would neurologically *improve* with age, however, so there may need to be a more social explanation for this. Calder et al. (2003) do note that older people are less likely to express negative emotions themselves, so it could be that this offers a partial explanation for why they may also recognise them less, especially if theories (Haxby, Hoffman, & Gobbini, 2000) regarding the role of mirror neurons and the somatosensory system prove to be

true (discussed in section 1.4). Such questions translate well into the clinical field: Might there be a link, even in neurological terms, between the *expression* of emotion and the *recognition* of expressions in others? The possible link between neurology and experience in the recognition of emotions is a very important one to consider, especially when thinking about neurodevelopmental groups who have atypical exposure to social interactions.

The literature reviewed thus far enables one to draw several conclusions: The processing of spatial relations between features probably underlies both recognition of facial identity as well as facial expressions in typical adults, and may well be developed as early as 4 years of age. Precisely *which* configural relations are used, and their role in a more holistic use of facial information across different ages and at different time points in development, is still debated; it may be that divides in this area are the basis of dissociability between identity and expression processing. Whether or not these two domains *are* dissociable is also a topic of ongoing debate, with mixed behavioural and neurological findings. In the field of expression identity, it may also be the case that different emotions are processed in different ways, utilising different cues, and this may be something that further improves or deteriorates with age. The role that experience plays in this may be critical, especially in neurodevelopmental groups. Such a mixed backdrop in the literature pertaining to typical development makes teasing apart trends within the clinical literature even more difficult. The following section outlines *models* of face processing which frame the issue of how interconnected or dissociable the processing of emotion and identity are.

1.4 Models of Face Processing

As outlined above, face processing involves attention to and encoding of the parts that make up a face to deduce identity, the possible expressions depicted on that face, and the interplay of and modulation on eye gaze direction in both of these dimensions. Debate is ongoing as to precisely to what extent the processing of identity and expression *can* be pulled apart. Models of face processing have typically attempted to postulate the possible ways in which these different dimensions fit together or separate out, supported in recent years by a wealth of neurological research. This section outlines the key models, framing the debate as to how dissociable or interconnected facial identity and emotion processing might be.

The Bruce and Young (1986) model of face processing was the first to formally outline that different routes are used to deduce facial identity and emotion. Claiming an overall dissociation between the processes involved in identifying a face and recognising the expression of a face, they proposed that face processing occurs via structural nodes, some of which interconnect and others which work in isolation. The early processing of a face as being a face is shared by both routes, and more complex attributions (such as the contextual familiarity of the face) may also involve some interplay between the routes at a later stage of the cognitive process, with separate processes operating in between these points.

The Bruce and Young (1986) model proposed a system of weighted nodes in which the recognition of familiar versus unfamiliar faces depends upon different types of 'structural codes'. An unfamiliar face must be processed using 'directed visual processing' (Bruce and Young, 1986) that structurally encodes key defining features, whereas a familiar face can be identified through a variety of visual and/or semantic routes. 'Expression codes' (Bruce and Young, 1986) operate as distinct units so that, regardless of the expression on a person's face and the corresponding configural changes that accompany it, we are still able to recognise Bob as Bob. However, *identifying* a face may involve a variety of interconnected nodes, such as the visual aspects (features and/or configurations) as well as the retrieval of more semantic information, such as where we know Bob from or what Bob looks like when he's angry. This model of face processing has stood the test of time and it is still generally accepted that there are at least *aspects* of identity and expression processing that must operate along different routes, recently supported by neurological research.

The Haxby et al. (2000) model builds on the work of Bruce and Young (1986) in stating that the processing of identity and affect are neurologically dissociable. Their argument follows that, if the same mechanisms were involved in identifying faces and recognising emotions, we would think somebody was a different person every time they showed a change in expression! They cite the example of prosopagnosia as further evidence for the selectivity of brain regions in face identification: Patients with this disorder are unable to identify faces but have no problem in naming emotional expressions. Haxby et al. (2000) therefore agree with Bruce and Young (1986) in that there must be one system for invariant features and another for processing the cues that denote expressions.

Based on fMRI studies in which participants were asked to state whether either the identity *or* expression of a person matched a previously shown target, Haxby et al. (2000) found very distinct patterns of brain activation, with activity predominantly in the frontal gyrus (FG) when judging identities compared to more activation in the superior temporal sulcus (STS) for expression judgements. Schultz (2005) have observed similar findings in that the STS does seem to be more responsible for the processing of movement or changes in spatial relations. McKone and Yovel (2009) have noted, however, that emotions can also be identified on distinguishing features. For example, we might not necessarily need to analyse spatial relations between the eyes if we know that an upturned mouth is a smile, provided we *understand* what that smile represents. Indeed, Haxby et al. (2000) stress that more 'peripheral' areas, such as the limbic system and amygdala, integrate with those mechanisms responsible for detecting spatial changes and these are where meaning is attached to those configurations. Specifically, Haxby et al. (2000) suggest that the role of the amygdala is to 'bias cognition' (p.230), such that it responds to any salient stimuli, especially stimuli requiring an urgent fight or flight response. Haxby et al. (2000) have further made the intriguing suggestion that, in understanding complex emotions, the somatosensory system comes into play so that we can experience for ourselves the emotion that we are viewing. Such an assertion is more in the realm of theory of mind and conceptual, rather

than perceptual, processing of emotions; this issue of percepts versus concepts is addressed in the following section.

The role that the amygdala plays in the processing of emotional expressions has been hotly debated (Baron-Cohen et al., 2000a; Adolphs and Tranel, 2003) and research is ongoing as to whether it plays a role in general emotion processing or more ‘quick and dirty’ (Johnson, 2005) negative emotion expressions, such as the detection of fear and/or anger. Whilst Haxby et al. (2000) credit the amygdala with a more periphery role in expression recognition, citing it to be involved in ‘biasing cognition’ based on already encoded visual aspects, Johnson’s (2005) model puts the amygdala in a more central role. He states that the amygdala plays a more modulatory part in the identification of facial expressions, as evidenced by early event related potential (ERP) activity stemming from the amygdala and spreading to other cortical regions. He puts forward a model in which there is a three way feedback between cortical and subcortical routes whereby the amygdala is implicated in both the early detection and emotional attribution of emotions, mediated by the cortex. Johnson (2005) notes how the ‘extreme’ emotions that require a fast response tend to consist of low spatial frequencies, and it is these that appear to trigger amygdala activation. One very interesting assertion made by Johnson (2005) is that children do not show any greater amygdala activation to fear than what is seen in other brain regions, whereas adults do. He cites this as evidence for later connectivity between cortical and subcortical regions, perhaps mediated by the role of experience. This neurological evidence offers support for behavioural studies showing poorer recognition of fear in younger compared to older typically developing children (Baron-Cohen et al., 2001) and highlights the fact that the recognition of different emotions may depend upon separate neurological processes. It is also supported by Calder et al.’s (2003) assertion that recognition of fear *declines* in older adults, who typically show *less* amygdala response.

Not all researchers agree that dissociable processes underlie face identification and expression. The possibility that there may, in fact, be some neurological overlap between the processing of face identity and expression has been suggested by Ganel, Valyear, Goshen-Gottstein and Goodale (2005). Arguing against the Haxby et al. (2000) model, they suggest that the frontal gyrus (FG), typically referred to in the face processing literature as the Fusiform Face Area (FFA), is not exclusively activated in response to the identities of faces but *also* when processing emotional expressions. The inferior frontal gyrus has also been implicated (Rizzolatti & Craighero, 2004) in the mirror neuron system when both observing and imitating the actions of others; this may point to a neurological link between both the perception and *experience* of emotions.

Ganel et al. (2005) used a similar design and premise (but different paradigm) to that used by Calder et al. (2000a) in that they wanted to create both congruent and incongruent expressions and identities to establish whether or not the processing of both are treated separately in neurological terms. Participants (11 typical adults) were presented with a face (Person A or person B) depicting either happiness or anger and were then asked to state the identity or expression of a test face. The test face was manipulated to be either congruent or incongruent with the original image on the

unattended to dimension (See Figure 1.2). This design allowed for the analysis of the effect of implicit processing of either dimension and its neural underpinnings.



Figure 1.2: Stimuli used in Ganel et al. (2005), p.1646, reproduced with permission

Ganel et al. (2005) found activation in the FG, STS and amygdala when identifying emotions but also when identifying identities when emotions were incongruent, suggesting an implicit neurological processing of facial expressions, activating the FFA. They posit this as evidence for more of a *network* involved in both facial identity and facial expression processing and not the two dissociable systems that the Haxby et al. (2000) model argues. Ganel et al. (2005) explain this finding in that, in order to identify an emotion, we need to have the identity of the face as a reference point at the minimum. A similar idea of the referential value of featural cues has been made by McKone and Yovel (2009), although their review confined this theory to the processing of identities rather than affect. It is worth bearing in mind, however, that activation of the FG may purely be in response to the fact that *faces* are presented, regardless of the type of cue or dimension that participants were asked to attend to. Unfortunately, Ganel et al. (2005) did not examine accuracy on their task, which would have better highlighted possible relationships or interference between the recognition of identities versus expressions.

Very little research to date has examined the dissociability of expression and identity in *children*. Spangler et al. (2010) used a sorting task paradigm with children aged 5-11 years ($n=72$) in which they were asked to sort photos of faces according to either identity (ignoring gaze direction, emotional expression and facial speech) or one of those other dimensions, ignoring facial identity. It was hypothesised that reaction times

across the different conditions would be comparable if the underlying processes were separate, therefore not causing any interference that would be seen in differing reaction times.

The results showed that there was evidence of a clear dissociability between eye gaze and identity, with children of all ages able to ignore identity when asked to categorise based on gaze direction, and vice versa. However, interference effects were seen when participants were asked to ignore identities whilst categorising facial speech and emotional expression, with reaction times in this condition significantly slowed. Interestingly, this was an asymmetrical pattern in that participants were able to ignore the other dimensions when asked to categorise identities. Bruce and Young (2012) have cited examples across the literature in which this asymmetrical pattern is also observed in typical *adult* populations. No interactions were seen in the analysis to suggest different patterns of processing between the different age-groups, with only overall poorer accuracy seen with age. However, the participants recruited to the different conditions (ignoring identities or another dimensions) were different cohorts therefore it is impossible to state that these findings are indicative of actual dissociability between *processes* rather than caused by some other between-subject differences. Future studies should examine this dissociation between the different aspects of faces across childhood more systematically in future, as it may be that there is a developmental change in the inter-relatedness of these dimensions and their role in effectively interpreting faces and the meaning they afford, or it might simply be the case that children of a certain age are showing the types of asymmetries also seen in adulthood.

To summarise the literature reviewed thus far, the processing of faces in typical development and into adulthood is comprised of many aspects: Recognition of the *identity* of faces appears to operate separately from that of gaze, although there may be some interplay between the specific emotions being processed and gaze direction, as well as some overlap between identity and expression recognition. To what extent these different aspects are underpinned by featural, holistic or configural processing may depend on the age of the child as well as which specific emotions are being processed. Findings are mixed as to at what age sensitivity to spatial changes is fully developed, and this may depend on the extent of the spatial change and the salience of other cues available.

Whilst all of the above research has focussed on *perceptual* aspects of face processing, it is important to consider the *conceptual* understanding of emotions from faces. As Haxby et al. (2000) have suggested, the limbic system may play a peripheral role in the *interpretation* of emotions; examination of the divide or overlap between perceptual and conceptual processing of emotions may build a framework for better understanding of from where difficulties might stem in neurodevelopmental groups.

1.5 Social Perception versus Social Cognition

There is clearly a great deal of variation across studies as to precisely what *perceptual* processes are at play when examining a face. There has been far less research conducted as to what *conceptual* meaning faces have: Once a face has been identified as ‘angry’, for example, how do we then know what to do with that information or how to act on it? What do we *understand* about the term ‘angry’? It has been postulated by Haxby et al. (2000) that the limbic system takes a peripheral role in this type of *interpretation* of emotions, but very few behavioural studies have systematically examined the relationship between *perceiving* the emotion shown on a face and mapping this on to an *understanding* of that emotion. The focus of the current PhD research will be on exploring the ways in which the accurate identification of emotions and an understanding of them may be related or dissociable, in both typical development and in neurodevelopmental groups.

Tager-Flusberg and Sullivan (2000) have suggested that the perceptual and cognitive components of “social knowledge” (p.60) are underpinned by separate neurological routes and, in order to have a full awareness of the social environment, one needs to be able to integrate social-perceptual and social-cognitive information. For example, understanding why Jayne might be crying at a wedding requires us not only to perceive the configurations of the face to deduce that she is crying from happiness (rather than sadness), but to then understand the social context and why she might be happy and not sad. Chapter 6 offers a comprehensive account of the literature in this field, with a particular focus on how divides between social-perception and social-cognition may underpin the behavioural profiles seen in neurodevelopmental groups.

Pineda and Hecht (2009) have built on the theoretical model proposed by Tager-Flusberg and Sullivan (2000) in highlighting how different patterns of neural activity underpin tasks requiring social perception versus social cognition. The premise behind their experiment was that mu rhythms (electrical brain activity in the somatosensory cortices when at rest) are found to be suppressed when observing the motor action of another. This pattern of brain activity has been dubbed the ‘mirror neuron system’ and is reputed to be evidence of the ability to experience what is being observed in another. Their hypothesis was that mirror neurons would be active during social-perceptual tasks because these are a more automatic type of process not requiring any declarative reasoning, unlike social-cognition, which takes place in largely dorsal areas. However, they found some overlap in brain activity between tasks that were designed to be perceptual versus cognitive; whether this points to the interconnectivity of the two systems or discrepancies in task design remains to be seen.

Studies such as that of Pineda and Hecht (2010) are critical for beginning to unravel the interconnections between recognising emotion, understanding intent and pinpointing what processes may lie beneath. However, as brain imaging studies are expensive and reliant on usually small sample sizes, and the validity of the mirror neuron system itself

is much debated, behavioural measures using well designed tasks may be a better way forward in the short-term.

1.6 Summary

Models of face processing and neurological evidence all point to the fact that social perception and social cognition, similarly to the recognition of identities versus expressions, may be underpinned by largely separate processes. Precisely what these processes are may well depend upon the facial expression, other cues available (such as gaze direction) and the age and/or experience of the person making the judgement. However, in order to make *attributions* to derive ‘social knowledge’ (Tager-Flusberg & Sullivan, 2000), there may need to be some level of connectivity between these systems, with certain aspects being modulated by or dependent on others. The above literature has focussed specifically on these processes in typical development; the key question is how deviant or delayed these processes may be in neurodevelopmental groups and to what extent such differences might explain the behavioural profiles seen in these disorders? That social perception and social cognition may be dissociable will be the governing framework of the current argument that the social behaviours seen in Williams syndrome and autism may stem from different difficulties within these domains. Chapter 2 will outline the genetic, cognitive and social profiles of individuals with these two neurodevelopmental disorders.

Chapter 2: Social and Cognitive Profiles of Autism and Williams syndrome

Chapter 1 provided an overview of the face processing literature in typical development and briefly summarised models of face processing as well as outlining the important distinctions between social perception and social cognition. The focus of Chapter 2 will be on outlining the cognitive and social profiles of individuals with Williams syndrome (WS) and autism (ASD). In order to pinpoint where the difficulties in social communication might lie and what might specifically underpin them, it is important to have an overview of the broader profiles of these disorders. The following sections review evidence from studies with individuals with WS and ASD as to where their strengths and weaknesses are in the cognitive and social domains: How much uniformity or heterogeneity is there both within and between these neurodevelopmental disorders?

2.1 Williams syndrome

Williams syndrome (WS) is named after Williams et al. (1961, cited by Skwerer & Tager-flusberg, 2002) who noted a similar and distinct profile of mainly developmental and physical problems in a small group of patients which later led to the recognition and classification of the disorder. The problems observed included growth delay, cardiac and gastrointestinal problems and a very specific ‘elvin’ face shape. Advances in medicine since then have now attributed WS to a specific genetic deletion on chromosome 7, affecting up to 28 genes (Korenberg et al., 2000) one of which is the elastin gene. WS is diagnosed using a method of fluorescent in situ hybridization (FISH). This procedure highlights the absence of one copy of the elastin gene on chromosome 7 and is used as the genetic marker for diagnosis. Many of the medical problems associated with WS, such as delayed growth, aortic stenosis and poor muscular control, are considered to be related to the absence of the elastin gene. The social and cognitive profiles associated with WS, however, are highly likely to be due to the interplay between several genetic abnormalities on chromosome 7 as well as neurological and environmental factors.

As with other genetic disorders, such as Fragile X or Down syndrome (DS), prevalence rates vary from study to study but the most cited statistic is that WS occurs in approximately 1 in 20,000 live births (although Stromme, Bjomstad, & Ramstad (2002) have found prevalence rates as high as 1 in 7,500 births). Because of the nature of the cardiac problems present in the disorder, the prognosis has not been very positive but advances in medicine mean that the cardiac and gastrointestinal issues are manageable and do not need to greatly reduce life expectancy. The implications of this are that there

is now an older generation of people with the condition but very little research has taken place to explore the developmental trajectory of WS.

Howlin, Davies, & Udwin (1998) have examined cognitive skills in 61 WS adults (mean age 26 years) and have shown that there appears to be very little improvement in any of the subtest domains typically tested on standardised IQ tests between child and adulthood. Differences between verbal and performance IQ were slightly less pronounced in adults but other skills (such as reading, arithmetic and general social adaptation) were comparable to those of children with WS. Further, Davies, Udwin, and Howlin, (1998) have reported (from interviews conducted with the parents/care-givers of adults with WS) that the emotional and social difficulties seen in childhood remain to be prevalent in adulthood and become more problematic, with others tending to be less understanding of those behaviours in an adult than they might be a child and adults with WS having a higher rate of mental health disorders than are seen in the TD population (Stinton, Tomlinson, & Estes, 2012)

Given the relatively stable cognitive and social profile seen in WS with age, this chapter will now review these domains in turn. The majority of studies have been carried out with children, therefore drawing a definite developmental picture of how WS might manifest across age is, at this point, difficult. Future studies may address this issue by studying a wider age range or, ideally, adopting a longitudinal design.

2.2 The Cognitive Domain in WS

Individuals with WS have a consistently mild-moderate intellectual impairment, reported to be in the 50-60 region on standardised IQ tasks (Searcy et al., 2004). Low intellectual functioning therefore has an impact across a wide range of other cognitive skills, such as memory and attention. However, it is this typically low IQ that makes the areas of strength seen in WS so striking: There are typically very large divides seen between verbal and performance IQ on standardised tasks (Howlin et al., 1998) and individuals with WS are frequently cited, both anecdotally and on empirical behavioural tasks, as having relatively strong and varied language skills in relation to their low full scale IQ. Santos and Deruelle (2009) have termed the strengths and deficits found within the WS profile as ‘verbal peaks and visual valleys’ as a way of describing discrepancies in performance between language and visual-spatial domains. They state how language abilities tend to be far better than what would be expected relative to poor visuo-spatial skills in individuals with the disorder.

The early work of Bellugi, Wang and Jernigan (1994) comprehensively tested this pattern of strengths and deficits across a cohort of more than 50 individuals with WS (aged between 10 and 20 years old). Specific groups of individuals took part in various experiments comprising a battery of tasks aimed at examining the different domains of language and cognition. Participants were compared to individuals with Down syndrome (DS) matched on age, sex and IQ, some of the findings of which are reported below.

2.2.1 Visuo-Spatial

Typically classed as one of the ‘hallmark’ deficits in WS, problems with visuo-spatial processing have been widely and consistently reported (Farran, Jarrold, & Gathercole, 2003; Meyer-Lindenberg et al., 2005a). Anecdotal evidence comes from parents who report that those with WS struggle to navigate or follow simple directions, even having difficulty in negotiating flights of stairs. On tasks such as the block design task, in which participants are asked to recreate formations of blocks from a 2-d pattern, those with WS particularly struggle (Hoffman, Landau, & Pagani, (2003). Studies designed to elucidate precisely where the problem might lie on tasks such as these have typically concluded that those with WS utilise a featural style of processing, whereby attention is paid to individual parts rather than the wider image. Hoffman et al. (2003) conclude that the crux of the deficit is in putting together and representing spatial relationships. Given the wealth of literature on how faces are processed configurally (discussed in Chapter 3) depending upon the processing of these very spatial relations that those with WS appear to struggle with, it is therefore essential to consider processing style in this domain.

Farran and Jarrold (2011), like Bellugi, Wang and Jernigan (1994), have shown that individuals with WS perform consistently poorly on block design tasks but struggle more on tasks specifically asking them to *construct* the designs, rather than *perceiving* (choosing from various pictorial options) which arrangements of blocks form a particular pattern. Further, Farran and Jarrold (2003) have noted how segmenting blocks does aid performance in those with WS in much the same way it does TD individuals, perhaps suggesting that when the task is broken down into manageable steps, individuals with WS *are* able to integrate parts into a whole. This could be suggestive of more of a memory or attention problem, more than likely driven by low IQ. Subtle differences also emerge on the classic Navon task (Navon, 1977) when participants are asked to draw versus *perceive* global configurations: A local bias is shown on drawing tasks that disappears when individuals are provided with instructions and are asked to *choose* rather than recreate configurations. Farran and Jarrold (2011) have therefore suggested this might be more of a planning and execution difficulty.

In support of this is a study by Atkinson et al., (2001), who administered a combination of questionnaires and assessments to examine early sensory difficulties, spatial skills and language ability in 108 children with WS (mean age 7 years, 3 months). They found that, whilst children with WS had a higher incidence of visual sensory perception problems than seen in the typical population, these in no way correlated with visuo-spatial difficulties on standardised tasks; this may suggest, as Farran and Jarrold (2011) have done, that the underlying issue is not with perception per se. This study also highlighted the fact that language development appears less delayed in WS: Improvements with age were far greater for language tasks than those testing visual-spatial skills, although they never reached CA level, showing how the strengths of language seen in WS are *relative* to deficits in other domains, rather than being competent at an age-appropriate level. The studies reviewed above do suggest that there are clear visual-spatial deficits seen in WS, but heterogeneity within this domain makes

it difficult to establish precisely where the underlying difficulties are. A similar profile of heterogeneity can be seen in the language domain also (Porter & Coltheart, 2010)

2.2.2 Language in WS

One of the language tasks developed by Reilly, Bellugi and Klima (1990) involved participants being asked to narrate the 'Frog, Where are you?' story (Reilly et al., 1990). Individuals with WS were found to be more likely than those with DS to give emotional affect to their stories, employing prosody and referring more to the emotions of characters. They used grammar and syntax appropriately and had a much higher incidence of using uncommon and often stereotyped language, more akin to that typically seen in autism. Perhaps the most striking example of the divide between language and visuo-spatial abilities is seen in Figure 2.1 (Bellugi, Lichtenberger, Mills, Galaburda, & Korenberg, 1999) and is suggestive of a very specific deficit in the visuo-spatial domain, not underpinned by any difficulties of an *understanding* of what an elephant is. Bellugi et al. (1999) have suggested that there may be a neurological basis for this divide, with anatomical atypicalities in the dorsal stream. They also note a relationship between increased volume in the frontal cerebral brain region and increased language abilities.

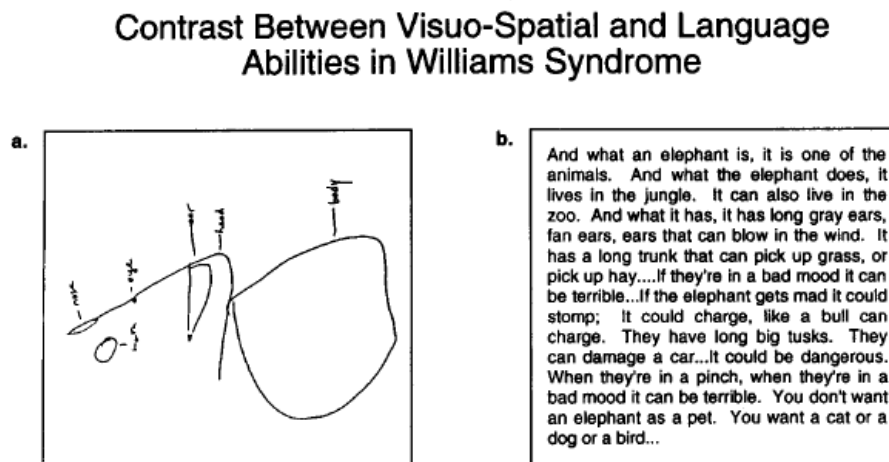


FIG. 2.6. Contrast between visuospatial and language abilities in WS. (a) Drawing of an elephant by an 18-year-old WS woman, whose IQ is 49. (b) Her verbal description of an elephant.

Figure 2.1: Example of a WS drawing and description of an elephant (Bellugi et al., 1999)

However, even within the language domain, discrepancies have been shown. For example, Brock et al., (2007) note that children with WS perform above mental age (MA) level on language tasks measuring receptive vocabulary but are unable to perform at MA level on tests of expressive language. Stojanovik (2006) has also shown that children with WS (mean age 9 years, 6 months) tend to show qualitative differences in the types of difficulties they have with language, compared to those (matched on language ability) with a specific language impairment (SLI). When asked to have a

conversation about a picture (such as a birthday party scene), they found that children with WS made more pragmatic errors and tended to give more inappropriate statements than those with an SLI, with less evidence of inferencing. Despite the same overall language ability as children with SLI, Stojanovik's (2006) study therefore showed that the *types* of error seen in WS appear to be more concerned with an *understanding* of social content, such as inferring the meaning of a social situation. This mirrors the types of difficulties that they face in everyday social exchanges.

Jones et al.(2000) have also examined the narratives and responses to interview in children with WS relative to TD controls and children with DS. They observed that children with WS used far more 'audience capture' techniques, such as exclamations or questions, and gave complex social narratives with many emotion terms (evaluative devices). This contrasted with the very short, non-expressive stories given by those with DS. There was a high presence of grammatical mistakes throughout the narratives, compared to controls, and those with WS were also found to use significantly fewer cognitive inferences such as explaining *why* a character felt a certain way or what they were thinking. This study suggests how language may very closely mirror behaviour; children with WS have a propensity for approaching and engaging with others, yet show deficits in understanding the needs and beliefs of others. An interesting observation made by Jones et al. (2000) was that, during the interviews, children with WS tended to turn questions back onto the examiner. For example, one child, when stating he had a dog then asked the experimenter "Do you have a dog? What kind of dog?" (Jones et al., (2000), p.36). This type of building on social statements and reciprocity of social conversation is distinctly lacking in autism, and therefore highlights the contrast between the social profiles of the two disorders. Whether this is evidence for a hyper-social profile or of a dislike of talking about oneself is an intriguing question.

The link between language and other domains is an important one and it is essential to consider heterogeneity of strengths and deficits *within* as well as across domains. Landau and Zukowski (2003) observed in their study in which children with WS (mean age 9 years, 7 months) were asked to describe events seen in video clips, that their descriptive language was at chronological age (CA) level yet they were very poor at describing anything concerned with spatial relations or locations. Given the problems that those with WS have in actually carrying out tasks requiring visuo-spatial skills, it is perhaps not surprising that weaknesses appear in language terms in this domain. The fact that the areas of language and visuo-spatial skills are in some way linked lends support to the argument that experience may play a key role in the interplay between cognitive domains.

2.3 The Social Domain in WS

2.3.1 Social Approach

One of the defining characteristics of WS is the description of a ‘hyper-social’ behavioural profile (Jones et al., 2000). Parental reports often state that individuals with WS will approach strangers and initiate conversations with them; similarly, amongst their peers, those with WS excessively seek out social exchanges, also engaging in more eye contact and hugging behaviours than is seen in typically developing individuals of the same age (Järvinen-Pasley, Vines, et al., 2010). Despite such a ‘friendly’ characteristic, those with WS tend to become socially isolated with increased age and report high levels of social anxiety (Davies et al., 1998), finding it very difficult to form and maintain satisfying social relationships (Frigerio et al., 2006) It is therefore essential to question where this need to approach others so excessively stems from.

One suggestion is that, given their seemingly poor ability to process the emotional content of faces (discussed in Chapter 3), perhaps those with WS approach others due to a misunderstanding of their friendliness? If they do not know, for example, that a frown might suggest somebody is angry and not safe to approach, there is no reason *not* to approach them. However, Karmiloff-Smith et al. (2004) have noted how on face *identity* tasks, those with WS are able to differentiate between people, therefore regardless of expression, they should at least know who is familiar to them or not. So it might therefore be an *understanding* of why it is not appropriate to approach strangers that is lacking.

Jones et al. (2000) were the first to systematically explore the over friendly nature of individuals with WS. They conducted various measures as part of a large-scale study focussing on language, social anxiety and social approach in toddlers, school-age children and adults with WS, compared to individuals with DS (for the language tasks) and typically developing controls. Two experiments were designed to measure social approach and anxiety, respectively. In a classic approachability task, 26 individuals with WS (mean age 23.6 years) were matched to TD individuals of the same CA and a separate group of children (mean age 8.3 years) matched on IQ. Participants were shown photographs of unfamiliar faces depicting positive or negative facial expressions and were asked to rate, using a Likert scale, how much they would “like to go up to each person and begin a conversation with them” (Jones et al., 2000, p.40). Analysis of participants’ responses showed that the individuals with WS gave significantly higher (more likely to approach) ratings than CA or MA peers towards both positive and negative faces. Jones et al. (2000) cited this as evidence for a general drive to approach others, regardless of facial affect; whether or not this is due to the perceptual interpretations of the emotions or a deeper understanding was not systematically examined, although anecdotal evidence points to the possibility that the difficulties lie within interpreting the more subtle aspects of facial expressions. For example, one participant with WS described what was termed a ‘mischievous-looking smirk’ by a TD individual, as “... happy, because he’s smiling” (Jones et al., 2000, p.41).

Approachability ratings on this task were corroborated by real-life approachability measures taken from a parent-report questionnaire, in which it was evident that those with WS were far more likely than individuals with DS or TD controls to approach strangers in everyday life. Even anecdotally, the researchers observed during a warm up task that the WS children were so keen for social interactions that they would stare at the experimenter's face rather than focusing on the task at hand and would seek out conversational exchanges when it was not appropriate (Jones et al., 2000).

Jones et al. (2000) have also measured social anxiety in a classic separation task: Twenty two toddlers (mean age 18 months) were matched on CA and gender to 14 TD controls, and responses to their caregiver leaving them alone in a room were analysed in terms of vocal and facial affect (frequency and intensity). It was found that the infants with WS showed fewer and less intense *negative* facial emotions, teamed with less intense vocal emotions, compared to controls. These children also needed less consoling upon the caregiver's return. No differences were found between the groups in terms of positive emotions. These findings can be interpreted in a variety of ways: The infant with WS may not have been as distressed because they did not understand the implications of their parent leaving; there may be something about expressing negative emotions that individuals with WS have difficulty with, or it may, as Jones et al. (2000) claimed, be evidence for a more friendly disposition in even young infants. Pinpointing precisely what level or mechanism is driving such social behaviours is the focus of the present research.

Frigerio et al. (2006) showed pictures of basic emotions (happiness, sadness, fear, anger, disgust) to 21 individuals with WS (mean age 16.5) matched on CA and MA to TD controls in an approachability task. Participants were shown photos of unfamiliar faces depicting the various emotions and were asked to rate how much they would want to play/talk to those people; they were then asked to state, on a scale of 1-4, how much they would either approach or not approach them (definitely/definitely not, etc.). Frigerio et al. (2006) found that WS participants tended to rate the faces using the extremes: Happy faces were rated as more approachable than controls typically stated whereas 'negative' faces were given significantly lower ratings than those given by controls. Frigerio et al. (2006) conclude this is evidence for, firstly, the fact that WS individuals are clearly able to distinguish between different emotional expressions and, secondly, understand which emotional expressions would warrant them to approach or avoid. However, this is not in accord with the behavioural profile of WS individuals' tendencies to approach and engage with strangers. One might then question whether the stimuli used in this particular experiment (with 'extreme' facial expressions) could have elicited responses not found in day-to-day life or if the problem in WS is not with face perception at all but with a higher-level cognitive skill. It could also be the case that individuals with WS use a blanket strategy when using rating scales, in that they always default to the extremes in cases of uncertainty.

Porter, Coltheart, and Langdon (2007) have also observed that individuals with WS do seem able to accurately judge which facial expressions warrant avoidance or approach, supporting the findings of Frigerio et al. (2006). They compared individuals with WS to

both CA and MA matched typically developing controls as well as a group with DS, on a task in which they had to label the emotion (happy/sad/angry/scared) and then rate the approachability of faces, voices and body gestures. Porter, Coltheart and Langdon (2007) found that WS participants gave similar responses to CA peers on measures of approachability and performed at the level of MA-matched controls when identifying the emotions, suggesting an ability in line with what would be expected from IQ in perceiving emotional affect. Both individuals with WS and their MA peers tended to mislabel negative emotions as positive. Most importantly however, no particular bias (above that seen in TD CA matches) towards approaching positive faces was found in the WS group when correct responses to emotion labelling were taken into account.

It may be the case that the over-friendly social approach behaviours seen in WS are present from early in infancy. Doyle, Bellugi, Korenberg, & Graham (2004) posed the question of whether there would be any evidence of developmental change in the social profile of individuals with WS. They recruited 64 individuals diagnosed with WS, split into three age-groups (under 4 years; 4-7 years and 7-13 years), compared to children of the same ages with DS, and a TD control group. The parents of participants were asked to fill out the Salk Institute Sociability Questionnaire (SISQ): A measure designed to assess the intensity and frequency of everyday social behaviours. Analysis of the parent reports revealed that individuals with WS were overall more sociable than any of the other individuals in the study; high sociability was seen in the WS cohort from the youngest age, and was greater than individuals with DS at every age point. Doyle et al. (2004) therefore conclude that the highly sociable nature of WS appears not to be mediated by experience, but is seen early on in development and remains relatively stable throughout. This type of consistency stands in marked contrast to the broad and changeable pattern of social behaviours seen in ASD (Bachevalier & Loveland, 2006).

Together, these studies point to the fact that it is not the perception of emotions or the awareness of knowing when to approach somebody that might be the problem in WS. There does appear to be a tendency for individuals with WS, like their TD peers of the same MA, to mislabel faces as positive, and this may be concerned with difficulties in analysing and interpreting more subtle facial cues (such as knowing when a smile is more of a smirk). However, the studies reviewed above do suggest that individuals with WS are able to understand that faces depicting negative affect are best avoided. This does not, however, map onto everyday social behaviours seen outside of the laboratory. Porter et al. (2007) have suggested that the tendency of those with WS to approach strangers may therefore be driven by an inability to *inhibit* social responses, despite *knowing* that it is not appropriate to approach. Dodd, Porter, Peters, and Rapee (2010) add further weight to this argument with their finding that pre-school children diagnosed with WS will approach strangers even when their faces are covered; this suggests that there is more of a compulsion to approach others in WS, rather than any difficulty in reading facial expressions. However, the motivation for what drives an individual with WS to approach others may vary from person to person, with heterogeneity also seen in this social domain (Little et al., 2013).

2.3.2 Social Cognition and Theory of Mind (ToM)

Theory of Mind is the ability to form an understanding of how *other people* represent the world; what beliefs and mental representations another person might possess that do not necessarily match our own. Baron-Cohen, Leslie, and Frith (1985) designed the Sally-Anne task, which has since become the classic measure of testing both first and second-order false beliefs (See Figure 2.2). The premise of this task is that it requires the participant to make a distinction between the knowledge that he/she possesses, and the knowledge that somebody they are viewing possesses. Further, in second-order tasks, participants are required to understand what a character thinks that somebody else is thinking. Studies have shown that children as young as 5 years are able to pass second-order belief tasks; when the verbal and memory demands of the tasks are simplified, children as young as 4 years are able to explain and understand second-order beliefs (Sullivan, Zaitchik, & Tager-Flusberg, 1994).

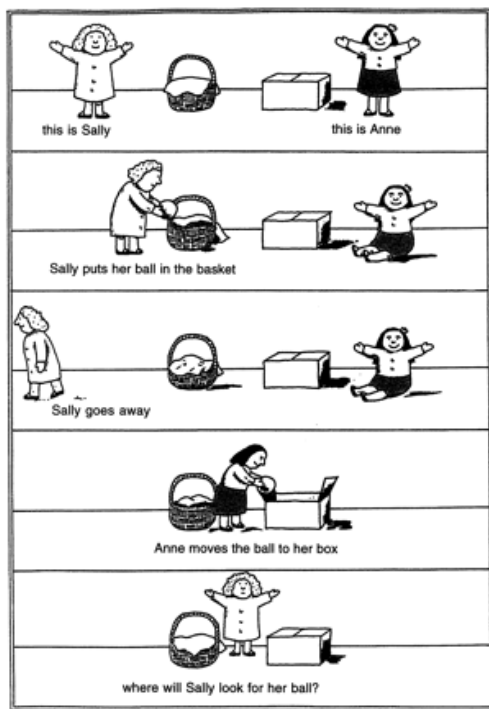


Figure 2.2: The Sally-Anne first-order belief task. Second –order belief tasks pose the Q: “Where does Anne think that Sally will look for the marble?” (Taken from Baron-Cohen et al. 1985)

Difficulties in forming a theory of mind about other people have long been cited (Baron-Cohen et al., 1985) as part of the underlying problem in autism but less research has been conducted with individuals with WS. Karmiloff-Smith et al., (1995) were one of the first to examine theory of mind abilities in WS. In two experiments, they adapted the classic second-order false belief tasks to revolve around more complex verbal stories in which, rather than there being a false belief of the *world*, false beliefs about the beliefs of another were represented (Both characters in the story knew that an ice-cream seller had moved his van to the park, but one character does not know the other

character has been informed about this). 31% of the 18 WS participants tested were able to pass this task. However, when the term ‘believe’ was swapped for ‘knows’ in a similar second-order type story, 88% of participants were able to pass the task. Karmiloff-Smith et al. (1995) have claimed these results as evidence for a relatively spared theory of mind in WS (relative to low IQ and visuo-spatial perceptual abilities); teamed with other findings from a battery of experiments conducted amongst their WS cohort showing good performance in inferring emotional states from eye gaze and an understanding of sarcasm, they conclude that social cognition in WS is a strength, although there does seem to be a discrepancy between an understanding of one’s *knowledge* versus *beliefs*.

Tager-Flusberg and Sullivan (2000), however, have compared children with WS to IQ, age and language matched participants with Prader-Willi syndrome (PWS), as well as a group with non-specified developmental delay (NSDD) and found that they were only comparable when asked to label basic facial emotions; individuals with WS were *below* the performance of all other groups on a classic second-order false belief task. Tager-Flusberg and Sullivan (2000) posit this as evidence for both the importance of theory of mind in interpreting emotions as well as the fact that individuals with WS do have difficulties in this area. Previous to this, Sullivan and Tager-Flusberg (1999) had also found that, on false belief tasks, the area posing the greatest problem for those with WS was in understanding the *beliefs* of others; when tested on what *knowledge* another person had, they were relatively spared, in line with the findings of Karmiloff-Smith et al., (1995). In their experiment, Sullivan and Tager-Flusberg (1999) compared 22 children (mean age 11.5) to individuals (as above) with PWS and NSDD. The task was a verbal story (supported by either being acted out with dolls for children under 10, or a comic-style animation for older children) in which two characters hold different beliefs about the knowledge of a third person. Participants were initially asked a first-order question and provided with feedback in cases of errors; they were then asked a second-order question about what beliefs and knowledge one of the characters had about another. Participants were also asked to justify their responses in order to gain an insight into their *understanding*.

Sullivan and Tager-Flusberg (1999) found that there were no differences between the groups on the first order tasks; individuals with WS were comparable to those with PWS on second-order tasks, and did better than those in the NSDD group. It is worth noting, however, that all groups had at least a 70% pass rate. Analysis of the types of justifications that individuals gave revealed the most difficulties in understanding the *beliefs* of another, with all participants doing better on second-order *knowledge* questions. These results do suggest that there is something beyond IQ that drives an understanding of social knowledge in WS, with a possible divide between the understanding of another’s knowledge versus beliefs. However, the absence of any TD control group in these studies means that it is impossible to state how atypical the profiles of WS are in relation to the typically developing population. The ways in which individuals with neurodevelopmental disorders make sense of social information, and the types of cues they find most useful and how these differ from TD peers, will be explored as part of the current research.

2.3.3 Theories of social behaviours

There have been two main theories put forward to explain the social behaviours seen in WS: The frontal lobe hypothesis and the amygdala explanation, which will now be discussed in turn. The frontal lobe hypothesis (Galaburda & Bellugi, 2000) takes evidence of abnormalities in the frontal lobes seen in individuals in WS (Meyer-Lindenberg et al., 2005b), and a propensity for being poor at controlling responses on classic inhibition tasks to be suggestive of more of a *control* problem in social approach behaviours. This may also be teamed with a lack of social *understanding*.

Rhodes, Riby, Park, Fraser and Campbell (2010) have examined the link between social behaviours and executive functioning: They compared individuals with WS (mean age 18 years) to CA and verbal-IQ matched TD controls on a battery of neuropsychological assessments tapping into attention, planning and memory, and also took parent report measures of everyday social behaviours. They found a strong correlation in the WS group between poor attention shifting/planning and higher social approach in real life. Overall, individuals with WS were significantly poorer on neuropsychological tasks than their TD peers, lending further support to the frontal lobe hypothesis. Direct tests of these brain regions and real-life approachability behaviours have yet to be explored, however. Similarly, the question of why individuals with WS are so drawn to *social interactions* as a manifestation of inhibition problems, rather than being drawn to animals or objects, has not been empirically examined. Jawaid et al. (2010) note in a review of the area how individuals with WS suffer from levels of hypo-arousal, which appear to be increased when attending to human faces. This may suggest some kind of ‘comforting’ aspect that is gained from attending to others, but the mechanisms behind this are so far undisclosed. However, a recent hypothesis put forward by Kemp and Guastella (2011) suggests that oxytocin levels may modulate and influence positive and negative social behaviours.

One final neurological explanation of the hyper-social profile seen in WS is the amygdala theory. Because of the important role the amygdala has been attributed with in models such as Johnson’s (2005) in emotion processing and perhaps even *understanding*, it is of great interest to note that neurological studies have shown increased amygdala volume in individuals with WS (Martens, Wilson, Dudgeon, & Reutens, 2009) teamed with heightened activation in response to faces. Haas et al. (2010) have shown, however, that there may be some interplay between the *types* of facial expressions being processed and amygdala activation. They found that reduced activation in the right amygdala is seen in adults with WS (n=12) in response to fearful versus neutral facial expressions; further, significant correlations were found between this reduced activation and evidence of real-life social fearlessness, as measured by parent-report questionnaires. Haas et al. (2010) suggest that these results provide a neurological explanation for the over-friendly approach behaviours seen in WS. Järvinen and Bellugi (2013) offer a review of the literature focussed on hypoarousal in WS and conclude that baseline autonomic nervous system (ANS) activity tends to be low compared to controls, but is increased above and beyond that seen in TD peers in response to faces. Further, behaviourally, individuals with WS do not become so easily

habituated to faces. Given that individuals with WS typically have various cardiac defects, the role of oxytocin regulation in governing social behaviours may be particularly important.

To sum up, despite a clear genetic root, the profile of WS is still very complex, encompassing a range of skills and deficits in the visual and language domains. However, even apparently spared abilities may involve underlying atypical mechanisms and patterns of heterogeneity. The social profile of those with WS is particularly intriguing, raising questions about the link between brain and behaviour and where areas of dissociation or overlap might lie. The core question that the present research will set out to address is ‘what precisely governs this behaviour’?

2.4 Profiles: Autism

Autism is a neurodevelopmental disorder that, unlike WS, is currently not attributed to any single or clear-cut genetic cause. Betancur (2011) has highlighted how more than 100 genes may be implicated in the different facets of the autistic profile but there is, to date, no hard and fast diagnostic genetic cause. Indeed it is most likely that autism is a multifactorial disorder of complex origin. Prevalence rates also vary widely across the literature, perhaps because of the more subjective methods of diagnoses that depend on observations of behaviours and parent report; the most commonly cited statistic is that autism occurs (in the UK) in approximately 1% of the population (Baird et al., 2006) and is four times as common in males than females.

Defining ‘a’ profile of autism is virtually impossible given that autism itself has been considered to be one node on an entire spectrum of affiliated disorders (DSM-IV). Autism was previously diagnosed using DSM-IV depending on evidence of behaviours under a ‘triad of impairments’ (Wing & Gould, 1979) falling under the categories of communication, social interaction and restricted/repetitive interests. Observational schedules such as the ADOS (Autism Diagnostic Observation Schedule) are designed to specifically measure incidences of behaviours as listed under DSM criteria. For example, a lack of eye contact/joint attention; difficulties in maintaining reciprocal conversation; excessive repetitive behaviours; stereotyped language, etc. DSM 5 no longer identifies separate disorders on this spectrum, however, but considers different *clusters* of behaviour, categorised by their impact on everyday functioning so that a diagnosis of ‘autism spectrum disorder (ASD)’ is now given, with a rating of severity.

Two main areas of impairment are considered for DSM 5 diagnosis, rather than a triad: Social communication and interactions, and restrictive/repetitive behaviours, interests or activities. Sensory issues are now incorporated into this category and an additional disorder labelled ‘social communication disorder’ has been created for those individuals not scoring up on this latter domain. These changes reflect the heterogeneous nature of ASDs and the fact that any number of combinations of difficulties within the two domains can manifest very differently in terms of the severity and impact that they might have on everyday functioning.

For clarity, ‘autism’ (ASD) here refers to the severest end of the spectrum although, even then, the majority of studies cited will have involved samples of a mixture of high and low functioning ability. IQ ranges tend to be hugely varied across individuals with autism; consequently, language and everyday functioning is also extremely heterogeneous. Here lies the crux of the problem when trying to pinpoint ‘the autistic profile’: There is so much variation across the spectrum, with such a range of IQs and abilities, that no one individual diagnosed with the disorder may appear in any way similar to the next. Of course, there are some relatively stable core hallmarks of ASD, used on observational schedules such as the ADOS to determine an official diagnosis; such schedules are used in the absence of any genetic markers. Similarly, unlike in WS, there are no particular physical or medical characteristics that may flag up a diagnosis of ASD although early milestones, such as potty training and walking, may be significantly delayed and young infants may demonstrate atypical sensitivities to sensory stimuli and/or heightened aggression (Chawarska et al., 2007). The autistic profile is therefore largely determined purely by particular atypical behavioural markers throughout infancy, such as the presence of repetitive behaviours, inattention to social cues (such as pointing or joint attention) and inappropriate social exchange.

Because there is no distinct genetic or anatomical cause of autism, several cognitive and social theories have been put forward to explain the core pattern of symptoms seen in the disorder. These are reviewed here in tandem with a summary of the behavioural evidence highlighting the core areas of atypicality seen in the different domains.

2.5 Cognitive Theories of autism

2.5.1 Weak Central Coherence

Weak central coherence theory (WCC) (Frith, 1989) has predominantly and robustly been cited as an explanation for the atypicalities and perceptual style typically seen in ASD. Based on the consistent and frequent observation across studies that individuals with ASD process stimuli featurally rather than globally, and initially confined to the realms of visuo-spatial processing, this theory has since been expanded to account for a variety of the cognitive trends seen throughout the ASD profile.

Frith (1989) reported examples such as heightened performance on the embedded figures (Shah & Frith, 1983) and local aspects of Navon tasks (Navon, 1977) in ASD. The embedded figures task requires participants to find a shape hidden within a larger scene, whilst the Navon task involves participants naming the letter depicted at either a local or global level; in this task, the local and global letters may be either congruent or incongruent, so that interference for local versus global processing can be examined (Figure 2.3). For example, if participants’ response times to naming the global letter when it is incongruent are slower than when asked to name the *local* incongruent letter, it would be evidence of a more featural processing style. Frith (1989) has shown that individuals with autism are more prone to interference from the local features of Navon figures, whilst this is not seen in TD controls.



Figure 2.3: Examples of a Navon figure and Embedded figures image (Taken from Happé (1999))

Jolliffe and Baron-Cohen, (1997) compared high functioning adults (n=17) with ASD to CA matched TD adults as well as a group of individuals diagnosed with Asperger’s syndrome (AS) on their reaction time and accuracy on the embedded figures task. Individuals with both ASD and AS were significantly faster and more accurate than TD controls, suggesting a local processing bias: They were able to more rapidly pick out the hidden isolated feature rather than being distracted by the global image. Happé (1999) has since noted how those with ASD are less susceptible to illusions that depend upon a global style of processing, lending further support to a lack of global processing in individuals with ASD.

The block design task (Figure 2.4) is another test on which individuals with ASD have been found to excel (Shah & Frith, 1983), regardless of whether or not the blocks are pre-segmented into their constituent parts. Whilst TD individuals benefit from this pre-segmentation, as it encourages them to focus on the ways in which individual blocks might fit together rather than being distracted by the Gestalt, those with ASD demonstrate far less difference in performance times between segmented and un-segmented conditions (Shah & Frith, 1989). This is further evidence for a local processing bias, although it might be questioned why there is any advantage of segmentation at all, if the problem in ASD is weak central coherence? It is also difficult to explain high levels of accuracy on the block design task, if individuals with ASD fail to process the global whole initially? How do they self-correct and know that the image is satisfactorily complete without being able to see the Gestalt?

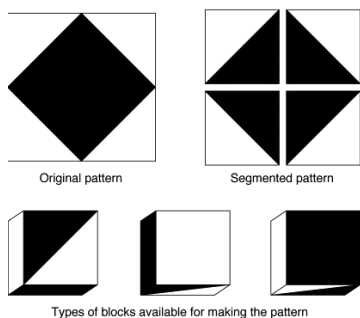


Figure 2.4: Example of a typical block design task, in un-segmented and pre-segmented conditions (Happé, 1999)

Whereas, in the WS population, little has been done to link deficits in global processing to higher level cognitive processes, the work of Frith (1989) and Happé (1999) goes some way to drawing together the impact of weak central coherence on the wider ASD phenotype. Happé (1997) asked participants with high functioning (HF) autism to read sentences consisting of homophones and observed that, compared to TD controls, they did not utilise preceding words in the sentence in order to determine the correct pronunciation. This suggests that, in language, a lack of global processing can have a direct effect. Indeed, the everyday language of those with ASD tends to be sporadic and disconnected (Jolliffe & Baron-Cohen, 1999) suggesting an inability to link together ideas. Similarly, some of the repetitive behaviours seen in ASD, such as repeatedly flicking one small part of a toy rather than playing with it functionally, might be attributed to getting ‘stuck’ on the small details of things due to a more feature by feature type of processing.

Language in ASD is an extremely heterogeneous area, with individuals’ language skills varying from non-verbal to competent, although usually marked in some way with incidences of pedantic, echolalic or stereotyped speech (Whitehouse, Barry, & Bishop, 2008). The variation is such that it is not possible to describe one characteristic language profile; it is clear, however, that an inability to join together concepts and ideas may be an underlying cause of the sporadic nature of speech in the disorder. In turn, inappropriate or fragmented language will inevitably have an impact on everyday social exchanges. The WCC account of autism therefore goes some way to explaining the wide range of difficulties seen in the disorder.

2.5.2 *Executive Function Deficits*

Whilst the WCC does seem to account for a wide variety of issues seen in ASD, it does little to explain the abundance of repetitive behaviours that are a core characteristic in this population. Individuals with ASD tend to get ‘stuck’ on activities, and parental reports consistently point to the fact that those with ASD carry out very rigid routines and rituals in their day to day lives. These routines are typically accompanied by high levels of anxiety if they become disrupted. As in WS, where problems in inhibiting approach behaviours may be due to frontal lobe abnormalities, the same brain regions may be implicated in ASD (Ozonoff & Jensen, 1999) in terms of their perseverative behaviours. Ozonoff, Pennington and Rogers (1991) have proposed that deficits in executive function (EF) may be the cause of these types of behaviours seen in ASD. They compared 23 adolescents (mean age 12.3 years) with HF autism to TD peers matched on age, sex and IQ on a battery of tasks tapping into executive function, ToM, emotion processing and verbal memory. They found that individuals with ASD were significantly poorer than the controls on all of these measures and it was only in the group of autistic individuals that correlations were found between composite scores on ToM and EF tasks. Ozonoff et al. (1991), based on their results, have claimed that difficulties in directing and inhibiting attention therefore explain the repetitive behaviours seen in ASD, and these in some way underpin difficulties in also

understanding the beliefs of others. Precisely how the two areas are related was not, however, clarified by Ozonoff et al. (1991).

Ozonoff and Jensen (1999) have gone on to examine specifically which aspects of executive functioning are implicated in the problems seen in ASD. They administered three tasks to individuals with ASD, compared to individuals with attention deficit hyperactivity disorder (ADHD) and Tourette's syndrome, known for their characteristic deficits in lack of perseveration and inhibition, respectively. These tasks were the classic Wisconsin task, Tower of Hanoi task and Stroop task, shown to measure perseveration, planning and inhibition, respectively. Their results showed that those with ASD had the poorest performance overall, with the worst deficits on the Wisconsin and Tower tasks. Those with ADHD performed worst on the Stroop, showing the lack of inhibition as expected. Ozonoff and Jensen (1999) concluded from these results that perseveration and planning are problematic in those with ASD, as is inhibition to a lesser extent; abilities that are believed to be underpinned by frontal lobe activity. What is interesting here is the divergence in social profiles between those with WS and ASD, despite seemingly similar problems in inhibition: Why is it that a lack of inhibition in WS seems to manifest as a desire to approach people, whilst, in ASD, it manifests itself in ritualised and repetitive behaviours? It may be the case that there are specialised and dissociable brain regions involved in the manifestation of these types of behaviour.

2.5.3 *Theory of Mind*

Baron-Cohen et al. (1985) were the first to suggest that the social deficits seen in ASD (such as a lack of social conversation and a lack of empathy) might be driven by an inability to understand the mind-set of another. Based on their Sally-Anne task (described in section 2.3.2), they showed that children (mean age 11 years, 11 months) with autism were less able than TD children of a lower IQ to pass a first order false belief task. They therefore proposed that a specific deficit exists in autism whereby individuals are unable to put themselves in the position of another to deduce their internal mental state; this might concern beliefs, knowledge or emotions. A misunderstanding of the mental states of another would therefore explain some of the inappropriate social behaviours manifest in autism.

Since the seminal research of Baron-Cohen et al. (1985), an abundance of studies have been carried out to explore the exact nature of the possible ToM deficits in autism. Findings have been mixed, with some research firmly concluding a clear deficit in even first-order ToM tasks (Baron-Cohen et al., 2000b) whilst others have suggested that task design might be influencing and/or masking real abilities. Baron-Cohen et al. (2000) have reported consistently poor success rates amongst individuals with ASD in passing second-order false belief tasks. Frith, Happé and Siddons (1994) have, however, shown a more mixed pattern: They compared 24 individuals (mean age 15 years) with ASD to TD and mentally delayed (MD) controls matched on verbal IQ. These two control groups were significantly younger than those with ASD (4.8 and 8.9 years, respectively). Participants were given a classic second-order false belief task and were

then divided into those who did and did not pass. Within the ASD group, 16 participants failed the ToM tasks, suggesting that the majority of individuals with ASD do struggle with second-order beliefs. Participants' teachers were given the Vineland Adaptive Behaviour Scale (VABS) to complete; this measures a child's everyday living skills and social functioning. Regardless of their performance on ToM tasks, individuals with both MD and those in the TD group were found to evidence an awareness of ToM and an ability to adapt socially in everyday life (as measured by the VABS). Such an ability was seen to a lesser degree amongst those with ASD, although correlations were found between their performance on the standardised tasks and real-life behaviours.

Frith et al. (1994) claim that their research points to not only heterogeneity within the autistic profile in terms of their ability to demonstrate a ToM, but also that there may be more of a link between second-order belief and *everyday* social behaviours than is seen in TD peers, or those with other types of developmental delay. This could be underpinned by a lack of utilising other available social information as a compensatory mechanism. The role of experience in developing such compensatory strategies is important. One study to focus on the *development* of ToM was that of Steele, Joseph and Tager-Flusberg (2003). They conducted a longitudinal study over the course of one year, with 4-14 year old individuals with a diagnosis of ASD to examine if there would be any improvement on ToM tasks. They, in fact, saw improvements in performance in 70% of the sample, although none of the participants reached ceiling on the more complex ToM tasks. There was also no control group to compare this increase in performance to.

Steele et al.'s (2003) study suggests that social understanding may develop in those with ASD, just perhaps at a delayed rate compared to TDs. It may be that, with time, individuals with ASD are able to develop compensatory strategies to help them deal with social situations. Happé (1999) is an advocate of focusing on the strengths, rather than deficits of the ASD profile and suggests that, neurologically, the focus on featural cues demonstrated by these individuals might be concerned with denser concentrations of neurons in specific brain areas that result in "an embarrassment of riches at the neural level" (Happé (1999), p.222).

2.6 Neurological Theories of autism

2.6.1 Amygdala theory

Baron-Cohen et al.'s. (2000b) amygdala theory of ASD states that much of the atypical social profile seen in this group, from avoidance of social interactions to difficulties in interpreting and responding to emotions, are due to a lack of amygdala activation. Baron-Cohen et al. (2000b) conducted an fMRI study of six participants with ASD matched to typically developing controls in which participants were asked to judge either the gender or mental states of images based on the eye area only. Not only were those with ASD much less accurate on the mental state judgements but the imaging data showed that there was no activation in the amygdala upon presentation of the mental

state stimuli. Rather, relative to controls, there was heightened activation in the superior temporal gyrus; a brain region reputed to be involved in verbal labelling of complex visual stimuli (Baron-Cohen et al., 2000b). Baron-Cohen et al. (2000b) therefore concluded that the social deficits seen in the ASD population must be due to the atypical functionality of the amygdala. Bearing in mind the small sample on which these findings were based, however, and the lack of any systematic elimination that other brain regions might be involved, it is wise to question the robustness of this theory. Whilst studies like that of Adolphs and Tranel (2003) have found in their examination of patients with amygdala lesions, a direct relationship between amygdala function and performance in identifying emotions from faces, they note that the more encompassing social abilities of those with amygdala lesions tend to be less affected than those with ASD, perhaps because of the use of compensatory strategies. For example, those with amygdala lesions are aware that they have deficits in reading facial emotions and therefore utilise other social cues. However, those with ASD seem unable to do this, which suggests that something beyond the amygdala might be involved.

Kleinhans et al. (2010) have noted that there is a lack of replication of Baron-Cohen et al.'s (2000b) findings throughout the literature, with various studies finding both hyper and hypo-activation in the amygdala in response to judgements of facial expression. They instead claim that there might be some interaction in those with ASD between anxiety levels, emotion reading and the underlying brain mechanisms. In their study, participants with HF ASD matched to TDs were asked to complete a questionnaire measuring their social anxiety, as well as performing an emotion matching task whilst in an fMRI scanner. They found that there were no significant differences in terms of task performance between the groups but they did find different patterns of neural activation whereby those with ASD showed greater activation in the occipital lobes and reduced activation (compared to controls) in the fusiform face area (FFA) region. When participants were split into those with higher levels of social anxiety, it was found that there was a positive correlation between anxiety scores and left amygdala activation in the ASD group.

Taking these findings together, Kleinhans et al. (2010) conclude that the indifference to faces generally seen in the ASD population is due to heightened sensitivity, and subsequent anxiety, caused by hyper (rather than reduced) activation of the amygdala. Teamed with a reduction in FFA activity, it is plausible that this heightened amygdala activation is a compensatory mechanism. However, whether the high levels of anxiety reported by those in this study were causing or *caused* by the amygdala activation cannot be deduced. Given the heterogeneity seen in ASD as to how much individuals can tolerate looking at faces (with some anecdotal reports from individuals stating that "it hurts" to look at a face), it may be that variations in amygdala activity between individuals govern anxiety levels and subsequent face gaze behaviours. Indeed, findings across the literature are very mixed as to whether hypo or hyper-arousal is seen in response to faces in ASD. Similarly, anxiety measures were based on self-report rather than actual tests of anxiety (such as galvanic skin response [GSR]) and therefore it could be that the relationship between these and the amygdala is mediated by some other, more social, factor.

Research within both the clinical groups considered here and in typically developing individuals points to the fact that the amygdala appears to play a key role in the interpretation of emotions (Adolphs & Tranel, 2003; Schultz, 2005). It seems likely that its role may be closely related to levels of anxiety and arousal that may underlie the atypical profiles seen in WS and ASD (Dodd et al., 2010; Kleinhans et al., 2010). However, because the ASD profile is so broad in its characteristics, it may be that a more encompassing theory is also required. Deficits in possessing a theory of mind (ToM) have been proposed as an explanation for many of the social behaviours seen in ASD.

2.6.2 *The 'extreme male brain' theory of Autism*

Moving on from the amygdala theory of ASD (Baron-Cohen et al., 2000b), Baron-Cohen (2002) set out to explain the wider ASD social phenotype based on the fact that the majority of those diagnosed with the disorder are male. He stated that the male brain is typically more geared towards 'systemising' whilst the female brain is tuned towards 'empathising' and that the manifestation of autism is simply an extreme of the male brain type. He cites examples from the literature such as girls being more likely to share and take turns, less likely to engage in rough play and more likely to talk about their emotions, whilst boys are better at 'systematic' subjects such as maths and engineering, play more with toys such as Lego and show good attention to detail. However, it is worth considering that activities such as these can be interpreted in more than one way and 'systemising' and 'empathising' may not be as dissociable as Baron-Cohen (2002) suggests. For example, playing with Lego may be evidence of a systematic approach to play but it may also be evidence for empathy, in that children often invent stories about what the characters are doing and create a whole world for them. Similarly, turn-taking in girls' play could denote awareness of the feelings of others but is also evidence of following a system and understanding the rules of interactions.

Whilst the evidence cited by Baron-Cohen (2002) is somewhat subjective in its interpretation, the overarching argument is a promising one but may be better framed as an issue of internal versus external. For example, 'systemising' is concerned solely with external inputs: Observing a variety of factors, noting how they affect one another and predicting an output. Empathising, on the other hand, is about applying internal prompts to an external source. For example: I know when I receive a present it makes me feel happy, therefore this person I see receiving a present must be happy. This is more in line with possessing a ToM. Might it then be that the split between those with ASD and WS is in their use of external versus internal cues? Perhaps those with WS have a propensity towards social contact because they use internal cues (How *I* am feeling) without considering other external cues (such as an aggressive face) whilst those with ASD do not use internal cues at all and instead prefer to follow sources that enable straightforward systemising with no need for rule changes (such as objects)?

To draw together the research reviewed above, autism is such a heterogeneous disorder that no one encompassing theory can explain the varied symptoms. That individuals

perceive things at a local or featural level, and have difficulty in piecing individual aspects into a global whole seems to be fairly consistent; the extent to which this goes beyond the perceptual domain into language and more social skills remains to be seen. Individuals with autism also, generally, show difficulties in taking on the beliefs or knowledge of another in standardised tasks; in everyday functioning, this may underpin social behaviours, but functioning may also determine the types of compensatory strategy that individuals are able to put into place.

2.7 Heterogeneity and Overlap in Neurodevelopmental Disorders

When comparing the cognitive and social profiles of individuals with ASD and WS, the most striking difference is in the uniformity versus heterogeneity of IQ and language: Individuals with WS have consistently low IQs, standing in stark contrast to relatively spared language abilities. Conversely, those with ASD demonstrate very mixed levels of functioning paired with levels of verbal ability generally in line with IQ, and varying from non-verbal to pedantic speech. Both individuals with WS and ASD display a bias towards local processing, although this may be more in the *construction* than perception domain amongst those with WS. Individuals with both neurodevelopmental disorders also appear to have difficulties in forming a ToM; differences might emerge in this domain, however, with individuals with WS showing some understanding of *knowing* rather than *believing*, compared to an overall difficulty of those with ASD to put themselves in the mindset of another. Heterogeneity within both ASD and WS must be considered when attempting to pinpoint underlying causes of the social behaviours manifest in each disorder; similarly, the heterogeneous nature of these disorders means that there are points at which there may, in fact, be considerable overlap in the phenotypes of ASD and WS.

Little et al. (2013) have suggested, given the debate in the literature as to whether the social behaviours seen in WS are underpinned by frontal lobe (and inhibition) problems or more amygdala (emotion accuracy) atypicalities, that there might be different *subtypes* of WS. They therefore examined this possibility in 25 children and adolescents with WS (mean age 9.5 years). Participants were administered a forced choice emotion labelling task, an approachability rating task, and a modified Stroop task designed for pre-literate children (Archibald & Kerns, 1999). These tasks therefore measured emotion accuracy, social approach and response inhibition, respectively.

Little et al. (2013) used a method of cluster analysis in order to examine whether subgroups might emerge in which a tendency towards social approach could be differentiated by a particular aspect; examination of possible clusters within the WS profile revealed a striking example of how heterogeneous the disorder is: From a sample of only 25 participants, 4 clusters emerged, not correlated to age or IQ. Age and IQ also varied greatly *within* clusters. Further, it was found that response inhibition but not emotion accuracy could be used to separate out those individuals with high versus lower approach ratings on the standardised task. It is worth noting, however, that no self-report measures of social approach were included in this study, therefore it is not

possible to state that difficulties in inhibition response might underlie *real life* social behaviours. However, the mean approach ratings given were very high (3.05/4), suggesting a consistent tendency in WS to be likely to approach strangers. Participants in this study also performed consistently poorly in accurately labelling complex emotions (disgust/surprise/fear) as well as neutral faces, but these difficulties were not predictive of approach ratings. Plesa Skwerer et al. (2009) have reported a divide between accuracy in identifying emotions and physiological responses *to* emotional faces, perhaps suggesting that there is some intermediary mechanism governing the perception of and a propensity to *act* on the emotional expressions of others.

Little et al.'s (2013) research highlights the fact that, when analysing specific combinations of behaviours seen in WS, a heterogeneous pattern emerges, not necessarily driven by age or IQ. However, in line with the frontal lobe hypothesis, it may be that difficulties in inhibiting responses, rather than difficulties in accurately identifying emotions, are a consistent factor in approach behaviours. Searcy et al. (2004) have also raised the issue of to what extent IQ might determine the social profile seen in WS when IQ itself might not be constant. They employed a cross-sectional design of 80 adults with WS (aged 17-52 years) in which they conducted the Wechsler Adult Intelligence Scale (WAIS) at different age points in order to examine relationships between performance (PIQ) and verbal IQ (VIQ) scores with age. Using a standardised task such as this also allowed an examination of how the trajectory seen in WS might differ to those of a large normed TD sample.

Searcy et al. (2004) found that age was only related to PIQ and not VIQ or full-scale IQ, although 19 of the participants with WS had significantly higher VIQ than PIQ scores. This finding was corroborated by a longitudinal aspect of the design in which four participants who had previously been recruited (9.2 years earlier) also showed improvements in only PIQ. Normative TD data revealed a general trend towards a decline in PIQ after age 34, but this was not seen in the WS group. These findings demonstrate, again, a picture of heterogeneity in WS in which only some of those recruited were better on VIQ. It also suggests that WS has a very different developmental trajectory to that seen in the typical population. Of course, given the cross-sectional design of Searcy et al.'s (2004) study, it is not possible to confirm that changes seen with age were not concerned with some other, between-participant factors.

In an earlier study, Jarrold, Baddeley, Hewes, & Phillips (2001) did employ a longitudinal design in order to examine the relationship between age and IQ in WS. Jarrold et al. (2001) tested 15 individuals with WS (aged 6 years, 11 months to 28 years) every 8 months at six different time points using the British Picture Vocabulary Scales (BPVS) and the Wechsler Children's Intelligence Scales (WISC) block design subtest as a measure of visuo-spatial ability. They conducted a complex statistical analysis of the developmental trajectories seen over the course of the study and found that both measures improved with age, but the increase was greatest for vocabulary. There was a significant linear trend seen between vocabulary and VS measures, such that the magnitude of the difference between them increased with age; Jarrold et al. (2001) suggest this is indicative of a divergence between the two domains as a product

of age and experience. This also raises the issue of deficits versus delay in WS: Both skills *did* improve with time but at very different rates. This slower development of VS skills could be masked by studies that have not taken a developmental approach.

If there are definite improvements across development in WS, but operating at different rates depending on the domain being examined, it may be that comparisons that have been made between individuals with ASD and those with WS are not entirely accurate, especially if the developmental trajectories seen in ASD are quite different (Karmiloff-Smith et al., 2004). Lincoln, Searcy, Jones and Lord (2007) have claimed that there are aspects of the WS and ASD profiles that do show some overlap; they therefore examined which behaviours typically associated with autism (according to scores on the ADOS) might be seen in WS, and which symptoms might *differentiate* between groups.

Lincoln et al. (2007) examined 20 infants (mean age 41.6 months) with WS matched on age and IQ to children with a diagnosis of ASD. They administered the ADOS with all children and also conducted an analysis using specific measures on the ADOS to establish whether participants would meet DSM-IV criteria for a diagnosis of autism. Fifty-five percent of the individuals with WS met criteria on communication measures for a diagnosis of a pervasive developmental disorder not otherwise specified (PDD-NOS) whilst only 10% scored high enough to meet criteria when looking solely at the social domain. Two of the WS children met full criteria for a classification of autism.

Those with WS and ASD were comparable on their scores for gestures, showing, joint attention and pointing; however, those with WS could be differentiated from children with ASD by their levels of shared enjoyment, eye contact, facial expressions and social overtures/reciprocity. It is worth noting, however, that only a *lack* of these aspects of behaviour is coded by the ADOS schedule, therefore the atypically *excessive* behaviours seen in WS would not necessarily be captured by this type of measure. What these results do show, however, is that there may well be some overlap between the more physical traits in autism and WS (such as pointing and gaze following), perhaps underpinned by difficulties in the VS domain. It is this question of whether or not overlaps stem from the same cause that will be explored in the present research.

Klein-Tasman, Phillips, Lord, Mervis and Gallo (2009) have also compared children with WS (n=30) to MA and CA (ranging from 2.5-5.5 years) matched individuals with diagnoses of autism, PDD-NOS and disorders of a mixed aetiology, on ADOS measures. They divided their WS group according to ADOS scores and then conducted direct comparisons with members of the other groups in order to see if, within autism-type clusters, differences might still emerge. Klein-Tasman et al. (2009) found that, even in the group of WS participants where scores on the ADOS were very low and not suggestive of autistic traits, individuals with WS had more socio-communicative difficulties than did those in the mixed aetiology group. Individuals with WS, overall, showed fewer atypical behaviours across the ADOS than those with ASD and were most comparable to the infants with a PDD-NOS. Those with WS did, in all groups, show more reciprocal smiling than PDD-NOS participants, and had similar scores on measures of sharing and modulating eye contact as did those with ASD. Taken together, these findings point to the fact that there are overlaps between some of the social

behaviours seen in WS and ASD; however, again, subtle differences (such as limited versus excessive eye contact) would not be picked up by the ADOS, and it is these *differences* that might be modulating social behaviours.

One neurological model that attempts to explain the heterogeneity seen in ASD might also be helpful in elucidating the divides or overlaps between ASD and WS. Bachevalier and Loveland (2006) have proposed a neurological model of ASD in which the heterogeneous traits seen in the disorder are underpinned by an interplay between neurology and experience. They claim that the ventral stream (involving the amygdala and orbitofrontal cortex [OFC]) is concerned with the regulation of emotions and that connectivity dysfunctions in this region may be to blame for the social profile in ASD. They describe the amygdala and OFC as a ‘detector’ and ‘responder’ of and to emotions in which the amygdala weights the valence of emotional stimuli, coding for emotion, whilst the OFC is more concerned with the *expression* of emotion and anticipating reward. It could therefore be the case that problems with one or the other result in different patterns of social behaviour seen both within ASD and between ASD and WS. This offers a neat neurological explanation for the Little et al. (2013) study, in which response inhibition but not emotion accuracy appeared to be related to social behaviours.

Bachevalier and Loveland (2006) also note how the amygdala and OFC tend to develop at different points: The amygdala is typically fully developed at birth but the OFC begins maturing around 2 years of age and has been found to continue developing even into adulthood (Overman, 2004). It may therefore be that different social behaviours are a product of which brain region is affected in an individual, as connectivity with other regions and ‘cascade effects’ (Bachevalier & Loveland, 2006) may manifest very differently. It may also be the case that atypical behaviours might lie dormant for some time; this would explain the types of divergence reported by Jarrold et al. (2001) in the rates at which different cognitive skills might develop.

It is clear that, within both WS and ASD, there is great heterogeneity as to precisely which behaviours are manifest and the rate at which these develop. Some of the social behaviours seen in ASD can also be seen in WS, but the underlying mechanisms of these may be different. Individuals with ASD and WS both show a tendency to process things at a local level, teamed with social cognitive difficulties in understanding the thoughts and beliefs of another; the role that faces play becomes pivotal in how these two things relate in forming social interactions. Chapter 3 will summarise the literature on *face processing* in WS and ASD, drawing together evidence from studies that have directly compared individuals with these neurodevelopmental disorders. The experimental chapters that follow will focus on *specific* aspects of face processing in turn; therefore Chapter 3 provides an overview of behavioural evidence as to how individuals with ASD and WS process identities and emotions from faces.

Chapter 3: Face Processing in Neurodevelopmental Disorders

To begin to understand the mechanisms that drive the social profiles associated with WS and ASD, it is necessary to examine the purely perceptual strengths, weaknesses and atypicalities of face processing in these neurodevelopmental disorders. Can the atypical social exchange behaviours seen in WS and ASD be attributed purely to deficits interpreting facial identities or expressions, or does there appear to be something more ‘cognitive’ behind these profiles? This chapter will explore the literature on face processing in WS and ASD.

Researchers in the field have typically examined two different aspects of face perception associated with these neurodevelopmental disorders: Their overall abilities in terms of identifying faces and other social signals such as expressions (*what* they do); the *ways* in which they process faces (*how* they do it). This chapter will review the face processing literature in these domains.

3.1 Face Processing in Williams syndrome

Evidence from a variety of studies (Bellugi, Lichtenberger, Jones, Lai & St George, 2000; Karmiloff-Smith et al., 1995; Tager-Flusberg, Plesa Skwerer, Faja & Joseph, 2003) have suggested that individuals with WS are able to *identify* and differentiate between faces. The classic task that has been used to assess face recognition ability has been the Benton face task (Benton, Hamsher, Varney & Spreen, 1983). In that task, participants are shown a target face and are asked to detect the target face within a selection of distractor faces presented below it. Bellugi et al., (2000) reported that individuals with WS were able to perform as accurately as age-matched TD controls on this task. It must be noted, however, that the Benton task fails to pull apart which types of processing style may be used, and it could be the case that individuals were matching identities based purely on a feature, such as the eyes. Indeed, Duchaine and Nakayama (2004) found that patients with prosopagnosia (a condition in which patients with brain damage to the frontal gyrus are unable to recognise faces) were able to accurately match faces on the Benton task. As these patients have a definite deficit in the identification of faces, this suggests that it is possible to use more piecemeal strategies, focussing on specific cues perhaps, to perform well on this particular task.

Golarai et al. (2010) have also found in their sample of 16 adults with WS (mean age 19 years, matched to CA TD controls) that performance on the Benton task was comparable to TD adults, despite large differences in IQ. Participants in their study were, in addition to completing the Benton task, asked to passively view images of neutral faces, objects, landscape scenes and textures whilst in an fMRI scanner. The brain imaging revealed an FFA volume in individuals with WS that was on average two times the size of the FFA in TD controls. Moreover, it was only in the WS group that performance on the Benton task correlated with activation in the FFA region, although overall comparable levels of activation in the FFA in response to faces were shown

between both groups. Activity in the FFA was also enhanced in response to faces over any other type of image, in both individuals with WS and their TD matches. Golarai et al. (2010) suggest that the enlarged FFA in WS may, therefore, be responsible for accuracy on face identity tasks. As no heightened activation in the amygdala was seen in response to faces, which Haxby et al. (2000) have attributed more to the interpretation of *emotions*, they suggest that it is in this domain that more difficulties might lie in WS (Adolphs, Baron-Cohen, & Tranel, 2002). As no correlation was found between FFA activation and performance on the Benton task in the TD group, this might point to the possibility that different processing strategies might be employed by those with WS compared to TD adults.

In order to further pull apart the types of processing that individuals might be using when identifying a face, Tager-Flusberg et al. (2003) administered a part-whole paradigm to 47 adolescents and adults with WS (mean age 20 years, 10 months) using upright and inverted faces. This was precisely the measure later employed by Annaz et al. (2009) in which they found a more featural processing style in both WS and ASD. The logic behind such a paradigm is that, if faces are processed configurally, inverting the faces should disrupt the configurations so that the whole face advantage disappears. Tager-Flusberg et al. (2003) found that, whilst those with WS did have an *overall* poorer level of performance across the conditions, they did, however, show the same *trends* in performance. As predicted, the differences between part and whole matching disappeared in both groups when faces were inverted, and performance for upright whole faces was better than for those which were inverted. In both groups, performance on the Benton task predicted performance on the part/whole paradigm, although performance on this task was significantly poorer in the WS group. The authors of this study cite this as being evidence for configural processing in WS. However, their findings still point to inefficiencies in this system and the question remains as to why those with WS, despite apparently using configural processing, are unable to perform as effectively as their TD counterparts. It could be that the role of specific features comes into play: TD participants were found to be more accurate when the changed stimuli were eye (rather than mouth) cues; an effect that was not found in the WS group.

Whilst the findings of Tager-Flusberg et al.'s (2003) study does suggest typical processing patterns in those with WS, they do *not* show a sparing of abilities: Those with WS performed significantly worse than their CA matches overall. This points to the fact that perhaps configural processing needs to be in some way supported by other strategies in order for individuals with WS to accurately identify faces. Isaac and Lincoln (2011) have reported very similar findings to Tager-Flusberg et al. (2003) in that those with WS appear to demonstrate typical patterns of face processing but not to the same level of ability as their TD peers. In their study, they compared 10 WS adults to developmentally delayed (DD) MA and TD CA matched controls using a thatcherised faces paradigm. This paradigm involves the manipulation of eye and mouth features such that they are rotated, giving the face an unnatural appearance. Stimuli are presented in both upright and inverted conditions, the logic being that if processing is featural, performance for the thatcherised (versus non-thatcherised) faces in the inverted condition will improve because the features are restored to their natural appearance.

However, if faces are processed configurally, this advantage would not exist because the configurations are still disrupted. Participants in the Isaac and Lincoln (2011) study were shown pictures of a target face with two choices, one of which matched perfectly and the other with some dimension changed. The targets were a combination of happy/neutral expressions in upright/inverted orientation with thatcherised/un-thatcherised faces. Participants were asked to choose the face which matched the target.

Isaac and Lincoln (2011) found that all groups were more accurate on correctly matching the upright face targets overall and no differences were found between happy and neutral emotions overall. In all groups, accuracy was best for the upright rather than inverted thatcherised faces with no differences between the thatcherised and non-thatcherised faces in the inverted condition, suggesting intact configural processing. Despite the same trends across tasks, however, those with WS performed significantly worse than the TDs in overall accuracy, again suggesting that some factor other than processing style may be at play. They were, however, significantly more accurate than the DD group, which suggests that there is something beyond IQ driving task performance.

Whilst the findings of Isaac and Lincoln (2011) do support those of Tager-Flusberg et al. (2003), this study was lacking in that it failed to report any data regarding interactions between group and condition. As well as providing no information as to precisely which features and configurations were manipulated in the foil stimuli, no data were provided as to the effects of different combinations of the stimuli on accuracy. It might be that the WS participants excelled in one particular area, perhaps masking deficits in others, or that certain profiles that were atypical may have emerged as a consequence of such an analysis. Future researchers must be sure to explore and report the full wealth of information that they have available. These types of interactions will be analysed in the present research.

The above studies suggest that individuals with WS may be competent in *identifying* faces, using typical configural strategies, although not to the same efficiency as seen in TD individuals. Adolphs et al. (2002) have shown that patients with brain damage to the amygdala are far less competent in recognising *emotional expressions*; given that there may also be dysfunction in the amygdalae of individuals with WS (reviewed in section 2.3.3) it then follows that they may also be expected to show difficulties in the recognition of emotions.

In their study comparing WS participants to both CA matched TDs and a MA/CA matched DD sample, Skwerer, Verbalis, Schofield, Faja and Tager-Flusberg (2006) observed a mixture of findings, depending on the task employed and comparisons made. For their first experiment, Skwerer et al. (2006) gave participants (43 adolescents and adults with WS, mean age 20 years, 8 months) a version of the classic eyes task (Baron-Cohen et al., 2001) in which they were presented with stimuli of only the eye section of faces and were asked to choose from two labels of complex emotions which one best matched. Each image was presented twice and only those correctly identified *both* times were credited as a correct response, in order to reduce correct responses by chance. It was found that those with WS performed significantly less accurately than the TD

sample and were comparable to the DD group, suggesting that those with WS are not spared in emotion identification. However, it may well be the case that, if given the same task with whole face information, performance might have increased and this possibility cannot be ruled out. Similarly, rather than having the strict criteria of two correct responses to the same stimuli (whereby participants might change their answers the second time because they thought this would increase their chances of a correct response), it might have been more useful to provide more than two labels instead, elucidating precisely which emotions are more difficult or tend to be defaulted to in cases of uncertainty. It is also worth noting that one third of Skwerer et al.'s. (2006) WS sample *did* perform as well as the TD controls; given the high variability within the clinical groups, it would be worth looking at the differences between the high and low performing groups on the standardised tasks. This is especially important given the fact that, on the Benton task of face identity that was administered to participants, those with WS were only found to perform significantly worse than the TD matches at a borderline level, whereas those with developmental delay were clearly significantly poorer than both other groups.

In their 2nd experiment, Skwerer et al. (2006) wanted to examine if differences might appear when the stimuli were of a more real-life and dynamic nature. The same clinical participants alongside a new cohort of TD participants were asked to freely state what emotions they felt to be depicted in moving expressions. These expressions had previously been labelled by consensus by TD adults and a response was deemed 'correct' provided that it didn't conflict with these labels. For example, a response of excited or surprised or enthusiastic, etc. would be classed as correct for a face labelled 'happy' but a response of nervous, scared, etc. would not. This method of scoring is worthy of note because it may be slightly subjective. Nevertheless, a similar pattern of results to experiment 1 was found in that the two clinical groups did not differ from one another, and both performed significantly worse than the TD matches. However, when analysing a break-down of performance for the different emotions, those with WS did perform as well as their TD matches for the emotions labelled 'happy', 'sad' and 'angry' and were only differentiated by the more complex emotions of fear, surprise and disgust, as well as the neutral faces. Skwerer et al. (2006) explain the fact that more mistakes were made on the neutral faces in that perhaps those with WS felt they *had* to find a label, whereas TD participants might have better understood that a face can be emotionless.

Skwerer et al. (2006) also note that scores from experiment 1 and 2 correlated in those with WS but not the DD group, perhaps suggesting more of a fundamental issue with the interpretation of emotions in this population, rather than some artefact of task demand. However, because both the animism of the emotions as well as the type of paradigm were changed (explicit choice versus free labelling), it is not possible to pinpoint precisely what factors might underpin this link. Interestingly, in both experiments, the scores of those with WS on the experimental tasks only ever correlated with their standardised face identity scores, whereas the DD group's performance only correlated with IQ measures. This may suggest that there is something about 'the face' driving problems in interpreting emotions in the WS group, rather than IQ. The ultimate

finding from this study does seem to be that those with WS are not as competent as their TD counterparts in interpreting facial emotions, especially those that are more complex and demand more cognitive appraisal.

Addressing several of the issues raised by the Skwerer et al. (2006) study, Riby and Back (2010) have also explored how individuals with WS interpret complex emotions from dynamic faces. They matched 18 WS participants (mean age 13 years, 8 months) to both CA and MA controls and asked them to watch dynamic faces depicting one of eight complex emotions (such as relieved, disapproving, etc.) in which whole face information was available or the eyes/mouth were frozen and neutral. Participants had to choose the label that best matched from a choice of four possibilities. It was found that, over all conditions, those with WS had the significantly lowest performance although they did show the same trend as both other groups in that interpreting emotions from *whole* faces was the most accurate, even reaching levels comparable to CA matches in this condition. However, the main differentiating factor of interest was the observation that only the WS group's scores dropped significantly as a consequence of the eye cues being frozen. No differences were found on performance for particular emotions in any of the groups. This pattern of results observed by Riby and Back (2010) is intriguing because it suggests that, when dynamic whole face information is available, those with WS can identify emotions as accurately as their CA matched peers. This might appear as evidence that those with WS do process emotions using a holistic style; however, the fact that performance dropped in the WS group when eye cues were frozen points to an over-reliance on individual features, and the eyes specifically, in interpreting facial expressions. It is difficult to ally these findings with those of Skwerer et al. (2006), however, who found that those with WS were very poor in identifying emotions from eye cues alone.

To sum up the overall face processing profile of individuals with WS, it looks to be the case that they are better able to *identify* faces but struggle more with the recognition of facial expressions. This would explain some of their approach behaviours in everyday life, although does not necessarily explain why they do not appear to differentiate between strangers and people familiar to them, when choosing who to approach (Frigerio et al., 2006). Plesa Skwerer et al., (2009) have proposed that social approach in WS might be underpinned by the fact that individuals fail to habituate to faces, promoting a renewed interest in approaching others. Using the premise that heart deceleration is a signpost for habituation to faces, they examined heart rate changes in 29 adolescents and young adults (mean age 19 years) matched on CA to TD controls and both CA and MA to a group of individuals with learning disabilities (LD) shown dynamic clips of facial expressions. Participants were asked to watch three 5 minute clips of the 6 basic facial expressions (happiness / sadness / surprise / fear / anger / disgust) and neutral faces; depictions of the emotions were muddled up throughout the clips, and interspersed by a neutral scene of a landscape. Participants were also given a free labelling task of the emotions depicted.

Plesa Skwerer et al.'s. (2009) results showed that individuals with WS were comparable to LDs but significantly worse than TDs on the free labelling task, with all groups being

the least accurate in identifying fear, and best in identifying happy faces. Those with WS and LDs also tended to misattribute negative emotions to neutral faces. No correlations between physiological arousal and performance were found in any of the groups. However, compared to both controls, individuals with WS had significantly reduced arousal during the movie clips; specifically, when watching movies of angry and surprised faces, individuals showed reduced heart deceleration compared to controls, suggesting less habituation and more interest in those types of faces. This was teamed with lower levels of arousal measured by skin responses when viewing negative (angry and sad) faces. It is worth noting, however, that different emotions were displayed in quick succession, with only a short clip of a neutral scene, therefore it is perhaps not possible to accurately deduce precisely which depictions of emotions triggered which physiological responses.

Plesa Skwerer et al.'s. (2009) study does point to the fact that individuals with WS do not habituate to faces in the same way that typical individuals might, and fail to show the typical pattern of autonomic arousal in response to negative faces. However, the lack of any correlation between *accuracy* for identifying emotions and atypical patterns of physiological arousal suggests that something else may be driving social approach behaviours. It is therefore important to examine not only the *perception* of faces in neurodevelopmental disorders, but a broader *cognitive* understanding as well.

3.2 Face Processing in autism

One of the hallmark characteristics of ASD is their general avoidance of, or nonchalance towards, social interactions and a lack of attention to faces (Riby & Hancock, 2008). Such a profile stands in stark contrast to that of individuals with WS, who appear to seek out and thoroughly enjoy social interactions (Doyle et al, 2004). Where and why these profiles are so different, given seemingly similar visuo-spatial processing deficits, may therefore be concerned with attention to faces *specifically*.

Given the heterogeneity seen in ASD, it is not surprising that findings across studies as to how effectively individuals can identify and recognise emotions from faces, are mixed (Behrmann et al., 2006a). Golarai et al. (2006) report in their review of the literature how individuals with ASD show poor *memory* for faces (recognising whether or not a face has been seen previously), but appear to be competent on tasks that are more concerned with *matching* facial identities. Baron-Cohen et al. (2001) also note that individuals with ASD are able to perform as accurately as their TD peers of the same age on the Benton task, but show clear deficits when asked to recognise *emotions* from faces. Like in WS, it may be the case that there is a divide between these domains, perhaps underpinned neurologically.

Behrmann et al. (2006b) have explored the relationships between processing style and face recognition in individuals with ASD. Fourteen adults with a diagnosis of ASD were compared to two TD adults of the same CA and MA; the first experiment compared participants in their response times in discriminating between faces and

objects whilst two other experiments examined evidence of global versus local processing of non-face stimuli. The results suggested that individuals with ASD were significantly slower than TD peers in distinguishing between both faces and objects, and this correlated with a tendency towards adopting a local processing bias in those with ASD. Behrmann et al. (2006b) therefore conclude that the bias towards attending to local features seen in ASD underpins and is detrimental to their ability to discriminate between faces.

An eye tracking study by McPartland, Webb, Keehn & Dawson (2011) offers some compelling evidence that those with ASD may, however, process faces in a typical manner using configural information but also goes on to pinpoint where the underlying problems might be that drive poor face identification in ASD. In their study, 15 HF individuals with ASD (mean age 12 years) were matched to TD controls of the same CA and MA. A battery of standardised face and pattern recognition tasks were administered and participants were also asked to simply look at stimuli whilst being eye tracked. These stimuli were comprised of upright and inverted human faces, monkey faces, two-dimensional geometric patterns and Greebles (objects composed of different 'nodes' arranged in specific configurations). Additionally, participants were asked to complete a questionnaire to assess social adaptation.

The standardised tasks revealed that those with ASD were significantly less accurate in identifying faces compared to controls, but no difference was found on the recognition of patterns, indicating that any deficits in processing might be specific to faces. This goes against the findings of Behrmann et al. (2006b), however, who showed similar patterns of performance when discriminating faces and objects in individuals with ASD. In terms of gaze patterns in the ASD group, analysis of the eye tracking data revealed relatively typical patterns when compared to controls. For example, both groups tended to pay more attention to the upper areas of human and monkey faces, indicating that they realised the importance of cues in this area. Similarly, for inverted human faces, both groups showed *reduced* attention to the eyes, perhaps because they were presented at the bottom of the stimuli and this is typically a less useful region to look at. This may also be evidence of configural processing in that it shows disruption of those parts of the face that would be attended to in an upright condition. Both groups spent more time attending to the upper regions of faces than objects; however, the only differentiating factor in eye gaze patterns was the fact that those with ASD spent significantly more time attending to this region of objects compared to controls. This might indicate that those with ASD were not aware that this region of *objects* would provide less social information than in faces, or it might be that individuals with ASD have a tendency to employ one blanket strategy that typically works and are unable to adjust this accordingly. This is a plausible explanation given the correlation also reported, only in the ASD group, between social adaptation scores and performance on the face recognition tasks. It may therefore be that a 'strength' in ASD is the ability to make judgements based on appropriate cues, but transferring the knowledge of what entails an appropriate cue is more of a difficulty, as is interpreting what the combined cues mean.

Another factor worth considering, aside from which specific cues might be most beneficial to those with ASD, is how the *familiarity* of the face might play a part. In WS, the familiarity of a face clearly has no bearing on whether or not individuals choose to approach that person in real life (Frigerio et al., 2006) but less research has been conducted to explore the effect of familiarity on processing in ASD. Pierce and Redcay (2008) compared 11 children (mean age 9 years, 9 months) with HF ASD to CA TD children on a task in which they had to press a button when shown two consecutive faces depicting the same identity. The faces were either photos of friends and family of the children, or photos of strangers and also objects. fMRI brain imaging was conducted whilst participants performed this task. Analyses of brain activity revealed comparable patterns of activation in the FFA between those with ASD and their TD peers in response to *familiar* faces. However, when presented with unfamiliar faces, only 25% of the activation was seen amongst individuals in the ASD group; this was teamed with poorer accuracy and slower response times for face matching.

Pierce and Redcay (2008) suggest that their findings point to a divide between neurological activity when processing familiar and unfamiliar faces in ASD, not seen in TD peers. It may be that familiar faces are processed in a different way because individuals with ASD have *learnt* to attend to specific cues that they know on those people; when presented with a novel face, they struggle more to process unfamiliar features and/or configurations. However, Pierce and Redcay (2008) do not state whether any of the images used in their study depicted emotional expressions, and this may have been determining some of the patterns of results seen.

The role that experience plays in shaping neural architecture has been discussed by Gastgeb, Wilkinson, Minshew and Strauss (2011): The amount of time that a person spends attending to faces will have some impact upon how the brain processes those faces in future and the level of 'expertise' that is developed. Whilst the majority of researchers have posited a more bottom-up theory of deficit in ASD (Riby, Doherty-Sneddon, & Bruce, 2009) whereby configural processing is at the heart of the problem, Gastgeb et al. (2011) suggest that a top-down, experience driven approach is more in line with the neurological evidence. Using the prototype paradigm employed by Valentine (1991), they used eye-tracking on a group of 20 HF ASD adults matched on CA/MA to TD controls. They hypothesised that the ASD group would not be more likely to choose prototypical faces over faces containing previously seen features, as familiar, unlike TDs; this inability to form prototypes, they claimed, is from where the deficits in ASD stem.

As predicted, Gastgeb et al. (2011) observed that those with ASD chose the prototype faces significantly less often than their TD peers, with only 40% of the sample choosing the prototypes on at least 4/6 trials, compared to 75% of the TD sample. With this criteria (selection of prototype on 4/6 trials) set as a measure of 'good' versus 'poor' performers, Gastgeb et al. (2011) further analysed the relationship between ADOS scores and task performance and found a correlation between those ASD individuals who scored high on incidences of stereotyped/restricted interests/behaviour and poorly on the experimental task. Whilst this link was not explored further, it may be suggestive

of a more social aspect to face processing in that those who are more likely to stick to rituals (that perhaps do not involve interacting with faces) are the least likely to use a prototypical method. Further, if more *configural* problems exist in ASD, they may have simply struggled to differentiate between the two faces initially rather than having difficulty in forming the prototypes. However, this looks less likely when considering the eye tracking data collected by Gastgeb et al. (2011): The results were unexpected in that those with ASD spent the same amount of time looking at faces as did the TDs, and paid equal attention to the relevant aspects of faces. Similarly, there were no differences within the groups in attention to specific facial features, although those with ASD did spend significantly longer than TDs in looking at mouths, and this was marginally less time than was spent looking at the eye region.

Whether or not a prototype model of face processing is more fitting than the configural model for explaining some of the difficulties seen in ASD remains to be seen, but the fact that experience may differentially drive the face processing abilities of those with ASD is a compelling idea that is supported by the neurological data (Golarai et al., 2006). The eye-tracking aspect of Gastgeb et al.'s (2011) study also hints at the possibility that eye cues are not used as effectively as they are in the TD population; interestingly, an over-reliance on eye cues may also be detrimental in the WS population.

Evidence for the fact that those with ASD *do* attend to faces in a typical manner comes from Fletcher-Watson et al. (2009). They argue the case that many studies claiming abnormal processing of faces in ASD are based on static, isolated faces in which no social or contextual information is available; this in no way reflects the real-life scenarios in which social interactions take place. They therefore designed a task in which participants (12 HF adolescents and adults with ASD compared to CA matched TD controls) were asked to either simply look at a screen split into one social and one non-social scene, or were asked to make a judgement as to whether the person in the social scene was male or female. The scenes were carefully divided into specific portions for the purpose of the eye-tracking component of the analysis, in order to pinpoint even small differences as to where those with ASD, compared to TDs, might look.

When analysing the areas on which participants focused, the perhaps surprising finding was that no differentiating patterns emerged between those with ASD and their typical controls: As would be expected in typical development, more attention was paid to the person when identifying gender, and both groups looked more at the person than the background in this condition. Interestingly, both groups looked more at other parts of the face than the eyes specifically when identifying gender. Even in the free view condition, in which those with ASD had no explicit reason to examine the face of the person, no differences were found between face gaze time between TDs and ASDs. These findings not only suggest that those with ASD, who are relatively high functioning on the autism spectrum, understand which cues to utilise when asked to make gender judgements, but also fail to show a lack of attention to social scenes. However, it must be considered that there was no emotional face content in this

experiment: All faces were of a neutral expression. Therefore it may be that a lack of attention to the eyes was driven by different reasons between the two groups: Perhaps those with TD acknowledged that the eye region of a neutral face would not assist in identifying gender, whereas those with ASD simply avoided looking at the eye region because they didn't *want* to make eye contact.

Accuracy for identifying emotions in ASD has been explored by Rump, Giovannelli, Minshew, and Strauss (2009). They showed 19 HF ASD children (aged between 5 and 7 years) compared to CA matched TD children, dynamic images of emotional expressions (happy, sad, angry and fearful), which they were asked to label. The same experiment was then repeated with a much larger sample of ASD participants (matched to CA TD controls), to examine possible developmental changes. Participants were grouped according to age into 8-12, 13-17 and adult categories. Rump et al. (2009) found overall poorer accuracy for the identification of all emotions in ASD compared to TD groups, regardless of age. In the TD cohort, improvements in performance were found with age; such improvements were not found between the age-groups amongst those with ASD. These findings are strong evidence for the fact that individuals with ASD do struggle to accurately identify emotions and this appears to be a deficit that does not improve with age/experience. Precisely which mechanisms may not develop to underpin this stagnation in performance is yet to be deduced.

Kleinhans et al. (2010) have suggested that there is a complex relationship between the recognition of emotions, the physiological response to emotions, and social anxiety in ASD. They compared 31 HF adults with ASD to TD peers of the same CA and MA on a matching task featuring images of faces depicting anger and fear, as well as round shapes. Participants performed the task whilst in an fMRI scanner, and were also asked to fill out self-report measures to assess their levels of everyday social anxiety. Kleinhans et al. (2010) found that individuals with ASD performed comparably to TD adults in terms of their task accuracy; neurologically, individuals with ASD showed greater levels of activation in the occipital lobes for faces versus shapes than was seen in TD controls; Kleinhans et al. (2010) suggest this may be indicative of the fact that individuals with autism process faces more like objects. Further, less activation in the FFA was seen for faces amongst those with ASD than in the TD group, compared to *increased* amygdala activation; this pattern of neural activation correlated with higher measures of social anxiety in the ASD group. It therefore may be the case that more socially anxious individuals with ASD have a heightened sensitivity to faces; whether this is a cause of or caused by atypical activation in the FFA and amygdala remains to be seen. Given that performance in recognising emotions was similar between those with ASD and TD peers, however, it cannot be concluded that social anxiety is a result of being unsure about facial expressions. Similarly, it would be interesting to examine whether the same patterns emerged for fear and anger separately.

In a direct comparison of the recognition of emotional and non-emotional faces in adults with intellectual disability as well as those with a comorbid diagnosis of ASD, García-Villamizar, Rojahn, Zaja and Jodra (2010b) observed that those with the additional ASD diagnosis were poorer than controls on both types of task, although better on the non-

emotion conditions. The tasks were comprised of an identity discrimination paradigm, emotion matching/labelling tasks, and an age labelling/identity matching task. Social adaptation measures (using the VABS) were also taken. When correlating performance with measures of social adaptation, only the expression measures showed a significant correlation and only in the comorbid group. These findings mirror those of Kleinmans et al. (2010). Garcia-Villamizar et al. (2010b) claim this as being evidence for the fact that some of the social deficits seen in ASD may stem directly from problems in processing emotions from faces, rather than any difficulties in identifying the face initially. This is an important distinction when one considers the social behaviours seen in neurodevelopmental groups.

One study to explore divides between emotion and identity processing in ASD is that of Kirchner, Hatri, Heekeren and Dziobek (2011). In their study, Kirchner et al. (2011) recruited 20 HF adults with ASD and compared them to a sample of TD adults matched on CA/MA. Participants were given a standardised eyes task (Baron-Cohen & Wheelwright, 2010) and a face memory task and were also asked to complete two experimental tasks in which they were asked to make judgements about the sex/age of faces and identify 1 / 2 emotions from faces (always negative). Participants were eye-tracked during the tasks. On both the face memory and eyes task, those with ASD were found to perform significantly worse than controls. Those with ASD were comparable in identifying emotions but were significantly worse than controls on measures of face *identity*. The eye tracking data revealed less fixation to the face areas of interest in the ASD group, with no differences reported between the groups for attention to the eyes or mouth, supporting the suggestion of Riby and Hancock (2008) and Riby et al., (2009) that those with ASD show a general inattention to faces generally.

Just as Gastgeb et al. (2011) found a correlation between ADOS measures and performance in their task, Kirchner et al. (2011) also found a borderline significant negative relationship between social scores on the ADI-R and eye fixations in the ASD group. Eye fixations and task performance for emotion recognition also correlated positively in the ASD but not TD group. This lack of a relationship in the TD population is interesting and may highlight the fact that TD individuals utilise a variety of cues and other, perhaps more social cognitive factors, may be involved. This is corroborated by the apparent link between atypical social behaviour scores and deviant eye fixation patterns. The most robust finding to come out of the results was that, in the ASD group only, a negative predictive (regression) relationship was found between mouth fixations and performance in both conditions. Therefore, even though those with ASD do not appear to look at the eyes less than controls overall, they *do* use mouth cues disproportionately more, and this impacts upon both the recognition of identities and expressions. Those participants with ASD who did fixate on the eyes more tended to have better performance, although this was not a predictive relationship seen for the emotion condition in any of the groups. It therefore might be that, in ASD, over-reliance on mouth cues, rather than inattention to eyes, poses the greatest problem.

In summary, it would appear that those with ASD employ atypical processing mechanisms when interpreting both emotions and identities of faces. Like in WS, this

deviance may be due to an over-reliance on certain, inappropriate, cues. Whether this deviance is due to problems in perceptually processing certain aspects of features or in *understanding* when and why certain features are most useful, remains to be seen. Interestingly, the abilities of those with ASD to recognise facial identities and emotions seem to relate to their levels of social dysfunction as measured by schedules such as the ADI-R (Kirchner et al., 2011) and ADOS (Gastgeb et al., 2011), therefore it is looking more likely that there is some degree of social cognitive deficit involved.

3.3 Comparisons between WS and ASD

The above studies review the face processing literature in which cohorts of individuals with ASD and WS have been examined separately on different tasks, often compared to individuals who are developing typically. This makes it difficult to draw any firm conclusions as to the divergent / similar strengths and deficits individuals with these neurodevelopmental disorders might have. Given the markedly low IQ seen in WS, it is not reliable to run *direct* comparisons of individuals with WS and ASD without factoring out IQ. However, examining and comparing the types of trends and patterns seen in face processing strategies employed by those with WS and ASD can be very informative. A brief summary of studies that have conducted such comparisons is now detailed below.

Annaz et al. (2009) employed a part-whole paradigm and a trajectory analysis method, in order to pull apart the types of processing seen in ASD and WS, as well as the importance of eye versus mouth cues, and how these compared with the TD population at different stages of development. Testing a sample comprised of individuals with ASD (split into high and low functioning groups to explore within disorder heterogeneity), WS and DS, compared to a range of TD children using developmental trajectory mapping, they administered a task to participants using the classic part-whole paradigm (but with the memory demands removed) in order to assess whether participants in the clinical groups would use holistic or featural styles of processing. Further, whether there would be different patterns between the groups in terms of how eye versus mouth cues were utilised.

Annaz et al. (2009) found evidence for a more feature-based style of processing in the WS and ASD groups alike, in that performance for the part condition was consistently better than for the whole. This stood in contrast to what was seen in the TD comparisons. Unlike in the TD population, the inversion effect for parts did not disappear in the WS group, whilst it did for the whole faces; again suggesting a more featural style of processing in WS and a lack of using configural cues. This effect was found to be greater for manipulated eye versus mouth cues in WS but such a pattern was not observed in those with ASD. Annaz et al. (2009) conclude from their study that, in both ASD and WS, there does appear to be an atypical style of processing faces, with more reliance on features than in holistic analysis of configurations. In WS, this attention to features seems to be most prominent for the eyes; a finding that Riby and Back (2010) have also noted in the processing of facial emotions. It therefore may be

that the deficit in WS is not necessarily in an inability to process faces using configurations but in an excessive attention to eye cues when they are made available. The question remains as to why this might be.

It has been hinted that perhaps an over-reliance on eye cues may be involved in deficient face processing. Riby and Hancock (2008) have shown in their eye-tracking study comparing those with WS and ASD to both CA and MA TD counterparts that, indeed, individuals with WS do tend to spontaneously fixate on the eye region of faces. In their study, participants were asked to look at natural social scenes containing both objects and people whilst in an eye tracker. No particular extremes of emotion were used and none of the scenes had any negative content. The results showed a clear difference between the groups, in that TD children appraised the entire scene, shifting their gaze to all aspects that could give information, whereas those with ASD generally did not focus on the face areas of the scenes at all; those with WS paid excessive attention to faces, especially the eye region. Riby and Hancock (2008) therefore conclude that the preferences of children with WS and ASD in terms of attention to faces seem to differ greatly and the reasons behind these atypicalities could also be very different. It may be, for example, that those with WS have problems in disinhibiting gaze from the socially salient aspects of scenes, or perhaps they do not realise that other areas of a scene beyond the face can provide valuable information. Those with ASD, conversely, may find looking at faces uncomfortable, or perhaps find they can better interpret more 'clear-cut' cues that objects may afford. *Attention* to faces is a different mechanism than the *processing* of faces, and the ways in which social motivation plays a role in the ways that these two aspects are related is relatively unexplored.

One comprehensive study to explore the face processing profiles of those with ASD and WS is that of Lacroix, Guidetti, Rogé and Reilly (2009). They compared each clinical group to MA matched TD controls on a battery of five experimental tasks aimed to assess both emotion and identity processing of faces. For the identity measures, participants had to state whether faces were male/female or had their eyes open or closed. For the emotion tasks, they either had to state how a face was feeling (free labelling), were asked to match one of three faces to a target who 'felt the same' (matching) or had to point to the face who was feeling a specified emotion (identifying). Only basic emotions were used in these tasks as well as some neutral faces. The researchers found that participants with ASD were comparable to their matches on all of the emotion tasks but were not as accurate in identifying the female faces. Conversely, those with WS performed as well as controls on the face identity tasks but were significantly less accurate on the identity measure of emotion.

The findings of Lacroix et al. (2009) might initially suggest that individuals with ASD are able to interpret emotions from faces, even when asked to freely label them and not given an explicit choice, although they struggle with identifying faces. This stands in contrast to the WS group in this study, who had difficulty in matching faces to a given label rather than the other way around; a result that may be indicative of an inability to *understand* the relevant face cues. However, one very large confound, which the authors fail to adequately address, is the fact that those with ASD in this cohort had taken part

in an intervention program focused on interpreting social signals, therefore it is more than likely that these same results would not be replicated with a different sample. Indeed, Riby, Doherty-Sneddon and Bruce (2008) have noted an opposite pattern of results. It is therefore important to look at other studies which might offer some corroboration that this is a genuine pattern in those with ASD.

Riby et al. (2008) have noted that a lot of the inconsistency throughout the literature may be due to the fact that different studies have explored one area of face processing without using the same methods or even investigating the same domain as other studies from which they are trying to draw a consensus. In their study, they therefore compared the same WS and ASD individuals across a variety of face processing domains, matched to a developmentally delayed (DD) MA sample. Their aim was to establish whether the model of face processing initially proposed by Bruce and Young (1986) and developed by Haxby et al. (2000) could be applied to those with WS and ASD. In other words, would there appear to be a dissociation between the processing of identities versus the processing of emotions, and in what ways would these profiles differ between the groups?

In order to test this, Riby et al. (2008) gave participants four tasks to complete whereby each task had a recognition aspect ('tell me which face is happy/looking at you/saying "boo",' etc.) and a matching component. The expression task required participants to identify a facial expression; the identity task required them to identify a face; a gaze task involved participants having to process the gaze direction of a face and the lip reading task required participants to process the sound that the lips would make. In having such a comprehensive test battery, Riby et al. (2008) ensured that they were able to pull apart the differences and overlaps both within and between the groups in terms of their strengths and weaknesses in different face processing domains.

One general trend that emerged across all groups in this study was that the *recognition* aspects of each task resulted in higher accuracy than those utilising a matching strategy. This may be because it places fewer demands on appraisals of the faces in that it only requires the participant to make a choice rather than having to compare the details of each face to one another. Muñoz et al. (2010) however, have noted in their fMRI study that patterns of neural activation between labelling and matching tasks did *not* differ in their WS sample. Similarly, on the identity task, all groups' performance dropped when the external features of the faces were removed, suggesting reliance on peripheral cues in these populations. However, those with WS were the least affected, therefore it may be that they do employ a more typical pattern in using central face cues. Interestingly, those with WS performed better than their matches on the expression and gaze tasks whereas those with ASD had the strongest performance on identity and lip reading.

Another difference to emerge between those with WS and ASD was in their accuracy for specific emotions: Whilst those with WS were comparable to their matches in that identity of happy/sad was comparable and better than angry/surprised, those with ASD showed a clear drop in performance when identifying surprise, being significantly worse than their matches. Baron-Cohen, Spitz and Cross (1993) have observed a similar difficulty in identifying complex emotions such as surprise, amongst children with

autism. Furthermore, there was no advantage for sad emotions over angry emotions amongst those with ASD, as seen in the WS group. This highlights the fact that different emotions may either be processed in different ways or may hold a different cognitive salience to those with WS and ASD.

In order to further corroborate their results, Riby et al. (2008) ran a direct comparison of the WS and ASD group, with those participants who were not matched on MA excluded from the analysis. A significant interaction between group and domain was found, with those with WS being significantly better on expression and gaze tasks. A particularly important differentiating factor between the groups was the finding that, in the ASD group only, correlations were found for performance on the identity and gaze expression tasks. The Haxby et al. (2000) model would not predict any relationship between these two domains, which are believed to be underpinned by entirely separate neural processes. This may therefore suggest that either atypical brain regions are involved in the processing of faces in ASD or that some other strategies are put into place that mean similar strategies in emotion and identity processing emerge. The fact that CARS scores (a measure of autistic symptomatology) were found to negatively correlate with overall performance (more severe autism=poorer performance) lends further support to the argument that the nature of autism may be causing atypical processing strategies.

In terms of drawing conclusions from the Riby et al. (2008) study as to what strengths and deficits those with WS have, it appears as though they have problems in identifying faces but are relatively competent in interpreting emotions. This may be suggestive of a configural problem that is somehow compensated for by the socially salient aspects of emotional content. The opposite pattern is seen in ASD, although this group were still no better than their MA matches on lip and identity performance; these were just relatively good in comparison to the deficits found on gaze and expression. The fact that there may be a link between identity and expression processing in ASD may be to blame for deficits in both. The fact that it is the *socially relevant* aspects of face cues that seem to be the differentiating factor between the groups is most of interest and will be a core consideration of the present research.

3.4 Overlaps and Dissociations: A Framework

The evidence reviewed thus far has highlighted similarities and differences in the face processing abilities of individuals with WS and ASD, but what might be driving these? If, as is looking to be the case from both behavioural and neurological studies, the social interaction deficits in ASD and WS stem from the same biological root (involving the amygdala, FFA and OFC) but do not neatly map onto any specific issue with any one particular emotion, then it must be that the divergence lies on the more cognitive level. When viewing an emotional expression, how do those with ASD and WS appraise their own subjective experiences of that emotion and to what extent are they able to interpret these feelings in terms of what that other person might be feeling? Any atypical appraisals at any point along this route might lead to the branching of behaviours seen in WS and ASD.

The emotional *significance* that we attach to a face is absolutely key in both how well we will attend to that face and how we will interpret it. Very little research has attempted to explore the *subjective* experience of emotion in ASD and WS, mainly because of the constraints of attempting to quantify such a concept in populations with low cognitive and verbal ability.

Schultz (2005), in his review of the role of the amygdala and FFA in autism, states that early dysfunctions in limbic brain regions will result in less attention to the detection of faces, corroborated by the diagnostic criteria for ASD that children look at faces less. This then means that faces do not hold any particular salience for individuals with ASD and so no expertise is ever achieved. This issue of ‘expertise’ is an important one, as one of the criticisms on the body of FFA research is that no single study can unequivocally show that it is the face itself, rather than the familiar configuration, that promotes activation in this brain region (Ganel et al., 2005; Tong et al., 2000) Is expertise purely about the rapid identification of features? Or does it require some affective investment? If it can be established that the social deficits seen in ASD and WS stem from early, subcortical abnormalities in the amygdala which may be purely perceptual, the divergence in the behavioural profiles of these two groups is then likely to be more concerned with the *social* salience they give to their interactions. Perceptually, it would appear that neither group can be an ‘expert’ but, in WS, there appears to be something else driving a desire for social engagement that is lacking in ASD.

3.5 Overview of Research

The literature outlined here has offered a broad overview of face perception in typical development and where the core strengths and deficits in those with ASD and WS lie, as well as the neural mechanisms that may underpin them. A summary of theories of how face identity and emotion are processed has been offered to begin to map those areas of atypicality in the clinical groups onto a theoretical framework. The one consistent finding across the clinical literature is that both individuals with ASD and WS have difficulties in processing the spatial relations of stimuli (Behrmann et al., 2006a; Isaac & Lincoln, 2011) and it could be hypothesised that this may impact upon their ability to interpret emotions (although not identity) from faces. That *emotions* pose such a problem suggests something beyond the purely perceptual. The amygdala has also been heavily implicated in the role of emotion processing in typical development, therefore hyper and hypo-activation in this region in ASD and WS is of particular interest. Could it be that faces hold a particular and divergent salience in these groups?

Recent research (Klein-Tasman et al., 2009; Lincoln et al., 2007) has pointed to the possibility that there may be more overlap between some of the social behaviours seen in WS and ASD than was initially suggested by earlier literature. The extreme heterogeneity within both neurodevelopmental disorders means that there may be clusters or subgroups of individuals with very different patterns of social behaviour and this may be where overlaps between the two disorders occur. The purpose of the

present research is therefore to elucidate how similar or different the social-perceptual and social-cognitive profiles of individuals with WS and ASD are; further, to examine the possible overlaps or divides in the underlying mechanisms driving social behaviours. The following questions therefore guided a set of six experiments that comprised this PhD research: Can individuals with ASD and WS identify emotions from faces? Are any particular emotions or types of cue beneficial to individuals with ASD and WS when interpreting emotions? What social inferences and attributions do they make and, ultimately, do individuals with these neurodevelopmental disorders process and interpret social information in different ways?

Chapter 4: Processing of Faces

4.1 Introduction

One of the key questions governing the current research is whether deficits seen in social exchange in those with clinical disorders are underpinned by atypical processes at the perceptual or cognitive level. It is therefore important to establish whether those with Williams syndrome (WS) and autism (ASD) appear to process faces in a way that is different to those who are developing typically (TD). For example, when shown images of ambiguous images comprised of separate components in face-like configurations, will individuals with ASD and WS piece together parts to deduce a 'face' in the same ways that TD children might? Will the *human* nature of a face determine the types of aspect that children focus on, and how might these patterns differ in different neurodevelopmental groups?

In order to answer these questions, the current experiment presented individuals in WS, ASD and TD groups with images of four categories of images: Real human faces, real animal faces, ambiguous shapes comprised of lines, and shapes comprised of fruit parts; the individual features of the latter two categories were configured to resemble the structure of a face (See Figure 4.1). The premise behind this experiment was that configural processing would be necessary in order to piece together the ambiguous items to deduce the presence of a 'face' or the presentation of an emotion. Therefore spontaneous responses to these images were analysed for the presence of 'face' and/or emotion terms. It was further hoped that possible divides *between* fruit and line images might be indicative of different processing strategies across groups. For example, images comprised of fruit parts might naturally elicit a more featural type of processing, in which each local item could be perceived separately. Incidences in which participants spontaneously deduced a 'face' upon presentation of fruit images might suggest that the piecing *together* of configurations therefore in some way overrides more local features. The types of response that participants gave would therefore highlight the ways that real and non-face images were appraised across groups.

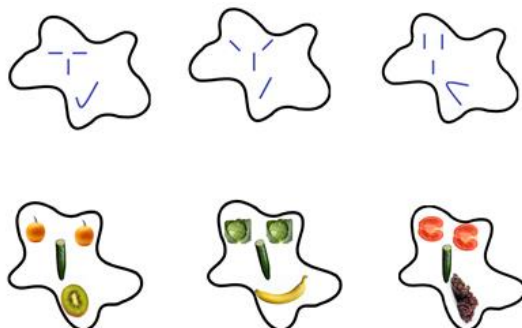


Figure 4.1: Examples of line (top row) and fruit images used in the Wii task.

4.1.1 The Development of Configural Processing of Faces in Typical Development

In order to fully examine the face processing profiles seen in clinical groups in terms of whether there is evidence for a deficit or delay, it is important to establish the *typical* developmental trends in face processing. Specifically, at what point do children demonstrate configural processing ability akin to that of fully developed adult processing? If the skill of piecing together the spatial relations of a face into a coherent whole underpins the act of *interpreting* facial cues, then it is important to understand precisely when this emerges in typical development.

In their seminal paper, Carey and Diamond (1977) proposed that an ‘encoding switch’ occurs around 8 years of age, whereby children progress from a piecemeal processing style to a more holistic form. If this is the case, it might be expected that participants in the present study would also show a shift upon presentation of ambiguous images whereby ‘face’ or ‘emotion’ responses would increase at around this age. However, Tanaka, Kay, Grinnell and Stansfield (1998) have proposed that even children as young as six years are capable of holistic processing. In their three experiments, Tanaka et al. (1998) compared 6, 8 and 10 year olds using a part-whole paradigm; short and long-term face recognition was tested, as well as a condition in which faces were inverted. In their first two experiments, Tanaka et al. (1998) found strikingly similar patterns of results across all three age groups, in that performance was significantly increased for recognition of parts presented in a whole-face, rather than isolated context. Whilst the older children did show higher levels of accuracy than those in the younger groups, there was no interaction between condition and age, suggesting the same processes were being utilised.

Tanaka et al. (1998) also included an inversion condition in order to examine whether or not younger children might show more featural strategies when processing inverted, compared to upright faces. Typically, parts of faces are recognised best when presented in the context of the full facial configurations in which they were initially presented. In Experiment 1 of the present thesis, it could be the case that the fruit images are treated more like inverted faces because of their novelty, and because they invite more of a focus on the component parts. This would be evidenced by fewer face/emotion responses to these images. Of interest was Tanaka et al.’s (1998) finding that there was a significant interaction between age and condition, in which the oldest group more accurately recognised upright faces. This may suggest improvements with age in which the size of the inversion effect becomes greater across development, despite the early establishment of holistic processing. Improvements across age groups in piecing together parts to deduce the presence of a ‘face’ will be explored in the present study. The specific strategies that might change and/or improve with age will be explored in Experiment 1 in an analysis of the *types* of response given by participants to the four different image categories.

De Heering, Rossion and Maurer (2012) have also examined the developmental trajectory of face identity abilities in their study: They split 108 children into three age brackets covering 6 years to 12 years 6 months, along with 36 undergraduate students

(mean age 19 years). The specific age-groups were 6 years-8 years 4 months; 8.4-10 years 3 months, and 10.3-12 years 6 months. Participants were asked to take part in a digitised version of a modified Benton task comprised of both upright and inverted face images. The premise behind such a paradigm is to establish at what point children may progress from a featural to configural processing style: Typical adults are consistently found to show a more piecemeal approach when identifying inverted faces, evidenced by low accuracy in identifying such images. It was found that there were accuracy improvements with age for both upright and inverted faces overall. Significant differences in accuracy were found between upright and inverted faces, with an interaction with age, suggesting that face-specific processes that develop gradually through childhood may be involved. The biggest difference between upright and inverted faces was noted between 6-8.3 year olds, later plateau-ing somewhat. This may suggest stabilisation of underlying abilities around this age, offering support for the possibility that a coding switch may occur at around this point, although to draw any firm conclusions a longitudinal design involving the same individuals at different age points would be more reliable.

Mondloch et al. (2007) have emphasised the importance of experience in the development of face processing in their previous studies showing that early visual disruption has negative consequences for processes that develop later on and only those processes: Earlier processes, such as the development of featural processing, appear unaffected by early visual complications such as cataracts. Specifically, they stress that it is essential to examine the processing of *unfamiliar* faces in order to answer the question of whether holistic processing is the *only* mechanism necessary for face expertise. For example, if it can be shown that young children show evidence of holistic processing, this fails to explain general improvements in accuracy with age and presumably experience, and therefore it must be the case that some further developments are necessary. This has clear implications for clinical groups, who may have different patterns of experience/exposure to faces as well as possible early deficits to neurological visual mechanisms.

Mondloch et al. (2007) tested 24 six year olds on a composite face paradigm in which they were asked to make same/different judgements about the top halves of faces. Faces were presented in aligned/misaligned conditions and the bottom halves were always different to each other; it was found that, as in a previous adult sample, accuracy for the misaligned faces was 26% (compared to 23% in the adult group) better than for aligned faces for judgements where the top halves were the same as the target presented.

Mondloch et al. (2007) cite this as evidence for holistic processing in children as young as six years, further supported by a similar pattern in terms of response speeds as well as accuracy. However, worthy of note is the fact that, for faces where the top halves were *different* to the target, accuracy amongst children was improved for *aligned* faces; this was not a trend seen amongst adults. It may be the case that, given that the bottom halves of faces were consistently different to one another, only 'same' judgements were affected by the alignment of two face halves; the fact that this was only a factor amongst children might point to the precedence of attention to the bottom halves of faces not seen in adults. This was not explored by Mondloch et al. (2007) and will be examined in

Chapter 5. Mondloch et al. (2007) suggest their findings point to the fact that holistic processing is “not sufficient...but it may be necessary” (Mondloch et al. (2007), p.573) for later expertise in face recognition, such as the superiority of identification of same versus other-race faces. If holistic processing is fully developed by six years of age, some further processes must be operating to account for later improvements in accuracy repeatedly seen with age.

It would seem that there is no definite consensus in the literature, as yet, as to at what age configural processing abilities are fully developed. McKone et al. (2008) have made the point that, rather than configural processing developing across age, a perceptual *narrowing* occurs, in which the individuation of certain differences in face images (such as between the features of monkey faces or other-race faces) becomes obsolete. Therefore the faces to which a person is exposed will play a part in the types of processing that develop. It should then be the case that typically developing individuals will piece together the individual features of human faces more often than they might animal faces, but will show evidence of configural processing when presented with face-like images. Whether or not this is found to be the case will be addressed in the present experiment.

4.1.2 Configural Processing of Faces in autism

Featural processing strategies have been frequently reported amongst those with ASD (Happé, 1999) with consistent reports across the literature on their inability to complete global Navon figure tasks but excelling on block design and the Embedded Figures test (See section 2.5.1). Over-reliance on featural face cues has often been cited (see Chapter 3) as a reason as to why those with ASD appear not to demonstrate accurate face identity perception, but *can* they employ configural processing strategies at all? The implication of this question in terms of *face* processing, specifically, has been less consistently researched, with different methodologies leading to very mixed findings. Behrmann et al. (2006b) aimed to test the relationship between general global processing and face/object discrimination. They compared 12 adults (age range 19-53 years) with ASD to TD peers matched for education level as well as CA on a battery of tasks tapping into the different domains. Specifically, participants were asked to perform a same/different judgement task for the identity and gender of faces; completed a classic Navon figures task, as well as a more complex primed matching task to examine more fine-tuned local processing, and completed a discrimination task with objects.

In summarising the results, Behrmann et al. (2006b) highlight how, on both face and object discrimination tasks, individuals with ASD were slower but as accurate in their responses compared to controls. This was especially true of items requiring more fine-tuned discriminations. Further, they showed a significantly greater bias towards the processing of local, rather than global details of images, being “primed by the local elements” (Behrmann et al., (2006b), p.123) and performing faster when asked to detect local details rather than their global product on the Navon task. Perhaps of most

importance was the significant positive correlation found in the ASD group between response times on discrimination tasks and incidence of local processing, suggesting that the featural approach may be in some way responsible for slower appraisal of both faces and objects; this effect was, however, reduced in the cases of objects.

If it is the case that individuals with ASD employ a blanket featural strategy when processing both face and non-face objects, it might be expected that no differences will be found between the fruit/line categories in the present study; further, that participants with ASD might be more inclined to comment on the individual features of all image types. One important issue is how the separate processes of featural versus configural processing relate and if different types of image might elicit different processing styles in different neurodevelopmental groups? One interesting question raised by Behrmann et al. (2006b) is whether individuals with ASD show a local *bias* or a configural *problem*; this is a difficult issue to pull apart but possible patterns of response type between line and fruit images in the present study may begin to shed some light on this issue.

4.1.3 Configural Processing of Faces in Williams syndrome

Far less research has been carried out into the face processing abilities of individuals with WS but the same question must be addressed: Is there a delay or deviance in the strategies employed in this population when identifying a face? Tager-Flusberg et al. (2003) have argued the case that it makes very little sense for those with WS to be poor at configural processing when they are consistently cited as being comparable to TD matches on standardised face identity tasks. A discussion of their experiment is detailed in section 3.1, their main conclusion being that individuals with WS do appear to use holistic processing when identifying faces, although not as *effectively* as their TD peers. Isaac and Lincoln (2011) support Tager-Flusberg et al. (2003) in their study also suggesting the use of holistic strategies in individuals with WS but to a poorer degree of accuracy than seen in TD groups.

Deruelle, Mancini, Livet, Cassé-Perrot and de Schonen (1999) have previously raised the issue of whether there might be an intact ‘face’ module in individuals with WS that apparently preserves their relatively spared face skills, or whether it might be more the case that efficient *local* processing strategies support face identification. Whilst more recent research (Karmiloff-Smith, 2007) has moved away from the claim that there are discrete and dissociable ‘modules’ underlying the patterns of strength and deficit seen in neurodevelopmental disorders, early studies examining divides between skills in the different domains have been useful for exploring the types of process that might be involved in response to different types of images. Deruelle et al. (1999) compared 12 participants aged 7-23 years (mean age 11.9 years) to two groups of TD participants matched on CA and MA (using the WISC III). Their premise was that performance on face tasks at CA level would be evidence for an intact face module, whereas performing only at MA level would be suggestive of general delay in face processing, in line with general cognitive functioning. In their initial experiment, Deruelle et al. (1999) gave

participants a task in which they were asked to choose which one of two faces matched a target on identity, expression, eye gaze, age, sex or lip movement. Overall, they found that participants with WS performed at MA level but with significantly poorer accuracy than their CA peers; this was true of all conditions except for lip movement, where all groups were comparable. A correlation with age was found in the TD group only, despite a large age range in the WS group, although a sample size of 12 may be too small to draw any firm conclusions from this. It is also important to note that the heterogeneity seen within WS makes comparisons across age fairly uninformative, in which an older child might well have a much lower MA than someone younger. It is difficult to draw any conclusions across such a range of measures as to what can be deduced regarding *configural* processing specifically; these findings highlight the difficulty in establishing where the profiles seen in neurodevelopmental groups might be developmental or more concerned with heterogeneity.

In their second experiment, Deruelle et al. (1999) aimed to investigate the underlying *processes* that might differentiate WS from TD groups, specifically. Participants were this time shown houses and faces, in both inverted and upright orientations, and were asked to make same/different judgements between two images and a target. Individuals with WS showed similar levels of accuracy for upright faces (~85%) to their MA peers but significantly reduced accuracy compared to CA matches. Perhaps of more importance regarding the question of differentiating processes, however, it was shown that individuals with WS did not show a main effect of orientation seen in the other TD groups. Further, whilst a significant orientation by condition interaction was seen in the TD CA group in which no inversion effect was found for houses, this interaction was not seen in the WS group: These individuals were unaffected by the inversion of both houses and faces.

Deruelle et al. (1999) suggest that their findings point to the fact that individuals with WS, whilst as able to accurately identify faces as their MA peers, must employ a more featural strategy in doing so, evidenced by the lack of an inversion effect. They also note that there appears to be no 'preferential' treatment of the face that facilitates the inversion effect in this population. This issue of the importance of faces versus non-faces will be examined in the present experiment: If faces are processed much in the same way as objects in WS groups, it might be expected that no differences in performance will emerge between real and non-face images in the present experiment. A more featural style of processing might also lend itself better to the identification of objects versus faces overall; might it therefore be the case that individuals with WS attend better to the individual features of objects, compared to TD peers, in the present study?

Standing in direct contrast to the work of Deruelle et al. (1999) is a recent study by Cashon, Ha, DeNicola and Mervis (2013) in which they have shown an inversion effect in toddlers with WS. The authors of this study claim that the heightened attention to faces seen in WS should facilitate an expert style of face processing, given that exposure to faces underpins the development of configural processing. The question of

familiarity and experience with faces will be tested in the present experiment in a comparison of different image types.

Cashon et al. (2013) employed a habituation switch paradigm: Fourteen toddlers (mean age 25.7 months) were familiarised with pairs of faces and were then shown one of three target images of either a familiar face, a ‘switch’ face, in which the internal/external features of the face pairs were switched to form a new configuration with familiar features, or an entirely novel face. Faces were shown in both upright and inverted orientations at both habituation and test phases. Cashon et al. (2013) hypothesised that their participants would display longer looking times to the switch than familiar face in the upright, but not inverted condition, and that looking times towards the novel face would be longer than for the familiar face in *both* orientations. This was what was found in statistical analysis, with no correlations observed between age or Mullen scores and looking times.

The results of Cashon et al. (2013) seem to suggest that even toddlers with WS can detect changes in facial configurations for upright faces, and employ a featural strategy for inverted faces, akin to that seen in 7 month TD infants (Cashon & Cohen, 2004). This may be indicative of a delay in young infants with WS; it is therefore important to further explore later developmental patterns to establish how they may change, and subsequently underpin everyday social interactions. For the purposes of the present study, if it is the case that very young infants, both TD and with a diagnosis of WS, display holistic processing of upright faces, it might be expected that group differences for the different images would *not* emerge between individuals with WS and their MA matches (mean age 4 years 7 months, in the present experiment). However, it must be noted that Cashon et al. (2013) did not have a direct comparison group in their study and it is possible that TD toddlers may have shown a very different pattern of results.

4.1.4 Summary and Aims

The What Is It task (Wii) aimed to establish which images might elicit featural versus a more holistic type of processing in both TD and clinical groups: Would individuals piece together ambiguous features to deduce the presence of a ‘face’ (or emotion) and in what ways might these patterns differ? Further, would, as Carey and Diamond (1977) suggest, there be evidence of a shift in featural to holistic encoding at around 8 years of age? The literature reviewed above suggests a possible local processing bias in ASD, compared to very mixed findings concerning individuals with WS. The impact that a featural style of processing might have on the accuracy of piecing together features in a face might operate differently in these two groups, depending on the parts of the images that are utilised by individuals or what interpretations are drawn from them. Also of importance is the question of discrepancies between overall *accuracy* and underlying strategies. The Wii task therefore aimed to explore these issues by examining how often TD and individuals with ASD/WS piece together individual features of real and face-like images and the types of response that they would spontaneously give in appraising these images.

The inclusion of fruit and line faces in the Wii task allowed for an analysis of whether participants would see a ‘face’ by combining the features together or whether they would only identify separate items of fruit/lines. In having *both* fruit and line faces, it was intended that the meaning attached to face-like objects could be analysed. For example, ‘faces’ should only be seen in line images if individuals piece together the individual, ambiguous, parts, to deduce a whole configuration that could be likened to that of a ‘face’. An over-reliance on local processing, conversely, would result in fewer ‘face’ attributions in response to fruit images, in which the features can be processed locally as individual items of fruit. It was expected that all participants would not have any difficulty in stating that the human/animal faces were faces, therefore the critical responses to these items were in the *types* of response given (see Data Analysis) and whether or not participants would piece together facial features to deduce an emotion. As this was a novel design, not employed in any known studies to date, no predictions were made regarding the types of response that individuals gave; possible implications, however, are outlined in the discussion.

4.2 Hypotheses and Predictions

4.2.1 Typical Development

There will be a significant increase in the number of ‘face’/ ‘emotion’ responses to line images with age across the TD groups, with a clear jump in number of responses to both fruit and line images between those aged under and over 6 years. There will be fewer ‘face’/‘emotion’ responses to fruit compared to line images in those aged under 6 years, where a featural strategy is more likely to be used than seen in older children.

4.2.2 ASD and TD Comparisons

A featural processing bias in the ASD group will be evidenced by significantly fewer face responses to line or fruit images than seen in TD groups, and no significant differences between responses to these categories. Emotion attributions to fruit/line images will be lower in the ASD group than seen in TD peers.

4.2.3 WS and TD Comparisons

A significant difference will be found in the WS group between face responses to fruit/line images, with more responses being given to line image types, indicative of a more featural strategy. Individuals with WS will be less likely than CA or MA peers to make spontaneous face *or* emotion attributions overall, underpinned by a less accurate ability to piece together ambiguous parts to form a face-like configuration. Based on anecdotal evidence regarding the hyper-social nature of those with WS, it is tentatively predicted that individuals with WS may refer more than TD peers to the emotions of real face images.

4.3 Method

4.3.1 Participants

Three groups of participants were recruited to this study: Those with a diagnosis of ASD, those with a genetic diagnosis of WS, and TD children matched to each clinical sample on both chronological age (CA) and non-verbal mental age (MA). The Ravens Coloured Progressive Matrices ([RCPM]; Raven, Court & Raven., 1990) was used as the standardised test. This measure has been reported (Riby & Back, 2010) to be suitable as a matching measure for non-verbal MA and has been used across a wide range of studies in which neurotypical participants are compared to those with developmental disorders. The test asks participants to choose, from six options, which section of pattern completes a larger picture (see Figure 4.2); there are three sets within the test, each comprised of 12 items, becoming progressively harder within each set. The maximum raw score is therefore 36.

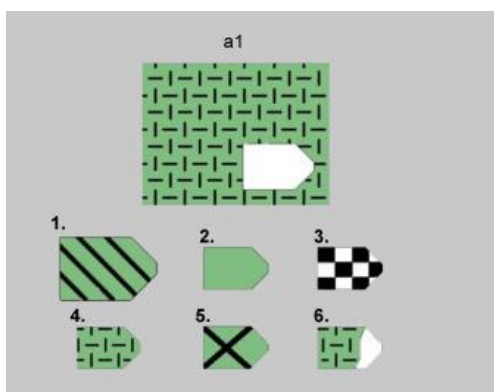


Figure 4.2: An example of item 1, Set A, on the RCPM (Raven et al., 1990).

4.3.1.1 ASD participants

Twenty-three participants with a previous clinical diagnosis of autism were recruited from two specialist schools. Diagnoses were confirmed by teachers' responses to the current version of the Social Communication Questionnaire ([SCQ] Rutter, Bailey, Berument, Lord & Pickles, 2003). Scores on this measure ranged from 7 to 23 (whereby higher scores indicate a higher number of autistic symptoms), with a mean of 14. Four children subsequently had to be excluded from the study due to scores indicative of being below the cut-off (a score of 12) for ASD diagnosis. One child was later excluded from the analyses as it was clear he did not understand the requirements of the task and he refused to complete the RCPM. Therefore a total of 18 children (16 males and two females), aged 8 years 1 month to 14 years 9 months (mean age 10 years, 10 months) comprised the final sample. Non-verbal ability scores for this group ranged from 9 to 33 (out of 36), with a mean score of 27.

4.3.1.2 *WS participants*

Fifteen participants with a previous behavioural diagnosis of Williams Syndrome corroborated by positive genetic testing on the FISH test were recruited through the Williams Syndrome Foundation. One participant was subsequently excluded from the analysis as she did not wish to participate in the full test battery and no RCPM score was obtained for this participant. The age range of the final 14 participants (eight males and six females) was 6 years 9 months to 16 years 5 months with a mean age of 10 years 10 months. Non-verbal ability scores for this group ranged from 8 to 21 with a mean score of 15.

4.3.1.3 *TD participants*

Seventy-three typically developing individuals were originally invited to take part in Experiment 1. Children were recruited through an early years centre and two primary schools in the North East of England; one secondary school in the same region and at a science museum. Teachers (where children were recruited through schools) and parents (for those recruited through the science museum), were asked to fill out the Strength and Difficulties Questionnaire ([SDQ] Goodman, 1997) to establish that the child did not have any potential emotional or behavioural issues. Some teachers were unable to complete these questionnaires for 15 of the children but did verbally confirm that the children in question appeared to have no issues at school. Overall scores on the SDQ ranged from 0 to 21, with lower scores representing 'normal' behaviours; the mean score was 7.

Due to 'abnormal' scores (17 and above for parent-completed questionnaires and 16 and above for those completed by teachers) on the SDQ, seven of the participants' data had to be discarded; one was additionally excluded due to his mother revealing he had a diagnosis of Asperger's Syndrome and a further two were not included in the analyses due to not being a suitable CA or MA match for any of the clinical participants. Therefore a final sample of 63 TD participants was recruited, as detailed in Table 4.1. For each clinical participant, an individual match from the TD population was found for both CA and MA in order to ensure equal variances across the groups. t-tests revealed no significant differences between the mean ages of each clinical group and their CA matches (ASD: $t(33) = .09, p = .93$; WS: $t(26) = .01, p = .99$), nor between non-verbal ability scores of clinical groups and their MA matches (ASD: $t(34) = .17, p = .87$; WS: $t(26) = .44, p = .67$).

Table 4.1: Age and MA demographics for TD matches to ASD and WS groups

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
ASD (n=18)				
CA Matches*	8.0-15.0	10.11 (2.4)	22-36	30 (4.56)
MA Matches	4.5-13.11	9.8 (2.8)	10-35	27 (5.95)
WS (n=14)				
CA Matches	6.8-16.6	10.10 (3.2)	22-36	30 (3.39)
MA Matches	3.7-8.4	4.8 (0.9)	9-22	16 (4.13)

*Due to time constraints, one CA match for an ASD participant (10 years, 4 months) was missing.

4.3.1.4 TD Age

A crucial question when examining clinical groups is how their performance maps onto that of those in the TD population. The same 63 TD participants as detailed above were additionally divided into four age groups. These groups were based on developmental phases according to broad educational key stages.

Table 4.2: Age and RCPM data for TD groups split by age.

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
Up to 6 years (n=14)	3.7-5.9	4.6 (0.6)	9-22	15 (4.06)
6-8 .5 (n=14)	6.7-8.4	7.5 (0.7)	21-32	27 (3.86)
8.6-11.5 (n=17)	8.8-11.4	9.7 (0.11)	21-35	28 (4.28)
11.6 and above (n=18)	11.6-16.6	13.5 (1.5)	28-36	32 (2.85)

4.3.1.5 TD Gender

Due to recruitment constraints, it was not possible to match the WS and ASD groups on sex as well as CA and MA. An analysis of males (28) versus females (35) across the whole TD group revealed no significant differences in performance based on total task score, calculated by the sum of the number of face and emotion responses ($t(61) = 1.34$, $p = .19$). The mean age for males was 9 years 11 months compared to 8 years 5 months for females. The mean scores on the RCPM were 27 for males and 25 for females.

Based on these findings, sex is not taken to be a confound when comparing the clinical participants to their TD matches.

Ethical permission was granted for Experiment 1 and all subsequent experiments to be conducted with all children recruited (See Appendix E for copies of consent forms/information sheets and ethical approval). Parental and teacher consent was obtained for all participants recruited through schools with parent/guardian consent being obtained for those children recruited through the science museum. Parents and children were provided with copies of an information sheet detailing what the study involved and it was made clear to each child that they did not have to take part and could withdraw at any time if they wished. Those children whose parents deemed them able to give their own assent also gave written permission.

4.3.2 Materials and Design

Experiment 1 was a free response task intended to elicit spontaneous responses to real face or face-like images (Figure 4.3). Images were comprised of human faces (men and women), animal faces (cats and dogs), face-like shapes comprised of items of fruit (fruit) as features and face-like shapes comprised of simple lines (line). All images were chosen/made to express an emotion (happy/angry/surprised) as clearly as possible in order to allow for spontaneous labelling of an emotion. A larger set of images were piloted on 40 TD adults in order to gauge a consensus of which emotions were depicted. Images were only retained if there was 80% agreement. Given the difficulty of sourcing natural expressions in animals, there was no item for ‘surprised’ as TD participants failed to reach consensus on those items initially included. Four of each real-face and three of each configural face category were included in the task interspersed with eight pictures of everyday objects as a control measure, equalling a total of 22 trials. These objects were included in order to prevent participants from getting into the habit of giving ‘face’ responses as a matter of course, and also to ensure there were no general difficulties in identifying the items depicted. The order of presentation was the same for each child and had originally been randomised.



Figure 4.3: Examples of animal, human, line, fruit and object images on the Wii task

4.3.3 Procedure

Participants were tested in their school or home with a guardian/teacher in the vicinity. Testing took place in a quiet space with the child seated at a table. All images were viewed on a DEL E5500 laptop (screen size 32 cm x 21 cm), displayed full-screen in Powerpoint. The same laptop was used for all participants in all experiments. In

Experiment 1, the participant was told that they were going to see some items one at a time and simply had to state what they could see in response to the question “what is it?”. It was stressed that there was no right or wrong answer and they could say as much as they wanted. Once participants had given their initial answers they were prompted with “What else can you tell me”? Each item remained on screen until the participants had finished giving their answer and then the next item was presented immediately. All participants viewed the images in the same order and the original order of presentation was randomised. Responses were recorded on an audio-recorder and coded for analysis (See below).

4.3.4 Data Analysis

Because the objective of Experiment 1 was to establish how often participants would *spontaneously* attribute social meaning to a given item, 1 point was awarded for each item if they stated that an item was a *face* and 1 point was awarded for each item if they referred to an *emotion* before any further prompting. For example, if a participant stated that a line stimulus looked like “a sad boy”, it would be credited with 1 point for both face and emotion. These response types were therefore analysed separately in two one-way ANOVAs. These types of spontaneous responses were only analysed for fruit/line images as it was decided that labelling a human or animal face as a ‘face’ would not be particularly indicative of evidence of combining features together to form a whole, given the lack of ambiguity in these types of image.

Three separate types of answer were subsequently coded, with 1 or 0 being given as to whether or not a particular term was mentioned for each item. These terms were: Reference to a *facial* feature (such as referring to the watermelon as a ‘mouth’), reference to an *emotion* term (describing an image as happy/surprised, etc.), and reference to an explanation for conceptually *why* a particular image might look that way (For example ‘He’s smiling because it’s his birthday and he knows he’ll get lots of presents’). Answers both before and after the prompt were included in this score and totalled for each of the four categories of images. All responses were double coded by an individual blind to group membership or the hypotheses of the experiment and reliability was found to be 100%. Due to an imbalance of the number of items in each category (4 of each human and animal faces and 3 of line and fruit), analysis in which direct comparisons were made was carried out on *percentages* of raw scores.

Scores for objects were given based on the same point system whereby 1 or 0 would be credited depending on whether or not any of the following three terms were mentioned: Correct identification of an object; reference to object features; functions of the object. Percentages for each term were therefore compared for the object condition.

No data was missing for any participant in experiment 1. When examining total task score (the total number of face/emotion responses across all categories), only two cases presented as outliers in the up to 6 years and 6-8.5 years groups. There were no outliers

found in the ASD or WS groups on this measure. Games-Howell post-hoc comparisons were used to examine all within participant main effects.

4.4. Results

4.4.1 TD Groups

4.4.1.1 *What Is It task: Spontaneous responses*

Initial ‘face’ responses to the open-ended question ‘what is it?’ upon presentation of images from the two categories (line and fruit) were analysed for each of the TD age-groups. A mixed design 4 x 2 (age-group x image category) ANOVA for ‘face’ responses did not reveal any significant main effect of category type or age ($p > .05$; $F < 1$), nor any significant interaction with age-group.

A mixed design ANOVA to examine ‘emotion’ responses did reveal a main effect of image category, $F(1, 59) = 70.24$, $p < .01$, whereby significantly fewer emotion responses to fruit than line images were found overall. The descriptive statistics for the number of face/emotion responses given to each category are stated in Table 4.3. A main effect of age-group was also observed, $F(3, 59) = 6.18$, $p < .01$, whereby both the oldest group and those aged 8.6-11.5 years gave significantly ($p < .01$ in Games-Howell posthoc comparisons) more emotion responses overall than the youngest group. There was no significant interaction between age-group and image category for ‘emotion’ responses ($p > .05$; $F < 1$).

Table 4.3: Mean number of face/emotion responses for fruit and line images, across TD age groups (standard deviations shown in parentheses; maximum number=3).

	Line ‘Face’	Line ‘Emotion	Fruit ‘Face’	Fruit ‘Emotion’
Up to 6 years (n=14)	.71 (1.07)	.93 (.83)	.64 (.93)	0 (0)
6-8.5 (n=14)	.93 (1.14)	1.21 (.70)	1.29 (1.11)	.36 (.93)
8.6-11.5 (n=17)	1.76 (1.15)	1.71 (.67)	1.29 (1.11)	.29 (.47)
11.6+ (n=18)	1.50 (1.30)	1.72 (.96)	1.50 (1.2)	1.06 (1.0)

4.4.1.2 *What Is It task: ‘Feature’ responses*

A mixed design ANOVA (age-group x image category [line/fruit/human/animal]) for *feature* responses was run on the percentages of the total number of each response given with age-group as between subjects factor. Analyses were run on percentages rather

than raw scores due to an imbalance of the number of items in each category. Mean number of responses (standard deviations in parentheses) for each age-group are reported in Table 4.4. A main effect of image category was found ($F(3, 177) = 5.64$, $p < .01$), whereby there were a significantly higher percentage of responses to human and line images than for animal. A main effect of age-group was also found, $F(3, 59) = 4.53$, $p < .01$; those aged 6 years and under gave significantly fewer feature responses over all categories than those in the oldest group ($p < .05$ in Games-Howell posthoc comparisons). There were no significant differences between any of the other age groups. No significant interaction ($p > .05$; $F < 1$) was found between age-group and image category, as is evident from Figure 4.4.

Table 4.4: Mean number of each response type (Features/Emotion/Why) for each image category (Line/Fruit/Human/Animal) across TD age groups (Standard deviations in parentheses). Maximum number of responses for line/fruit images=3; maximum number for human/animal images=4.

Response Type	Feature				Emotion				Why			
	Line	Fruit	Human	Animal	Line	Fruit	Human	Animal	Line	Fruit	Human	Animal
Up to 6 years	2.36 (.93)	1.93 (1.27)	3.07 (1.07)	2.14 (1.41)	1.50 (1.09)	.07 (.27)	1.14 (.77)	1.29 (.83)	.29 (.47)	0 (0)	.86 (1.17)	.29 (.83)
6-8.5	2.43 (.85)	2.50 (.94)	3.43 (.65)	2.79 (1.12)	1.43 (.85)	.57 (1.09)	2.50 (1.02)	1.93 (1.54)	.07 (.27)	0 (0)	.21 (.80)	.14 (.54)
8.6-11.5	2.76 (.69)	2.65 (.79)	3.24 (.83)	3.06 (.97)	1.71 (.69)	.71 (.85)	2.47 (1.01)	1.59 (1.0)	.24 (.44)	0 (0)	.24 (.44)	.24 (.44)
11.6+	2.72 (.58)	2.78 (.73)	3.50 (.71)	3.11 (.76)	2.06 (.80)	1.83 (1.1)	3.22 (.81)	2.94 (1.21)	.17 (.38)	.11 (.32)	.78 (1.4)	1.06 (1.11)

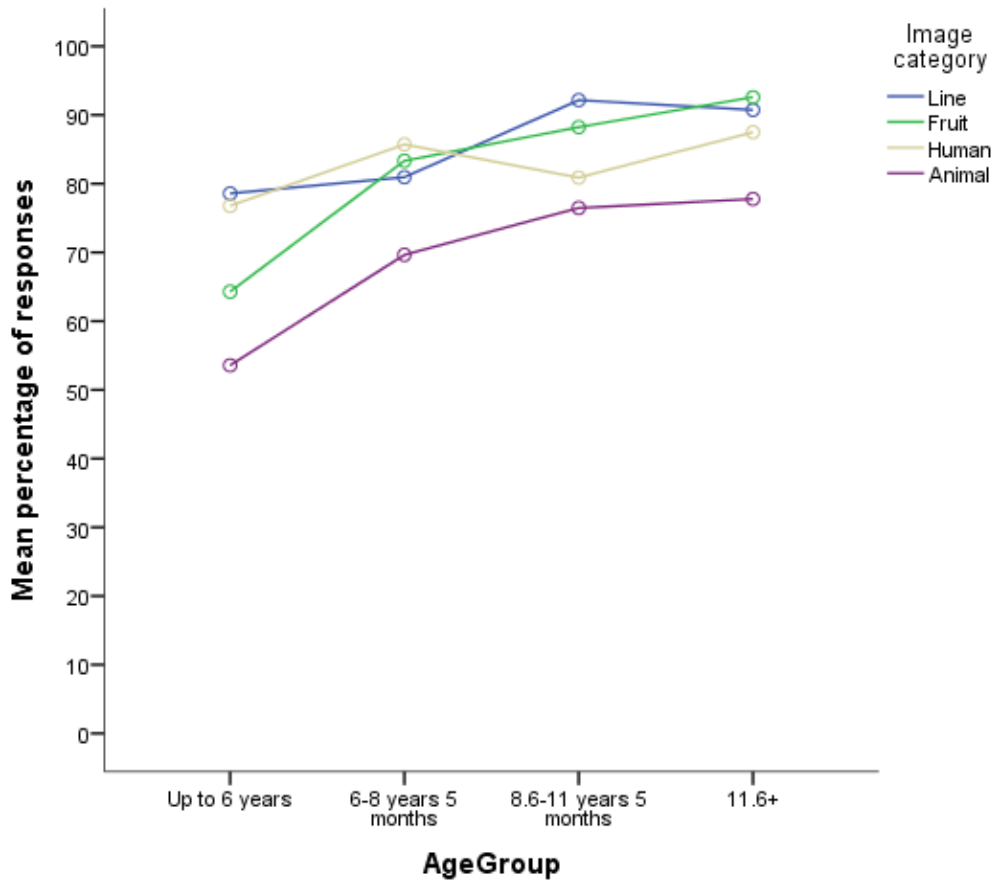


Figure 4.4: Mean percentages of 'feature' responses to each image category, across TD age-groups

4.4.1.3 What Is It task: 'Emotion' responses

Percentages of emotion responses to images were analysed in a mixed design 4 x 4 (image category x age-group) ANOVA. A main effect of image category was found, $F(3, 177) = 22.02, p < .01$, whereby a significantly lower percentage of emotion responses to fruit images were given than for any other category ($p < .01$). A main effect of age was shown ($F(3, 59) = 15.24, p < .01$) in which the oldest group gave significantly higher proportions of emotion responses than all other age groups, as well as a significant interaction between image category and age-group, $F(9, 177) = 2.22, p < .05$. Figure 4.5 shows this pattern of results.

In order to explore this interaction further, univariate ANOVAs were run for each image category separately. No significant differences were seen between age-groups for line images ($p = .17$). For fruit images, the oldest group gave significantly more responses ($F(3, 63) = 11.11, p < .01$) than all other groups, with the youngest group giving significantly fewer than the oldest *two* groups. This pattern was slightly different for

human images, in which the youngest group gave significantly fewer emotion responses than *all* other groups, $F(3, 63) = 13.98, p < .01$. Less clear age differences were seen for animal images, in which the oldest group gave significantly more emotion responses than those aged 6 years and under and those aged 8 years 6 months-11 years 5 months, but not the intermediate age group, $F(3, 63) = 6.36, p < .01$.

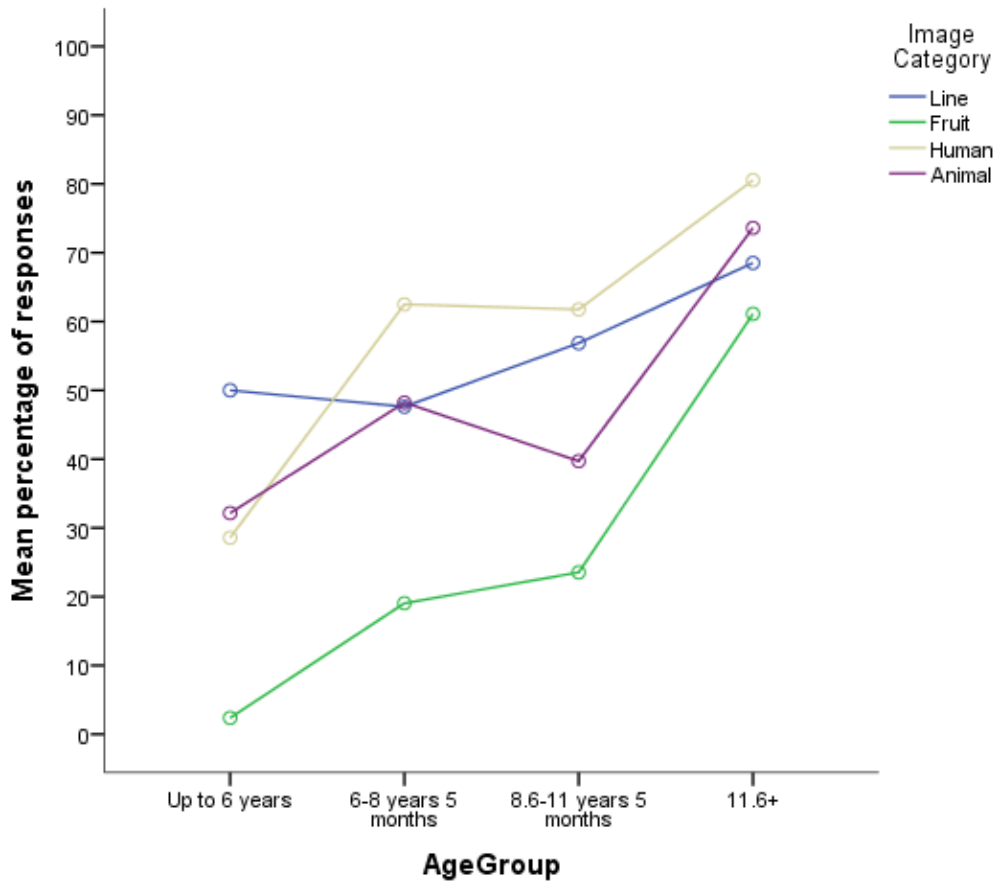


Figure 4.5: Mean percentage of ‘emotion’ responses to each image category, across TD age-groups

4.4.1.4 What Is It task: ‘Why’ responses

A 4 x 4 mixed design ANOVA (image category x age-group factor) was conducted for percentages of ‘why’ responses to images. Participants were credited as having given this type of response if they provided an explanation for why an emotion would be felt. For example “The man is excited because it’s his birthday.” Again, a main effect of stimulus type was noted, $F(3, 177) = 7.03, p < .01$. This main effect was driven by a significantly lower percentage of why responses to fruit images than for line ($p < .05$), human or animal images ($p < .01$). A main effect of age was also found ($F(3, 59) = 3.12, p < .05$) in which the oldest group gave higher proportions of this type of response than those aged 6-8 years 6 months; no other differences were found between the age groups. An interaction between the two factors was also found, $F(9, 177) = 2.21, p < .05$.

Further univariate ANOVAs were run for each category type separately in order to explore where this interaction occurred: There were no significant differences found between the age-groups on the line, fruit or human images; only on the animal images was there a main effect of age, $F(3, 63) = 18.54, p < .01$, in which the oldest group gave significantly more of this type of response than the two intermediate groups but, interestingly, not the youngest ($p < .05$ in Games-Howell post hoc comparisons). Figure 4.6 depicts this interaction.

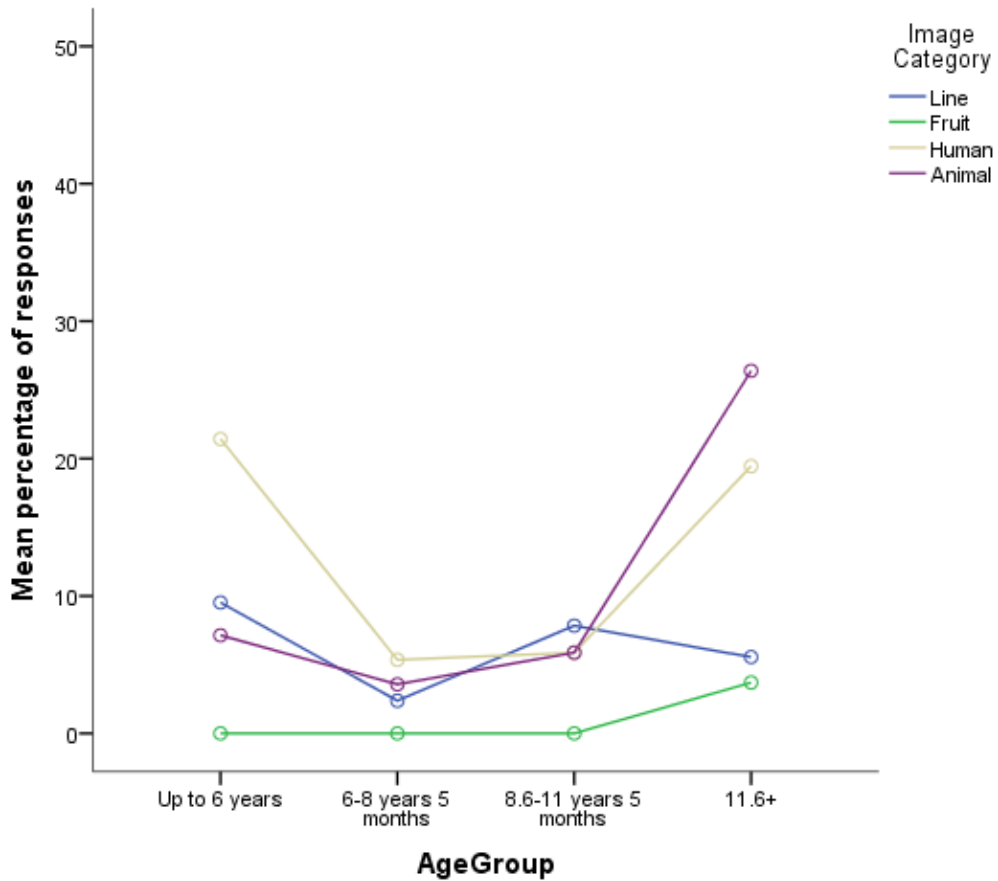


Figure 4.6: Mean percentage of 'why' responses to each image category, across TD age-groups

4.4.1.5 What Is It task: Responses to objects

The types of responses that participants in the different age-groups gave to object images were analysed in three separate univariate ANOVAs, for each response type (Correct identity/naming features/describing function). The mean numbers of responses are given in Table 4.5. No significant main effect of age was found for responses providing the *identity* of an object ($p > .05$; $F < 1$). However, age main effects were found for feature and function responses, $F(3, 63) = 12.02$, $p < .01$ and $F(3, 63) = 6.18$, $p < .01$, respectively. The youngest group gave significantly fewer feature responses than all other groups ($p < .05$ in Games-Howell posthoc comparisons); for the function condition, they gave significantly more of this response type than those aged 6-8.5 years and 8.6-11.5 years ($p < .01$).

Table 4.5: Mean number of each response type to object images, across TD age groups (maximum=8; standard deviations in parentheses)

	Identity	Features	Function
Up to 6 years	7.43 (.76)	4.29 (3.22)	4.43 (2.31)
6-8.5	7.43 (.65)	7.50 (1.35)	1.50 (1.91)
8.6-11.5	7.59 (1.23)	7.71 (.47)	1.06 (1.85)
11.6+	8 (0)	7.28 (1.18)	2 (2.91)

4.4.2 ASD with TD comparisons

4.4.2.1 What Is It task: Spontaneous responses in ASD groups¹

The same analyses as with the TD trajectories was performed on the face/emotion responses of participants in the ASD group, compared to their CA and MA matches. Table 4.6 shows the mean number of face/emotion responses that the ASD group, compared to their TD matches, gave for the line and fruit categories (standard deviations given in parentheses).

¹ 'ASD groups' and 'WS groups' in all results sections refer to the clinical groups and their TD peer comparisons.

Table 4.6: Mean number of face/emotion responses for fruit and line images, for ASD participants and TD matches (standard deviations shown in parentheses; maximum number=3).

	Line 'Face'	Line 'Emotion'	Fruit 'Face'	Fruit 'Emotion'
ASD (n=18)	1.11 (1.13)	.83 (.77)	.72 (.96)	.17 (.38)
TD CA Matches (n=17)	1.71 (1.16)	1.76 (.75)	1.59 (1.23)	.59 (.87)
TD MA Matches (n=18)	1.33 (1.33)	1.44 (.71)	1.11 (1.13)	.39 (.78)

Two separate mixed design ANOVAs were conducted for face and emotion responses, with image category (line/fruit) as a within subjects factor and group (3) as the between subjects factor. No significant main effect of image category or group was found ($p > .05$; $F < 1$). For *emotion* responses, a main effect of image category was found ($F(1, 50) = 78.70$, $p < .01$) whereby significantly fewer responses were given to fruit than line images overall ($p < .01$ in pairwise comparisons). A main effect of group was found, $F(2, 50) = 5.50$, $p < .01$. Participants in the TD CA group gave significantly more emotion responses across both images types than individuals with ASD ($p < .01$ in Games-Howell posthoc comparisons). No significant differences were found between the ASD and TD MA group ($p = .07$). Main effects of image category and group were not underpinned by any interaction between them ($p > .05$; $F < 1$).

4.4.2.2 What Is It task: Feature responses in ASD groups

A 4 x 3 (image category x group) mixed design ANOVA for percentages of feature responses was conducted; no significant main effect ($p = .60$) was found for image category. A main effect of group was evident, $F(2, 50) = 41.63$, $p < .01$, with those in the ASD group giving significantly fewer feature responses than either of their TD matches ($p < .01$). Overall fewer responses is indicative of individuals with ASD saying less when giving references to facial feature terms: Responses might have been categorised under one of the other response types or may not have been coded under any category (such as 'don't know' or talking about an aspect of the faces not under consideration). No significant interaction between group and image category was found ($p > .05$, $F < 1$).

Table 4.7: Mean number of each response type for each image category for ASD participants and TD matches (Standard deviations in parentheses). Maximum number of responses for line/fruit images=3; maximum number for human/animal images=4.

Response Type	Feature				Emotion				Why			
	Line	Fruit	Human	Animal	Line	Fruit	Human	Animal	Line	Fruit	Human	Animal
ASD	1.28 (1.07)	1.33 (.97)	1.78 (1.11)	1.89 (1.23)	1.06 (.87)	.22 (.55)	2.0 (1.09)	1.50 (1.1)	.11 (.47)	0 (0)	.22 (.65)	.11 (.32)
TD CA	2.82 (.39)	2.59 (1.0)	2.71 (1.16)	3.22 (.75)	1.94 (.75)	1.12 (1.22)	2.71 (1.16)	2.41 (1.37)	.35 (.49)	.06 (.24)	.53 (1.0)	.65 (.93)
TD MA	2.44 (.78)	2.67 (.77)	3.39 (.70)	2.94 (1.06)	1.72 (.83)	.78 (1.06)	2.56 (.98)	1.78 (1.35)	.17 (.38)	.06 (.24)	.39 (1.04)	.50 (.92)

4.4.2.3 *What Is It task: Emotion responses in ASD groups*

A 4 x 3 mixed design ANOVA was conducted for percentages of emotion responses to images. A main effect of image category was found, $F(3, 150) = 21.60$, $p < .01$. The fewest responses (see Table 4.7) were given to fruit images, with significantly fewer emotion responses being given to this image type than for any other image category ($p < .01$). These patterns were the same in all groups, as no significant interaction between group and image category was found ($p > .05$; $F < 1$). A main effect of group was found, $F(2, 50) = 6.57$, $p < .01$, whereby those with ASD gave significantly fewer responses overall than CA ($p < .01$) as well as MA matches ($p < .05$).

4.4.2.4 *What Is It task: Why responses in ASD groups*

A 4 x 3 mixed design ANOVA for percentages of 'why' responses to images found a main effect of image category, $F(3, 150) = 3.61$, $p < .05$. There were significantly fewer 'why' responses given to fruit images than animal ($p < .01$) overall but no significant differences, unlike with other response types, between line images and other categories. No significant main effect was found for group ($p = .09$) nor for the interaction between group and image category ($p > .05$; $F < 1$).

4.4.2.5 *What Is It task: Responses to objects in ASD groups*

The types of responses that participants across groups gave to object images were analysed in three separate univariate ANOVAs, for each response type (correct identity/features/function). Table 4.8 states the mean number of each type of response for the ASD group and their TD matches.

Table 4.8: Mean number of each response type to object images, in ASD groups and TD matches (maximum=8; standard deviations in parentheses)

	Identity	Features	Function
ASD	7.72 (.46)	3.67 (2.77)	4.33 (3.01)
TD CA	7.65 (1.22)	7.47 (.87)	1.88 (2.93)
TD MA	7.78 (.43)	7.22 (2.05)	2.11 (2.49)

No main effect of group was found for responses identifying objects ($p > .05$; $F < 1$). For feature responses, a main effect of group was found, $F(2, 53) = 18.89$, $p < .01$; those with ASD gave significantly fewer feature responses than TD CA and TD MA matches ($p < .01$), as is evident in Figure 4.7. A main effect of group was also found for function responses, $F(2, 53) = 4.10$, $p < .05$, in which participants with ASD gave significantly *more* of this type of response than their CA peers ($p < .05$). It is worth noting that individuals with ASD showed the same pattern of results (fewer feature responses and more function) as did the children aged under 6 years in the TD analysis.

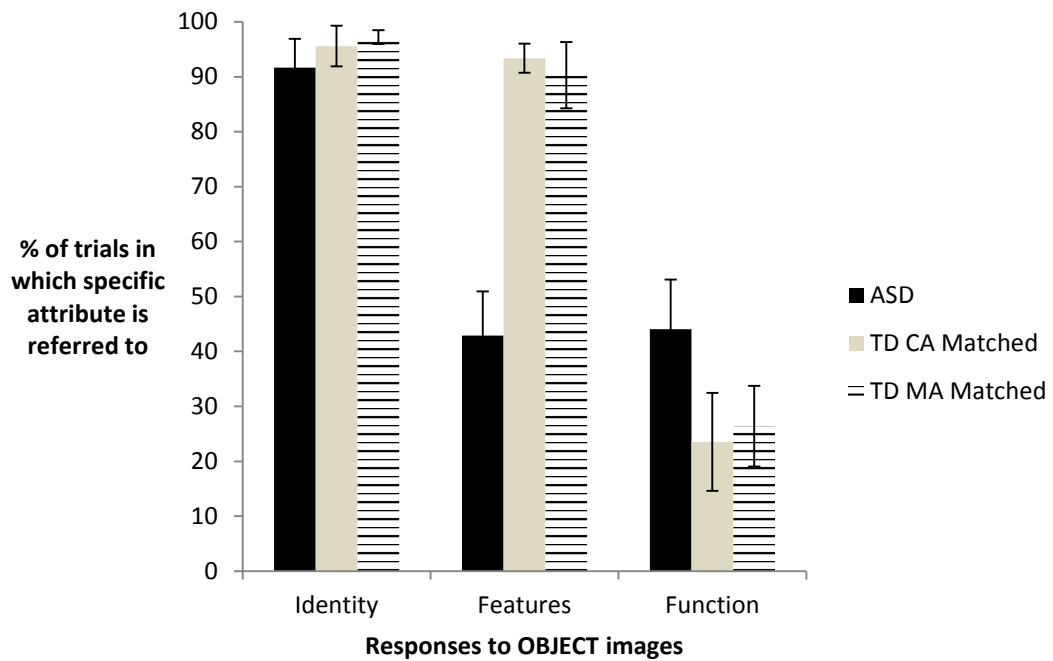


Figure 4.7: Response types to object images in ASD groups and TD matches on the Wii task²

4.4.3 WS with TD Comparisons

4.4.3.1 What Is It task: Spontaneous responses in WS groups

Table 4.9 shows the mean number of face/emotion responses that the WS group, compared to their TD matches, gave for the line and fruit categories (standard deviations are given in parentheses). Two separate mixed design ANOVAs, with image category (line/fruit) as within subjects factor and group (3) as between subjects factor were conducted for face and emotion responses separately. No main effects were found for image category or group for *face* responses to images ($p > .05$; $F < 1$) nor was any significant interaction found between these factors.

For emotion responses, however, a main effect of image category was found, ($F(1, 39) = 26.84$, $p < .01$) and there was a main effect of group, $F(2, 39) = 7.22$, $p < .01$. Overall, participants gave significantly ($p < .01$ in posthoc pairwise comparisons) more emotion responses to line than fruit images. Individuals with WS gave significantly fewer emotion responses overall than their CA matches ($p < .05$). No significant differences were observed between the WS group and their TD MA matches. No significant interaction ($p > .05$; $F < 1$) was found between image category and group.

² Error bars on all graphs throughout this thesis denote the standard error of the sample

Table 4.9: Mean number of face/emotion responses for fruit and line images, for WS participants and TD matches (standard deviations shown in parentheses; maximum number=3).

	Line 'Face'	Line 'Emotion'	Fruit 'Face'	Fruit 'Emotion'
WS (n=14)	.57 (.85)	.86 (.86)	.36 (.63)	.14 (.36)
TD CA Matches (n=14)	1.07 (1.07)	1.57 (.94)	1.21 (1.12)	.86 (.86)
TD MA Matches (n=14)	.86 (1.23)	.86 (.86)	.86 (1.10)	.86 (.86)

4.4.3.2 What Is It task: Feature responses in WS groups

A 4 x 3 (image category x group) mixed design ANOVA was conducted for percentages of feature responses. The descriptive statistics for each different response type for the four image categories are given in Table 4.10. A significant main effect of image category was observed, $F(3, 117) = 3.94, p < .01$ in which there was a significantly higher percentage ($p < .05$) of feature responses to human versus fruit or line images. No other comparisons revealed any significant differences. A significant main effect of group was found ($F(2, 39) = 9.96, p < .01$), with a further significant interaction between image category and group, $F(6, 117) = 3.88, p < .01$.

Univariate ANOVAS were run on each image category separately in order to explore the interaction between image category and group. The only images to show differentiations between the groups were the fruit/line categories. Main effects of group were found for fruit and line respectively, $F(2, 42) = 13.42, p < .01$; $F(2, 42) = 8.64, p < .01$, with those participants with WS giving significantly fewer feature responses than TD CA ($p < .01$) and TD MA ($p < .05$) matches, in both cases.

Table 4.10: Mean number of each response type for each image category across for WS participants and TD matches (Standard deviations in parentheses). Maximum number of responses for line/fruit images=3; maximum number for human/animal images=4.

Response Type	Feature				Emotion				Why			
	Line	Fruit	Human	Animal	Line	Fruit	Human	Animal	Line	Fruit	Human	Animal
WS	1.29 (1.20)	.64 (1.08)	2.64 (1.08)	2.21 (1.58)	1.0 (.88)	.21 (.43)	1.79 (1.31)	1.57 (1.40)	.21 (.43)	0 (0)	.21 (.43)	.29 (.61)
TD CA	2.71 (.61)	2.64 (.63)	3.29 (.73)	2.29 (1.49)	1.64 (.75)	1.43 (1.16)	3.0 (.88)	2.29 (1.49)	0 (0)	0 (0)	.50 (1.09)	.36 (.75)
TD MA	2.36 (.93)	2.0 (1.3)	3.07 (1.07)	2.21 (1.37)	1.43 (1.16)	.07 (.27)	1.21 (.80)	1.43 (.76)	.21 (.43)	0 (0)	.71 (1.14)	.29 (.83)

4.4.3.3 *What Is It task: Emotion responses in WS groups*

A main effect of image category was found for percentages of emotion responses, $F(2, 117) = 13.88, p < .01$. Mean numbers of responses can be found in Table 4.10. Significantly lower percentages of responses were given to fruit images than for any other category ($p < .01$). A main effect of group was found ($F(2, 39) = 10.50, p < .05$) with individuals with WS giving significantly lower percentages of emotion responses overall compared to CA (but not MA) matches ($p < .01$). A significant interaction between group and image category was also found, $F(3, 117) = 2.35, p < .05$

Further univariate ANOVAs of each stimulus type separately revealed main effects of group for the fruit and human categories, $F(2, 42) = 14.66, p < .01$ and $F(2, 42) = 11.15, p < .01$, respectively. In both cases, those in the CA TD group gave significantly more responses than their MA peers or those with WS ($p < .01$). Individuals with WS gave largely comparable numbers of emotion responses to all types of image category as did their MA matches.

4.4.3.4 *What Is It task: 'Why' responses in WS groups*

A 4 x 3 (image category x group) mixed design ANOVA was conducted for percentages of 'why' responses to images. Whilst no significant main effect was found for group ($p = .71$), one was revealed for image category, $F(3, 117) = 5.57, p < .01$, whereby overall, all participants gave significantly more 'why' responses to human versus fruit faces ($p < .01$). There was no significant interaction found between the two factors ($p > .05; F < 1$).

4.4.3.5 *What Is It task: Responses to objects in WS groups*

Three separate univariate ANOVAs were conducted for each response type to objects. The mean numbers of responses of each type are given in Table 4.11.

Table 4.11: Mean number of each response type to object images, in WS groups and TD matches (maximum=8; standard deviations in parentheses)

	Identity	Features	Function
WS	7.29 (1.14)	4.43 (2.24)	1.71 (2.34)
TD CA	7.71 (.61)	7.29 (1.33)	.86 (1.70)
TD MA	7.36 (.75)	4.86 (3.11)	3.93 (2.24)

No main effect of group was found for responses identifying objects. A main effect of group was found for the use of feature terms, $F(2, 42) = 6.06, p < .01$, whereby (as is evident in Figure 4.8), those in the TD CA group gave significantly more responses of this type than their MA peers ($p < .01$ in Games-Howell posthoc comparisons) or those with WS ($p < .01$). For function responses, a significant main effect was also shown, $F(2, 42) = 7.91, p < .01$; this was underpinned by those in the TD MA group providing *more* of this response type than those in the WS ($p < .05$) group or CA peers ($p < .01$). It is worth noting that the participants in this group were particularly young (mean age 4 years 8 months) and therefore this pattern of results can be compared to those aged under 6 years in the TD age analysis.

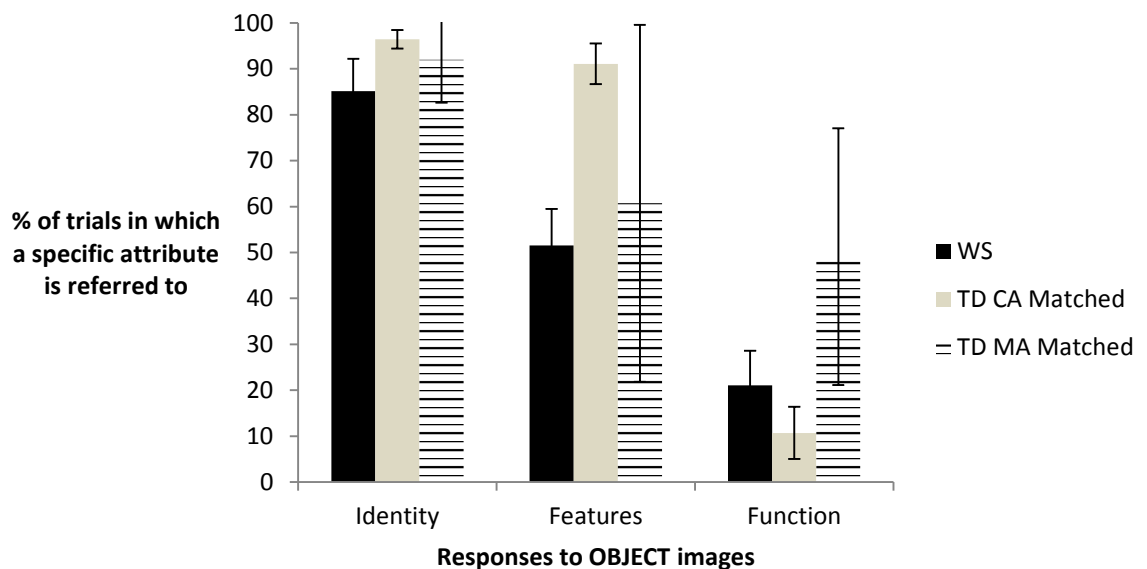


Figure 4.8: Types of response to object images for the WS group on the Wii task

4.4.4 Summary of Results

Analysis of *initial* responses to non-face images (line and fruit) revealed different patterns depending on whether ‘face’ or ‘emotion’ responses were given: No group differences emerged in any of the comparisons when analysing the number of times that participants spontaneously described images as a ‘face’. Similarly, no differences were found in any of the groups as to how many times participants gave a ‘face’ label to line versus fruit images. For ‘emotion’ responses, however, all participants were significantly less likely to give this type of response to fruit (versus line) images. Individuals with ASD and WS also did this less often than their CA, but not MA peers. TD children aged under 6 years failed to ever give an ‘emotion’ label to fruit images, with children in the oldest two groups doing this significantly more than the youngest children.

Analysis of the *types* of response that individuals gave to all four image categories (line/fruit/human/animal) showed that, overall, all participants gave higher percentages of feature responses to human faces than fruit images. It was also found in the TD

analysis that participants of all ages gave a higher proportion of feature responses to human versus animal faces. The youngest TD group gave significantly fewer of this response type overall than did the oldest group. Individuals with ASD also gave a lower percentage of feature responses over all image categories than either CA or MA matches; however, the pattern of results was the same, in that all participants gave a higher percentage of feature responses to human versus fruit images. In the WS cohort, an interaction emerged in which, only on fruit and line images did individuals with WS give fewer feature responses than both CA and MA peers; for real face images, those with WS were comparable to TD peers.

When considering ‘emotion’ responses to images, all participants overall gave the lowest percentage of this type of response to fruit images. TD children of different ages showed different patterns of results: Whilst there were no significant differences between the age-groups for line images, individuals in the youngest group gave a significantly lower percentage of emotion responses to human faces than any other age-group. For fruit faces, children aged under 6 years gave significantly lower percentages of emotion responses than children in the oldest two groups. Individuals with ASD gave significantly lower percentages of emotion responses overall than their CA and MA peers; the same *patterns* were seen in those with ASD and TD peers, however. An interaction was again found for those with WS compared to TD peers, in which differences were only found between the groups in the numbers of emotion responses that were given to fruit and human images: Individuals with WS gave significantly fewer emotion responses to these images than did their CA matches.

Across the TD analysis, significantly fewer ‘why’ responses were given to fruit images than for any other category; in the clinical analyses, over all groups, there were no significant differences between the number of responses given to fruit versus line faces. In the ASD analysis, a significantly higher percentage of ‘why’ responses were given to animal versus fruit faces; in the WS comparisons, this difference emerged between fruit and human faces only. No differences emerged between individuals with ASD or WS and their TD peers in the number of responses given to any category for ‘why’ responses. An interaction emerged in the TD age comparisons, in which the youngest and oldest groups did not significantly differ as to how many ‘why’ responses they gave to *animal* faces, with the oldest group giving significantly more than those aged 6-8.5 years and 8.6-11.5 years.

Regarding object images, all participants very consistently labelled an object with the correct identity: The mean number of responses did not fall below 7 (out of 8) in any participant groups. Therefore no differences emerged between any of the age-groups or between those with ASD/WS and their TD peers for this type of response. For ‘feature’ responses, in which participants described various parts of the object shown, children aged under 6 years gave significantly fewer of this type of response than all other age groups. Individuals with ASD also gave significantly fewer of this response type than both CA and MA peers; those with WS gave significantly fewer responses than CA peers but were comparable to TD MA matches. An analysis of ‘function’ responses (in which participants spontaneously talked about what an object was used for) revealed

that the youngest children in the age analysis gave more of this response type than those aged 6-8.5 years and 8.6-11.5 years. Individuals with ASD gave significantly *more* of this type of response than did either CA or MA peers. Those with WS gave significantly fewer function responses overall than their MA matches, but no differences were found between these individuals and TD CA peers.

4.5 Discussion

4.5.1 TD Age Groups

4.5.1.1 *Spontaneous responses to images*

When examining differences between the TD age groups, the prediction that an age by stimulus type interaction would be seen was not borne out: All participants showed the same trend with comparable number of face responses to fruit/line images, and significantly more emotion terms given in response to line versus fruit images. This divide between the types of ‘emotion’ responses that TD participants gave to line versus fruit images is an important one that adds support to the fact that the images used in the present study do tap into the use of strategies in which parts are pieced together to form an impression of the whole. Given that the line images were ambiguous and not comprised of shapes that might denote eyes or a mouth, spontaneously labelling these images as an emotion suggests the piecing together of the component parts, not only to deduce a ‘face’ but to label it with a specific emotion. Incidences of this type of labelling were very low for fruit faces, perhaps because the presence of specific fruit items detracted from the piecing together of parts which were clearly *not* facial features. If we make the assumption that to process these images as faces and infer emotion to them then the participant needs to use configural processing, the findings go against the work of Carey and Diamond (1977) and their assertion that children may switch from a featural to holistic form of processing at around 8 years. However, under the same assumption, the findings of the present study are very much in line with those of Tanaka et al. (2007) in that the same *patterns* emerged across all age-groups. It may well be the case that the age divides in the present study did not fully capture the point at which a possible coding ‘switch’ might occur (if indeed it does occur).

The fact that there was a divide between the number of responses given to fruit versus line images for ‘emotion’ and not ‘face’ responses may be indicative of different *types* of processing, as suggested by Haxby et al.(2000). Whilst individuals did spontaneously piece together the component parts of both types of image equally as often to deduce a ‘face’, this happened far less for fruit images than line. Fruit images were designed to allow for the appraisal of specific features, rather than line images, in which the features were all very similar, simply comprised of straight lines at different orientations, rather than varied in size or shape. It could therefore be the case that a more featural processing style was used for fruit images, insufficient to deduce an emotion, whereas it was enough to label items as a ‘face’.

The role of exposure to and experience with faces should not be neglected when considering the similar patterns in the data here: None of the participants would be particularly familiar with images of the nature used in the present experiment, therefore items might be treated as more novel objects, eliciting a featural processing style. Mondloch et al. (2007) have stressed the importance of early experience in the development of later visual processes: They have tentatively suggested, on the back of their findings, that holistic processing may facilitate attunement to more spatial relations and their use in the identification of familiar faces. The precise nature of these processes was not examined in the present experiment, as the focus was more concerned with how participants would piece together parts to form a whole. Interestingly, differences were only found for number of emotion responses between the youngest and oldest groups for fruit images. This difference might suggest an interplay between strategy use and the *salience* of images until configural processing is fully developed: Local, feature cues might dominate processing until around 11 years of age for items of a more ambiguous nature.

4.5.1.2 *Types of response*

In order to more deeply analyse possible differences between the groups in the present study, the *types* of response that individuals gave were examined. These were broadly categorised as references to facial features, emotion terms and reasons for an emotion. It was intended that evaluation of these would provide preliminary ideas as to precisely where those with ASD and WS would focus and how these patterns would map onto TD groups.

Depending on the response types being analysed, different patterns within the TD age groups emerged. For facial feature responses, the lowest percentage of this type of response was given towards animal faces versus human and line. Interestingly, there was no advantage of the human face over ambiguous images in eliciting facial feature responses. One critical point to note was the fact that differences did not emerge between percentages of responses given to line versus human image categories overall for any type of response, whereas differences were typically found between fruit and line images. This points to the fact that images configured to form a face in which there is a greater level of ambiguity (with only lines being used to represent parts) elicit more responses using ‘facial’ terms and social descriptions than images in which the individual features are clearly treated as separate fruit items. Similar types of response were given for line and human images, perhaps suggesting that they are treated and processed in the same way. In order to deduce emotions from the individual lines, this must involve some processing at the global level. That TD individuals do show a clear divide in their interpretation of line versus fruit images provides a robust point of comparison when examining the performance in individuals with ASD and WS.

For emotion responses, very different age trends emerged depending on the image presented: The youngest group gave significantly fewer emotion responses to human faces than all other groups, but were comparable to those children aged 6-8 years 5

months (who also provided very few of this type of description) when giving responses to fruit faces. It is difficult to accurately interpret this finding, given that deducing an emotion from fruit parts should be less intuitive than doing so from human facial features; this finding becomes more complex when considering the fact that there were *no* age differences in the number of emotion responses given to line images. One possible explanation of this unexpected finding is offered by Freitag and Schwarzer (2011) who have noted in their examination of how individuals identify a face based on changeable expressions, that emotions may be more facilitatory in younger children on the ability to identify a face. They state that, until configural processing develops (which they suggest occurs after age 5), individuals rely more on semantic, internal representations. This is borne out by the finding within the age trajectories that the youngest group gave the least number of emotion responses to human faces, whilst the oldest group gave significantly more emotion responses to fruit faces.

This pattern of results is critical for offering a framework as to where the profiles of those with ASD and WS may separate: As is discussed below, individuals with ASD showed lower proportions in giving emotion responses to all types of images overall compared to both CA and MA peers; those with WS showed no differences with MA peers for line images specifically. If developmental age does not appear to be consistently predictive of the ability to draw together ambiguous line cues to deduce an emotion, this lack of a difference in the WS and not ASD group may indicate syndrome specific deficits in the ASD group not seen amongst those with WS.

That differences emerged in the percentages of types of response given to human versus animal images for emotion and ‘why’ responses in the TD cohort may suggest that there is some specificity of the human face that drives processing style. This difference was not seen for facial feature responses. In terms of spontaneously describing facial features, this is perhaps not surprising, given that the cues were explicit. Once participants had stated an image was, for example, “A man/a dog”, it might then make sense, on being prompted ‘what else can you tell me?’ to then go on to describe what that man/dog looked like. If experience plays an important role (as Mondloch et al., 2007 suggest) in the development of and expertise in face processing, one might expect differences to emerge when interpreting *emotions* from human versus animal faces, as was found. It therefore seems that age/experience might underpin how likely children are to spontaneously talk about emotions and *why* an emotion might be felt in response to animal faces. This might suggest that different factors operate as to what children of different ages focus on or think about when viewing human versus animal faces.

4.5.2 Clinical Groups

4.5.2.1 Spontaneous responses to images

The findings of Experiment 1 reveal that those with ASD and WS *are* able to piece together individual features to deduce that an item is a ‘face’. However, they do this significantly less frequently than their TD CA counterparts, with generally fewer

responses referring to either ‘faces’ or ‘emotions’ when presented with either line or fruit faces. Individuals with both WS and ASD did provide face and emotion responses to fruit and line images as often as their MA peers, suggesting that difficulties might be more age/experience driven, indicative of a delay, rather than in any core deficits. Further, if mental age underpins the likelihood of individuals with both ASD and WS interpreting these types of images as a ‘face’ or an ‘emotion’, it suggests that similar processing strategies might be utilised, that are not as developed as those seen in peers of the same CA. The reduced number of face/emotion responses given by those with ASD/WS in comparison to their TD CA counterparts may be suggestive of *less* competent or less likelihood, of configural processing. Indeed, as Karmiloff-Smith et al. (2004) have noted, similar trends between clinical and TD individuals are not necessarily indicative of similar underlying processes. This could be the case in the present study: The low number of ‘face’/ ‘emotion’ responses towards fruit images in all groups could be mediated by different factors. For example, perhaps those in the TD group are less likely to state that ‘fruit’ images are an emotion because it makes little sense to do so when the individual parts are clearly fruit, whereas those in the clinical groups simply might not have pieced together any parts to deduce a face-like configuration. Analysis of the *types* of response that individuals with WS and ASD (compared to TD peers) gave did reveal more syndrome specific differences. These are discussed in section 4.5.2.2 and 3.

It was hypothesised that different trends would emerge in the WS and ASD groups in terms of divides between fruit/line images, whereby those with ASD would employ a more blanket featural strategy. It was predicted that this would manifest as no differences between face responses to these images amongst ASDs, whereas those with WS would be more inclined to use a featural strategy for fruit but a more configural process for line images, evidenced by significant differences between the two. In fact, no significant differences were found between ‘face’ responses to fruit/line images in *any* groups. For emotion responses, all groups also demonstrated significantly more emotion terms in response to line rather than fruit faces, although those in the clinical groups did this significantly less often than did peers of the same age. This finding points to the possibility that individuals with both ASD and WS are processing images in a similar manner to younger individuals, again suggestive of a developmental delay.

It may be worth considering that the use of ambiguous images in the present experiment elicited a style of processing that might have masked potential differences between the clinical groups compared to their peers: Objects have been found to be processed in a different way to faces in a wealth of studies, with neuroimaging data supporting behavioural research. Might it therefore be that, in all cases, the fruit and line images were treated more like inverted faces or objects?

One should bear in mind that the paradigm used in the present study was not designed to test hard and fast configural processing but set out to examine, preliminarily, whether or not those with WS and ASD would piece together non-facial features to deduce a ‘face’ (or an emotion). The precise nature of what factors might be involved will be further explored in later chapters.

Deruelle et al. (1999) noted but failed to explain the reasons behind a lack of an inversion effect in individuals with WS. Is it due to their failure to use configural processing, or because they use a blanket featural strategy, regardless of orientation, that is not as efficient as in the TD population, demonstrated by poorer performance in these groups for inverted faces? In light of the present experiment, however, if featural strategies were a 'buffering' factor in WS, it might be expected that responses to fruit images would be heightened; this was not the case. In fact, as with all other groups, responses to fruit images were the most diminished.

4.5.2.2 *Types of response: ASD*

Although no direct comparisons between the types of responses given could be conducted in the present study, due to the dependence of response types on one another (derived from the same answer, such as 'it's a cat and he looks excited because he's just been fed'), it is worth noting that the commonest response type across all four images categories in all groups was in referring to the facial features of items. However, it was on this measure that the most marked difference appeared between those with ASD and both matched groups. Those with ASD gave significantly fewer facial feature references than both TD matches overall, although no main effect of image category was noted in the ASD group or TD matches in that analysis. That individuals with ASD gave any descriptions of facial features to non-face images is, however, telling in that it suggests that, even without explicit cues to comment on, individuals with ASD will draw analogies between real faces and ambiguous images. However, it is worth noting that there may have been practice effects in the present experiment; whilst the experimenter did not give feedback to participants, instead giving neutral statements such as 'Uh huh, let's move on to the next one', individuals may have assumed that the lack of any corrections indicated 'right' answers, and therefore adopted the same types of descriptions throughout the experiment. Object images were inserted to avoid such practice effects but it may be worth considering.

The fact that those with ASD gave far fewer facial feature responses than CA or MA matches might be indicative of their not attaching any social significance to individual facial features, or a more general inattention to particular face parts. Were a divide found between use of facial features to real versus ambiguous images, it could be deduced that a more featural process was at play in the ASD group. Given that this was the case across all image types, however, with no significant differences being found in the percentages of responses given to any of the image categories, it may simply be that individuals with ASD were not making any attempt to label features at all. The present experiment, whilst pointing to possible ways in which the different groups may or may not be using featural cues, cannot answer the question of whether or not a blanket featural strategy is being utilised, or how effective this is. An inversion paradigm, like the one used by Cashon et al. (2013) would better speak to the issue of the role of novelty and orientation in determining processing strategies. Similarly, a replication of the Wii task in the future, perhaps with a more detailed break-down of categories that might tap into the *types* of cues specifically being used, might be more informative.

Examining incidences in which participants described the *physical* properties of features, for example, might provide an insight into where attention is being given when appraising face versus non-face images. A formal examination of holistic processing will, however, be addressed in Chapter 5.

When examining emotion, individuals with ASD gave a lower proportion of responses compared to both CA and MA peers, as hypothesised. The same patterns also emerged in that all participants gave the fewest of this type of response to fruit images, with no notable differences found in the number of responses given to human versus line images in any of the groups. This suggests that individuals with ASD, whilst they may not be as likely to label emotions as their TD peers, do process the different categories of image in a similar way. Differences between individuals with ASD and MA matches for emotion responses were less clear than compared to those in the CA group and those seen when examining feature responses: This may indicate a particular type of cue *use* in ASD. In the present study, mouth cues were always particularly expressive and unambiguous therefore it might be that those with ASD were able to use those above and beyond the cues available for the other image categories. McPartland, Webb, Keehn and Dawson (2011) found that those with ASD tended to stick to using one overarching strategy when attending to features of objects and faces, and this may go some way to explaining this pattern of results in the current ASD group: Human face cues are useful in interpreting expressions but different judgements might have to be made (using a more configural process) in the case of fruit faces.

Interestingly, no differences were found between the percentages of ‘why’ responses that participants in each group gave for any of the images, with the only significant difference being seen in that more ‘why’ responses were given to animal versus fruit images. In the TD age analysis, the oldest group gave higher percentages of this response type to animal faces compared to the middle two age groups (but not the youngest). This suggests that a tendency towards providing explanations for emotions in animals is not necessarily age driven but may be due more to *experience* with animals, which may differ greatly between participants. Anecdotally, many of the children in the ASD group did report having pets, therefore it might have been that this made such responses more salient for animal images. A formal examination of this would be informative in future.

4.5.2.3 *Types of response: WS*

A different pattern of response types appeared in the WS group in this experiment. For responses involving a facial feature, individuals with WS performed comparably to both CA and MA matches for the real (human and animal) images. However, they gave significantly fewer responses towards fruit/line images than either CA or MA peers. This divide may highlight the salience of real faces in drawing attention to facial cues and/or of particular difficulties those with WS face when asked to make attributions to ambiguous face parts. This pattern of results is extremely important when considering differences between individuals with WS and those with ASD: Individuals with ASD

gave fewer feature responses over *all* image categories than their CA or MA peers, suggesting a general lack of attention to, or inclination to describing, facial features when both real and explicit or ambiguous. That individuals with WS were as likely as even CA peers to describe the facial features of real faces suggests more of an interest in, or attention to, these types of cue than was evident amongst those with ASD. However, whether this divide between the appraisal of real versus non-face images in WS was due to difficulties in interpreting ambiguous images or more confidence in doing so with real face images, remains to be tested.

It was tentatively hypothesised that those with WS would be able to deduce *emotional* meanings from human faces, given their heightened exposure to this type of image in everyday interactions, and yet they were not found to provide emotion terms in response to human faces as often as their CA counterparts did; they were only comparable at the MA level. This might suggest that cognitive factors, rather than experience, are more important in how faces are interpreted in WS. This was also found to be the case for fruit faces.

Given the very young age of the MA matches in the WS cohort (mean age=4 years, 7 months), it is important to consider what the comparable performance of those with WS to this group tells us. Macchi Cassia, Turati and Schwarzer (2011) have suggested that children around 4 years of age have poorly tuned sensitivity to configural information; in the present study, this implies that performing at a comparable level to their MA matches in the WS group is indicative of developmentally delayed processing strategies. Indeed, this is one of the difficulties of employing a matched groups design in clinical research, in which individuals matched on MA tend to be very different ages, and it is difficult to draw conclusions across groups covering such a wide age range. However, the analysis between age groups across the TD cohort was informative in the present study: No age effects, for example, were found for ‘emotion’ responses to animal/line images and these were also the images to which no differences were found between those with WS and their TD peers of either CA or MA. This therefore indicates that, if age is a less important factor in the types of ‘emotion’ responses that individuals give to these types of images, differences between the WS and TD groups would not necessarily be found. More specific types of code in the present experiment might have better pulled apart more subtle differences between the groups.

It is difficult to fully explain the finding that individuals with WS were as likely to make emotional attributions in response to line images, given their lack of references to facial features compared to even MA peers on this measure. In order to deduce an emotion from such ambiguous images, one might expect that configural processing would need to occur, and yet analysis of the *spontaneous* responses to fruit/line images might suggest that individuals with neither ASD nor WS were as likely as TD peers to piece parts together to deduce a ‘face’. Both Tanaka et al. (1998) and Mondloch et al. (2007) have highlighted the importance of carefully pulling apart divides when testing clinical groups between *patterns* in the ways in which a task is approached and ultimate *accuracy*. Whilst the present experiment was not concerned with ‘correct’ responses per se, it might be possible that different use of cues for different images might still

manifest in similar patterns of response type between groups for certain items. The salience and utility of particular cues will be further explored in Chapter 6. One possible limitation of the present experiment was the lack of any response time data; Behrmann et al. (2006b) have shown that individuals with ASD, whilst performing as *accurately* as their TD peers, do so much more slowly when asked to discriminate between faces or objects. A lack of different patterns in response types in the present experiment might be underpinned by different processing speeds, and possible deviant strategies not elucidated here.

4.5.3 Responses to objects

The inclusion of objects in the present experiment was intended purely as a baseline measure to insure that participants understood the task demands and did not have any problems in accurately identifying images. Objects were also included to break up the possible routine of participants getting into a habit of continually stating that items were a 'face'. However, an interesting result emerged in that those with ASD talked significantly more about the *functions* of objects than their CA TD matches, whilst they labelled features significantly less than both groups of TD peers. An examination of the age groups revealed that this same inclination was found between the youngest group and the older ones. Individuals with WS talked about object features less than CA matches and functions less than MA matches; however, this MA group were very young (mean age 4 years, 7 months), therefore were the group who, in the TD age analysis gave significantly more function terms than any other children.

Two questions arise: Is this propensity towards talking about the functions of objects in ASD evidence of a developmental delay whereby perhaps object *use* is most salient to younger children who are exploring by doing all the time? Or is it driven by a heightened *salience* towards objects? Loth, Gómez, Happé and Carlos (2010) found in their study examining top-down priming effects of faces versus objects in individuals with ASD that only prior knowledge of *objects* appeared to facilitate the recognition of degraded images. This priming effect was not found for face images. This might add weight to the salience argument of why those with ASD provided more responses to object functions in the present study. However, the design of the present study must be considered in that it encouraged participants to think about 'alternative' responses to images: Once participants had given their initial response (which was predominantly to simply name the item shown, as would be expected when asked 'what is it?'), they were asked 'Can you tell me anything else about it'? It is therefore perhaps logical that individuals would go on to talk about the *use* of an item. It would be useful to therefore examine only the *initial* responses to object images in future analyses. However, that individuals with ASD chose to talk about functions rather than describing features, as TD children tended to do more often, appears to be specific to the disorder, as this was not seen in the WS cohort. This also stands in line with the finding that individuals with ASD talked far less about the facial *features* of items than did their TD peers.

The fact that individuals with ASD focus so predominantly on the *functions* of objects suggests that, for this type of image, they are able to employ a more holistic process in both recognising what the object is and then referring to its utility. This is further borne out by a clear reduction in talking about the individual *features* of objects amongst ASD individuals. This goes against the findings of Behrmann et al. (2006b), who have claimed that both face and object processing are underpinned by a more featural processing style in ASD. However, it should be noted that the images of objects used in the present study (See Appendix A) were not particularly complex, or comprised of various parts that needed to be combined into a whole in order to accurately deduce identity. This would be worth exploring in future experiments.

Experiment 1 points to some ways in which those with ASD and WS may differ in what they see when they look at a face or face-like images. Both groups show some evidence of the ability to piece together parts into a whole, yet there appears to be a possible reluctance amongst those with ASD to attribute facial features to ambiguous images or particularly focus on facial features in even human faces. Individuals with WS show a definite developmental delay in the likelihood of them piecing together individual *ambiguous* features to form a 'face'. However, individuals with WS are as likely as their TD peers of both CA and MA to describe the content of *real* faces; this may suggest either difficulties in interpreting ambiguous cues or more ability in processing *real* faces.

4.6 Summary of Chapter 4

Based on the findings of Experiment 1, it is not possible to conclude that children 'switch' from one processing type to another, nor that any particular type of cue determines the information that children utilise when drawing interpretations from images. In typical development, age does not appear to predict the types of things that children focus on when appraising ambiguous or real face images, although the number of overall responses does tend to increase with age.

Evidence of possible developmental delay is seen in both ASD and WS groups, who fail to provide as many responses as do their TD peers. However, similar response *patterns* emerge, perhaps indicating the same but less effective strategies. In WS, differences compared to TD peers diminish when the images shown are *real* faces. The fact that differences were not found between line and fruit images for any of the groups in their spontaneous responses does not necessarily imply use of the same underlying processes: Those with WS and ASD may have been utilising a blanket featural strategy. It may therefore be that different cues under different conditions determine the types of strategies used or which cues are most useful; amongst participants with ASD, for example, the functions of objects appear to be particularly important. This divide between object and face cues will be explored in Chapter 6.

The current experiment in no way attempted to measure the *accuracy* of the recognition of emotions from images. This would be particularly telling in that it may reveal deficits

on those images that require more configural types of processing to accurately deduce an emotion. Similarly, the question remains as to whether human faces might hold some buffering effect for the interpretation of *emotions* in WS? Therefore, Experiment 2 (The emotion task) will test the question of how accurately those with WS and ASD can interpret emotions from real and face-like images. Experiment 3 will go on to offer a more robust measure of configural processing by testing participants' recognition of emotions in a classic composite face paradigm.

Chapter 5: Processing of Emotions

5.1 Introduction

Experiment 1 explored the ways in which children with autism (ASD) and Williams syndrome (WS), compared to their typically developing (TD) peers, piece together features to deduce social content. It was found that, whilst those with ASD and WS were significantly less likely than their peers to spontaneously attribute face or emotion terms to ambiguous stimuli, they did show the same patterns of response. For example, no participants showed divides between the types of responses given to human versus animal faces and all participants generally gave very few spontaneous emotion terms to images comprised of fruit. *Accuracy* for the identification of emotions was not, however, examined in Experiment 1 therefore Experiments 2 and 3 explored accuracy for the identification of emotions in two tasks: A forced choice emotion identification paradigm using the same four categories of stimuli as used in Experiment 1, and a classic “composite” face task. The aim of Chapter 5 is therefore to i) Examine how accurately individuals in the clinical groups, compared to their peers, are able to identify emotions, ii) To explore the extent to which the demands of holistic processing and/or the facilitation of the *human* face may influence emotion identification and iii) To investigate whether eye versus mouth cues appear to hold any particular benefit for the identification of emotions, and the interplay between cue type and specific emotion.

Experiment 2, the Emotion Task (ET) is a forced choice task in which participants were presented with the same categories of image as used in Experiment 1 (see Figure 5.1 and Figure 5.2) portraying one of four possible emotions (happy/sad/angry/surprised); participants were asked to choose the emotion that best described the face, from a choice of three. The purpose of this experiment was to examine whether clinical groups would differ in accuracy for identifying specific emotions or would show different patterns of performance in response to particular *categories* of image. Would there, for example, be any *syndrome specific* patterns in accuracy for interpreting emotions from ambiguous or real faces?

Experiments 3a and 3b, the Parts (PT) and Composite tasks (CT) are based on assessments evident in the literature on the development of face skills (Durand et al., 2007; Singer & Sheinberg, 2006) and set out to examine accuracy for specific face cues and whether or not possible *interactions* would be evident between the use of holistic processing and the emotion shown. In the PT, participants were presented with isolated eye and mouth cues and were asked to identify (from a choice of happy/scared/angry), the emotion shown. This task was similar to that of Baron-Cohen et al. (1993) in which they compared performance for isolated eye/mouth cues as well as features presented in whole faces. A task such as this therefore allows for an exploration of whether a particular cue type would be more facilitatory in the accurate identification of emotions and if the utility of cues might be different between those with ASD and WS.

In the CT task, based on a design originally devised by Young, Hellawell and Hay (1987), participants were shown images of real faces with top and bottom halves

depicting different emotions (combinations of happy/scared/angry) either in aligned or misaligned format. This is a classic assessment of holistic perception (Calder et al., 2003; Durand et al., 2007). Participants were asked to attend either to the top or bottom halves of each face in order to state which emotion was shown. The purpose of this experiment was to elucidate whether misaligning facial features, and therefore reducing the demands on the processing of configurations, would be beneficial for specific emotions and not others, as well as whether accuracy would be enhanced for eyes versus mouths or vice versa; further, whether these patterns might differ between clinical and TD groups. Before describing the experiments, a brief review of the literature follows which will guide the specific hypotheses and predictions for these experiments.

5.1.1 Processing of Cues in Typical Development

If, as has been argued (Mondloch et al., 2002; Mondloch & Thomson, 2008) the processing of faces using configural information is something that develops across childhood, it follows that the utilisation of individual facial *features* may play a more prominent role amongst younger (compared to older) children or adults. Even when configural processing is fully developed, it may be the case that particular areas of the face are given priority over others and therefore certain facial cues become more important for the accurate identification of, especially complex, emotions (Baron-Cohen et al., 1993). The issue of whether the eyes or the mouths are the most useful cues in aiding the identification of emotion is one that has been widely debated throughout the literature.

Many researchers have agreed that *eye* cues are essential in judging the emotional content of faces, with even very young infants showing preferences towards attending to the eye regions of faces (Maurer, 1985). Baron-Cohen, Wheelwright and Jolliffe (1997) have shown in their set of three experiments that, whilst *whole* face information was most conducive to the accurate identification of both basic and complex emotions, use of eye cues was more helpful than mouth cues in identifying complex mental states. Specifically, adult participants in their study were shown either whole faces, mouths only or eyes only and were asked to choose from two basic emotions or mental state terms which best described the face/face part. For mental states, accurate identification from the eyes alone was as high as when participants were presented with whole face information. The different trend towards the utility of eye cues depending on the complexity of the emotion shown is testament to the fact that there is an interplay between emotions and cue use.

More recently, Blais, Roy, Fiset, Arguin and Gosselin (2012) have argued that the eye region may not be the most important area from which to interpret emotional states. They used the ‘Bubbles’ technique to compare performance in labelling the six basic emotions as well as neutral and “pain” expressions across cues available using dynamic and static stimuli. This technique involves presenting participants with various elements of faces, assigned by spatial frequency, time point or location in spatial dimension

(Spezio, Adolphs, Hurley, & Piven, 2007). Blais et al. (2012) observed that participants generally underutilised the eye cues of faces, and were more accurate in labelling emotions when presented with information from the *mouth* region. This advantage of the mouth cues became more pronounced in response to dynamic stimuli; the authors suggest that this may be because the discrimination *between* emotions often depends on the subtle movements of the mouth, whereas the eyes may provide a more definitive cue for the apexes of (static) emotions. Back, Jordan and Thomas, (2009) have shown that the emotion being identified will determine the utility of specific cues and whether or not the animacy is beneficial to recognition of that emotion. In their study, twenty TD adults (aged 18-35) were shown images of both static and dynamic complex mental states (such as bemused, flirtatious, doubtful, etc.) and were asked to identify, from a list, the emotion they thought was depicted; in a second experiment, specific parts of the face images (mouths versus eyes) were frozen whilst other parts remained dynamic. Back et al. (2009) found that, overall, participants were more accurate in recognising mental states from dynamic versus static faces. However, there were some differences depending on the type of mental state presented, with no benefit of animacy found for bemused, distrust, smug or thinking. Mouth cues were also found to be as important as eye cues in accurately deducing an emotion: Freezing mouth cues was as detrimental as freezing eye cues. Taken together, these findings suggest that the *animacy* of facial features is crucial for their interpretation, and there is some interplay between the types of cue that are most useful, depending on the emotion depicted.

The distinction between dynamic and static images of faces is an important one, as it may well be the case that different cues play a different role in the *changing* versus stable configurations of faces. Unfortunately, the interplay between emotion type and cue use was not examined by Blais et al. (2012); very few studies to date have attempted to explore this cross-over, perhaps due to the constraints of experimental design in this area. It is, however, possible to examine accuracy for identifying emotions as a function of the relationships between face cues (eye versus mouth) and the emotion depicted; this will be the focus of Experiment 3. As Back et al. (2009) have suggested, different emotions/mental states may be processed in different ways, using different cues. It is therefore important to examine differences *between* emotions as to how easily they are processed and in what ways.

5.1.2 Emotion Specificity in Typical Individuals

The accuracy with which individuals identify emotions may depend upon the emotions themselves. However, across the literature on emotion specificity in the TD population, there is very little consensus as to which emotions appear to be given priority in how rapidly and accurately they are processed. Hansen and Hansen (1988, cited in Farran et al., 2011), based on their studies of angry versus happy face detection amongst targets, found that there appears to be what they termed an ‘anger superiority effect’ (ASE) whereby angry faces are detected faster, and with fewer false alarms, than happy faces. They state that this effect has an evolutionary basis, whereby the detection of a threatening face is advantageous for rapid defensive responses. Indeed, a wealth of

neuro-imaging studies (Chiang et al., 2007) have found the amygdala, long associated with ‘fight or flight’ and affective responses, to be more active in response to threatening faces in typical development. However, the findings of Hansen and Hansen (1988, cited in Farran et al. [2011]) have not been consistently replicated, and Farran et al. (2011) note that several other research groups have also found an advantage for happy over angry faces. This therefore begs the question of whether extremes of emotion (such as happy and angry) hold a particular salience. It may also be the case that perceptual biases might underpin the salience of a face: Teeth in a grimace may offer a bright contrast and this, rather than any utility of emotion, might govern the faster speed in which an angry face is typically recognised (Santos, Silva, Rosset, & Deruelle, 2010). Control over such perceptual differences has been generally lacking across studies and it is therefore difficult to draw absolute conclusions about the more *social* aspects of faces that might drive differences between the recognition of emotions.

Offering neurological evidence, Kret, Pichon, Grèzes and de Gelder (2011) examined differences in neurological activation for dynamic emotional versus neutral bodies and faces; the aim of their research was to pull apart whether the *movement* aspects of emotions might trigger specific neural processes and whether these would be specific to faces. This is an important issue that bridges the gap between emotion recognition and the configural processing of facial information: It is the *rearrangement* of configurations that determines emotional content, therefore how this is affected by different emotions or cues is of particular interest. This stands in line with Blais et al. (2012) and Back et al.’s (2009) suggestions that cues might hold different processing weights in static versus dynamic presentation of emotions, depending on what those emotions are.

Kret et al. (2011) showed dynamic clips of bodies and faces depicting either angry (to half of the participants) or fearful (the remaining half of participants) faces, as well as neutral faces and bodies, whilst in an fMRI scanner. Despite the presentation of different emotions, showing faces to participants resulted in heightened amygdala activation, with a wider spread of brain regions occurring in response to body gestures. No significant differences were found in activations of specific regions between emotional and neutral faces. Kret et al. (2011) therefore suggest that the amygdala is more of a ‘salience’ module that responds to faces specifically rather than any specific emotions. However, whether this activation was in response to emotions per se or more general configural changes remains to be seen. Farran et al. (2011) have also suggested that the style of the stimuli may play a large part, with the ASE occurring more in studies employing schematic stimuli compared to a better performance for detecting happy faces when the stimuli are more ecologically valid. This question of the level of interplay between emotion, cue use and the animacy of faces is one that will now be considered.

5.1.3 The Link between Emotions and Processing of Cues in Typical Individuals

Green, Williams and Davidson (2003) have suggested that there is a neural basis for the types of response shown to different emotions in typical development, and that the ways in which particular facial cues are attended to may both be a product of and facilitative to emotion processing. In a passive viewing task using happy, sad, angry, fearful and neutral faces, they found significantly more attention and for longer durations was spent focussing on the eyes, nose and mouth of threatening versus any other type of face. The distribution and priority of attention to different facial cues is an important issue and it may be the case that reliance on eye cues is not the default strategy in typical development; different cues may be utilised differently depending on the emotion.

As well as examining *attention* to cues, the Green et al. (2003) study also observed that there were longer distances between fixations for threatening faces, suggesting that the appraisal of cues and the ways in which they are perceived also differed for threatening faces specifically. Interestingly, these patterns were more pronounced for anger than for fear; it could be that appraisal of fear is more cognitive, requiring a higher level theory of mind. For example, we must understand why a person is looking fearful; is it because threat is near? Whereas an angry face represents the threat itself. The inclusion of an emotion labelling task to also deduce accuracy would have been informative in this case in examining the interplay between attention and accuracy for specific emotions. These subtle differences are precisely the conceptual issues that may be posing a problem in WS and ASD and must be the focus of future empirical investigation.

5.1.4 Processing of Cues in autism

It has been well documented (Baron-Cohen et al., 1997; Riby & Hancock, 2008) that individuals diagnosed with ASD show less attention to the eye regions of faces than do TD peers. However, this lack of attention to the eye cues of faces does not necessarily mean that, when specifically instructed to use eye cues, those with ASD are not able to utilise the emotional information available from them. Experiment 3 in the present set of experiments will explore this question with the use of explicit instructions. Baron-Cohen et al. (2001) have argued that individuals with even high functioning autism are not as able as TDs to deduce emotional states from the eye regions of a face. In a revised version of their 'Reading the mind in the eyes' task (Baron-Cohen et al. 1997) in which they increased the response options from only two to four, they found that 15 high functioning adults with autism performed at significantly lower levels of accuracy than was found on normed data for 274 TD adult participants. They also found a negative correlation between autism symptom severity and accuracy for deducing correct mental states on the eyes task. Baron-Cohen et al. (2001) have claimed, based on their study, that the utility of the eye region in deducing an emotion is so pivotal to the nature of autism that it can be used to differentiate between clinical and TD groups. However, Baron-Cohen et al. (2001) failed to devise any stimuli featuring mouth cues for this set of studies; a direct comparison of

performance between the two might be more helpful in elucidating *differences* between the ways in which facial cues are used by those with ASD compared to TDs. Back et al. (2009) have shown that mouth cues are as important as eye cues in accurately identifying emotions in TD individuals, therefore it is important to establish whether this is true in neurodevelopmental groups as well.

Going against the findings of Baron-Cohen et al. (2001), De Wit, Falck-Ytter and von Hofsten (2008) set out to investigate whether atypical scanning patterns for positive versus negative emotions could be responsible for deficient emotion perception in ASD. They gave 11 children aged 3-6 years with ASD (mean age 5 years, 2 months), matched to MA typically developing controls, a passive viewing task comprised of happy, calm, angry and fearful faces. Participants were eye-tracked whilst viewing these images. The researchers also administered a subsection of the ADI, tapping into social exchange behaviours. De Wit et al. (2008) hypothesised that there would be differences in scan patterns both between groups and emotions, such that the particular problems found in recognising negative emotions in ASD might be explained by abnormal scan behaviours. However, this was not borne out by the data. Rather, there were no differences in looking time for positive or negative emotions in either group and both groups spent longer looking at the eyes for negative emotions. Worthy of note is the fact that there was a borderline significant difference ($p < .06$) whereby children with ASD spent 'marginally less' time fixating on mouths overall versus eyes. This same trend was also found amongst TD children. Perhaps the most informative finding in support of a role for autism in these results was the observation of a strong negative correlation between severity of autism symptoms (as measured on the ADI-R) and total time spent looking at faces. Whilst this may indicate that individuals with ASD were simply not engaged with the task, it was found that participants with more deficits reported in the social/communication areas of the ADI-R were found to show shorter looking time towards the mouths *specifically*. This finding stands in direct contrast to the work of Klin, Jones, Schultz, Volkmar and Cohen (2002) who have shown a *positive* correlation between duration of attention to mouth regions and level of social impairment. However, as De Wit et al. (2008) themselves note, the Klin et al. (2002) study employed dynamic video clips of emotional conversational exchanges, and a group of participants who were severely impaired in the verbal domain. It might therefore be that heightened attention to the mouth region was necessary to try and make sense of the verbal content of the scenes. However, it should be noted that duration of fixations on specific cues are not necessarily indicative of the *ways* in which those cues are being used; it could be that lower-level aspects of certain cues attract the attention of individuals and looking is a passive activity without deriving any specific *meaning*.

The difference in the format in which emotions are presented, and the demands of the task itself, are an essential issue to which there is no consensus across the literature. De Wit et al.'s (2008) study was a *passive* viewing task, in which participants were not asked to make any judgements as to the emotion being shown. An examination of the interplay between the cues being used and accuracy for specific emotions might be a more informative comparison. Similarly, Klin et al. (2002) failed to question their participants on what they had *seen* happen between the characters in the scenes they

were shown. Experiments 2 and 3 here aim to bridge this gap by establishing the *accuracy* in which participants are able to utilise cues to deduce specific emotions. De Wit et al. (2008) do note that their finding of similar patterns of gaze between those with ASD and TDs could still be explained by different underlying causes. It may be the case that individuals with ASD were passively looking at cues without deducing any social *meaning*; including a measure of emotion recognition would have been useful in elucidating this. An exploration of the *use* of certain facial cues could, for example, point to differences between the ways that individuals with neurodevelopmental disorders *use* those cues: Whilst it may appear that individuals with ASD and their TD peers are both showing similar patterns in attending more to the *eye* cues of negative emotions, for example, it may be that the underlying processes are different. Perhaps individuals with ASD use a blanket strategy of focussing on a particular cue type, whilst their TD peers selectively choose which cue offers the most socially relevant information. Given that different emotions may be better interpreted using different facial cues, the interplay between the two therefore becomes especially important. In order to examine these types of underlying mechanism, a more robust paradigm is required and it is this *interplay* that will be examined in Experiment 3.

5.1.5 Emotion Specificity in autism

Given that, perceptually, the area of face perception weakness seen to be greatest in both WS and ASD is in the processing and understanding of emotion, rather than the processing of identity recognition (Lacroix et al., 2009) one must explore the role that the emotions themselves play in the face perception atypicalities seen in WS and ASD. For example, most studies in this field use the six basic emotions as stimuli, assuming that they all have equal significance to the people viewing them, but this may not be the case. Might it be that certain emotions pose a particular problem or facilitate meaning for those with WS and ASD different to that seen in the TD population? In examining accuracy for specific emotions in these clinical groups, we can begin to understand where perceptual and conceptual deficits might diverge or overlap, building a fuller picture of how some of the components of social interactions might operate.

Baron-Cohen et al. (1993) examined accuracy for the *categorisation* of emotions in one of their seminal papers comparing 15 children with autism (mean age 12.6 years) to 15 TD children matched on MA (mean age 4.4 years). Participants in their study were asked to sort piles of photographs of faces expressing the emotions happy, sad and surprised. They found that, whilst the groups were comparable in accurately categorising happy and sad faces, individuals with autism failed to recognise surprise to the same level as their TD peers, often confusing this with happy. It should be noted that the photographs in this study provided *whole* face information; a comparison of the interplay between isolated mouth versus eye cues and the categorisation of emotions would have provided interesting insights into the ways in which facial cues might differ dependent on emotion.

Baron-Cohen et al. (1993) concluded from their experiment that individuals with autism had a specific deficit interpreting surprise; they claimed that this was due to it being a more complex emotion that requires a higher level of cognitive appraisal, which they state individuals with autism to be lacking. It could be the case that, whilst basic emotions such as happy can be directly interpreted from a situation, in order to understand more complex mental states, one needs to form an understanding of *beliefs*. Beliefs are concerned with being able to appraise and apply one's *internal* states to others, whereas the understanding of a situation may be purely *external*, based on the percepts available in a scene or image. This divide between the internal and external might differentiate between those with ASD and WS; later experiments in the present research will aim to explore this idea further.

Following on from more recent neurological studies such as that of Meyer-Lindenberg et al. (2005a), in that people with neurodevelopmental disorders display deviant amygdala volume and activation that may be related to the perception of negative emotions, Farran et al. (2011) set out to examine if emotion recognition of real faces would be poorer when of a threatening or negative nature. The anger superiority effect (ASE) has been cited as an evolutionary by-product that enables us to fight or flee when required (Santos et al., 2010) In the TD population, many studies have found that, even when surrounded by many distractor items, angry faces are rapidly detected above happy faces due to their salience in acting as a cue to avoid threat. Farran et al. (2011) were interested in pursuing the idea that the anger superiority effect (ASE) only tends to occur with schematic stimuli whilst a superiority effect for happiness is more likely with the presentation of real faces (Farran et al., 2011), perhaps accounting for some of the inconsistencies fuelling the current amygdala debate. This is an interesting and often overlooked point: That the very nature of the stimuli itself might be having large effects on processing style, and is an avenue of research that will be explored by the use of both schematic and real-face stimuli in Experiment 2.

In their study, Farran et al. (2011) showed pictures of real faces showing the six basic emotions to ASD (low and high functioning) and TD participants matched on CA and MA (mean ages 12.3 years and 10.8 years, respectively). Their task was to choose which picture out of six (one target item, one distractor item and four neutral items) matched a spoken emotional label. They found that reaction times were significantly faster within the ASD group for happy faces than for the other emotions and that anger, fear and sadness were significantly slower than surprise and disgust. For these latter two emotions, performance between the ASD and TD groups was comparable, although one may question whether this might have been a product of not separating out high from low functioning children within the ASD sample. To sum up the findings of this study, it would appear that children in the ASD group did find it easier to quickly respond to happy rather than more negative faces. However, no ASE was noted in the TD group in this particular study either, again stressing the importance of the types of stimuli used in emotion recognition tasks. Whether the difference between the recognition of different emotions is driven by different processes at a neural level or is dependent on the social *complexity* of the emotions themselves, remains to be seen. Of most interest to the

current research question, is the ways in which the profiles of those with WS may differ to this, especially given their hyper-sociability: This question will now be explored. .

5.1.6 The Link Between Processing of Cues and Emotion Specificity in Williams syndrome

Anecdotally, those with WS are reputed to spend excessive durations of time attending to the eye regions of faces when in social situations. The same question as regarding those with ASD may therefore be asked: Are these eye cues being utilised in the same way as in typical development to interpret emotions? Tager-Flusberg, Boshart and Baron-Cohen (1998) have examined the ability of individuals to read emotions from the eyes alone on the classic 'Reading the mind in the eyes' task (Baron-Cohen et al., 1997). In their study, adult participants (mean age around 26.5 years) were given the task in which they were asked to choose from two options which basic emotion and mental state terms best described images of eyes alone. Participants with Williams syndrome (n=13) were recruited in addition to an IQ matched group of individuals with Prader Willi syndrome, and a group of TD adults. They found that individuals with WS significantly outperformed their IQ matches and were as capable in accurately identifying emotions as almost half of the CA matched group, although there was a significant difference between individuals with WS and TD adults whereby those with WS were overall less accurate. No significant interaction was found in any of the groups between performance and the type of emotion (basic or more complex) presented. Further, no correlations between task performance and language or IQ measures were found in any of the groups.

The Tager-Flusberg et al. (1998) research may point to the fact that there is something about eye cues that buffers performance for identifying emotions in individuals with WS, above what might be expected for their MA level. However, the fact that half of the CA adults *did* outperform this group may suggest that there is large heterogeneity amongst the Williams syndrome population, perhaps underpinned by a wealth of other, more cognitive than perceptual, factors. Similarly, it cannot be ruled out that there is something unique about the nature of Prader-Willi syndrome in interpreting eye cues that caused the lower performance amongst this group. Furthermore, given that Tager-Flusberg et al. (1998) did not ask participants to perform any similar task using other facial cues (such as the mouth or whole face information), it is not possible to ascertain whether it is the *eyes* per se that might aid the interpretation of emotions. Riby et al. (2009) have examined this very issue of what role eye and mouth cues play in both WS and ASD. They employed a battery utilising the three classic paradigms previously discussed throughout this literature (see section 1.1.3): Thatcherised faces, a part-whole paradigm and manipulations of configurations in which the relations and features of faces were swapped. Children with WS and ASD were matched to both MA and CA controls and were asked to take part in all three tasks. On the thatcherised task, either the eyes *and* the mouth or alternate eyes/mouth were flipped and participants were asked to judge which of two faces looked the strangest. On the part-whole paradigm, participants were asked to match faces for identity and in the configural task,

participants were asked to state whether two faces were the same when either the features or the relational spaces between them were manipulated. In having tasks such as these, the researchers were able to explore not only evidence of processing style but also the use of specific facial cues.

As with other research on WS (Tager-Flusberg et al., 2003; Skwerer et al, 2006), Riby et al. (2009) found that this population demonstrated a typical pattern of processing style, with evidence of configural processing. As with these other studies, significantly more use was made of the eye cues than in the TD groups. Conversely, those with ASD used the eye cues significantly less than their TD counterparts (being less affected when judgements from the eyes needed to be made) although this was not a trade-off with using mouth cues more, perhaps pointing to a general inattention to *all* face cues. Importantly, all groups were susceptible to inversion effects on the tasks, indicating use of configural processing, although those with ASD were poorer on the configural task in detecting changes to spatial relations than in detecting feature changes. Teamed with the fact that those with ASD do not seem to rely on eye or mouth cues in any way, this finding is somewhat difficult to explain. Whilst a seeming advantage in detecting spatial changes for those with WS may be due to their reliance on eye cues, a lack of this attention to features is more difficult to reconcile with apparent relatively typical configural processing seen on the part-whole task in the ASD group. What is clear, however, is that neither of the clinical groups reached CA level on any of the tasks, and both groups showed atypical patterns in their over or under-reliance on the eyes. This may well be at the root of face processing difficulties in both groups, but manifesting in very different ways. Experiment 3 will therefore make this comparison, additionally against those in the TD population as well as with ASD.

Riby and Hancock (2008) have shown in their eye-tracking study comparing those with WS and ASD to both CA and MA TD counterparts that, indeed, individuals with WS do tend to initially appraise and fixate on the eye region of faces more than individuals with ASD and more than they do to other parts of the face. In the Riby and Hancock (2008) study, participants were asked to look at natural social scenes containing both objects and people; eye movements towards the scenes were tracked throughout this passive viewing task. No particular extremes of emotion were used and none of the scenes had any negative content. The results showed a clear difference between the groups in that TD children appraised the entire scene, shifting their gaze to all aspects that could give information, whereas those with ASD gave little attention to the face areas of the scenes at all and those with WS paid excessive attention to faces, especially the eye region.

Riby and Hancock (2008) conclude that the preferences of children with WS and ASD in terms of attention to faces seem to differ greatly and the reasons behind these atypicalities could also be very different. It may be, for example, that those with WS have problems in disinhibiting gaze from the socially salient aspects of scenes, or perhaps they do not realise that other areas of a scene beyond the face can provide valuable information. Those with ASD, conversely, may find looking at faces uncomfortable, or perhaps find they can better interpret more 'clear-cut' cues afforded

by objects. It should be noted, however, that eye-tracking studies only provide insights into the *scanning* of faces, rather than the ways in which cues are actually being used. This may explain some of the discrepancies between studies in the literature. For example, Riby and Back (2009) have shown that individuals with WS struggle to identify emotions when eye cues are not available, whilst Skwerer et al. (2006) have found that individuals with WS have difficulties (relative to both age and IQ matched controls) in accurately interpreting emotions from eye cues alone. Different methodologies between studies may be responsible for the facilitation of the ways in which cues are used.

5.1.7 Emotion specificity in Williams syndrome

The question of the specificity and salience of some emotions above others is an important one, especially in a population known for being atypically over-friendly in nature (Doyle, Bellugi, Korenberg, & Graham, 2004b). Research into the role of the amygdala in WS (Meyer-Lindenberg et al., 2005a) for example, is increasingly showing the special nature of fear in this disorder. Meyer-Lindenberg et al. (2005a) have shown that, when examining threatening or angry faces compared to threatening scenes, the amygdala of WS participants shows hypo-activation relative to controls and hyper-activation for scenes versus faces, suggesting a reduced fear response to threatening faces but not scenes. This of course raises the question of what it is about a face that is not threatening or what it is about a scene that is? This role of the human face specifically will be addressed in Experiment 4. An examination of these questions in ASD also needs to take place to produce potentially interesting comparisons of the two profiles. What Meyer-Lindenberg's (2005a) research also shows is that there may be very specific neural responses to different emotions in clinical groups, which may underpin and differentiate their everyday behaviours.

Santos et al. (2010) set out to examine whether hyper-sociability in WS might be explained by a missing ASE. They found that the accuracy and speed at which an angry target was detected by TD children (mean age 8.8 years) was unaffected by the number of distractor items, whereas a higher number of distractor items (8 versus 2 or 5) did have a negative effect on response accuracy and speed for identifying the angry target in the WS group (mean age 13.5 years). Both groups were detrimentally affected by number of distractor items for happy faces. This study does seem to suggest that those with WS do not give such salience to angry faces to the point of being unaffected by distractor items. Also worth consideration is if the ASE is specific to angry faces or if it might extend to a more general positive versus negative emotion divide. Again, this issue of specificity will be explored by a detailed examination of responses to emotions in Experiment 3.

The lack of any exploration of the ways in which emotions and cues interact in affording the accurate identification of emotions in clinical groups is one that stands out from the above cited studies. One study to fill this gap is that of Porter, Shaw and Marsh (2010) who examined both scan paths and emotion recognition in individuals with WS

compared to TD controls. Participants (n=16) in their study were eye-tracked during a passive viewing task of happy/angry/fearful and neutral faces; subsequently, they were asked to identify the emotions presented. The results showed that, whilst initial attention to the eye regions of faces was not heightened in the WS group over that of controls, fixations once on the eyes tended to be of a longer duration. Further, individuals with WS were less able to correctly identify anger than other emotions. This lack of anger as a salient emotion in WS stands in line with the work of Santos et al. (2010). No interactions were found between scan path pattern and accuracy for emotions in either of the groups.

Porter et al.(2010) conclude from their research that there may be very specific deficits in which emotions individuals with WS can make sense of; whilst this may not necessarily be underpinned by their use of facial cues and attention to certain regions of the face, deviant strategies in over-attending to the eye regions may not be *aiding* the interpretation of emotions. This interplay between cue use and emotion specificity will be examined in Experiment 3.

5.1.8 Summary

Research points to the fact that there may be certain preferences for specific emotions, which differ depending on the format in which those emotions are presented. Similarly, the use of eye or mouth cues may differ, depending on the emotion and the utility of those cues. In clinical groups, understanding when and how to use these cues may deviate from that seen in the typical population. Research has, however, typically looked at emotion specificity *or* cue use but very little, especially amongst individuals with neuro-developmental disorders, has examined the interaction between the two. Therefore, Experiment 2 will begin by establishing how capable individuals are in identifying basic emotions from both real and schematic faces, whilst Experiment 3 will go on to examine the interplay between configuration, cue use and emotion.

5.1.9 Experiment 2: Summary and aims

The Emotion task (ET) set out to explore accuracy for the identification of emotions when presented in both real (human and animal) and schematic (line and fruit) formats. Further, to establish whether any specific emotions (happy, sad, angry and surprised) are associated with heightened or reduced accuracy in different ways in the clinical groups.

5.2 Experiment 2: Hypotheses and Predictions

It was hypothesised that the accurate identification of emotions depends upon the ability to piece together the configuration of a face and would therefore be affected

by the category of image used. It was further hypothesised that the accuracy with which different emotions would be processed would vary between the participant groups.

5.2.1 Typical Development

There will be increases in performance with age for line and fruit images only, as these are those that require configural processing where developments in this type of processing will be apparent with age; accuracy for surprised faces will be lowest overall.

5.2.2 ASD and TD Comparisons

Those with ASD will perform significantly less accurately than TD peers for all categories of image; the same patterns are expected to emerge in ASD and TD groups, with poorer accuracy for surprise compared to other emotions.

5.2.3 WS and TD Comparisons

Those with WS will also perform significantly less accurately than TD peers on line and fruit images but will be comparable on human and animal faces. Those with WS will show comparable or increased accuracy relative to controls for happy emotions.

5.3 Method: Experiment 2

5.3.1 Participants

The same cohort of participants that took part in Experiment 1 was recruited to this task (See section 4.3.1). Because it was not possible to match participants on sex as well as age and NVIQ measures (due to practical constraints), an independent samples t-test was conducted to compare total scores on this task between male and female participants; no significant differences were found: $t(61) = .08, p = .94$, therefore sex was not taken to be a confound.

5.3.2 Materials and Design

This experiment consisted of 16 items, covering the same four categories as in Experiment 1. It was designed to measure the accuracy of identifying emotional expressions from faces. All images were different to those in Experiment 1 to prevent boredom or practice effects. Images were presented in the same order for each child, initially randomised. Fruit stimuli were designed so that the individual features were the same fruit item each time (see Figure 5.1) in order to prevent cueing effects.

Each trial was comprised of a picture of the face or face-like object with three choices of emotion word to the left (from a combination of happy, sad, surprised or angry). Participants were asked to choose the one emotion that “best describes the face”. The options were read aloud to participants as well as being presented on the screen. The choices were selected to ensure that the answer was not entirely obvious but not too challenging. The level of difficulty was established based on percentages of agreement during the piloting of images, as detailed in Experiment 1. Four of each emotion were depicted across the 16 trials but were not balanced equally across category due to the constraints of the stimuli (See Figure 5.2 for examples). Specifically, within the animal category, there were two depictions of sad and none of surprised; for humans, there were two surprised emotions and none of sad.

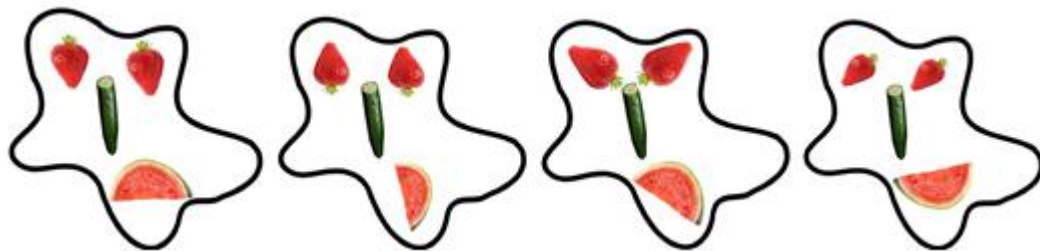


Figure 5.1: Examples of fruit images on the Emotion task: Sad; Surprised; Angry; Happy (l-r).



Figure 5.2: Examples of stimuli on the Emotion task: Angry; Happy; Surprised; Sad (l-r)

5.3.3 Procedure

Participants were told that they were going to see some faces and would be asked to choose how the face was feeling. On each trial, the experimenter asked the child ‘Does this face feel’ followed by the choice of three emotion terms on the screen. Participants were asked to state their answers aloud. Participants were moved onto the next item either as soon as they had given a response or if they stated that they did not know/wished to move on. Answers were either coded as correct or incorrect resulting in

a total score out of 16. All participants viewed the images in the same order and the original order of presentation was randomised.

5.3.4 Data Analysis

Answers were either coded as correct or incorrect (1 or 0) for each item, to give a total score for both category and also emotion expressed. For example, a correct response for the happy fruit face would receive a score of 1 for each of ‘fruit’ and ‘happy’. Category and emotion were analysed separately due to an imbalance across the items.

5.4 Results: Experiment 2

5.4.1 TD Groups

Two separate mixed design ANOVAs were conducted in order to explore the interplay between age-group and accuracy of responses to emotions and image category across the TD age groups.

5.4.1.1 Emotion task: Category

A 4 x 4 (Category (Line/Fruit/Human/Animal) x age-group [<6 years; 6-8.5; 8.6-11.5; >11.6]) ANOVA revealed a main effect of category, $F(3, 177) = 12.42, p < .01$ and a main effect of age-group, $F(3, 59) = 5.38, p < .05$. The interaction between factors was not significant. As is indicated in Table 5.1, participants overall gave fewer correct responses to line than human or animal stimuli (significant at $p < .05$). Correct responses to fruit images were lower than for human ($p < .01$), and there were no significant differences between those of human and animal, ($p > .05$). The youngest group overall performed significantly worse than all other age-groups ($p < .01$) but no significant differences in the number of correct responses were found between any other age-groups ($p > .05$).

Table 5.1: Mean number of correct responses (Maximum number = 4) for categories of image, across TD age-groups (Standard deviations in parentheses)

	Line	Fruit	Human	Animal
Up to 6 years (n=14)	3.14 (.66)	3.0 (.96)	3.86 (.36)	3.21 (.98)
6-8.5 (n=14)	3.36 (.63)	3.71 (.47)	4.0 (0)	3.79 (.43)
8.6-11.5 (n=17)	3.41 (.62)	3.76 (.44)	3.88 (.49)	3.65 (.61)
11.6+ (n=18)	3.33 (.49)	3.67 (.59)	3.83 (.38)	3.89 (.32)
Total	3.32 (.59)	3.56 (.69)	3.89 (.36)	3.65 (.65)

5.4.1.2 Emotion task: Emotion

A 4 x 4 (Emotion (Happy; sad; angry; surprised) x age-group) ANOVA revealed main effects of both emotion and age ($F(3, 177) = 18.78, p < .01$ and $F(3, 59) = 3.69, p < .05$, respectively) but no significant interaction between them. Overall, responses to surprised emotions were significantly ($p < .05$) worse than to all others, as reported in Table 5.2. There was also significantly more accurate performance for sad than angry faces ($p < .05$). In terms of age differences, the youngest group performed significantly ($p < .05$) worse than the 6-8 years 5 months group, and the oldest group additionally ($p < .05$).

Table 5.2: Mean number of correct responses (Maximum number = 4) for emotion, across TD age-groups (Standard deviations in parentheses)

	Happy	Sad	Angry	Surprised
Up to 6 years	3.36 (.75)	3.79 (.80)	3.36 (.75)	2.71 (1.07)
6-8.5	3.93 (.27)	3.86 (.36)	3.57 (.51)	3.50 (.65)
8.6-11.5	3.94 (.24)	3.71 (.59)	3.41 (1.0)	3.41 (.71)
11.6+	4.0 (0)	4 (0)	3.78 (.55)	2.89 (.76)
Total	3.83 (.46)	3.84 (.52)	3.54 (.74)	3.13 (.85)

5.4.2 ASD with TD comparisons

5.4.2.1 Emotion task: Category

A 4 x 3 (Category x group [ASD; TD CA matches; TD MA matches]) ANOVA revealed a main effect for category only, $F(3,150) = 9.78$, $p < .01$ with no interaction between group and category ($p = .40$). Pairwise comparisons revealed that there were significant differences ($p < .05$) in performance between the line images and every other category; as indicated in Table 5.3, performance for the line condition was poorest against all other categories. Additionally, there was a significant difference between fruit and human images ($p < .05$) overall, with accuracy for fruit images being lower. There was no significant main effect of group ($p > .05$) as all participants scored highly on this task, with accuracy never falling below approximately 80% for any images.

Table 5.3: Mean number of correct responses (Maximum number = 4) for categories of image in the ASD group and TD matches (Standard deviations in parentheses)

	Line	Fruit	Human	Animal
ASD (n=18)	3.33 (.69)	3.33 (1.19)	3.61 (.61)	3.67 (.59)
TD CA (n=17)	3.24 (.56)	3.76 (.44)	4.0 (0)	3.71 (.59)
TD MA (n=18)	3.28 (.67)	3.5 (.71)	3.89 (.32)	3.72 (.46)

5.4.2.2 Emotion task: Emotion

Performance for correct responses to which emotion was depicted were separately analysed for each group. Due to extreme violations of homogeneity of variance and a lack of any variation on some emotions caused by performance at ceiling level, an ANOVA could not be performed. A Kruskal-Wallis analysis revealed no significant relationships ($p > .05$) across any of the categories, differentiated by participant group. The mean number of correct responses for emotion are reported in Table 5.4: There were very few noticeable differences between the groups and only an overall dip in performance for the surprised emotion, with accuracy still being high (the lowest was approximately 70% in the ASD group). There was also a suggestion of those with ASD being less able than their CA peers in correctly labelling happy and surprised faces, as indicated by borderline significance, $Z = -1.76$, $p = .056$ and $Z = -1.63$, $p = .063$ in Mann-Whitney U tests.

Table 5.4: Mean number of correct responses (Maximum number = 4) for emotion in the ASD group and TD matches (Standard deviations in parentheses)

	Happy	Sad	Angry	Surprised
ASD	3.44 (1.04)	3.61 (.78)	3.67 (.69)	2.83 (.86)
TD CA	3.94 (.24)	3.71 (.59)	3.53 (1.0)	3.29 (.69)
TD MA	3.83 (.51)	3.94 (.24)	3.5 (.71)	3.11 (.76)

5.4.3 WS with TD comparisons

5.4.3.1 Emotion task: Category

For the WS group, there was a main effect of category, $F(3, 117) = 2.81, p < .05$ and a significant main effect for group, $F(2, 39) = 3.81, p < .05$ with no significant interaction between the two factors. In line with the literature, pairwise comparisons indicated that the WS group performed with poorer accuracy than their CA matches overall ($p < .05$) but comparably to MA controls (See Table 5.5). In terms of category differences, there were significantly ($p < .05$) more correct responses to human faces than line or fruit; participants overall also gave more correct responses to animal than fruit faces ($p < .05$). Specifically, on the fruit and human faces, individuals with WS performed with significantly lower accuracy than their CA peers: $t(26) = 2.04, p < .05$ and $t(26) = 2.10, p < .05$, although accuracy in the WS group was consistently above at least 70%. Interestingly, even compared to MA peers, individuals with WS were not able to match accuracy for human faces, $t(26) = 3.04, p < .05$, suggesting that the human nature of an image does not facilitate emotion identification in the WS group.

Table 5.5: Mean number of correct responses (Maximum number = 4) for categories of image in the WS group and TD matches (Standard deviations in parentheses)

	Line	Fruit	Human	Animal
WS (n=14)	3.29 (.47)	3.14 (1.10)	3.36 (.50)	3.64 (.84)
TD CA (n=14)	3.57 (.51)	3.79 (.43)	3.79 (.58)	3.86 (.36)
TD MA (n=14)	3.21 (.58)	3.14 (.95)	3.86 (.36)	3.29 (.99)

5.4.3.2 Emotion task: Emotion

Due to extreme violations of homogeneity of variance and a lack of any variation on some emotions caused by performance at ceiling level, an ANOVA could not be performed. However, the results of a Kruskal-Wallis test found significant group differences for the happy emotion, $\chi^2(2) = 7.49, p < .05$. As can be seen in Table 5.6, there was a dip across all groups in correct responses for surprise, with larger differences for this emotion between the WS group and CA matches. A Mann-Whitney U test for surprised images showed a significant difference between those with WS and their CA peers, $Z = -2.41, p < .01$, whereby individuals with WS were significantly less accurate.

Table 5.6: Mean number of correct responses (Maximum number = 4) for emotion in the WS group and TD matches (Standard deviations in parentheses)

	Happy	Sad	Angry	Surprised
WS	3.64 (.50)	3.71 (.83)	3.64 (.84)	2.43 (.85)
TD CA	4.0 (0)	4.0 (0)	3.64 (.50)	3.29 (.83)
TD MA	3.50 (.65)	3.71 (.83)	3.50 (.65)	2.79 (1.12)

5.4.4 Summary of Results: Experiment 2

The same patterns emerged in all participant groups, whereby accuracy for line and fruit images fell significantly below that of human faces; no differences emerged between human and animal images overall. Of particular interest was the finding that, in both the ASD and WS analyses, individuals in the neurodevelopmental groups performed less accurately than their CA peers (and MA peers in the case of WS) when identifying the emotions of *human* faces. This suggests that the accurate recognition of emotions may be improved by the presence of *real* facial cues in typical development but this facilitation is not seen in clinical groups.

Also seen across all participant groups was a dip in the number of correct responses towards the surprised faces overall; the design of this experiment unfortunately did not allow for any analysis of how emotion and category might interact. The only differences to emerge between those with ASD and WS compared to their TD matches were on the happy and surprised emotions, where participants in both ASD and WS groups failed to provide as many correct responses for these images as their peers. This may be suggestive of a particular issue in processing the types of cues necessary for these emotions. However the major issue of ceiling effects across groups (and especially in the TD group) means this requires further attention in future studies.

5.5 Experiment 3: Hypotheses and Predictions

Experiment 3 was designed to directly examine how individuals would use the upper and lower halves of photos of real human faces to decipher emotions. Experiment 3a (The Parts task) examined the ability of participants to recognise emotions from isolated eye or mouth cues; Experiment 3b used a composite paradigm in which upper and lower face halves were incongruent, in order to examine the holistic processing of emotions from faces. It was hypothesised that the misalignment of images would disrupt holistic processing, aiding the identification of incongruent emotions. This would be more evident in older groups, where holistic processing should be more developed, and would not be the case in individuals with ASD and WS, where holistic processing is reported to be deficient (for example, see Chapter 3).

5.5.1 Typical Development

On the parts task, there may be a shift with age from accuracy on mouth to eye cues, although research as to which cues are utilised most effectively is mixed. Performance overall will be better for misaligned than aligned stimuli in experiment 3b, suggestive of holistic processing. This is based on the findings of Calder et al. (2000a) and Durand et al. (2007) who have shown that the misalignment of top and bottom face parts diminishes the interference from incongruent face cues. Superior performance for threatening emotions (angry/scared) will be seen across all groups in the two tasks, demonstrative of an anger superiority effect (ASE) (Hansen and Hansen, 1988; cited in Farran et al. 2011).

5.5.2 ASD and TD Comparisons

In experiment 3a those with ASD will give fewer correct responses to eye cues than their TD peers. Individuals with ASD will give fewer correct mental state emotions (surprised/scared), as suggested by Baron-Cohen et al. (1997). Misalignment of faces in Experiment 3b task will be less advantageous in the ASD group compared to TD individuals of comparable CA because of their use of a blanket strategy of attending to specific cues rather than employing holistic processing. There may be a clearer interaction seen between top/bottom halves and alignment in the ASD group than amongst TD matches: Mouths may be better attended to than eyes overall therefore the effect of alignment would be less when asked to make judgements on the bottom halves of faces.

5.5.3 WS and TD Comparisons

In Experiment 3a, those with WS will perform as well as their TD matches when presented with only eye cues. In Experiment 3b, interactions between responses to the top/bottom halves of faces and alignment will emerge in the WS group but not their TD

peers. Given evidence (Riby & Back, 2009) suggesting a heightened utility of the eye region amongst individuals with WS, this trend will be in an opposite direction to those with ASD in that the effect of alignment will be diminished when making top part judgements. Across both tasks, those with WS will show an increased performance, relative to peers, in identifying happy above other emotions, as Farran et al. (2011) have shown that individuals with WS are most able to accurately identify happy faces compared to those depicting threat. A dip in performance for angry faces is predicted to be seen in the WS group, relative to controls.

5.6 Method: Experiment 3

5.6.1 Participants

It should be noted that some of the participants in the clinical groups (six in the ASD cohort and 10 in the WS cohort) were the same as those recruited to Experiments 1 and 2.

5.6.1.1 ASD participants

Seventeen participants with a clinical diagnosis of autism were recruited from three specialist schools. Diagnoses were confirmed by teachers' responses to the Social Communication Questionnaire (SCQ). Scores on this measure ranged from 7 to 23 (Maximum score=40, whereby higher scores indicate a higher number of autistic symptoms), with a mean of 14. One child subsequently had to be excluded from the study due to a score indicative of being below the cut-off (a score of 12) for ASD diagnosis. Six children either could not understand the task instructions or did not wish to take part, therefore a total of 10 children (7 males and 3 females), aged 7 years 3 months to 16 years 6 months (mean age 11 years 8 months) comprised the final sample. It is acknowledged that this was a small sample size; possible implications of this will be raised in Chapter 8.

SCQ scores amongst these finally selected participants ranged from 12 to 22, with a mean score of 16.5. Non-verbal ability scores on the Ravens Coloured Progressive Matrices (RCPM) for this group ranged from 16 to 34 (out of 36), with a mean score of 26. The RCPM is a consistently used measure of NVIQ amongst groups with neurodevelopmental disorders.

5.6.1.2 WS participants

Fifteen participants with a clinical diagnosis and positive genetic confirmation of Williams Syndrome using a FISH test were recruited through the Williams Syndrome Foundation. One of these children did not wish to complete all of the tasks, therefore was excluded from the analysis. Testing took place in the homes of participants with a parent or guardian always present. The age range (eight males and six females) was 8

years to 17 years 5 months with a mean age of 13 years 1 month. Non-verbal ability scores on the RCPM for this group ranged from 9 to 31 with a mean score of 16.

5.6.1.3 *TD participants*

Seventy-four typically developing individuals were originally invited to take part in the study. Children were recruited through an early years centre and two primary schools, three secondary schools in the same region and at a science museum. Teachers (where children were recruited through schools) and parents (for those recruited through the science museum), were asked to fill out the Strength and Difficulties Questionnaire (SDQ) to establish that the child did not have any potential emotional or behavioural issues. Some teachers were unable to complete these questionnaires for 20 of the children but did verbally confirm that the children in question appeared to have no issues at school. Overall scores on the SDQ ranged from 0 to 17, with lower scores representing 'normal' behaviours; the average score was 5. Due to abnormal scores (17 and above for parent-completed questionnaires and 16 and above for those completed by teachers) on the SDQ, four of the participants' data had to be discarded. A total of nine children recruited did not wish to take part in the task, leaving 61 TD participants in total. For comparisons with clinical groups, five were not included due to not being a suitable CA or MA match for any of the ASD or WS participants. An additional 6 children were excluded from the analysis, due to the ASD participants they were matched to being unable to complete the task. The final sample for the purposes of matching was therefore comprised of 48 TD participants, as detailed in Table 5.7

For each clinical participant, an individual match from the TD population was found for both CA and MA in order to ensure equal variances across the groups. Independent samples t-tests revealed no significant differences between the mean ages of the participants in the ASD group and their CA matches [$t(18) = 0.3, p = .97$]; this was also the case between those with WS and their CA matches: $t(26) = .72, p = .48$. No significant difference was found between the ASD or WS groups and their MA matches on RCPM raw scores [$t(18) = .13, p = .90$; $t(26) = .00, p = 1.0$, respectively].

Table 5.7: Age and MA demographics for TD matches to ASD and WS groups for Experiments 3a and 3b (Parts and Composite task)

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
ASD (n=10)				
CA Matches	7.4-16.2	11.9 (3.1)	21-36	32 (4.33)
MA Matches	4.11-9.6	8.2 (1.10)	15-32	26 (5.13)
WS (n=14)				
CA Matches	7.10-17.3	12.3 (3.4)	23-36	31 (4.22)
MA Matches	4.1-14.4	5.11 (3.3)	9-31	16 (5.65)

5.6.1.4 TD Age

Sixty-one of the TD participants as detailed above were additionally divided into four age groups based on broad developmental phases in line with educational key stages. Because those TD children recruited to Experiment 3 were a different cohort to those who took part in Experiments 1 and 2, the age bands are slightly different to those used, in order to allow for an equal balance of participants per group. However, in developmental and school year terms, the bands used were largely comparable. Those 11 participants who had been excluded due to their matches not completing the task or not being a suitable MA or CA match, were entered into the TD age analysis. Table 5.8 outlines the mean ages and NVIQs for these groups (standard deviations in parentheses).

Table 5.8: Age and RCPM data for TD participants recruited to Experiments 3a and 3b, split by age.

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
Up to 6.6 years (n=16)	4.1-6.3	4.10 (0.8)	9-25	16 (4.77)
6.6-9.0 (n=13)	7.4-9.0	8.6 (0.6)	19-36	28 (4.82)
9.1-11.11 (n=13)	9.1-10.8	9.9 (0.7)	21-34	29 (4.34)
12 years and above (n=19)	12.6-17.3	14.6 (1.5)	22-36	32 (3.91)

5.6.1.5 TD Gender

Due to recruitment constraints, it was not possible to match the WS and ASD groups to their typical matches on sex as well as CA and MA. An analysis of males (28) versus females (33) across the whole TD group revealed no significant difference in performance (total number of items correct) for either Experiment 3a or 3b, respectively, $t(59) = .72, p = .48$ and $t(59) = .52, p = .61$. The mean age for males was 10 years 11 months compared to 8 years 7 months for females. Despite this difference in average age between the sexes, the mean scores on the RCPM were 28 for males and 25 for females, which was not found to be a significant difference ($t(59) = 1.3; p = .12$), therefore sex is not taken to be a confound when comparing the clinical participants to their TD matches.

Parental and teacher consent was obtained for all participants recruited through schools with parent/guardian consent being obtained for those children recruited through the science museum. Parents and children were provided with copies of an information sheet detailing what the study involved and it was made clear to each child that they did not have to take part and could withdraw at any time if they wished. Those children whose parents deemed them able to give their own assent also gave written permission.

5.6.2 Overview of experiments

Experiment 3 comprised of two parts: The Parts task (3a) and the Composite task (3b). Both involved Caucasian child face images taken from the Radboud faces database (Langner et al., 2010), but there was no duplication of images between the two tasks. Both Experiments 3a and 3b were conducted on a laptop using PowerPoint. Participants were initially given a training phase, in which they were shown full frontal photos of Caucasian child faces (using different images to those in the main experiment) depicting happy/scared/angry emotions, and were asked to state what emotion they felt was shown. Six items were provided, two of each emotion. Feedback was provided, with attention drawn to the specific arrangements of features.

5.6.3 Materials and Design: Experiment 3a

Twelve items were created by isolating either the eye or mouth region from full frontal face photos of emotionally expressive faces. Eye regions comprised of the area just above the eyebrow, to the bridge of the nose; mouth regions were taken directly below the nose and to the top of the chin (see Figure 5.3). Six of the items were of eyes, and six of mouths. Within each eye/mouth region, two of each happy/scared/angry emotions were depicted. The order of presentation was randomised and all participants were presented with the images in the same order. Due to a lack of power, the feature presented and the emotion depicted were treated as two separate variables, without any exploration of interactions between them. The small number of trials on this task was necessary in order to prevent boredom effects in clinical groups, especially those who

typically do not enjoy attending to faces. Experiment 3b addressed this lack of power in a more comprehensive design focused on these types of interactions.



Figure 5.3: Examples of mouth and eye stimuli on the Parts task

5.6.4 Procedure: Experiment 3a

Participants were told that they were going to be shown isolated parts of faces, and would be asked to state the emotion shown from the same three choices as in the practice phase: Happy/scared/angry. It was stressed to participants that these would only ever be the three response choices. Additionally, each item had these three emotions written underneath it as a reminder, and the experimenter also read the options aloud every time. Participants were then shown each item, one by one, and were asked to state which emotion was shown. The experimenter moved onto the next item only once the participant had made their response or stated that they did not know/wished to move to the next item. Responses were scored as correct or incorrect, based on the label assigned to that image in the Radboud (Langner et al., 2010) database. Participants therefore received a total score out of 4 for each of the emotions, and totals out of 6 for eyes/mouths.

5.6.5 Materials & Design: Experiment 3b

Images were created by taking full frontal photos of emotional expressions (happy/scared/angry) and dividing them horizontally in half through the bridge of the nose. New faces were then created by merging the two halves (aligned condition) or by presenting them in a split format, whereby the half to be attended to was presented in the centre of the screen with the other half off-set to the right, with the ear and nose aligned. Emotions depicted in the two halves were always incongruent (see Figure 5.4).



Figure 5.4: Examples of aligned, misaligned top and misaligned bottom images in experiment 3b (the Composite task)

There were two conditions in Experiment 3b in which the comparison was ‘top’ versus ‘bottom’, depending on which half of the face participants were asked to attend to. These were counterbalanced across participants so that half of the participants within each clinical/match group completed the top/bottom trials first. All items were otherwise presented to participants in the same order, having been randomised. The images selected for both top and bottom trials were exactly the same, presented in different orders within each condition, to prevent familiarity effects and cueing.

Within each condition, there were 24 items; half of these were presented in aligned format, and the remaining half misaligned. Within these clusters of twelve, four of each happy/scared/angry of the target feature were depicted. The variables under investigation were therefore alignment, half attended to, and emotion depicted.

5.6.6 Procedure: Experiment 3b

Participants were told that they would be presented with a set of faces that “will not look like faces you would see in real life” and should try to focus only on the top/bottom half. It was stressed to participants that they should do their best to ignore the half they were not asked to attend to. Participants were then presented with items, one at a time, and asked “How does he/she feel?” followed by the choice of the three emotions, which were also presented on screen. The experimenter would frequently remind the participant to only look at the top/bottom half. The experimenter moved onto the next item only once the participant had made their response or stated that they did not know/wished to move to the next item. Responses were scored as correct based on the Radboud (Langner et al., 2010) labels.

5.7 Results: Experiment 3a

5.7.1 TD Groups

Two separate ANOVAs were run to examine accuracy dependent on the emotion shown and the type of cue presented (Table 5.9). A 3 x 4 (emotion x age-group) mixed design ANOVA suggested significant main effects of emotion ($F(2, 114) = 3.29, p < .05$) and age ($F(3, 57) = 2.77, p < .05$), but no significant interaction between them ($p > .05$). Posthoc analysis showed that this main effect was driven by the oldest group giving significantly more correct responses than the youngest ($p < .05$) overall. The main effect of emotion was related to a borderline significant difference ($p = .077$) whereby, overall, participants gave fewer correct responses to scared than angry images. No further differences were found between any other emotions.

Table 5.9: Mean number of correct responses (standard deviations in parentheses) across emotions and features for each TD age-group in Experiment 3a (Maximum score = 4 for emotions and 6 for features)

	Happy	Scared	Angry	Eyes	Mouths
Up to 6.6 years (n=16)	3.06 (.77)	2.5 (1.10)	3.0 (.73)	4.56 (.89)	4.38 (1.20)
6.6-9.0 (n=13)	3.31 (.48)	3.08 (.76)	3.31 (.95)	4.85 (.80)	4.85 (.69)
9.1-11.11 (n=13)	3.08 (.49)	3.15 (1.21)	3.38 (.87)	4.38 (.77)	5.23 (1.09)
12 years and above (n=19)	3.42 (.51)	3.05 (1.18)	3.58 (.69)	4.84 (1.12)	5.21 (1.08)

To explore accuracy for deciphering emotions from different face regions a 2 x 4 (eyes/mouth x age group) mixed design ANOVA was conducted. There was no significant main effect of age ($F(3, 57) = 1.50, p = .23$): No performance differences between age-groups emerged when considering accuracy dependent on cue types shown, unlike in the case of emotions. No significant main effect of feature was found ($p > .05$) and there were therefore no notable interactions between age group and the facial cue presented, as is evident in Table 5.9.

5.7.2 ASD with TD Comparisons

A 3 x 3 (emotion x group) mixed design ANOVA showed no significant main effect of emotion ($p = .06$), group ($p > .05$), or the interaction ($p > .05$) between them. However the trend towards borderline significance for the emotion factor was driven by an overall dip in accuracy in recognising 'scared' across all participant groups. Table 5.10 outlines the mean number of correct responses for each emotion and feature presented.

Table 5.10: Mean number of correct responses (standard deviations in parentheses) across emotions and features for the ASD group and TD matches (Maximum score = 4 for emotions and 6 for features)

	Happy	Scared	Angry	Eyes	Mouths
ASD (n=10)	3.2 (.42)	2.6 (.84)	3.10 (.99)	4.60 (.97)	4.30 (.82)
TD CA (n=10)	3.10 (.57)	2.90 (1.37)	3.60 (.52)	4.60 (.84)	5.0 (.94)
TD MA (n=10)	3.4 (.70)	3.10 (1.10)	3.50 (.53)	4.70 (1.25)	5.30 (.82)

A 2 x 3 (eyes/mouth x group) mixed design ANOVA failed to find any significant main effect of feature, ($p > .05$) group ($p > .05$), or any interaction between the two factors ($p > .05$). As is evident in Table 5.10, there was noticeably less accuracy for correctly identifying the emotions depicted from mouth cues in ASD compared to both groups of TD peers, and individuals with ASD were also poorer in making judgements from this cue type versus eye cues; a profile not apparent in TD groups. None of these differences were found to be significant however, although this might be the case given a larger sample size or more experimental items.

5.7.3 WS with TD Comparisons

A 3 x 3 (emotion x group) mixed design ANOVA showed no significant main effect of emotion ($p > .05$), group ($p > .05$), or the interaction between them ($p > .05$). Table 5.11 provides the mean number of correct responses for factors for each participant group. It may be worth noting that, for the happy emotion, there was a difference in the performance of those with WS compared to their TD peers, with fewer correct responses in the WS group, although this was not significant.

Table 5.11: Mean number of correct responses (standard deviations in parentheses) across emotions and features for the WS group and TD matches (Maximum score = 4 for emotions and 6 for features)

	Happy	Scared	Angry	Eyes	Mouths
WS (n=14)	2.79 (.58)	2.64 (1.0)	3.14 (.66)	3.79 (.89)	4.79 (.98)
TD CA (n=14)	3.29 (.47)	3.21 (.89)	3.14 (1.17)	4.50 (.94)	5.14 (.95)
TD MA (n=14)	3.07 (.73)	2.36 (1.08)	2.79 (1.19)	4.21 (1.19)	4.0 (1.52)

A 2 x 3 (eyes/mouth x group) mixed design ANOVA revealed a significant main effect of feature ($F(1, 39) = 4.92, p < .05$) but no main effect of group or any interaction between them. As can be seen in Table 5.11, the main effect of feature was caused by all individuals being more accurate in identifying emotions from mouth versus eye cues.

5.8 Results: Experiment 3b

5.8.1 TD Groups

In order to examine the factor of emotion and its interplay with condition (aligned or misaligned) and the face part being interpreted, three separate mixed design ANOVAs were run. Separate analyses were carried out due to a lack of power for each variable. It was not possible to have a large variety of emotions, due to the fact that participants in the clinical groups would not have attended to a large number of items per condition.

5.8.1.1 Half x Alignment

A 2 x 2 x 4 mixed design ANOVA was conducted for half (top versus bottom) and condition (aligned versus misaligned), with age as between subjects factor. A significant main effect of half ($F(1, 57) = 19.93, p < .01$) was found, as well as a significant main effect of condition, $F(1, 57) = 39.61, p < .01$. Additionally, a main effect of age-group was found, $F(3, 57) = 11.54, p < .01$ without any interactions between age and either factor ($p > .05$). The main effect of age was driven by significantly more accurate responses overall in the two oldest groups than the youngest ($p < .05$) and the oldest group performing significantly better than the two youngest groups ($p < .05$). A significant interaction was found between half and condition, without any further interaction with age ($F(1, 57) = 5.65, p < .05$): In all groups, there were significantly more correct responses to the misaligned presentations of both top and bottom face halves ($t(60) = 6.07, p < .01$ and $t(60) = 3.57, p < .01$, respectively) and this difference between alignment conditions was more pronounced for top halves. The mean numbers of correct responses for each combination of factors are reported in Table 5.12.

Table 5.12: Mean correct responses for combinations of face half and condition across TD age groups (standard deviations in parentheses; Maximum score=12)

	Top Aligned	Top Misaligned	Bottom Aligned	Bottom Misaligned
Up to 6.6 years	4.75 (2.24)	5.63 (3.16)	6.56 (1.83)	7.31 (1.99)
6.6-9.0	4.77 (2.35)	6.46 (2.70)	7.23 (1.96)	8.08 (1.32)
9.1-11.11	6.62 (2.18)	8.15 (2.38)	8.84 (2.29)	9.89 (1.20)
12 years and above	6.42 (2.50)	9.11 (2.49)	8.84 (2.29)	9.89 (1.56)
Overall Total	7.43 (3.0)	7.43 (3.0)	7.67 (2.03)	8.54 (1.84)

5.8.1.2 Emotion x half

A 3 x 2 x 4 ANOVA (emotion x half with age as between subjects factor) found a main effect of emotion, $F(2, 114) = 23.78$, $p < .01$, caused by significantly fewer correct responses to scared faces than for either other emotion ($p < .01$). A main effect of face half was also found, $F(1, 57) = 25.24$, $p < .01$, whereby participants gave more correct responses when asked to attend to the bottom halves of faces. There was a main effect of age-group ($F(3, 57) = 16.15$, $p < .01$) and a three-way interaction between age-group, half and emotion, $F(6, 114) = 2.73$, $p < .05$. The mean numbers of correct responses for each combination of factors are reported in Table 5.13.

Table 5.13: Mean correct responses for combinations of face emotion and half across TD age groups (standard deviations in parentheses; Maximum score=8)

	Happy Top	Happy Bottom	Angry Top	Angry Bottom	Scared Top	Scared Bottom
Up to 6.6 years	1.50 (1.79)	6.69 (1.30)	4.63 (2.45)	4.38 (2.50)	2.81 (2.54)	2.50 (2.58)
6.6-9.0	2.38 (1.94)	7.46 (1.13)	4.62 (2.06)	5.92 (1.44)	4.23 (2.05)	1.92 (2.69)
9.1-11.11	3.46 (1.98)	7.69 (.63)	5.38 (1.61)	5.77 (1.48)	5.92 (1.98)	2.85 (1.21)
12 and above	4.11 (1.66)	7.84 (.38)	5.53 (1.93)	6.74 (1.20)	5.89 (1.97)	4.16 (2.48)
Overall Total	2.92 (2.07)	7.43 (1.01)	5.07 (2.04)	5.74 (1.91)	4.74 (2.48)	2.97 (2.95)

In order to pull apart the three-way interaction, paired samples t-tests were conducted on each age group separately³, comparing performance for each face half per emotion. In all but the group aged 9 years 1 month to 11 years 11 months, the only significant differences ($p < .01$ after Bonferroni corrections) in performance between top and bottom halves were for happy faces, with more accurate responses when asked to label bottom halves. For the youngest group, $t(15) = 12.64$, $p < .01$; for those aged 6.6-8.11, $t(15) = 8.89$, $p < .01$; in the groups aged 9.1-11.11, $t(15) = 6.92$, $p < .01$; and in those aged 12 years and above, $t(15) = 10.22$, $p < .01$. In the 9 years 1 month to 11 years 11 month group, an additional significant difference ($t(15) = 2.77$, $p < .01$) was observed for scared faces, whereby *top* halves were recognised most accurately.

5.8.1.3 *Emotion x Alignment*

A 3 x 2 x 4 mixed design ANOVA was conducted for emotion x condition (aligned versus misaligned), with age group as between subjects factor. A main effect of emotion was found, as outlined previously, $F(2, 114) = 23.78$, $p < .01$. A main effect of condition was also found ($F(1, 57) = 57.91$, $p < .01$) in which participants were overall more accurate in identifying emotions from misaligned faces. A main effect of age-group was shown, as reported above, $F(3, 57) = 16.15$, $p < .01$. No significant interactions were found between either factor and age-group ($p < .05$). There was, however, a significant interaction between emotion and alignment. As is detailed in Table 5.14, accuracy for misaligned versus aligned faces was higher overall but this difference was greatest in response to happy faces; paired samples t-tests for aligned versus misaligned conditions of each emotion revealed only a significant difference ($t(60) = 8.60$, $p < .01$) for happy faces, after Bonferonni corrections.

³ Paired samples t-tests were conducted to break down all 3-way interactions in Experiment 3b in order to precisely pull apart specifically where differences between the groups were seen on which individual emotions/conditions. This was especially important in the clinical groups, in which specific hypotheses had been made about the direction of the effect of aligning specific face halves. A 2-way ANOVA would not have allowed for such an in-depth exploration of specific interactions.

Table 5.14: Mean correct responses for combinations of face emotion and condition across TD age groups (standard deviations in parentheses; Maximum score=8)

	Happy Aligned	Happy Misaligned	Angry Aligned	Angry Misaligned	Scared Aligned	Scared Misaligned
Up to 6.6	3.56 (1.41)	4.63 (1.46)	4.5 (1.46)	4.50 (1.93)	2.44 (1.97)	2.88 (2.77)
6.6-8.11	4.23 (.93)	5.62 (1.94)	4.85 (1.68)	5.69 (1.38)	2.92 (1.38)	3.32 (1.92)
9.1-11.11	4.77 (.83)	6.38 (1.50)	5.46 (1.33)	5.69 (1.12)	4.15 (.80)	4.62 (1.81)
12+	4.74 (1.33)	7.21 (.98)	5.79 (1.81)	6.47 (1.12)	4.74 (2.13)	5.32 (1.70)
Overall Total	4.33 (1.26)	6.02 (1.75)	5.18 (1.65)	5.62 (1.58)	3.62 (1.94)	4.08 (2.30)

5.8.2 ASD with TD comparisons

5.8.2.1 Half x Alignment

A mixed design 2 x 2 x 3 (half x condition x group) mixed design ANOVA was run. A significant main effect of half, ($F(1, 27) = 13.82, p < .01$) was found, as well as a significant main effect of condition, ($F(1, 27) = 44.88, p < .01$). As is evident in Table 5.15, all participants were more accurate in responding to the bottom halves of faces ($p < .01$) and those that were misaligned ($p < .01$). No significant interaction was found between these factors or between either factor and group. There was, however, a main effect of group, ($F(2, 27) = 5.92, p = . < .01$).

Table 5.15: Mean correct responses for combinations of face half and condition in the ASD group and TD matches (standard deviations in parentheses; Maximum score=12)

	Top Aligned	Top Misaligned	Bottom Aligned	Bottom Misaligned
ASD	3.70 (1.25)	5.20 (2.44)	6.20 (1.69)	7.40 (3.2)
TD CA	5.40 (3.06)	7.50 (2.92)	8.20 (1.99)	9.50 (1.35)
TD MA	5.90 (2.28)	7.50 (2.95)	7.40 (1.51)	8.20 (1.0)
Overall Total	5.0 (2.44)	6.73 (2.9)	7.27 (1.87)	8.37 (2.21)

A Games-Howell posthoc analysis showed those with ASD to give significantly fewer correct responses than either CA or MA matches overall (significant at $p < .05$), with no significant differences being noted between the TD groups. As Figures 5.5 and 5.6 show, individuals with ASD only performed at around chance level (33%) for aligned and top face halves.

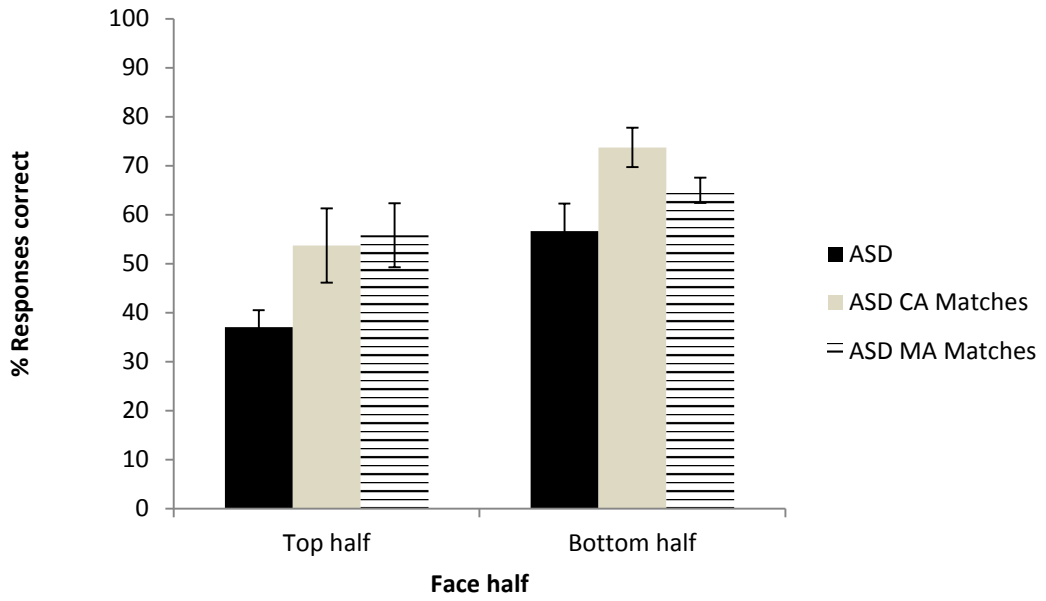


Figure 5.5: Correct responses by face half for ASD participants and TD matches in Experiment 3b

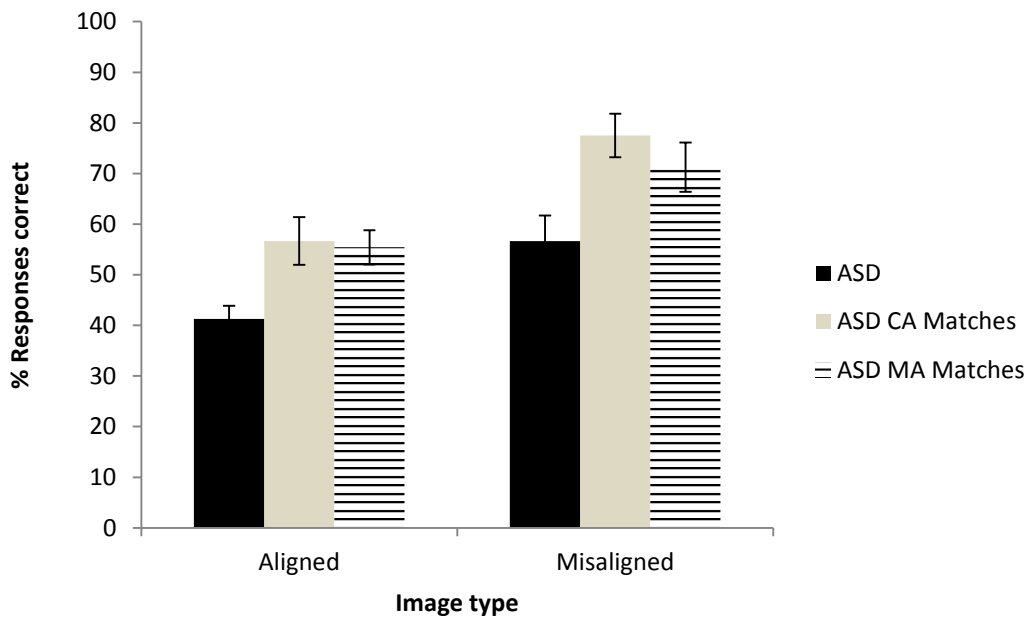


Figure 5.6: Correct responses by condition for ASD participants and TD matches in Experiment 3b.

5.8.2.2 Emotion x Half

A 3 x 2 x 3 ANOVA (emotion x half x group) found a main effect of emotion, $F(2, 54) = 16.05, p < .01$. The main effect of emotion, as can be seen in Table 5.16, was caused by significantly fewer accurate responses to scared faces than for either other emotion ($p < .05$). A main effect of half was also found, $F(1, 27) = 13.89, p < .01$, whereby participants overall gave more correct responses to the bottom halves of faces than top. A main effect of group was found ($F(2, 27) = 3.32, p < .05$), without any significant interactions between group and emotion or face half. A significant interaction was, however, found between face half and emotion, $F(2, 54) = 81.54, p < .01$. Paired samples t-tests showed overall greater numbers of correct responses for the bottom versus top halves of all but the scared emotion ($p < .01$); this difference was most pronounced for happy emotions, $t(29) = 10.36, p < .01$ and was reversed for scared ($p < .01$), driving the interaction.

Table 5.16: Mean correct responses for combinations of face emotion and half in the ASD group and TD matches (standard deviations in parentheses; Maximum score=8)

	Happy Top	Happy Bottom	Angry Top	Angry Bottom	Scared Top	Scared Bottom
ASD	2.50 (1.27)	6.50 (2.01)	3.70 (1.49)	5.90 (1.73)	3.50 (1.58)	2.30 (1.64)
TD CA	3.0 (1.83)	7.80 (.63)	4.70 (2.0)	6.40 (1.35)	5.20 (2.7)	3.50 (2.37)
TD MA	2.90 (2.23)	7.40 (.97)	5.30 (2.58)	5.90 (1.10)	5.20 (2.7)	2.30 (1.83)
Overall Total	2.80 (1.77)	7.23 (1.41)	4.57 (2.11)	6.07 (1.39)	4.63 (2.34)	2.70 (1.99)

5.8.2.3 Emotion x Alignment

A 3 x 2 x 3 mixed design ANOVA was conducted for emotion x condition (aligned versus misaligned), with group as between subjects factor. Mean number of combinations of responses are reported in Table 5.17. A main effect of emotion was found as reported above, $F(2, 54) = 10.54, p < .01$. A main effect of alignment was also evident, $F(1, 27) = 12.25, p < .01$ whereby overall more correct responses were given to misaligned faces ($p < .01$). A main effect of group was also noted, $F(2, 27) = 7.51, p < .01$. A significant three-way interaction was found between alignment, emotion and group, $F(4, 54) = 5.74, p < .01$, as is depicted in Figure 5.7.

Table 5.17: Mean correct responses for combinations of face emotion and condition in the ASD group and TD matches (standard deviations in parentheses; Maximum score=8)

	Happy Aligned	Happy Misaligned	Angry Aligned	Angry Misaligned	Scared Aligned	Scared Misaligned
ASD	4.50 (1.18)	2.70 (1.25)	3.90 (1.60)	4.20 (1.14)	2.70 (1.42)	3.50 (2.12)
TD CA	4.60 (.70)	6.20 (1.0)	5.0 (2.06)	6.10 (.99)	4.0 (1.49)	4.70 (1.42)
TD MA	4.20 (1.03)	6.10 (2.13)	5.50 (1.51)	5.70 (1.83)	3.60 (1.71)	3.90 (2.23)
Overall Total	4.43 (.97)	5.0 (2.23)	4.80 (1.81)	5.33 (1.56)	3.43 (1.59)	4.03 (1.96)

Paired samples t-tests were conducted on each group separately to compare the number of correct responses for aligned versus misaligned faces for each emotion. The difference driving the three-way interaction was found to be for responses to happy faces only (after Bonferonni corrections): Individuals with ASD gave significantly more correct responses for aligned versus misaligned happy faces, $t(9) = 3.67, p < .01$ whilst TD CA peers gave significantly more correct responses for happy misaligned versus aligned faces, $t(9) = 6.0, p < .01$. In the TD MA group, a borderline difference was found, favouring misaligned happy faces, $t(9) = 3.14, p = .07$. No significant differences were found between aligned and misaligned faces for any other emotions in any of the groups.

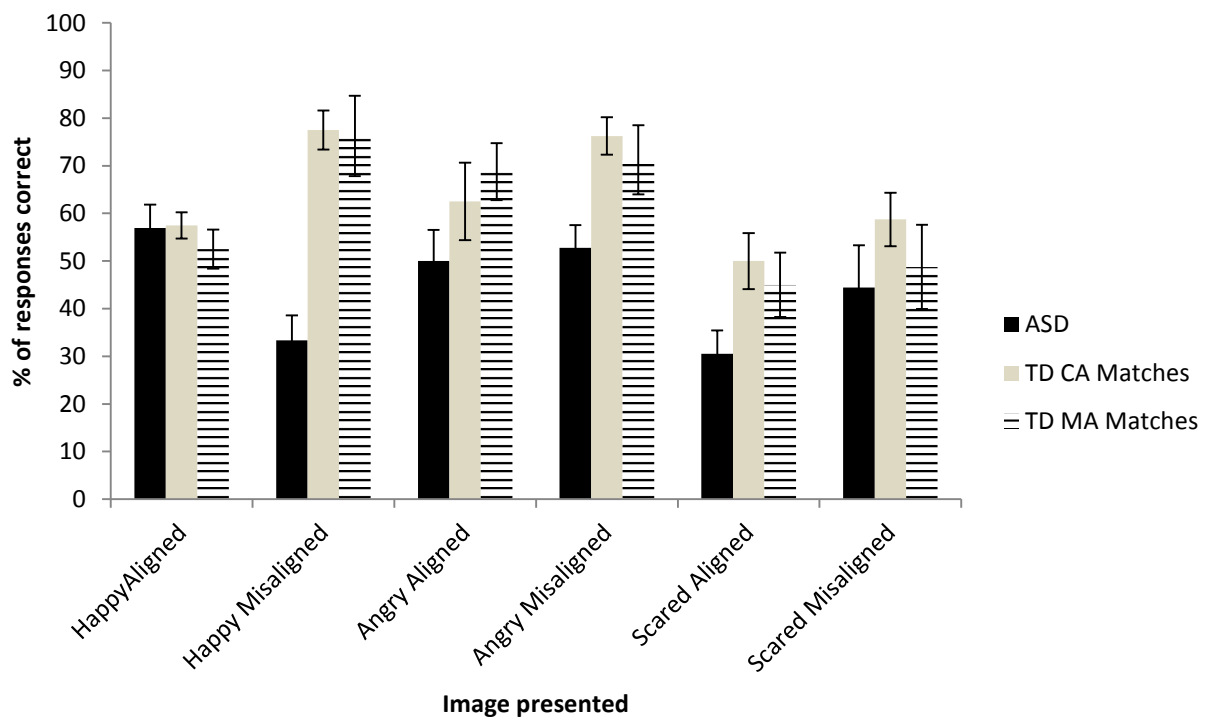


Figure 5.7: Percentages of correct responses for combinations of emotion x alignment in the ASD group and TD matches

5.8.3 WS with TD comparisons

5.8.3.1 Half x Alignment

A 2 x 2 x 3 (half x condition x group) mixed design ANOVA was run. A significant main effect of half, $F(1, 39) = 33.73, p < .01$ was found with an interaction with group, $F(2, 39) = 4.93, p < .01$. Statistical confirmation of this was revealed in two mixed design ANOVAs with top and bottom halves entered separately, where a main effect of group was only seen in the top half trials, $F(2, 39) = 11.66, p < .01$, in which the TD CA group gave significantly ($p < .01$) more correct responses than either TD MA controls or those

with WS. Bottom half trials, $F(2,41)=2.39$, $p=.11$. Mean number of correct responses for these combinations of factors are given in Table 5.18.

Table 5.18: Mean correct responses for combinations of face half and condition in the WS group and TD matches (standard deviations in parentheses; Maximum score=12)

	Top Aligned	Top Misaligned	Bottom Aligned	Bottom Misaligned
WS	3.0 (1.66)	4.71 (2.16)	6.57 (1.56)	8.29 (1.90)
TD CA	6.21 (2.91)	8.79 (2.55)	8.0 (2.18)	8/36 (1.74)
TD MA	4.21 (1.76)	5.14 (2.83)	6.36 (1.65)	7.64 (2.24)
Overall Total	4.48 (2.52)	6.21 (3.08)	6.98 (1.92)	8.10 (1.95)

A main effect was also found for condition, without any interaction with group ($p>.05$), $F(1, 39) = 29.02$, $p<.01$, with participants overall giving more correct responses to misaligned than aligned images ($p<.01$). A main effect of group was also shown, $F(2, 39) = 11.88$, $p<.01$. A Games-Howell posthoc analysis showed this main effect to be driven by significantly better performance ($p<.01$) in the CA group than both those with WS and MA matches. As Figures 5.8 and 5.9 indicate, individuals with WS performed at around chance level (33%) for top and aligned face halves; this was a very similar finding to that noted in the ASD group.

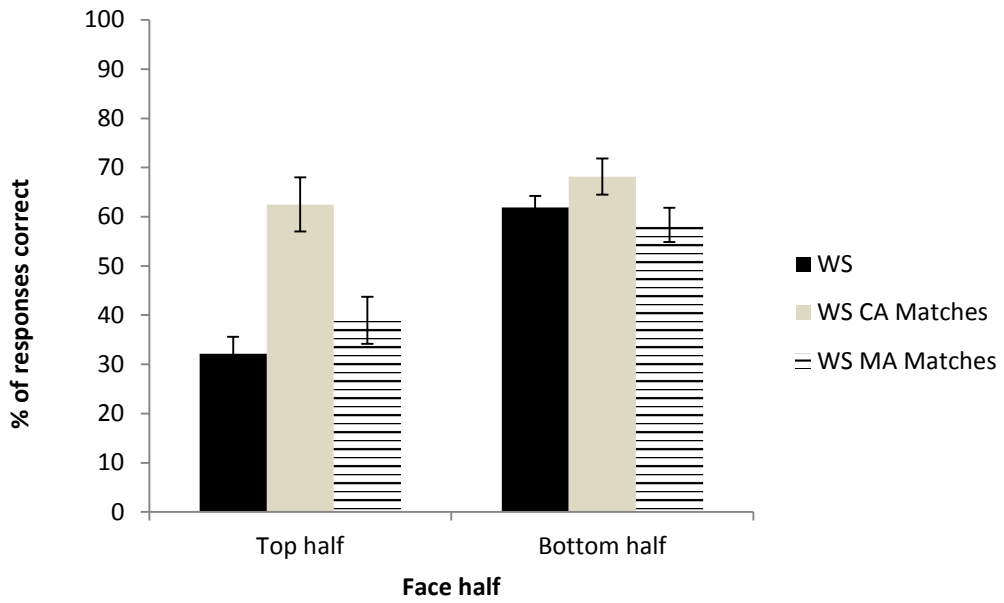


Figure 5.8: Correct responses by stimulus half for WS participants and TD matches in Experiment 3b.

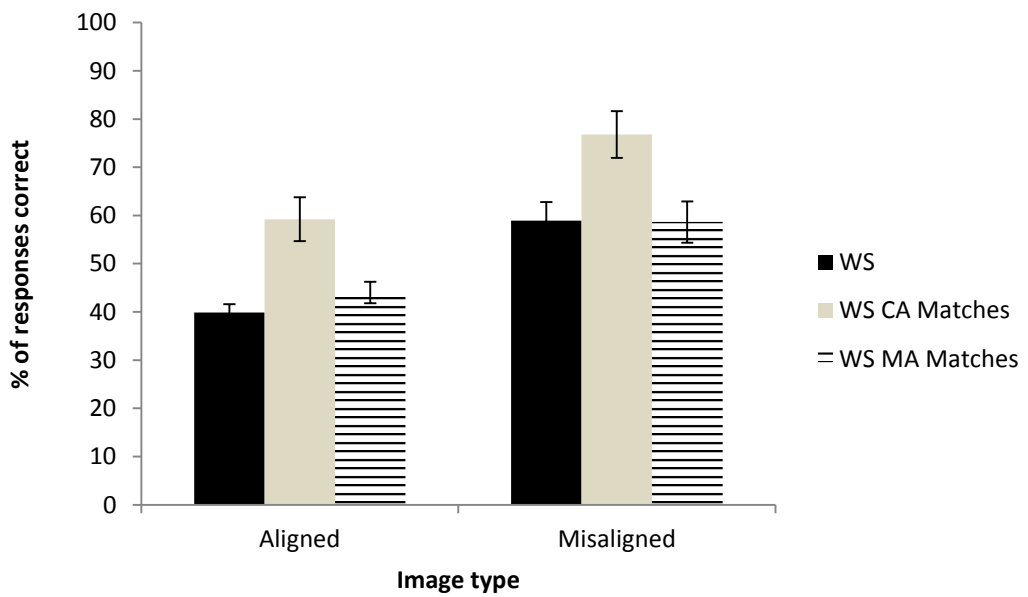


Figure 5.9: Correct responses by condition for WS participants and TD matches in Experiment 3b.

5.8.3.2 Emotion x Half

The mean correct responses for each combination of factors are reported in Table 5.19. A 3 x 2 x 3 mixed design ANOVA (emotion x half x group) found a main effect of emotion, $F(2, 78) = 29.95, p < .01$. The main effect of emotion was caused by significantly fewer correct responses to scared faces over all groups than for either other emotion ($p < .01$) with no significant interaction being found between emotion and group ($p > .05$). A main effect of face half was also found, $F(1, 39) = 27.83, p < .01$ with a significant interaction with group ($F(2, 39) = 3.77, p < .05$), as outlined above. A main effect of group was observed, $F(2, 39) = 8.96, p < .01$. A significant interaction between half and emotion was noted, $F(2, 78) = 64.50, p < .01$. Paired samples t-tests revealed this interaction to be driven by a significant difference ($t(41) = 10.36, p < .01$) between top and bottom halves of only *happy* faces; no significant differences ($p > .05$) were found for face halves for either other emotion.

Table 5.19: Mean correct responses for combinations of face emotion and half in the WS group and TD matches (standard deviations in parentheses; Maximum score=8)

	Happy Top	Happy Bottom	Angry Top	Angry Bottom	Scared Top	Scared Bottom
WS	2.29 (.91)	6.36 (1.08)	3.93 (1.9)	6.29 (1.20)	2.79 (1.25)	3.07 (2.09)
TD CA	4.0 (1.80)	7.86 (.36)	5.57 (1.87)	5.50 (1.65)	5.43 (2.14)	3.0 (2.18)
TD MA	1.93 (1.82)	6.86 (1.17)	4.64 (2.24)	4.93 (2.50)	2.79 (2.67)	2.21 (2.23)
Overall Total	2.74 (1.78)	7.02 (1.12)	4.71 (2.08)	5.57 (1.90)	3.67 (2.41)	2.76 (2.15)

5.8.3.3 Emotion x Alignment

A 3 x 2 x 3 mixed design ANOVA was conducted for emotion x condition (aligned versus misaligned), with group as between subjects factor. A main effect of emotion was found ($F(2, 78) = 23.46, p < .01$), as detailed above. There was no significant interaction between emotion and group. A main effect of condition was observed, $F(1, 39) = 8.96, p < .01$ as well as a main effect of group overall, $F(2, 39) = 13.37, p < .01$; further, a significant interaction between all three factors was observed, $F(4, 78) = 6.88, p < .01$.

Table 5.20: Mean correct responses for combinations of face emotion and condition in the WS group and TD matches (standard deviations in parentheses; Maximum score=8)

	Happy Aligned	Happy Misaligned	Angry Aligned	Angry Misaligned	Scared Aligned	Scared Misaligned
WS	4.36 (.84)	3.07 (.92)	4.50 (1.70)	3.79 (.80)	2.29 (1.44)	3.43 (1.34)
TD CA	4.93 (1.44)	6.93 (1.07)	5.07 (1.9)	6.0 (1.36)	4.21 (1.93)	4.21 (2.23)
TD MA	3.71 (1.20)	5.07 (1.69)	4.71 (1.44)	4.86 (1.70)	2.14 (1.70)	2.86 (2.57)
Overall Total	4.33 (1.26)	5.02 (2.02)	4.76 (1.67)	4.88 (1.60)	2.88 (1.92)	3.50 (2.13)

In order to pull apart the three-way interaction, paired samples t-tests were conducted on each group separately to compare the number of correct responses for aligned versus misaligned faces for each emotion. Significant differences ($p < .05$) between aligned and misaligned faces (after Bonferonni corrections) were only found in any of the groups for happy faces. In the WS group, there were more correct responses given to *aligned* versus misaligned happy faces, $t(13) = 3.23, p < .01$. However, in both TD CA and MA groups, this pattern was reversed, with more correct responses for *misaligned* happy faces, respectively, $t(13) = 1.04, p < .01$ and $t(13) = 3.80, p < .01$. Worthy of note, as can be seen in Figure 5.10, is the fact that individuals in the CA TD group gave exactly the same mean number of correct responses to aligned and misaligned scared faces.

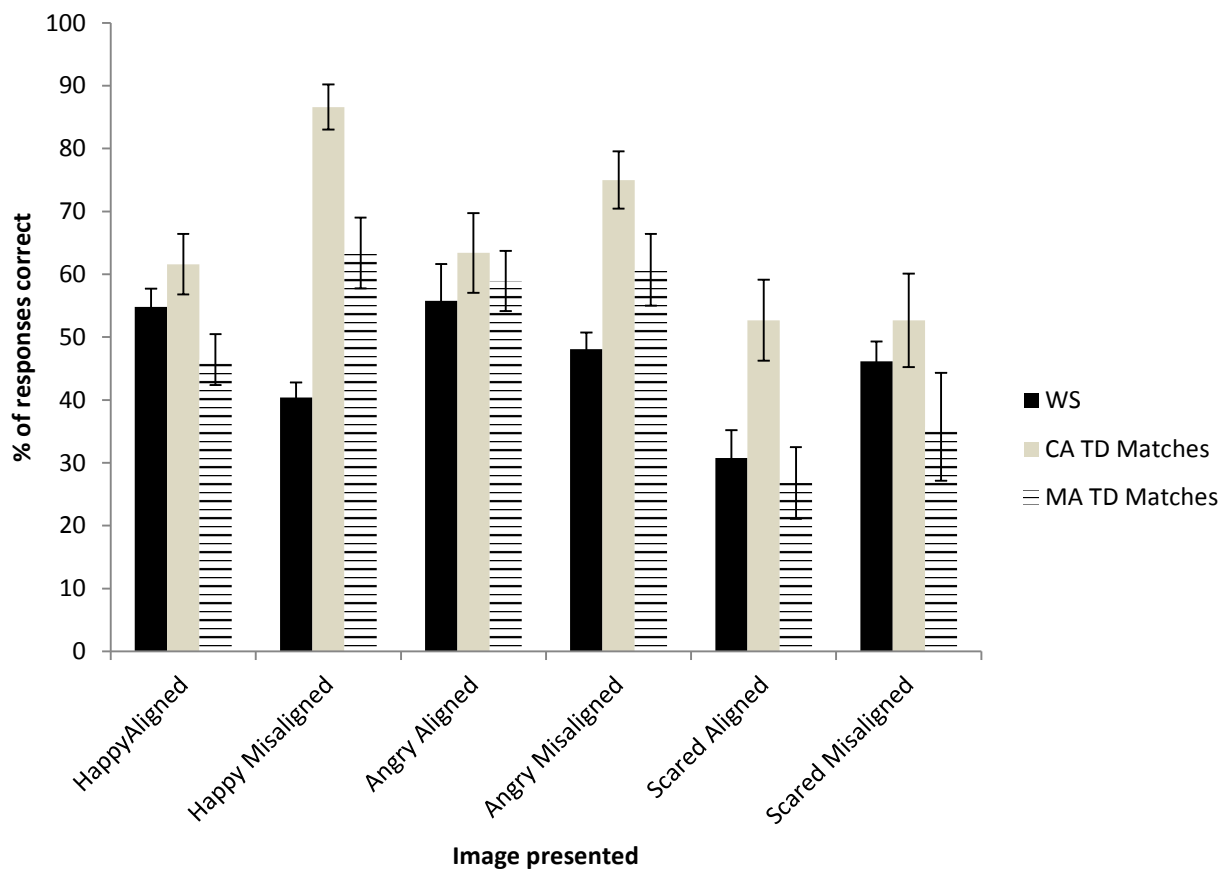


Figure 5.10: Percentages of correct responses for combinations of emotion \times alignment in the WS group and TD matches

5.8.4 Summary of Results: Experiment 3

5.8.4.1 Experiment 3a

When labelling the emotions of isolated face parts, (eyes versus mouths), no particularly distinctive patterns emerged between any of the groups. Amongst the TD population, the oldest group of children outperformed the younger groups and participants gave fewer correct responses to scared expressions than happy or angry, but this was the same in all age groups. No differences were found between accuracy for eye versus mouth cues. The same patterns emerged in the ASD analysis, although there was a (non-significant) trend towards those with ASD being poorer in deducing emotions from mouth versus eye cues. In the WS cohort, all participant groups gave more correct responses to those images containing mouths versus eyes but no differences in performance between emotions were apparent. Therefore, from Experiment 3a, there is no evidence to suggest that individuals in the clinical groups were more attentive to mouth cues relative to TD peers or that any one emotion differentiated performance.

5.8.4.2 Experiment 3b

Three questions were explored: Would there be any interactions in accuracy for a particular face half depending on alignment? Would different *emotions* be interpreted more or less accurately depending on their alignment? And would accuracy for emotions vary depending on the half attended to? In all cases, would the patterns be the same or different between clinical groups and their TD peers?

The interplay between alignment and face half was not significant in any comparisons, whereby all participants had better accuracy when faces were misaligned, regardless of which half of the face they were asked to attend to. All participants were also overall better in identifying emotions from the *bottom* halves of faces. Whilst this pattern held true in the clinical comparisons, it was observed that individuals with ASD performed less accurately than their TD peers, with accuracy for the top halves of faces and aligned presentations being at only chance level (approximately 33%) in the ASD group; CA matches in the WS cohort outperformed those with WS (and TD MA peers) for only the *top* halves of faces. Individuals with WS were also at chance level for aligned and top presentations of faces.

In terms of an interaction between the emotion presented and face half presented, amongst all TD groups (with the exception of those aged 9 years 1 month to 11 years 11 months) performance was better for the bottom halves of happy faces compared to the tops. No differences between face half accuracy emerged for any other emotion. In the 9 years 1 month to 11 years 11 months group, however, it was for the scared emotion where a difference emerged, in which the *top* halves of faces were more accurately identified versus bottoms. In both the ASD and WS comparisons, the same pattern emerged in that all participants were overall better in recognising emotions from the bottom halves of faces, with the difference between top and bottom presentations being most pronounced when identifying 'happy'.

When examining the effect of alignment on accuracy for emotions amongst TD participants, the same trend was seen in all age groups in that accuracy was higher for misaligned (versus aligned) happy faces, and alignment did not affect accuracy for angry or scared emotions. There were no different patterns depending on age-group, and the oldest group gave more accurate responses than the two youngest groups. Whilst this does not provide evidence for the superiority of anger in the TD population, as hypothesised, it does suggest an interplay between emotion and processing strategy.

In the ASD comparison with typical controls, the only difference to emerge between aligned and misaligned faces was amongst those participants with ASD, whereby these individuals were more accurate on aligned than misaligned happy faces. This same profile was seen in individuals with WS, whilst TD matches tended to be more accurate in labelling *misaligned* happy faces. This finding is interesting as it suggests something specific about happy faces in both ASD and WS that facilitates a less holistic style of processing.

5.9 Discussion

5.9.1 Experiment 2

The Emotion task was designed to establish whether those with WS and ASD would be able to piece together the configurations of non-face images to deduce an emotion. Further, to explore whether different emotions might result in emotion specific patterns of performance between the groups. In fact, the same trends emerged in that those with ASD, WS and their TD matches, all showed significantly reduced performance for line and fruit images versus human and animal faces. This may suggest that even those in the oldest TD group did not piece together ambiguous features to deduce an emotion, in the same way that they did real face cues: All groups may have relied more on individual features to label the emotions, which were not sufficient to do so with great accuracy in the case of line and fruit images. De Wit et al. (2008) have also noted comparable trends in performance between those with ASD and their peers. The question remains as to whether comparable performance is underpinned by comparable process.

The observation that both individuals with WS and ASD did not perform as accurately as their peers when labelling the emotions of *human* faces is particularly striking, given the divergent everyday approach behaviours between these two groups (Dodd et al., 2010) It was expected that the human face might buffer against difficulties in emotion recognition in the WS group and this was evidently not found to be the case. It must therefore be that some, perhaps more cognitive, factors are at play in driving differences between the social exchange behaviours seen in WS and ASD; indeed, that basic emotion identification alone might underpin broader social exchange profiles is highly unlikely. The issue of what other factors might play a role in an understanding of social contexts will be explored in Chapter 6.

In terms of performance for emotions, differences did emerge between the groups, with fewer correct responses being given to happy and surprised faces in both the WS and ASD groups relative to their peers. It was expected, based on the findings of Santos et al. (2010) that those with WS might show detrimental performance to angry, rather than happy faces, but this was not shown to be the case. Farran et al. (2011) have argued that there may be some interplay between the type of stimuli presented and the emotions depicted; unfortunately, this was not explored in Experiment 2 but would be a worthy topic of future research.

No clear improvement with age overall was found, possibly due to the fact that accuracy was approaching ceiling; in all groups, the poorest performance was for surprised images. The fact that very few notable differences were found between image types or emotions that might pull apart the clinical groups may have been a product of task design: Having a forced choice may have promoted ceiling effects and also given rise to the utilisation of specific face cues that could not be established through this type of design. Experiment 3 was therefore intended to pull apart this type of interaction between emotion and cue use. Future eye tracking studies would also be informative in exploring precisely which facial cues might be attended to in which emotions.

The reduced accuracy found amongst all participants for surprised images in Experiment 2 is consistent with the work of Baron-Cohen et al. (1993), who have shown that, especially amongst individuals with ASD, surprise and happiness are very easily confused and mislabelled. Analysis of specific error types was not conducted in the present study, given the limited number of items; in future, considering the type of errors made in mislabelling emotions would be very informative. These types of errors were considered, however, in Experiments 4 and 5 (See Chapter 6). Kret et al. (2011) have suggested that it is the *salience* of an emotion that determines the level of processing and subsequent attention to it. They have also proposed that the animacy of a face is an important factor affecting the type of processing used. If it is the configural arrangements of faces, rather than the emotional content, that trigger amygdala activation, examining the interactions between image type and emotion in the present study would have been most informative: Is emotion recognition comparatively accurate across one specific form of presentation? To what extent might the configural arrangement affect emotion recognition? Or is it more an issue of cue use? These questions were addressed in Experiment 3.

5.9.2 Experiment 3

Experiments 3a and 3b were designed to highlight possible differences in accuracy for specific emotions, processing style, cue use, and the interplay between them. This is an important issue given the complexity of emotions: If one can pinpoint where those with neurodevelopmental disorders might be utilising information differently, it may be possible to better understand the ways in which they process emotions from faces. Experiment 3a revealed a surprisingly uniform pattern, however, both across typical age-groups and in clinical participants compared to their peers: No

differences in accuracy emerged between comparison groups, and performance for images depicting scared face parts was generally poorer than that for happy or angry. Also worthy of note was the fact that both individuals with ASD and WS gave fewer (although not to the point of significance) correct responses for isolated cues depicting happy emotions. This was not predicted in the case of WS, as Farran et al. (2011) have suggested individuals with WS are *better* at accurately detecting happiness. However, perhaps this is only true when provided with *whole* face information.

The only differentiating pattern in Experiment 3a was in the WS cohort, where all participants performed better on mouth versus eye cues. Given the propensity of those with WS to focus on the eye regions of faces (Riby & Back, 2009), this is an interesting finding, as it may indicate that attention to eye cues does not necessarily equate to accurate *utilisation* of the information available from those cues in this group, given the lack of any clear differences in performance between emotions for isolated eye/mouth cues. Riby et al. (2009) have noted very different profiles between those with ASD and WS as to which cues are utilised the most in tasks involving configural processing of faces, examining the interplay between task demands and accuracy for using specific cues. Therefore Experiment 3b aimed to examine the way in which face *configurations* might underpin the accurate identification of specific emotions.

Experiment 3b (the composite task) was designed to further pull apart the ways in which accuracy for emotion cues might depend upon the face region being attended to. The premise behind the composite paradigm is that, if holistic processing occurs, the misalignment of incongruent face halves will result in better performance than those that are aligned. This was, indeed, overall found to be the case in all participant groups. This is a somewhat surprising finding given the evidence reviewed in Chapter 3 suggesting difficulties in the piecing together of configurations in individuals with ASD and WS. However, the fact that all participant groups also performed better overall when asked to attend to the bottom halves of stimuli may suggest that, even in typical development, alternate processing strategies are at play: Whilst it is plausible to find an advantage of one half over the other in *misaligned* conditions, this advantage should disappear on images where the faces are believed to be processed holistically (the aligned condition), therefore it was predicted that an interaction between face half and alignment would have been found in TD groups. This was not the case. This may suggest a particular importance of cues from the bottom halves of faces that underpin the appraisal of emotions from faces. Blais et al. (2012) have shown the importance of mouth cues in interpreting emotions in their work.

It is worthy of note that no clear age interactions were found in any analyses across the TD age groups. Overall, the oldest group performed better than their younger peers in Experiment 3a, and accuracy for emotions overall in Experiment 3b was found to be significantly different between the groups at each end of the age range (the two youngest compared to two oldest) but not between neighbouring age groups. This may be suggestive of more of a 'peaks and plateaus' pattern of development.

Whilst individuals in the clinical groups did not appear to have any difficulties, relative to peers, in interpreting emotions from *isolated* face parts, their overall performance was

reduced compared to TD matches on Experiment 3b, suggestive of a configural processing problem. Individuals with both ASD and WS were only at chance level (approximately 33%) in identifying the emotions from the top halves of faces and aligned faces; those with ASD were significantly less accurate overall than both CA and MA TD peers. Individuals with WS were poorer than CA peers for the *top* halves of faces. This difference between individuals with ASD and WS relative to peers may be suggestive of a different type of cue use between individuals with these neurodevelopmental disorders. Riby and Back (2009) have shown that eye cues are particularly important for individuals with WS to accurately interpret emotions and Riby and Hancock (2008) have shown heightened *attention* to the eye region in WS; this is difficult to reconcile with the findings of Experiment 3b, as poorer performance for the top halves of misaligned faces would suggest less accuracy in effectively using eye cues. In the aligned condition, it might suggest more distraction from the lower face region, which would not be expected in WS.

One final interesting finding to emerge from Experiment 3b was the fact that both participants with ASD and WS were more accurate in identifying emotions from *aligned* happy faces whilst TD matches gave more correct responses to happy faces that were *misaligned*. No differences between the advantage of misalignment were seen for other emotions in any of the groups, suggesting something specific about ‘happy’ and the way in which it is processed. Finding an explanation as to why *aligning* incongruent face parts would facilitate better recognition of ‘happy’ in those with ASD and WS is very difficult. It might have been that accuracy for misaligned happy faces was poor if individuals had certain difficulties with particular cues depending on alignment, but no interaction between face half and alignment was found in those with WS or ASD, therefore this doesn’t appear to be a plausible reason. It might be that *misaligning* happy face halves is more beneficial for those who are typically developing because they make better use of individual cues than do those with ASD and WS; individuals with ASD did show a (non-significant) trend towards being poorer in recognising isolated mouths compared to peers, for example. However, this still would not explain why an *advantage* was shown for aligned happy faces in the groups with neurodevelopmental disorders.

The fact that both Experiments 2 and 3 were comprised of forward-facing, direct gaze images may have buffered against some of the ways in which faces of different stances might be processed in real life. Lobmaier et al. (2008) have previously shown that expressions of emotion were more rapidly recognised depending on gaze direction, with averted gaze facilitating recognition of fear and sadness and direct gaze facilitating happy and angry expressions, although Haxby et al. (2000) along with Bruce and Young (1986) have argued the case for the *dissociability* of these different aspects of face information. Lobmaier et al. (2008) have further explored whether this relationship between emotion and gaze is reciprocal: Will a face depicting a certain emotion affect where the viewer would perceive the gaze to be directed? They found that significantly more ‘looking at me’ responses were made to happy faces than for any other emotion, with anger being the second most facilitative of a ‘looking at me’ response, and no difference between fear and neutral expressions. Lobmaier et al.(2008) posit these

findings as evidence for a ‘self-positivity bias’ in which we generally like to think that people looking at us must be happy. Indeed, this idea that emotional expression can mediate perception of gaze direction could explain some of the fundamental social interaction atypicalities in WS and ASD and is worth further exploration in future studies.

Another limitation of Experiments 2 and 3 is the inconsistency of emotions tested between the two tasks. Whilst the choice of emotions used in Experiment 2 was due to the constraints of designing emotionally expressive faces using fruit items, this meant that scared was not included. A direct comparison of performance between Experiments 2 and 3 may have been informative. For example, there were no interactions in Experiment 3b in which different levels of accuracy were evident for any specific emotions between the clinical groups and their TD peers, but Experiment 2 found both those with WS and ASD to be poorer than TD peers in identifying surprised faces. Featureally, the configurations of scared and surprised are very similar therefore these differences relative to TD peers may have been driven more by the different *meanings* taken from these emotions. The inclusion of both in each experiment may have answered to this question. Similarly, due to the constraints of image design, it was not possible to include enough items to conduct a full three-way analysis between emotion type, alignment condition and face half in Experiment 3. This would be a more robust method in future studies of fully separating out the interactions between the different aspects of face information.

5.10 Summary of Chapter 5

The most prominent finding to arise from Experiment 2 is how similarly those with ASD and WS perform relative to their TD peers in that performance was better for real versus non-real faces, with a reduction in accuracy for surprise. In Experiment 3b, the same profiles were apparent towards utilising mouth cues, performing more accurately when attending to the bottom regions of faces; misalignment advantages on a composite task were evident in all participant groups. However, when analysing accuracy for, and the interplay with, emotions some differences did begin to emerge, suggesting possible divergent strategies in utilising specific cues, depending on the emotion presented. Specifically, differences were apparent for ‘happy’. This issue of attention to and utilisation of cues, dependent on specific emotions, will be further explored in Experiment 4.

Chapter 6: Attribution and Understanding of Cues

6.1 Overview

Experiments 1-3 have outlined the fact that whilst those with ASD and WS are not as *accurate* or as likely to deduce social information or emotions from faces and face-like images as do TD peers of the same CA, they do appear to employ similar strategies to those that TD peers are using, with no clear differences observed as to different strategies used *between* those with WS and ASD. The divide between clinical groups and typical matches appears to be more driven by the *type* of cues that are being utilised in these populations. Experiments 4 and 5 will therefore examine this further: Is there a difference between how those with WS and ASD utilise face and object cues? Do those with WS and ASD show differences relative to peers in how they understand and interpret these types of cues? And how different do these profiles (relative to peers) appear compared to one another across the neurodevelopmental groups? Further, in what ways (social or physical) will individuals in the different groups make attributions about ambiguous stimuli? Experiments 4 and 5 were designed to answer these questions.

6.1.1 Experiment 4: Introduction

The focus of the present chapter is on the utilisation and attribution of cues within social (containing images of people) versus non-social stimuli. The behavioural profiles of those with ASD and WS suggest that there may be a general lack of interest in (for ASD), compared to propensity towards (for WS), social situations in everyday life; it is therefore important to examine what specific cues might facilitate these patterns of behaviour. Is it the case that individuals with WS and ASD typically make use and attributions of different cues in different ways to that seen amongst TD peers? And might these profiles (relative to peers) be different in each neurodevelopmental group? Might it be, for example, that the *emotional* content of a face is what draws or disengages those with WS and ASD, in a different way than it does with TD peers? Or is it that the non-social aspects of a scene determine the different ways in which that information is used, with different profiles relative to peers seen in ASD and WS groups? Further, what tendencies do individuals with WS and ASD have when asked to put an ambiguous situation into a social or physical context? In exploring potential differences between individuals with ASD and WS relative to TD CA and MA peers at the level of utilisation and attribution, it may be possible to pull apart differences between the two groups that have not appeared thus far at the purely social-perceptual level. This is important in order to pinpoint what underlying factors might be driving the very different social approach behaviours seen in individuals with these disorders.

The question of what cues are *useful* to individuals with ASD and WS, as well as what draws their attention, is one that has not been explored in a comparative study thus far. The purpose of Experiment 4 is therefore to examine these questions: How do social versus non-social cues facilitate the understanding of social versus non-social scenes?

Do these cues support or distract in certain contexts, depending on emotional content? Experiment 4 partly replicates a paradigm devised by Da Fonseca et al.(2009). They compared 19 HF children with autism (mean age 12 years 8 months) to MA matched controls in a task where they were shown social scenes in which a face or object was masked out. Participants were required to choose, from three cartoon-like response options, the missing object.

It was found that overall, those with ASD were poorer in choosing the correct answer, despite being matched on MA and no correlations being found between IQ and task performance. Both groups were better in choosing the correct missing *object* than face, with those in the ASD group being comparable to TDs on this measure. When participants were required to find the correct missing facial expression, however, those with ASD showed a detriment in performance compared to controls. When examining performance across the age range (7-18 years), improvements with age were found in both groups.

Da Fonseca et al.(2009) cite their findings as evidence that individuals with ASD are able to use global context to identify missing *objects* in a scene but find the identification of missing facial expressions more problematic. It therefore seems that those with ASD struggle to use emotional cues to deduce how another person is feeling; this suggests a problem in the more social-cognitive (theory of mind) than social-perceptual domain. However, Da Fonseca et al.(2009) did not balance the object and face trials, in that the missing object trials only ever depicted a person with a neutral face, missing any possible interplay between emotional expressions and use of object cues. All scenes also contained a person; perhaps a different pattern of results might emerge for purely non-social scenes.

Using the same experimental paradigm and the same sets of images, Santos, Randon, Milne, Démonet and Deruelle (2008) have repeated this study with WS participants (mean age 17 years, 2 months) and, very interestingly, found precisely the opposite pattern of results: That individuals with WS were comparable to both CA and MA (mean age 9 years, 7 months) TD controls on the emotion condition but showed poorer performance to both groups in correctly choosing the missing object. Santos et al. (2008) therefore concluded that there must be something about the social significance of emotions that boosts the ability of WS participants to make accurate judgements, above and beyond the cues that objects can afford. This apparent split between those with WS and ASD is an intriguing one that highlights the issue of what *meaning* different cues might have in the two groups and how they may be utilised. Experiment 4 set out to examine the complex combination of emotion cues and social content in identifying the missing object or face within social and non-social scenes.

6.1.2 Attention to Faces

The early work of Johnson, Dziurawiec, Ellis, and Morton (1991) has shown that new born infants have a tendency to orient towards human faces versus non-face configurations. This work has been seminal in driving a research literature focused on the idea that humans have an 'innate' tendency towards faces. Would faces presented in Experiment 4 therefore be found to distract participants from attending to other relevant information? How might individuals with WS and ASD differ from TD peers as to the types of cues that might affect performance, and would these profiles look different between the two disorders?

Remington, Campbell and Swettenham(2012) reiterate the idea that, in typically developing children, an attentional bias for faces is evident. They therefore questioned whether the same attentional bias would be seen for individuals with autism. The premise of Remington et al.'s (2012) research was based on perceptual load theory: When the attentional demands of a central task are high, attentional resources do not tend to be given to distractor items. However, this does not tend to be the case when the distractor items are faces. Therefore, would this also be found amongst those with ASD?

Remington et al. (2012) devised a paradigm in which adults (n=16) with ASD (mean age 23 years 8 months) matched to TD controls (mean age 26 years, 8 months) based on NVIQ were asked to identify the sex of a target name that was presented within an array of 1, 3 or 5 distractor non-words (See Figure 6.1). Distractor faces were presented to either be congruent or incongruent with the sex of the target name. It was hypothesised that, for TD individuals, the incongruent faces would cause more distraction, evidenced by slower reaction times (RT). This was found to be the case, regardless of the set size of distractor non-words. However, in the ASD group, RTs were only increased when the perceptual load of the central task was low (1 or 3 items), suggesting that individuals with ASD did not show the characteristic pattern of prioritising attention to faces over the demands of a perceptually demanding central task. One may question, however, whether the discrepancy between the groups on this task was due to a lack of attention to faces in the ASD group or simply an inability to efficiently handle higher task demands.

In order to ascertain whether this effect was specific to face distractors, the same paradigm was used whereby participants were asked to state whether a target word was a string or wind instrument, presented with a congruent or incongruent image of an instrument. Both TDs and those with ASD failed to show heightened RTs in the more demanding task condition (3 or 5 items), indicating that faces do have a unique hold over attention in those who are typically developing, not seen in individuals with ASD. Whilst this additional experiment does suggest a difference in the utility of faces in drawing attention, it fails to address the question of whether those with ASD struggle to process more complex arrays of information.



Figure 6.1: Example of a 'high' incongruent perceptual load item in the Remington et al. (2012) study

Riby, Brown, Jones and Hanley (2012) have also shown a lack of attention to faces when presented as distractor items: Within their cohort of 28 children diagnosed with ASD (mean age 12 years, 11 months), matched on NVIQ to TD controls (mean age 10 years, 4 months), they found that those with ASD were not slowed by the presence of a neutral distractor face when asked to detect the presence/absence of a butterfly in a scene, relative to when distractors were only objects. In the TD group, the RTs for responses when the face was present were significantly slower. Interestingly, those in the ASD group who were the least affected by the presence of a face tended to also have lower levels of functioning (assessed by teachers using the Childhood Autism Rating Scale (CARS), Schopler, Rechler & Renner.,1988). Riby et al. (2012) posit their findings as strong evidence for the over-riding effect of faces on attentional resources in the TD population, given that the presence of faces in this design did not serve any purpose in identifying the target item.

Whilst the work of Riby et al. (2012) does, like Remington et al. (2012) suggest that faces do not hold the same 'pull' in ASD that they do in TD children, it is important to question whether perhaps the underlying processes are not concerned with a lack of attention to faces, but an inability to *disengage* from objects. In the Riby et al. (2012) study, those with ASD took longer overall than TDs to respond to the conditions in which no face was presented, suggesting that they struggle to process the central array as quickly as TDs. This may be due to a 'pull' of objects akin to that seen for faces in the TD cohort. Riby and Hancock (2008) have also shown in their eye tracking study using a passive looking task that children with ASD spend less time looking at faces and tend to focus more on objects in the periphery of a social scene. Whether or not this shows an indifference to faces or a propensity towards objects has yet to be confirmed.

The inappropriate allocation of attentional resources could also be the cause of the tendency for those with WS to *overly* attend to faces. Lense, Key, and Dykens(2011),

have explored this possibility using an attentional blink paradigm. This design is based on the consistently noted finding that TD individuals are poor in detecting second targets when they are presented in close proximity to a first; this is believed to be due to the allocation of attentional resources to the first target, that therefore detracts from the second. The attentional blink paradigm provides a useful means of pulling apart attention and disengagement: The *magnitude* of the attentional blink effect (AB), determined by the decrease in accuracy between targets 1 and 2, is a measure of attentional allocation; the *duration* of the AB, measured by the time it takes to switch from target 1 to 2, can be used to deduce disengagement.

Lense et al. (2011) recruited 14 adults with WS (mean age 28 years, 4 months) matched to TD controls (mean age 26 years, 2 months) on an AB paradigm task using letters of the alphabet as targets. Their analysis revealed that both groups were comparable in terms of the detriment of attention to target 2 (attentional allocation) but those with WS displayed longer durations between targets 1 and 2 compared to TD controls, suggestive of problems with disengagement. This suggests that individuals with WS may have trouble re-aligning attention from one item to the next, even when the stimuli are not faces. It could be the case that the typical pattern seen in those with WS to over-attend to faces is driven by a more general inability to disengage attention.

Riby et al. (2011) have also shown in their set of experiments that it is when required to *disengage* from faces that individuals with WS can be differentiated from TD peers. Across four experiments examining attention to, distraction of and bias towards faces (versus objects), Riby et al. (2011) showed that individuals with WS (mean age 13 years) were no more likely than TD peers to be drawn to an upright face amongst arrays of inverted faces, but did show faster responses to targets when cued by faces versus objects, as was also seen amongst TD peers. However, on a priming task in which faces and objects were presented incongruently to the primed target, individuals with WS were significantly slower to disengage from faces versus objects; a pattern that was not seen in either MA or CA TD groups. Riby et al. (2011) therefore tentatively suggest that the social behaviours seen in WS may be driven by difficulties in switching attention *from* faces once it has been allocated.

The evidence reviewed here suggests that those with ASD do not show the same attentional prioritising for face stimuli seen in the typically developing population. Amongst those with WS, the problems may lie more in *disengaging* attention from certain stimuli. It is therefore important to examine what particular cues might hold the greatest utility and meaning in these groups.

6.1.3 Attentional Preference for Faces versus Objects

It may be the case that individuals with ASD fail to be drawn to faces (or overly attend to objects) because of relative strengths and difficulties in using such cues. Kuusikko-Gauffin et al. (2011) tested 45 high functioning children with autism (mean age 11 years, 6 months) and their parents, along with a control sample of CA matched

TD children and their parents on the object recognition and face memory tasks on a standardised battery of tasks designed for neurological assessment (NEPSY). The purpose of their study was to examine possible age effects, as well as heritability trends, within the two groups, although the age range of the children only varied from 10 to 13.5 years and no comparisons were made *between* children and adults. Despite this limited age range, Kuusikko-Gauffin et al.(2011) did find that those with ASD were significantly less accurate than the TD group on the face memory tasks, but this difference disappeared amongst the oldest participants. Further, those with ASD were more accurate than controls on the object identity task. A similar pattern of results was also found among the parents of those children, suggesting that autistic type traits may run in families and therefore there may be some degree of heritability as to the types of everyday cues that hold meaning for individuals with autism. Whether such parental influence is genetically or environmentally based is a matter of future debate.

Whilst the findings of Kuusikko-Gauffin et al.(2011) suggest that individuals with ASD tend to perform better when presented with objects versus faces, the nature of the task may be pivotal to this finding. The object recognition task, for example, consisted of pixelated images, therefore it might be that this was advantageous for individuals known to favour a more feature-based processing style. The face task was focused on *memory* mechanisms as it required participants to recognise faces that they had previously been exposed to; any memory difficulties within the sample recruited to this study would therefore have underpinned this discrepancy, rather than a difficulty with faces *per se*. It is therefore important to directly compare face and object stimuli using a paradigm whereby all other factors are held constant.

McCleery, Akshoomoff, Dobkins, and Carver(2009) have previously offered neurological evidence to suggest that there may be neural underpinnings for object preference in individuals with ASD. They examined twenty 10 month olds who had an older sibling with a diagnosis of autism (at-risk group) compared to twenty infants of the same age without any history of ASD in the family (low-risk group) in an ERP study comparing faces and objects. The infants were shown images of familiar/unfamiliar faces and familiar/unfamiliar toys whilst being monitored for electrical brain activity. The results showed that there were faster ERP responses to faces versus objects in the low risk group at the amplitude P400, contrasted with faster responses to objects versus faces in the high risk group (evidenced by peaks in the N290). Furthermore, a hemispheric asymmetry was seen in the low risk group across the categories that was not apparent amongst the high risk infants.

Given the fact that these infants were categorised as *at risk* of autism, rather than having had any formal diagnosis, it is not possible to state that the differences between the groups are responsible for the behavioural phenotype in ASDs. However, the fact that differences were found purely by virtue of having a relative with a diagnosis, is striking. It may be worth considering, however, that having an older sibling with the behavioural traits seen in ASD might shape younger infants' preferences towards faces. If a sibling is reluctant to make eye contact and engage in play, it will inevitably have some impact on the way that the younger sibling responds to and interacts with others. Karmiloff-

Smith (1997) has long been an advocate of the importance of the interplay between genes and environment in shaping neural mechanisms; it could be that this example is a case in point for the ways in which this interaction occurs.

The literature reviewed thus far suggests that those with ASD may have the neural underpinnings to support atypical preferences to objects rather than faces. No studies to date have explored this pattern in those with WS although it may be the case that individuals with WS have difficulties in *disengaging* from faces versus objects. It is therefore worth considering if there are any specific aspects of the face itself that may capture and hold the attention of those with WS, or prove problematic for those with ASD.

6.1.4 Experiment 4: Summary and Aims

In summary, the literature suggests that individuals with ASD do not give the same attentional priority to faces as do those in the TD population; whilst individuals with WS do appear to show similar attentional biases as their TD peers, they may have more difficulties in *disengaging* from faces versus objects. Further, objects may hold heightened facilitation for individuals with ASD. Regarding the use of cues in understanding social and non-social scenes, very little research has been carried out directly comparing individuals in the two neurodevelopmental groups, or examining the *interplay* between the type of cues available and accuracy in the understanding of social versus non-social scenes. Experiment 4 was designed to explore such interactions. Would the presence of certain cues facilitate or be detrimental to accuracy in understanding social and non-social scenes in order to deduce a missing face or object?

Experiment 4 was comprised of 36 images of everyday scenes containing no social content (no people), a neutrally expressive person giving an instrumental gesture, or emotionally expressive people. An object or face was masked out and participants were asked to choose from 5 options what item was missing. Error types were analysed according to whether participants incorrectly chose the wrong category of response (a face when the correct item was an object, for example [Distractor errors]) or their choosing an incorrect response option *within* the correct category (such as a sad face when the correct answer was a happy face [Understanding errors]).

6.2 Experiment 4: Hypotheses and Predictions

6.2.1 Typical Development

Attention for emotional faces will be prioritised in TD groups. This will be evidenced by heightened accuracy in conditions requiring identification of missing emotions compared to objects. The presence of additional emotional cues in a scene will facilitate more accurate emotion identification but will result in poorer performance for object identification. There will a higher proportion of distractor than understanding

errors made (See section 6.3.4 for an explanation of terms) and a higher proportion of these errors will be in incorrectly choosing a face rather than an object.

6.2.2 ASD and TD Comparisons

Individuals with ASD will provide more correct responses to missing objects versus faces. No interaction will be observed between condition and accuracy, given that individuals with ASD are not found to be typically distracted by neutral or emotionally expressive faces. Unlike TD peers, individuals with ASD will make a higher proportion of understanding versus distractor errors for face items only. Individuals with ASD are also predicted to make more understanding errors than both CA and MA peers. No differences are expected to be found between the proportion of face versus object distractor error types.

6.2.3 WS and TD Comparisons

It is hypothesised that individuals with WS will show a lack of disengagement from faces. This will be evidenced by a reduction in accuracy in identifying missing faces when additional emotional cues are present compared to TD controls. Performance in identifying missing objects will also be reduced relative to TD controls and significantly fewer correct responses will be given to missing objects versus faces in the WS group. The proportion of distractor versus understanding errors will be comparable within the WS group, with a higher proportion within distractor error types towards incorrectly choosing faces over objects.

6.3 Method

6.3.1 Participants

Those participants who took part in Experiment 3 were recruited to take part in Experiment 4 (See section 5.6.1) with the addition of five individuals with ASD who had declined taking part in Experiment 3 and one child with WS. Therefore, an additional 11 TD were also tested. Age and NVIQ data for all participants are outlined in Table 6.1. The ages of the final ASD participant group (n=15) ranged from 6 years 5 months to 16 years 6 months, with a mean of 11 years 2 months. NVIQ scores on the Ravens Coloured Progressive Matrices (RCPM) ranged from 12 to 34 (Maximum score=36), with a mean of 25. The final WS cohort (n=15) had an age range from 8 years to 17 years 5 months; mean age 12 years 6 months. NVIQ scores ranged from 9 to 31 (out of 36) with a mean of 17.

Table 6.1: Age and MA demographics for TD matches to ASD and WS groups for Experiment 4

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
ASD (n=15)				
CA Matches*	6.10-16.2	11.3 (3.3)	21-36	31 (4.23)
MA Matches	4.3-15.9	8.5 (2.9)	12-32	25 (5.82)
WS (n=15)				
CA Matches*	7.10-17.3	12.3 (3.4)	23-36	31 (4.22)
MA Matches	4.1-14.4	6.1 (3.2)	9-31	17 (6.64)

*Due to recruitment issues, one CA match was missing for each clinical comparison

Independent samples t-tests were conducted in order to ensure that there were no significant differences in age and NVIQ between clinical groups and their CA and MA matches, respectively. There were no significant differences found between the mean ages of those in the ASD cohort compared to their CA matches ($t(27) = .09, p = .93$) or between those with WS and their CA matches: $t(27) = .22, p = .83$. Similarly, no significant differences were found for the NVIQ scores of those in the ASD and WS clinical groups and their MA matches ($t(28) = .12, p = .90$ and $t(28) = .00, p = 1.0$, respectively).

Within the ASD cohort, there were 10 males and five females; in the WS cohort there were seven females and eight males. Due to this imbalance between the sexes, an independent samples t-test was conducted to compare total scores on this task between male and female participants over the TD group. No significant differences were found, $t(59) = .73, p = .47$, therefore sex was not considered further in the analysis. TD groups and sex data were exactly the same as outlined in Experiment 3, as being a suitable match for a clinical participant was not a criterion for a TD participant to be entered into the TD groups analysis.

6.3.2 Materials and Design

Experiment 4 was comprised of 36 trials depicting everyday scenes taken from web-based image searches, all presented in PowerPoint with one scene per slide. All of the scenes were designed to be situations with which the participants would be familiar; for example, a child being told off by a teacher at school, a scene of a playground, etc. Further examples of the types of scenes presented are documented in Appendix A. Scenes were chosen and categorised according to three criteria: No social content (only object cues present), neutral content (an expressionless person was present, making an

instrumental gesture) and emotional content (a person was present in the scene with a clear emotional expression). Figures 6.2 and 6.3 provide examples of these images. Images were piloted on 20 TD adults in order to establish agreement as to which emotions (or neutral expressions) were depicted. Only those images in which 85% agreement was reached were included in the final experiment.

In each scene, either an object or a face was masked out with a white oval shape containing a red question mark; in half of the scenes the missing item was an object, and in the other half it was a face. Within these 18 scenes for each missing image type, there were six of each condition (as detailed above).

Five response options were presented beneath each scene: On items where the correct choice was a face, three faces depicting different emotional expressions (one of which was the correct response) were presented, along with two distractor objects. On items where the correct response was an object, three objects (one of which was correct) were presented, alongside two distractor faces (see Figures 6.1.1 and 6.1.2, respectively). The response options were cartoon-like depictions, in order to prevent participants attempting to match *exact* features. The order of presentation of response options and which specific items were used was randomised across all the trials. ‘Correct responses’ for each item were deduced by consensus (of 85%) through the pilot study. Any items in which participants did not reach 85% agreement were removed and replaced with an alternative response option, piloted again until 85% agreement was reached.

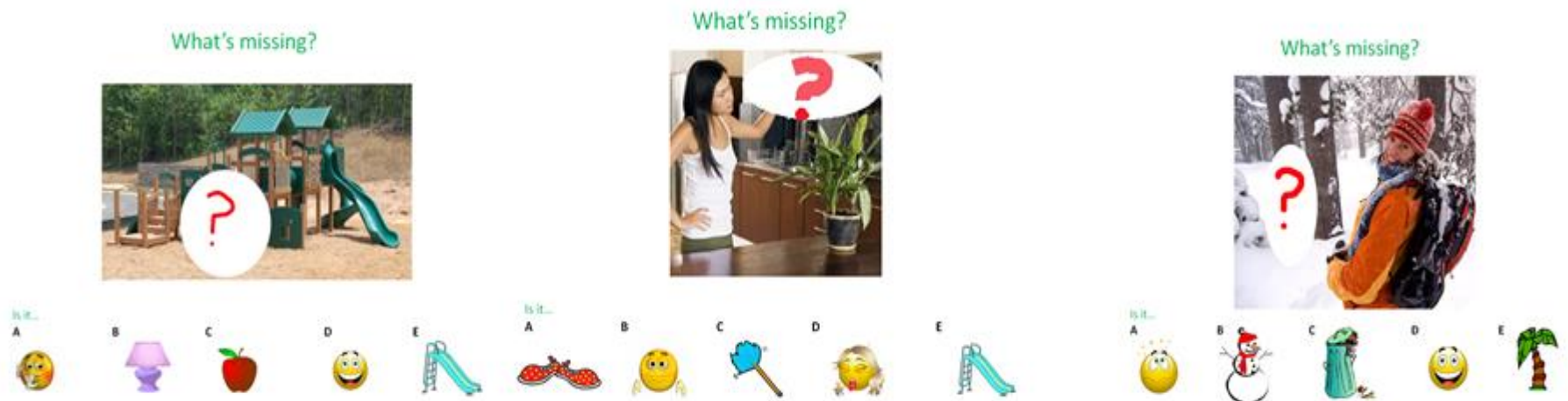


Figure 6.2: Examples of missing object images across conditions (no cues; neutral cues; emotion cues) in Experiment 4



Figure 6.3: Examples of missing face images across conditions (no cues; neutral cues; emotion cues) in Experiment 4

6.3.3 Procedure

Participants were told that they were going to “be a Detective” and would be asked to find the missing item from each scene presented. It was explained to participants that they would see many scenes, one at a time, and must look carefully to work out what was missing. They were informed that they would be presented with five possible options underneath each scene “which will not look exactly the same” but that they should pick the one that would *best fit*. Participants were told that the correct choice would either be a face or an object, and that they should use the ‘clues’ in the scene to work out the correct answer.

The experiment began as soon as the experimenter clicked onto the first slide. Participants were asked ‘What’s missing?’ and this question was also presented above each scene on every slide. As soon as the participant gave their response (either by stating the corresponding letter of their response choice, by pointing or by giving a ‘don’t know’ response), the experimenter moved onto the next scene.

6.3.4 Data Analysis

Each of the 36 items were coded as either correct or incorrect. Data were then analysed using mixed design ANOVAs with separate variables entered (See Results section). The variables of interest were: The number of faces versus objects correct and the number within each condition correct.

Error types were also analysed according to whether they were due to *understanding* (choosing the correct response type but not correct answer, such as choosing a sad face when the answer was a happy face) or *distractors* (choosing the wrong response type, such as choosing a face when the answer should have been an object). Within the distractor error category, the number of faces versus objects incorrectly chosen was also analysed: Face errors were those in which a face was incorrectly chosen when the correct choice was an object, and vice versa for objects.

6.4 Results

6.4.1 TD Groups

6.4.1.1 Response types: Accuracy

A 2 x 4 ANOVA (missing item type x age-group) was run for total correct responses. A main effect of missing item type was found ($F(1, 57) = 61.78, p < .01$) whereby, overall, participants gave more correct responses to objects versus faces. Table 6.2 outlines the mean number of correct responses for missing item type (and condition) across TD groups. A main effect of age-group was also found, $F(1, 57) = 33.45, p < .01$, underpinned by a significant difference in performance between the youngest group and

the older three groups overall ($p < .01$). No significant interaction was found between missing item type and age-group ($p > .05$).

Table 6.2: Mean number of correct responses for missing item type (Maximum=18) and condition (Maximum=12) across TD age groups in Experiment 4 (Standard deviations in parentheses)

	Missing item type		Condition		
	Face	Object	No social	Neutral	Emotion
Up to 6.6 years (n=16)	8.38 (3.10)	11.38 (4.08)	6.31 (2.6)	6.94 (2.44)	6.13 (2.19)
6.6-9.0 (n=13)	14.62 (2.22)	16.54 (1.51)	10.15 (1.35)	9.77 (1.64)	10.46 (1.45)
9.1-11.11 (n=13)	14.08 (2.63)	17.23 (.93)	10.23 (1.01)	10.08 (1.12)	10.08 (1.75)
12 years and above (n=19)	15.58(1.54)	16.89 (1.15)	10.89 (.99)	10.0 (1.0)	10.74 (1.10)
Total	13.16 (3.75)	15.44 (3.35)	9.39 (2.47)	9.16 (2.09)	9.33 (3.52)

In order to examine the possible interaction between missing item type and the cues available in the scene, a 3 x 2 x 4 ANOVA was conducted (Condition (no social cues/neutral expression/emotional expression) x missing item type x age-group). No significant main effect of condition was found but there was a main effect of missing item type, $F(1, 57) = 102.80$, $p < .01$, as can be seen in Table 6.2. No significant interaction between condition and age-group was evident ($p > .05$) and no significant interaction between condition and missing item type was found ($p > .05$). Therefore, regardless of the content of cues within the scene, participants across all age groups gave more correct responses when the missing item was an object. There was a main effect of age, $F(3, 57) = 32.36$, $p < .01$ in which the youngest children gave significantly fewer correct responses overall than all other age groups.

6.4.1.2 Response errors

Two one-way ANOVAs were conducted for understanding and distractor error types separately to compare age groups. A main effect of group was found for both distractor and understanding error types, $F(3, 60) = 12.65$, $p < .01$ and $F(3, 60) = 36.37$, $p < .01$, respectively. The mean numbers of each error type are reported in Table 6.3. Games-

Howell posthoc comparisons indicated that, for both understanding and distractor error types, the youngest group gave significantly more of each error type than the older three groups ($p < .01$). Figure 6.4 depicts how, when considering the error types made as a percentage of the *total* number of errors, all participants made a higher percentage of understanding errors.

Table 6.3: Mean numbers of error type (distractor versus understanding, Maximum number=36) across TD age groups in Experiment 4 (Standard deviations in parentheses)

	Distractor Errors	Understanding errors
Up to 6.6 years	5.0 (3.86)	11.25 (3.99)
6.6-9.0	.77 (1.30)	4.08 (2.22)
9.1-11.11	.92 (1.19)	3.77 (2.09)
12+ years and above	1.05 (1.35)	2.47 (1.68)
Total	2.0 (2.86)	5.39 (4.41)

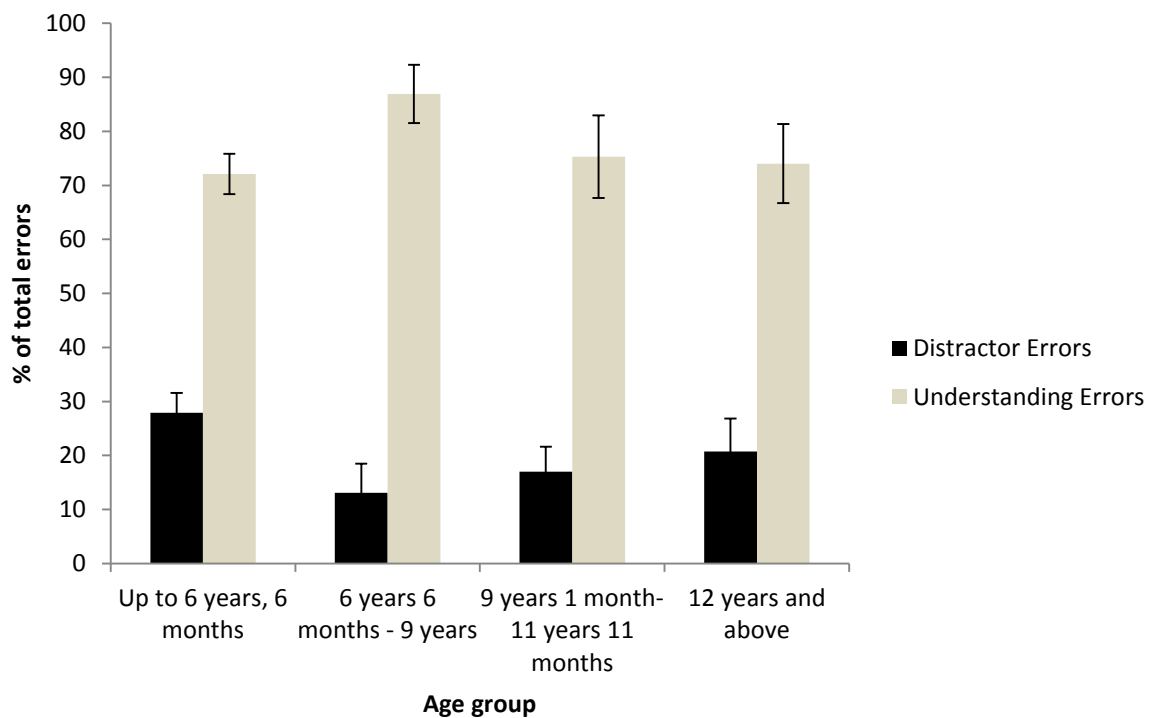


Figure 6.4: Distractor and Understanding errors as a percentage of total number of errors for TD age-groups on the Masking task

Within the distractor error types, two one-way ANOVAs were carried out to compare the number of face versus object distractor errors made in each age-group (See data analysis section for an explanation of terms). A main effect of age-group was found for face distractor errors ($F(3, 61) = 10.66, p < .01$) as well as for object distractor errors ($F(3, 61) = 5.44, p < .01$). For face distractor errors, individuals in the youngest group made significantly more of this error type than the oldest group ($p < .05$) as well as those aged 6.6-9 years and those aged 9.1-11.11 years ($p < .01$). For distractor object errors, individuals in the youngest group gave significantly more of this type of error than the oldest group and those aged 6.6-9 years ($p < .05$) but no differences were found between the youngest group and those aged 9.1-11.11 years.

Figure 6.5 shows the percentages of each type of face/object distractor error as a function of the total number of distractor errors made. It is clear that all age-groups (with the exception of those aged 9.1-11.11 years) tended to make a higher percentage of distractor face than object errors, whereby faces were incorrectly chosen as the missing item when it should have been an object.

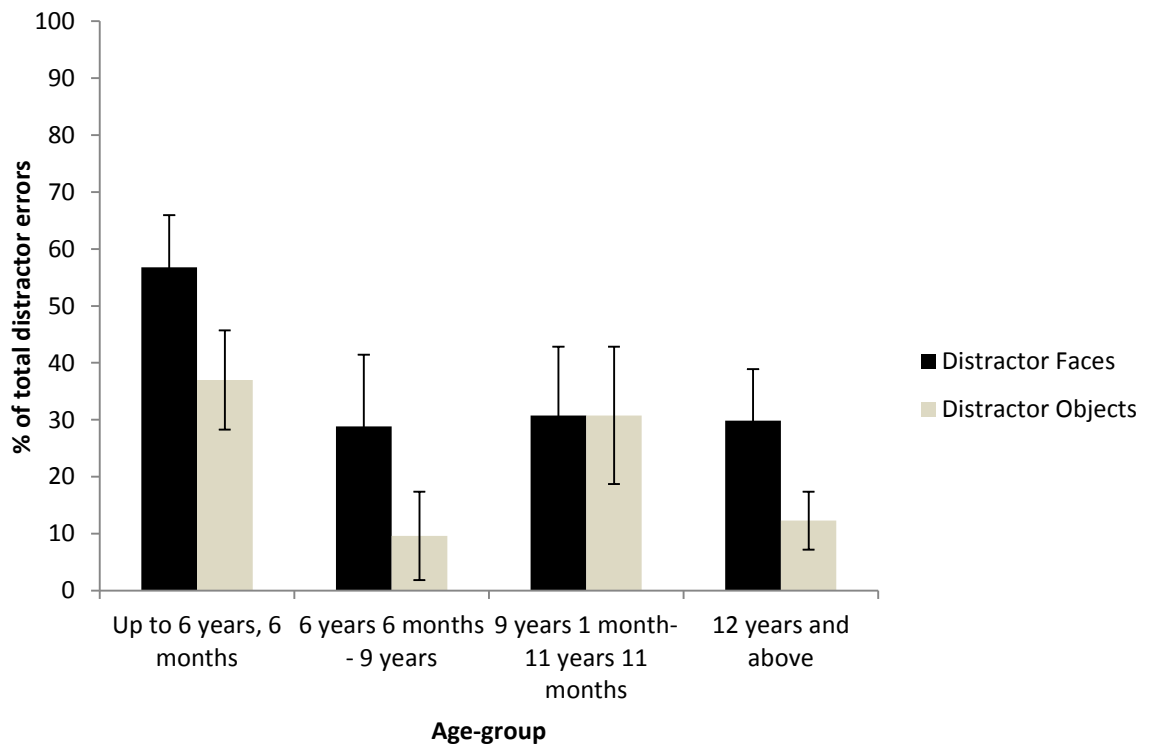


Figure 6.5: Face and object distractor errors as a percentage of total number of distractor errors made, across TD groups in Experiment 4

6.4.2 Results: ASD with TD Comparisons

6.4.2.1 Response types: Accuracy

A 2 x 3 ANOVA (missing item type x participant group) was run on the number of correct responses. A main effect of missing item type was found ($F(1, 41) = 48.20$, $p < .01$) whereby, overall, participants gave more correct responses to objects versus faces, as is indicated in Table 6.4. A main effect of group was found, $F(1, 41) = 6.61$, $p < .05$, which a Bonferroni posthoc analysis revealed to be due to those with ASD making significantly more errors overall than their CA matches ($p < .05$). Individuals with ASD did not give significantly fewer correct responses for either face or emotion relative to MA peers ($p = .93$). No significant interaction between missing item type and participant group was observed ($p > .05$).

Table 6.4: Mean number of correct responses for missing item type (Maximum=18) and condition (Maximum=12) in the ASD group and TD matches in Experiment 4 (Standard deviations in parentheses)

	Missing item type		Condition		
	Face	Object	No social	Neutral	Emotion
ASD (n=15)	9.73 (4.06)	13.47 (3.98)	8.2 (2.81)	7.60 (2.59)	7.07 (2.52)
TD CA (n=14)	14.64 (3.05)	17.07 (.83)	10.57 (1.22)	10.07 (1.14)	10.21 (1.48)
TD MA (n=15)	12.93 (4.0)	15.3 (3.43)	9.13 (2.62)	9.13 (2.70)	9.53 (2.42)
Total	12.39 (4.20)	15.30 (3.43)	9.27 (2.49)	8.91 (2.49)	8.91 (2.55)

The effect of condition on responses to item type was analysed in a mixed 3 x 2 x 3 ANOVA (condition x item type x group). Over all conditions, the same trends emerged in that those with ASD performed significantly worse than CA matches only ($F(2, 41) = 6.06$, $p < .05$) and performance for objects was better, with a significant main effect, $F(1, 41) = 77.11$, $p < .01$. No significant main effect of condition was found or any significant interactions between either factor and group ($p > .05$). No significant interaction between condition and missing item type was found ($p > .05$).

6.4.2.2 Response errors

Two one-way ANOVAs were conducted with distractor and understanding error types entered separately as variables, with group as the between subjects factor. A main effect of group was found for both distractor and understanding errors ($F(2, 43) = 3.51, p < .05$ and $F(2, 43) = 7.42, p < .01$, respectively). Mean number of incorrect responses for each error type are given in Table 6.5. In both cases, Games-Howell posthoc comparisons found those individuals with ASD to make significantly more errors than their CA (but not MA) matches ($p < .01$), as is indicated in Figure 6.6.

Table 6.5: Mean numbers of error type (distractor versus understanding, maximum number=36) in the ASD group and TD matches in Experiment 4 (Standard deviations in parentheses)

	Distractor Errors	Understanding errors
ASD	4.53 (4.60)	8.27 (4.06)
TD CA	1.0 (1.30)	3.29 (2.40)
TD MA	2.40 (4.0)	5.20 (3.80)
Total	2.68 (3.83)	5.64 (4.01)

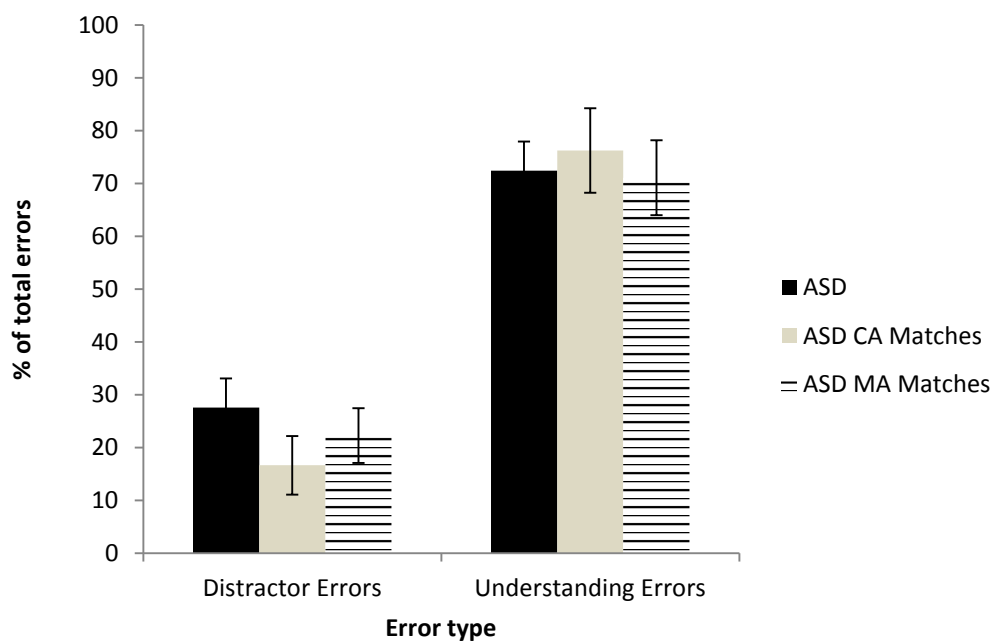


Figure 6.6: Error types made as a percentage of total number errors, in the ASD group and TD matches in Experiment 4

Analysis of distractor error types was run in two separate one-way ANOVAs to compare the number of face versus object distractor errors made in each group (See data analysis section for an explanation of terms). No significant differences were found between any of the groups for the number of distractor object errors found ($p > .05$). A borderline significant main effect of group was found for distractor face errors, $F(2, 43) = 2.85, p = .07$. As Figure 6.7 shows, a relatively lower percentage of object errors were made (choosing an object where the correct response was a face) in all groups.

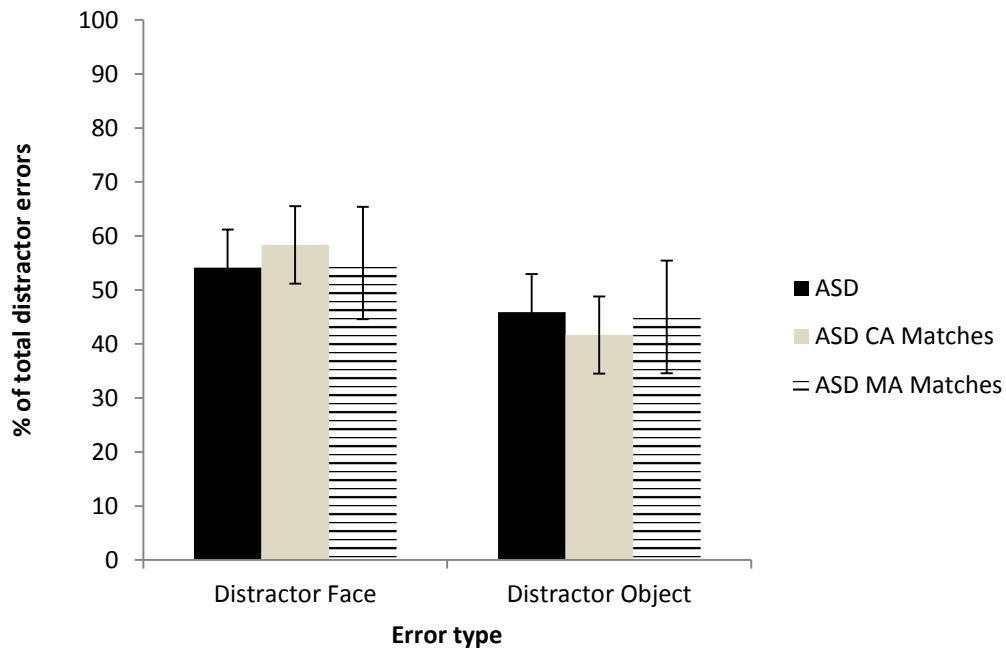


Figure 6.7: Face and object distractor errors as a percentage of total number of distractor errors made, in the ASD group and TD matches in Experiment 4

6.4.3 Results: WS with TD Comparisons

6.4.3.1 Response types: Accuracy

A 2 x 3 ANOVA (missing item type x participant group) was run on the number of correct responses. A main effect of missing item type was found, $F(1, 41) = 39.47, p < .01$. Participants gave more correct responses to objects versus faces, as indicated in Table 6.6. A main effect of group was additionally found, $F(2, 41) = 16.17, p < .01$, without any significant interaction with missing item type. Bonferroni posthoc analysis showed this to be due to participants in the TD CA group performing significantly better overall ($p < .01$) than either those in the TD MA group or those with WS. Individuals with WS did not provide significantly fewer correct responses than MA matches ($p = .87$).

Table 6.6: Mean number of correct responses for missing item type (Maximum=18) and condition (Maximum=12) in the WS group and TD matches in Experiment 4 (Standard deviations in parentheses)

	Missing item type		Condition		
	Face	Object	No social	Neutral	Emotion
WS (n=15)	9.07 (4.17)	12.53 (3.09)	7.40 (2.44)	6.27 (2.19)	7.60 (2.26)
TD CA (n=14)	14.86 (1.29)	16.71 (1.27)	10.29 (1.07)	9.79 (.98)	10.57 (1.28)
TD MA (n=15)	8.53 (3.72)	11.80 (4.33)	6.73 (3.17)	6.93 (2.43)	6.27 (2.53)
Total	10.73 (4.34)	13.61 (3.79)	8.09 (2.82)	7.61 (2.47)	8.09 (2.75)

A mixed design ANOVA was conducted to examine the effects of condition and missing item type (and the possible interplay between them) on response accuracy. Overall the same pattern as with the face versus object analysis emerged in that a main effect of missing item type was still observed, across all conditions ($F(1, 41)=57.18$, $p<.01$), as was a main effect of group ($F(2, 41)=15.29$, $p<.01$). No main effect for condition was found, or any significant interaction between condition and group, although this was approaching significance, $F(4, 82)=2.27$, $p=.068$. There was no significant interaction between condition and missing item type.

6.4.3.2 Response errors

Two one-way ANOVAs were conducted for understanding and distractor error types separately, with group as between subjects factor. For both distractor and understanding error types, main effects of group were found, $F(2, 43)=7.07$, $p<.01$ and $F(2, 43)=14.93$, $p<.01$, respectively. As is outlined in Table 6.7, Games-Howell comparisons showed that the TD CA group made significantly fewer of both types of error compared to the TD MA and those with WS. No significant differences for the number of either error type made were found between WS and TD MA matches ($p=.80$ and $p=.26$ for distractor and understanding errors, respectively). Figure 6.8 depicts how all participants clearly made a higher percentage of understanding errors as a function of the total number of errors made.

Table 6.7: Mean numbers of error type (distractor versus understanding, maximum number=36) in the WS group and TD matches in Experiment 4 (Standard deviations in parentheses)

	Distractor Errors	Understanding errors
WS	5.93 (5.0)	8.47 (4.0)
TD CA	.86 (1.29)	3.57 (1.70)
TD MA	4.87 (4.0)	10.80 (4.92)
Total	3.95 (4.32)	7.70 (4.65)



Figure 6.8: Error types made as a percentage of total number errors, in the WS group and TD matches in Experiment 4

Analysis of the distractor types (faces and objects) was carried out in two separate one-way ANOVAs to compare possible differences for each error type between groups. Significant main effects of group were found for both distractor face and distractor objects, $F(2, 43) = 4.30, p < .05$ and $F(2, 43) = 3.51, p < .05$, respectively. Posthoc analysis revealed that the significant difference was driven in both cases by more errors being made in the WS group relative to CA peers. No significant differences were found between those with WS and MA matches for distractor faces ($p = .92$) or distractor objects ($p = .81$), respectively. Figure 6.9 shows how, as a percentage of the total number

of distractor errors made, all groups showed a strikingly similar profile with no noticeable differences in the percentage of each distractor type made.

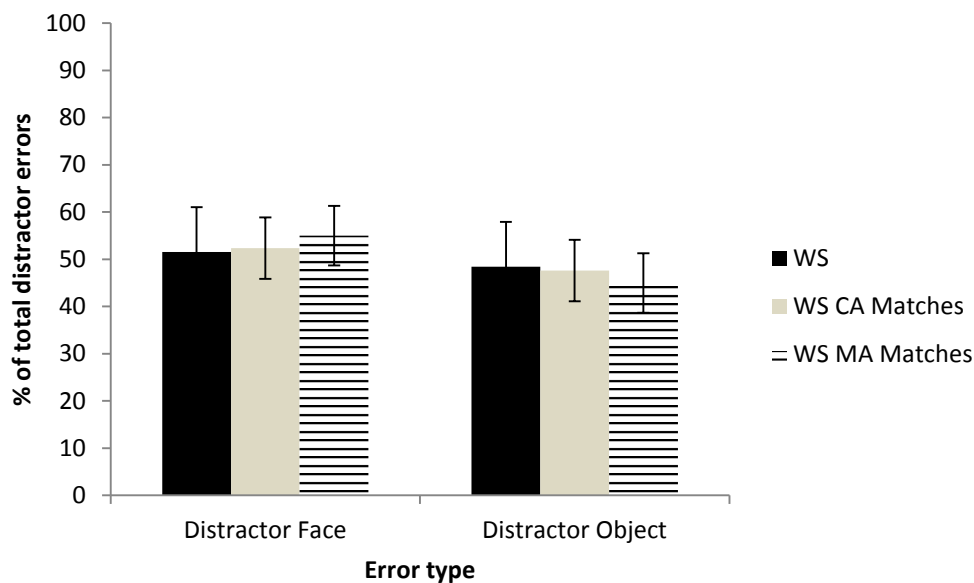


Figure 6.9: Face and object distractor errors as a percentage of total number of distractor errors made, in the WS group and TD matches in Experiment 4

6.4.4 Summary of Results

Experiment 4 was designed to examine the facilitation or distraction of faces and objects across social and non-social scenes in ASD and WS groups, compared to their typically developing peers. All participants were more accurate in correctly identifying objects versus faces and this did not depend on the cues available in the scenes.

Overall, the youngest TD group (< 6 years) showed the least accurate performance; in the clinical groups, both those with WS and ASD were comparable to MA TD matches but significantly poorer than their CA matched peers, suggestive of more of a delay than deficit.

In terms of the *types* of error made, all participants also showed the same pattern of performance whereby a higher percentage of total errors were made for items showing an *understanding* of response choice than for choosing the correct *category* of missing item. This goes against the suggestion that perhaps those with WS and ASD might have different underlying difficulties in the social cognitive mechanisms that drive the understanding of social and non-social scenes. Individuals with WS and ASD struggled more than TD peers both with an *understanding* of what missing cues should be chosen as well as with the *type* of missing item category, but all participants showed a higher proportion of understanding type errors.

When analysing the types of *distractors* on which errors were made, within the youngest TD group the difference between the percentages of face and object errors made as a function of the total number of distractor type errors was more pronounced than in the older groups. There was very little difference between the proportions of face and object error types amongst WS or ASD participants.

Taken together, the findings of Experiment 4 suggest that faces and objects do not facilitate or distract from performance in different ways in WS and ASD, with profiles being similar to those seen in TD MA matches. The types of cue available in social and non-social scenes did not afford any particular advantages for any participants who took part in this experiment. Therefore the question remains as to what *does* drive the disparate social profiles of those with WS and ASD. Experiment 5 aims to examine these factors.

6.5 Experiment 5: Introduction

In order to understand the ways in which individuals with WS and ASD do or do not make sense of social situations, both compared to each other and to typically developing peers, it is essential to try and deduce which social-cognitive factors might be involved: What information do people with these disorders extract from complex scenes involving interactions and how do they attribute this? Most importantly, do individuals with WS and ASD show different profiles from one another as to how information is extracted and used, and how do these profiles differ to those in the TD population? Experiment 5 used a revised version of the social attribution task paradigm (SAT) to examine the social or physical attributions that individuals with ASD and WS might make (relative to TD peers) in response to ambiguous animations of moving shapes.

6.5.1 Social Attribution in Typical Development

The classic SAT was devised by Heider and Simmel (1944) in which shapes were depicted to ‘chase and bump’ one another around a scene. In this paradigm, participants’ narratives are typically analysed using a detailed system of indices in order to pull apart the types of detail that they form attributions about, such as use of mental state terms, pertinence of exchanges, physical descriptions, etc. The Heider and Simmel (1944) animation has been used across a multitude of studies with TD children and adults, with the consistent finding that individuals tend to give social labels to the motion of the shapes (See Figure 6.10). Hu, Chan and McAlonan (2010) recruited a large sample of TD children (n=154) aged between 6-13 years (mean age=9.88 years) to examine changes in performance on the SAT across developmental age. In addition to the classic SAT, they also developed a revised version in which animals were depicted rather than moving shapes in order to eliminate the possibility that younger children simply might not comprehend the demands of the task when faced with such ambiguous

stimuli. Participants also completed a standardised battery of executive functioning (EF) tasks.

To summarise the findings of Hu et al. (2010), a floor effect was observed in the youngest group (6-9 year olds) whereby they failed to provide appropriate social narratives on either the SAT or revised task, with very reduced use of mental state terms. Significant improvements with age were, however, noted on the revised version across the age-groups. Children aged up to 7 years tended to use significantly more physical terms than the other age-groups; those aged 8-10 years did show some evidence of considering social intent, whilst an indication of a broader social understanding of the interactions was not evident until children reached 11 years of age. No relationship was found in any of the groups between EF performance and performance on either experimental task; interestingly, girls overall performed better than boys. This may be of importance given the higher incidence of autism amongst males, perhaps offering support for Baron-Cohen's (2002) male brain theory of autism.

The fact that younger children have been found to use fewer mental state terms and more physical ones tallies with the possibility that those in ASD and WS are 'stuck' at this lower developmental level of social understanding. As the findings of Experiment 4 in the present research indicated, individuals with both WS and ASD were overall as accurate as MA but not CA peers in piecing together both social and non-social scenes to deduce missing objects and faces. This is suggestive of delays rather than deficits and it may be proposed that while, in typical development, children progress from a focus on physical descriptions to piecing together interactions in a more social way, those with ASD and WS may be slower to make this jump.

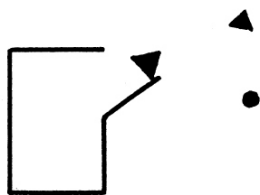


Figure 6.10: A still of part of the Heider and Simmel (1944) animation

6.5.2 Social Attribution in autism

Klin(2000) has led the way in examining the social and non-social attributions that individuals with ASD make when presented with ambiguous scenes. His standpoint has been that theory of mind deficits alone cannot account for the full behavioural profile seen in ASD; he argues that the classic theory of mind tasks are often explicit and dichotomous in nature and could be scaffolded by verbal skills in high functioning individuals, therefore it is important to look at more ecologically valid measures of social cognition.

The issue of the role of language in theory of mind has been explored by Colle, Baron-Cohen and Hill (2007), who have argued the importance of developing non-verbal measures of assessing theory of mind to eradicate possible confounds of language ability in a disorder with an extremely heterogeneous language profile. In their study, they recruited 12 individuals with ASD (mean age 8 years 1 month) matched on MA to typical controls (mean age 4 years 6 months) as well as a specific language impairment (SLI) cohort. Participants were given a false belief task designed not to require any verbal ability: In a training phase, a 'hider' would place a sweet in one of two boxes, unseen by the participant, and a 'communicator' would correctly point out to the participant where the sweet was hidden. In the test phase, participants would see the 'hider' switch the sweet whilst the 'communicator' was absent; the participant was then asked which box they thought the 'communicator' would point to upon their return. True belief was also assessed in which both participants and the 'communicator' saw the sweet being switched and participants were asked where the 'communicator' would point. This was to ensure that participants would not simply assume that the 'communicator' was deliberately misleading them every time.

Colle et al. (2007) found that individuals with autism gave significantly fewer correct responses to the false belief question than SLI or TD controls but were comparable on the true belief measure. Those with an SLI and TD controls had far fewer difficulties with the false belief task compared to those with ASD, with the young children in the TD group performing above chance level and those in the SLI group getting approximately 80% of false belief questions correct, compared to only around 15% in the ASD group. Colle, Baron-Cohen & Hill therefore claim that false belief understanding is a deficit *specific* to autism and cannot be underpinned by language ability, therefore claims by Klin (2000) that fewer deficits might be seen in higher functioning individuals may not be due to their *language* abilities. Klin (2000), however, has argued that theory of mind is not the only problematic area in the manifestation of autism, and it is essential to look more broadly at what other social-cognitive skills might underpin social exchange.

Klin (2000) examined 40 HF adults with autism/Asperger's, matching them on both CA and VIQ to 20 TD controls. Participants were initially shown the original Heider and Simmel (1944) animation (an example is shown in Figure 6.10) and were asked to provide a narrative of what they saw. Importantly, all participants had been shown to pass a second order false belief task. Following this, the animation was re-played, broken down into six segments to reduce memory demands and to enable the participants to provide more detailed narratives of each section. The experimenter then provided their own narrative so that questions about the content of the scene could be explicitly asked. Responses were scored using a complex system of indices to assess aspects such as the use of mental state terms, pertinence and salience of the scene, and understanding of personalities, etc.

Klin's (2000) results indicated that those with HF ASD and Asperger's syndrome were comparable and showing a different pattern of attributions to TD controls, despite being matched on both verbal and developmental age. Those in the clinical groups were less likely to use mental state terms and tended to label items that were deemed to be pertinent to the scene, as non-pertinent. They also failed to grasp the social salience of potentially social cues. Compared with TD participants, individuals in the ASD/Asperger's groups generally provided significantly shorter narratives which were often found to be irrelevant, providing details about things that were in no way linked to the movements depicted in the scene. Klin (2000) suggests that this is indicative of a lack of awareness of the social implications of movements. The use of explicit questions about the scenes did marginally boost performance in the ASD group but was of no advantage amongst TD participants, who provided pertinent and appropriate narratives overall.

Based on his study, Klin (2000) concludes that those with ASD show difficulties in *integrating* social information to make attributions about social intent and exchange. Individuals may attempt to scaffold gaps in their understanding by referring to terms and narratives that they are familiar with, which may prove not to be pertinent to the reality of the situation. For example, they may show a tendency towards using more physical terms and descriptions. This could suggest that one of the key problems in ASD is not in not having a theory of mind, but in knowing when and how to utilise it.

In a follow-up to Klin's (2000) work, Klin and Jones(2006) set out to further explore the use of physical versus social attributions in those with ASD. Forty high functioning adolescents (mean age 13 years) with ASD were matched to TD adults (mean age 21.8 years), as in the previous study, and were asked to perform the same task using the same format as that used in Klin's (2000) previous research. Additionally, participants were presented with another animation featuring shapes moving in a manner that was deemed to be representative of a rocket taking off and orbiting the moon; this was designed to elicit the use of purely physical terms. Klin and Jones (2006) argued that, if one of the underlying problems in ASD is difficulty in *perceptually* piecing together components of a scene, performance on both tasks would be equivalent, and below that of the TD cohort.

Analysis of the types of responses given by those with ASD, using the same indices as used by Klin (2000), revealed that those with ASD were equally as likely as TDs to use pertinent physical terms to describe the physical animation. Differences only emerged on the *social* animation, in which those with ASD consistently made the same types of error as Klin (2000) had previously shown. The authors therefore concluded that those with ASD do not struggle to gauge the significance of social interactions due to any difficulties in global processing, but must have a deficit specific to social *understanding*. Given that those with ASD were found to give relatively more physical terms to the social animation, it is worth considering whether physical movements and objects might hold some heightened salience within this group; this could have been why performance was improved in the physical animation condition, and would fit with the neurological evidence offered by McCleery et al. (2009).

Other researchers to question the atypical ways in which individuals with ASD attribute ambiguous situations are Abell, Happé, & Frith (2000). They have argued that the Heider and Simmel (1944) animations, given their highly ambiguous nature, may not allow for the use of mental state terms in populations who might struggle to understand more abstract concepts. They therefore devised the ‘triangles playing tricks’ (TPT) task in order to provide more opportunity for those with ASD to use more social terms. The TPT task was comprised of three conditions in which animations of moving shapes were shown and were initially introduced to participants as being either ‘animations’, ‘animals’ or ‘people’ (Abell et al., 2000). In line with these ‘characters’ the animations were designed to depict random movement, goal-directed (GD) actions or exchanges requiring a theory of mind (ToM). Forty-five participants were recruited to the study, comprising three groups of ASD, those with a learning disorder (LD), and TD controls (mean age 8.6 years) matched on VIQ. The ASD and LD groups were of approximately the same CA (~13 years). Participants were shown four different versions of each of the GD and ToM animations and two of the random condition and were asked to provide narratives of what happened. Their responses were scored for accuracy (how closely they matched a group of TD adults) and categorised as to whether they used action, interaction or mentalising terms.

Results showed that, overall, there were no differences between the ASD group and TD matches in terms of accuracy, with all groups performing better in the GD than ToM conditions. All groups tended to provide action descriptions for the random condition and interaction terms for the GD condition. The ASD group became distinguishable, however, from both those with LDs and the TD matches in terms of the number of *inappropriate* interaction descriptions provided for the random animations. Those with ASD did give a comparable number of mental state terms on the ToM condition, but these proved to be less appropriate than those given by either other group. Specifically, 36% of the mentalising statements provided by those with ASD were inappropriate, compared to approximately 10% in both other groups. This indicates a specific difficulty in accurately judging social interactions in ASD, regardless of mental age.

The findings of Abell et al. (2000) indicate that the biggest difficulty in ASD appears to be in *accurately* taking appropriate information from ambiguous scenes in order to deduce relevant social content. Even given the reduced demand to *spontaneously* label shapes by being introduced to the stimuli as ‘people’, those with ASD were unable to provide appropriate mental state terms. However, this design in itself could be problematic: Perhaps, when told that the stimuli were people, those with ASD felt ‘forced’ to provide more social narratives, without having the social understanding to support these. Experiment 5 addressed this issue by focusing on purely *spontaneous* (un-cued) responses to ambiguous animations.

Bal et al. (2013) have recently explored the development of social attributions across age in an ASD population. They used the TPT (Abell et al., 2000) to examine *spontaneous* attributions to moving shapes by omitting the cueing aspect of the task. Forty-one HF individuals with ASD were matched on CA and IQ to TD controls ranging in age from 7-17 years (mean ages in both groups=10.5 years). Participants were asked to provide

narratives to the same TPT animations as used in the Abell et al. (2000) study and their responses were coded for appropriateness and intentionality. Bal et al. (2013) found that, in the GD and ToM conditions, those with ASD overall gave significantly fewer appropriate terms indicating intentionality. Accuracy was poor in the ASD group and they showed further inappropriate use of mental state terms. Correlations between age and performance were found in both groups for GD and random animations but not for the ToM condition in those with ASD, indicating a deficit in this domain that does not improve with age. It therefore may be the case that the comparable levels of accuracy found in the research by Abell et al. (2000) were being masked by the cueing of 'characters' and individuals with ASD do struggle to form appropriate mental state attributions, regardless of age.

6.5.3 Social Attribution in Williams syndrome

How do individuals with WS make spontaneous social attributions? Santos and Deruelle (2009) have shown that individuals with WS have a problem in piecing together information from visual scenes in order to derive social meaning. They tested 19 individuals diagnosed with WS, ranging from age 7-26 years (mean age 14.4 years), compared to MA matched controls (mean age 8 years, 2 months) on a task designed to assess the attribution of intentions to others (Santos & Deruelle, 2009). The experimental trials consisted of either, a verbal (three sentences) or a visual (three comic-strip style images) depiction of a scenario, and participants were asked to choose from one of three possible answers what happened next. All of these experimental scenarios involved human intentions (See Figure 6.11 for an example). In the control condition, the scenarios involved physical causality rather than any human intentions (Figure 6.12).

It was found that the only difference in accuracy between the two groups was in the visual experimental condition: Those with WS were significantly poorer in stating the correct answer for visually presented scenarios in which a human intention needed to be derived. Santos and Deruelle (2009) cite this as evidence for a specific ToM deficit in purely the visual domain in WS.

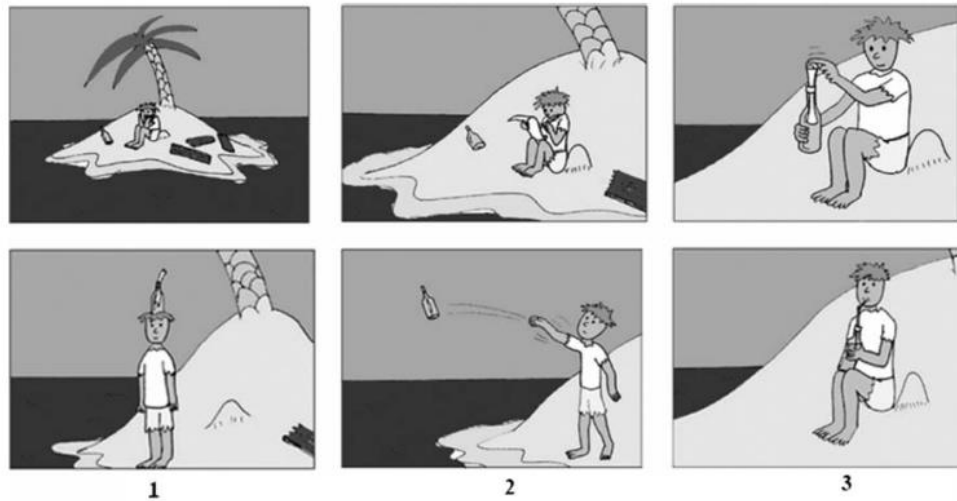


Figure 6.11: Example of an attribution of intentions comic strip (Correct response=2). (Santos & Deruelle, 2009).

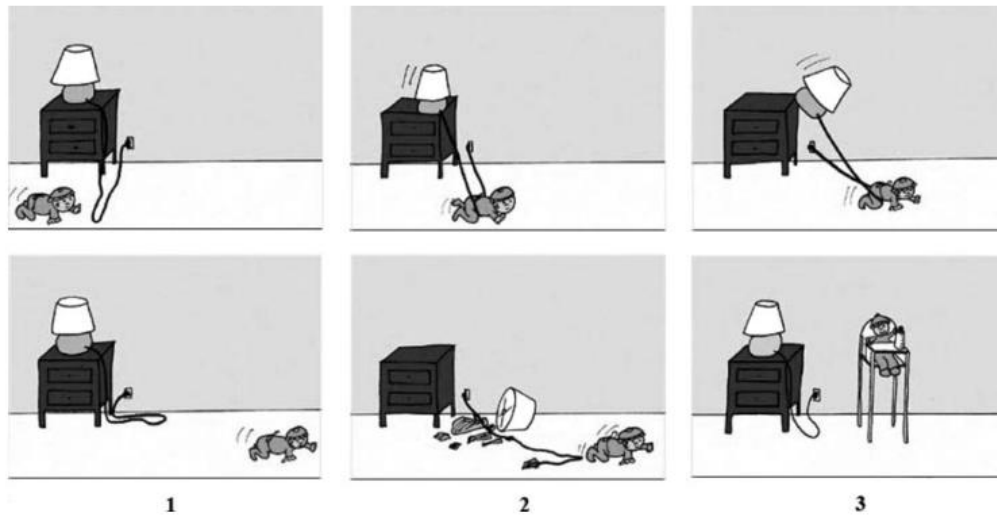


Figure 6.12: Example of a Physical attribution of intentions comic strip (Correct response=2). (Santos & Deruelle, 2009).

Interpreting the findings of the Santos and Deruelle (2009) study is less clear-cut: The fact that individuals with WS performed better for verbally presented scenarios may be suggestive of a buffering effect of language, in that verbally explained scenarios are easier to understand, or it may be that they were not able to fully process visually presented scenes because of problems in global processing. However, if this was the case, a modality difference should also have been found in the control condition. Alternatively, it may be possible that the presence of a person in the experimental trials distracted those with WS from attending to the rest of the scene and therefore being able to deduce the social intentions. Or it may be that they do lack the more social cognitive theory of mind when interpreting such scenes. It should also be noted that the physical

causality condition did contain scenarios that may be attributed to social intentions as well. For example, a baby dragging a lamp from a table (See Figure 6.12). Eye-tracking data of this experiment would be useful for teasing apart these possibilities.

Van der Fluit, Gaffrey, & Klein-Tasman (2012) have addressed the question of what underpins social understanding in their examination of 24 children (aged 8-15 years; mean age 12 years, 5 months) diagnosed with WS. Their research question has focused on the issue of how real-life social behaviours in WS might be underpinned by problematic strategies in making social attributions. In order to answer this question, they administered the classic SAT task (Heider & Simmel, 1944) to their participants but with the addition of an 'improvement' index: A measure calculated by looking at the difference in performance between prompted and unprompted narratives. Data was also obtained from parents on the Social Communication Questionnaire (SCQ) and Social Reciprocity Scales (SRS), two standardised questionnaires aimed to assess the everyday social functioning of children.

Van der Fluit et al. (2012) found that the poorest performance was on the ToM and pertinence indices, similar to what Klin (2000) found to be the case in ASD. However, there was no correlation between these two indices in the case of WS, perhaps suggesting different underlying mechanisms to that seen in the ASD group? Also unlike trends seen within ASD cohorts (Bal et al., 2013), improvements with age *were* found on the indices of salience, ToM and problem-solving. Significant negative correlations were noted between aspects of the SCQ/SRS and ToM indices on the SAT, suggesting that real-life measures of social exchange might indeed be underpinned by difficulties in making mental state attributions to social interactions. Of interest is the fact that 35% of individuals scored above the cut-off for a diagnosis of ASD on the SCQ; this may point to the fact that autistic traits emerge as a consequence of an inability to make appropriate mental state attributions. However, it might also be that the SCQ fails to differentiate between the *direction* of atypicalities measured, as it operates using a scoring system in which traits are *quantified* (using yes/no responses) but not classified (no differentiation between reduced or excessive approaches to other children, for example).

Analysis of the improvement index in the Van der Fluit et al.(2012) study revealed that 21% of participants showed increased performance when provided with narratives; these participants were those who also had higher IQ. Whilst these relationships should be explored in a TD population to form a comparison as to how typical or specific to WS this profile is, these findings do suggest that problems in making social attributions might underlie the social behaviours seen in WS, and that the greatest difficulty is when these individuals have to use their own initiative to deduce social content. Those at the higher functioning end of the scale may benefit from social prompts by others; this has also been found to be the case in ASD (Abell et al., 2000).

6.5.4 Summary of Literature

The overview of research outlined here paints a picture of possible atypicality in the domain of ToM, specifically amongst individuals with ASD. Research focused on those with WS is much sparser and illuminates the need to examine further the social attributions that individuals with WS make in the present experiment. The evidence outlined above suggests that individuals in these neurodevelopmental groups can be supported in making social attributions, depending on the explicitness of the task demands; this may suggest that, whilst they do not *spontaneously* form social attributions, an understanding of social interactions can be built. Heterogeneous language and functioning abilities may also play a role in the success of support strategies. Experiment 5 was designed to examine the spontaneous attributions that individuals with WS and ASD (compared to their TD peers) would make to ambiguous animations and, further, what *understanding* they would derive from the social and physical interactions depicted.

6.5.5 Experiment 5: Summary and Aims

The Animation task was designed to examine the *spontaneous* attributions that those in the clinical groups, relative to their TD peers, would make towards ambiguous moving shapes. Based on Abell et al.'s (2000) TPT task, two types of animation were shown, to depict physical or social motion, and responses were coded both for accuracy and content. As in the classic SAT task, a narrative was provided after participants gave their initial responses, in order to elicit understanding of the animations. The aim was therefore to establish whether the behavioural tendency of those with WS and ASD to respectively seek out and show indifference to social interactions would be underpinned by similar tendencies in *interpreting* ambiguous scenes.

6.6 Experiment 5: Hypotheses and Predictions

6.6.1 Typical development

Age will be predictive of the types of social attributions that individuals make. Specifically, it is predicted that younger children will use more physical terms than older groups, and will be less likely to focus on social interactions, as suggested by the work of Bal et al. (2013). Accuracy will improve with age overall, for both social and physical animations.

6.6.2 ASD and TD Comparisons

Based on the findings of Klin and Jones (2006) those with ASD will make significantly fewer social than physical attributions to animations compared to TD peers. They will make a higher proportion of mislabelling errors in providing physical labels to social animations than vice versa. As Klin and Jones (2006) noted, accuracy will be comparable to both MA and CA TD matches.

6.6.3 WS and TD Comparisons

Those with WS will make significantly fewer and less accurate social attributions than CA matches, as evidenced by Van der Fluit et al. (2012). It is expected that performance in both conditions will be in line with IQ (MA matches), as it was observed in the Van der Fluit et al. (2012) study that IQ and performance correlated in both TD and WS groups. No differences will be seen between social and physical mislabelling errors, as indicated by Experiment 4 and a lack of propensity towards social cues.

6.7 Method

6.7.1 Participants

The same participants as took part in Experiment 4 were recruited to this task (See section 6.3.1). However, three of those participants in the ASD group, and one from the WS group did not wish to take part or were not able to complete the task. Therefore a total of 12 ASD and 14 WS participants comprised the final sample. Data for the TD matches is outlined in Table 6.8. The ages of the final ASD participant group ranged from 6 years 5 months to 16 years 3 months, with a mean of 11 years 2 months. NVIQ scores (tested using the RCPM) ranged from 12 to 34 (Maximum score 36), with a mean of 25. The final WS cohort had an age range from 8 years to 17 years 5 months; mean age 12 years 4 months. NVIQ scores ranged from 9 to 31 with a mean of 18.

Table 6.8: Age and RCPM data for TD matches for both clinical groups in Experiment 5 (the AT task) (Standard deviations in parentheses)

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
ASD (n=12)				
CA Matches*	6.1-15.11	11.4 (3.1)	21-36	31 (4.55)
MA Matches	4.3-9.6	7.11 (2.5)	12-32	25 (6.43)
WS (n=14)				
CA Matches*	7.10-17.3	12.1 (3.4)	23-36	31 (4.22)
MA Matches	4.10-14.4	6.3 (3.3)	9-31	17 (6.86)

*Due to recruitment issues, one CA match was missing for each clinical comparison

Independent samples t-tests were conducted to ensure that there were no significant differences between age and NVIQ between clinical groups and their CA and MA matches, respectively. There were no significant differences between the mean ages of

those in the ASD cohort compared to their CA matches ($t(21) = .14, p = .89$) or between those with WS and their CA matches: $t(25) = .26, p = .80$. Similarly, no significant differences were found for the NVIQ scores of those in the ASD group and their MA matches ($t(22) = .15, p = .88$) or for the WS cohort and their MA matches: $t(26) = .03, p = .98$.

Within the ASD cohort, there were seven males and five females; in the WS cohort there were six females and eight males. An independent samples t-test was conducted to compare total accuracy scores on this task between male and female participants over the TD group to ensure that sex was not a confound; no significant differences were found, $t(59) = .23, p = .82$. TD groups and gender data were the same as outlined in Experiments 3 and 4.

6.7.1.1 Verbal IQ

Due to the verbal nature of Experiment 5, all participants were asked to complete the verbal form (VIQ) of the Wechsler Intelligence Scales for Children, version IV ([WISC] Wechsler., 2003) This is a standardised battery of tests designed to assess both verbal and performance IQ; for the present experiment, only those tasks designed to produce a verbal IQ measure were administered. The similarities task is comprised of a maximum of 23 items whereby the participant is asked to state how two items are related (such as milk and water are both drinks), and a vocabulary task (36 items), in which participants are asked to define words, increasing in difficulty (for example 'what is a thief?'). Participants are stopped once they have made five consecutive errors, deriving a total verbal score based on the sum of both tasks. On both tasks, some of the items can receive a score of 2, depending on the detail of the answer. Therefore the total maximum scores are 44 and 68, respectively.

Five participants were under the lower age limit for the WISC, therefore completed the Wechsler Preschool and Primary Scale of Intelligence, third edition ([WPPSI] Wechsler., 2002), which is comprised of the same two tasks but consisting of age appropriate items. The scores are deduced in the same way and are designed to be equivalent to the WISC scales.

In the ASD group, two participants did not wish to take part in the WISC therefore data was available for 10 participants. The mean VIQ for this group was 28 (out of a maximum possible of 112) (standard deviation 4.65). Data was available for all WS participants, either from testing as part of the current experiment or from previous research within the last 2 years: Mean 50 (standard deviation 5.04). Across the whole TD group, eleven participants declined or were unable to complete the WISC, giving a total of 50 participants, with a mean score of 46 (standard deviation 2.84).

6.7.2 Materials and Design

Experiment 5 consisted of eight short animations comprised of moving coloured shapes. Figure 6.13 depicts an example of one social and one physical scene. The animations were devised and presented in PowerPoint and the mean duration was 3.90 seconds (standard error 0.41 seconds).

For each animation, either physical or social interactions (four of each condition) were elicited by creating movement of shapes that might be suggestive of purely physical or social exchanges. For example, animation 1 was designed to represent a cat chasing a bird, whilst animation 8 mimicked the motion of a flower growing. All animations were piloted on a sample of 39 TD adults to deduce consistency of responses and to gauge a measure of ‘accuracy’ (see data analysis section). 85% agreement in the types of responses that participants gave was noted for all animations, therefore it was not necessary to make any changes to the animations.

At the end of each animation, participants were presented with an on-screen multiple choice question (MCQ) asking ‘What happens?’ Three possible response options were provided, one of which was always in contradiction to the social content of the scene or physically impossible. These were designed to probe into whether or not participants had understood the social or physical content of the animation. Examples of one social and one physical MCQ are given in Figure 6.14. The variables of interest in this experiment were therefore what *types* of response participants gave to the scenes; the focus and accuracy (relative to TD adults in the pilot study) of their description; what types of error they made, and accuracy on the MCQs.

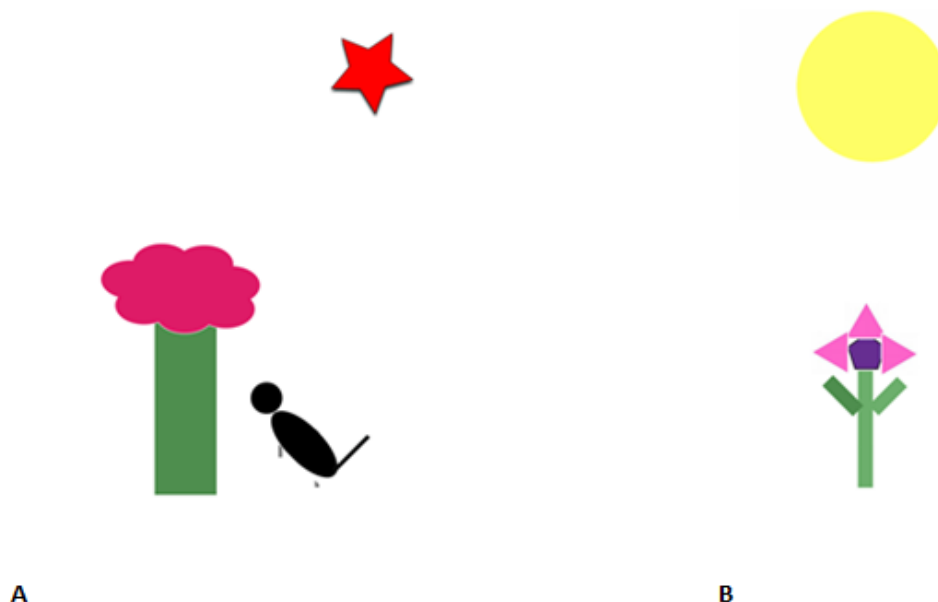


Figure 6.13: Screenshot of social (A) and physical (B) animations in Experiment 5

What happens??

- | | |
|--|---|
| <ul style="list-style-type: none"> ❖ The bird will come back to eat some fruit on the tree. ❖ The cat is sad because he couldn't catch the bird. ❖ The tree will grow bigger. <p>A</p> | <ul style="list-style-type: none"> ❖ The flower will change colour. ❖ More petals will grow on the flower. ❖ It will rain. <p>B</p> |
|--|---|

Figure 6.14: Examples of MCQs for social (A) and physical (B) animations

6.7.3 Procedure

Participants were instructed that they were going to be shown some clips of moving shapes and that they should watch very carefully. They were told that they would be asked to ‘say what they saw’ at the end of the clips and that there were no right or wrong answers. They were informed that they would then hear a story about what they had seen that was the experimenter’s own version, so that they could ‘talk a little bit about what might happen next’. Participants were shown each clip once, unless it was clear that they were not paying attention, in which case the clip would be repeated for a second time.

Once participants had given their explanation of what happened in the scene (responses were recorded on a Sony Digital audio recorder for coding after the testing session), the experimenter gave their version of the story. Refer to Appendix A for the scripts for each animation. Participants were then presented with the MCQ screen, which the experimenter also read aloud, and were asked to choose the option that was the ‘most likely to happen’. Once the participant gave their response (or stated that they did not know), the next animation was played. All participants saw the animations in the same order, which was originally randomised.

At the end of the experimental session, participants were asked to complete the verbal measures on the WISC/WPPSI. These were administered to each participant individually and varied in duration, dependent on the participant’s ability, from approximately 3 to 10 minutes.

6.7.4 Data Analysis

For each animation, word for word responses were transcribed and then coded into one of four categories: Physical/Emotion/Social Label/Social Interaction. These categories were devised based on the types of responses noted during the pilot phase of the experiment. Physical responses were those that were entirely absent of any social descriptions and focused purely on physical movements, descriptions of shapes, or attaching object labels. A response was categorised as 'emotion' if any emotional labels were given. Social labels were classed as the identification of a shape as a social being, such as an animal or person, without any reference to social *exchange*; this type of response was categorised under the social interaction category. Whilst comparisons of all response types were examined, only physical versus social interaction responses are reported in the Results section, as this was the comparison of interest and mirrors those variables of interest examined in Experiment 6. Ten percent of the responses for each group were re-coded by an additional experimenter, blind to the membership of each participant or the hypothesis of the experiment and 86.7% reliability was reached. The total number of responses for each category were then totalled and divided by 8 to give a percentage.

Accuracy was examined by comparing the content of each participant's response to those responses gathered during the pilot phase. Responses that in no way matched the typical answer were given a score of 0; those that included all of the key terms consistently used in the TD pilot were scored 2; partially matching responses received a score of 1. This measure was also re-coded by a second experimenter and reliability was found to be 92.67%. Further, the types of errors that participants made were calculated by adding up the number of times that they gave only physical terms to social scenes (MisSocial) and the number of times that they gave a social response (emotion or social label/interaction) to physical animations (MisPhysical). Accuracy on the MCQs was established by scoring the answers as correct or incorrect for each animation.

An initial bivariate Spearman's correlation was run between the z-scores of the data obtained from the WISC/WPPSI and total accuracy scores. As significant differences were found on VIQ scores between individuals with WS and their MA matches ($t(25) = 2.86, p < .01$) and those with ASD and their CA matches ($t(15) = 2.74, p < .05$), it was necessary to establish whether there were any relationships between verbal ability and task performance in Experiment 5. Whilst, overall, a significant correlation was found across all TD participants [$r(50) = .66, p < .01$], this significant correlation was not seen when groups were looked at individually: No significant correlations were found between the two measures in the ASD or WS groups, nor within the separate matched groups (with the exception of the TD MA group matched to those with ASD) or groups broken down by age. Table 6.9 provides correlation values for each group separately. Although a significant correlation was found in the ASD matched TD MA group, as no significant difference was found between the VIQ scores of individuals with ASD relative to their MA matches [$t(18) = 1.82, p = .09$] and given the lack of any significant correlations in any of the other groups, it was not deemed necessary to factor out VIQ as

a confound in subsequent analyses. Further discussion of this issue will be raised in the discussion section.

Table 6.9: Correlation coefficients and significance values between VIQ and task accuracy for all participant groups in Experiment 5 (denotes significance, $p < .05$)*

	Correlation (ρ)	Sig value
Up to 6.6 years	.23	.45
6.6-8.11	-.20	.51
9.1-11.11	.14	.66
12+	-.18	.58
ASD	.48	.17
TD CA Matches	.50	.25
TD MA Matches	.68	.03*
WS	-.18	.55
TD CA Matches	.01	.98
TD MA Matches	.42	.15

6.8 Results

6.8.1 TD Groups

6.8.1.1 Response types

The mean number of each response type given in response to animations [Physical/Emotion/Social label/Social Interaction] (Maximum possible =8) are outlined in Table 6.10. Analyses were conducted for scores for tendencies towards giving physical versus social interaction response types (See Data analysis section). A mixed design ANOVA was conducted using a 2 x 4 design (response type (physical/social interaction) x age group). No significant main effects ($p > .05$) were found for response type or age group and no significant interaction was found between these two factors ($p > .05$).

Table 6.10: Mean number of each response type (Maximum number=8) across TD age groups in Experiment 5 (Standard deviations in parentheses)

	Physical terms only	Emotion terms	Social labels	Social interaction terms
Up to 6.6 years (n=16)	4.44 (1.32)	.00 (.00)	.81 (.83)	2.75 (1.73)
6.6-8.11(n=13)	3.62 (1.19)	.38 (.51)	.38 (.65)	3.54 (1.20)
9.1-11.11(n=13)	4.0 (1.35)	.31 (.48)	.23 (.44)	3.46 (1.13)
12 and years and above (n=19)	3.42 (1.12)	.74 (.87)	.26 (.45)	3.53 (1.22)
Total	3.85 (1.28)	.38 (.64)	.43 (.64)	3.31 (1.36)

6.8.1.2 Accuracy

In addition to exploring the *types* of response that participants gave, their accuracy for social versus physical animations was also examined in a 2 x 4 (animation type x age-group) ANOVA. A main effect was found for animation type, $F(1, 57) = 9.16, p < .05$, whereby participants were overall significantly more accurate on social than physical animations. This is evident in Table 6.11. No interaction with age-group was found ($p > .05$), although there was an overall main effect of age ($F(3, 57) = 12.14, p < .01$) in which the youngest group gave significantly fewer accurate responses overall than all groups other than those aged 9 years 1 month to 11 years 11 months.

Table 6.11: Mean accuracy score (Maximum possible=8) for physical and social animations across TD age groups in Experiment 5 (Standard deviations in parentheses)

	Physical accuracy score	Social accuracy score
Up to 6.6 years	4.38 (1.36)	4.25 (2.11)
6.6-8.11	5.85 (1.07)	6.77 (1.09)
9.1-11.11	5.31 (2.06)	6.38 (2.29)
12 years and above	6.37 (1.34)	7.47 (1.26)
Total	5.51 (1.64)	6.25 (2.12)

6.8.1.3 Errors

Two separate one way ANOVAS were conducted on each type of error made (MisPhysical and MisSocial-See Data analysis section for an explanation of terms) to compare possible differences between age groups. No significant differences were found between the age groups for MisPhysical errors. For MisSocial errors, a main effect of age group was found, $F(3, 60) = 4.49, p < .01$, whereby individuals in the youngest group made significantly more of this error type than those in the oldest group ($p < .01$). Table 6.12 provides the mean numbers of each type of error made. No other differences were found between the groups.

Table 6.12: Mean number of mislabelling errors (Maximum possible=4) in TD age groups in Experiment 5 (Standard deviations in parentheses)

	MisPhysical	MisPhysical %	MisSocial	MisSocial %
Up to 6.6 years	.56 (.81)	35.90	1.0 (.82)	64.10
6.6-9.0	.77 (.93)	66.96	.38 (.65)	33.04
9.1-11.11	.46 (.66)	50	.46 (.97)	50
12 years and above	.68 (.95)	86.08	.11 (.46)	13.92
Total	.62 (.84)		.48 (.79)	

As Table 6.12 indicates, it was only the youngest group who made proportionally more MisSocial errors.

6.8.1.4 MCQs

In order to assess understanding of the physical versus social relationships depicted in the scenes, as illuminated by narration by the experimenter, a 2 x 4 (MCQ scores for physical/social scenes x age-group) ANOVA was conducted. As is evident from Figure 6.16, there was a main effect of age ($F(3, 57) = 28.57, p < .01$) whereby those in the youngest group gave significantly fewer correct responses than all other groups. No main effect of animation category or any significant interaction between this and age-group was found ($p > .05$).

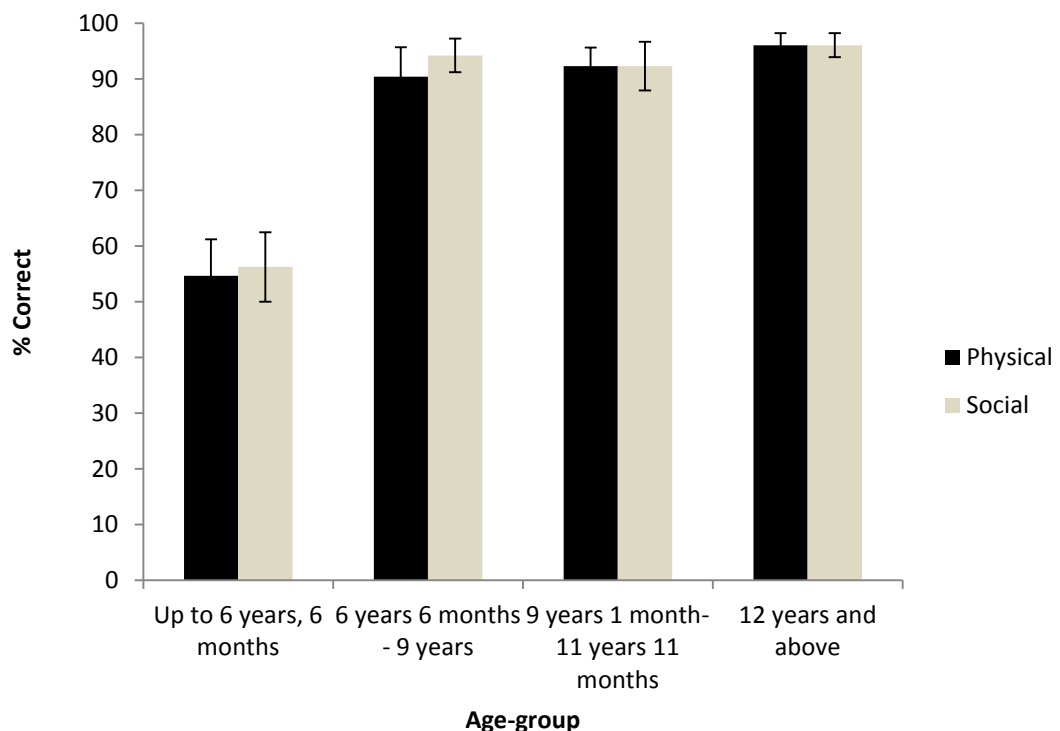


Figure 6.15: Percentages (Out of 4) correct on the MCQs for physical and social animation categories, across TD age groups in Experiment 5

6.8.2 Results: ASD with TD Comparisons

6.8.2.1 Response types

The mean number of responses for each response type categorised are outlined in Table 6.13. A 2 x 3 mixed design ANOVA was run to examine the number of physical versus

social interaction response types between the ASD group and their TD matches. No significant main effect of response type or group was found ($p > .05$) with no significant interaction between these factors ($p > .05$).

Table 6.13: Mean number of each response type (Maximum number=8) in the ASD group and TD matches in Experiment 5 (Standard deviations in parentheses)

	Physical terms only	Emotion terms	Social labels	Social interaction terms
ASD (n=12)	4.50 (1.83)	.25 (.62)	.50 (.67)	2.67 (1.61)
TD CA (n=11)	3.45 (1.64)	.45 (.69)	.35 (.51)	3.73 (1.56)
TD MA (n=12)	3.42 (1.17)	.17 (.39)	.58 (.90)	3.75 (1.86)
Total	3.80 (1.61)	.29 (.57)	.49 (.70)	3.37 (1.72)

6.8.2.2 Accuracy

Accuracy for social versus physical animations were analysed in a mixed design 2 x 3 (animation type x group) ANOVA. A main effect was found for condition, $F(1, 32) = 11.53$, $p < .05$ with a borderline significant interaction with group ($F(2, 32) = 2.90$, $p = .07$), but no significant main effect of group ($p > .05$). Overall, and as is outlined in Table 6.14, pairwise comparisons revealed that all participants were more accurate ($p < .05$) on social versus physical animations, although this difference was greater in TD groups than seen in those with ASD.

Two separate one way ANOVAs were conducted for accuracy for physical and social animations separately in order to explore the borderline interaction with group. No significant group differences were found for physical animations ($p > .05$) but a significant main effect for group was found for social animations, $F(2, 34) = 4.69$, $p < .05$. This was underpinned by individuals with ASD giving significantly less accurate responses than CA matches on this type of animation. No significant differences were found between the ASD group and MA matches.

Table 6.14: Mean accuracy score (Maximum possible=8) for physical and social animations in the ASD group and TD matches in Experiment 5 (Standard deviations in parentheses)

	Physical accuracy score	Social accuracy score
ASD	4.50 (1.78)	4.58 (1.44)
TD CA	5.0 (2.15)	6.91 (2.07)
TD MA	5.08 (1.56)	6.25 (2.09)
Total	4.86 (1.80)	5.89 (2.08)

6.8.2.3 Errors

Two separate one way ANOVAS were conducted on each type of error made (MisPhysical and MisSocial). No significant main effect of group was found for MisPhysical errors ($p > .05$). However, a significant main effect of group was observed for the number of MisSocial labelling errors made, $F(2, 34) = 5.59, p < .01$, whereby individuals with ASD made more errors than their MA TD matches. No significant differences were found between those with ASD and their CA peers, or between those in the TD CA and MA groups.

Table 6.15: Mean number of mislabelling errors (Maximum possible =4) in the ASD group and TD matches in Experiment 5 (Standard deviations in parentheses)

	MisPhysical	MisSocial
ASD	.58 (1.17)	1.17 (.94)
TD CA	.82 (1.17)	.27 (.91)
TD MA	.92 (1.08)	.33 (.49)
Total	.77 (1.11)	.60 (.88)

Figure 6.17 demonstrates how, in the ASD group, a higher proportion of errors were made in which participants labelled a social scene with a physical label, compared to making MisPhysical errors. This pattern was reversed in TD groups. As a proportion of the total number of mislabelling errors made, those with ASD showed a higher percentage of MisSocial errors than TD peers, compared to fewer MisPhysical.

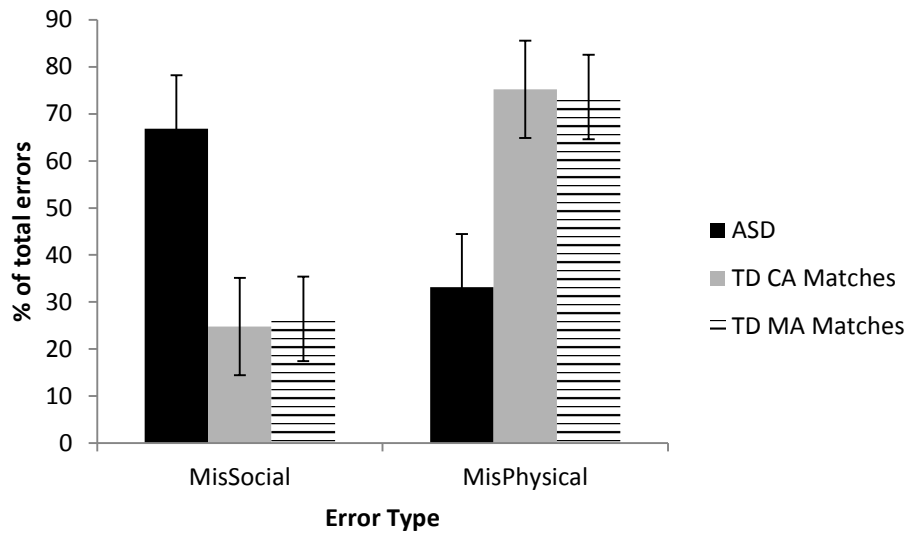


Figure 6.16: Percentages of each type of mislabelling error made (MisPhysical/MisSocial) as a percentage of the total number of mislabelling errors made in the ASD group and TD matches in Experiment 5

6.8.2.4 MCQs

A mixed design ANOVA to compare correct MCQ responses to physical versus social animations was conducted, with group as a between subjects factor. A main effect of group was found, $F(2, 32) = 6.41, p < .05$. A Games-Howell posthoc analysis found this to be due to those with ASD giving significantly fewer correct responses overall than either group of TD matches, as can be seen in Figure 6.18. No significant main effect of animation category or significant interaction ($p > .05$) between the two factors was found.

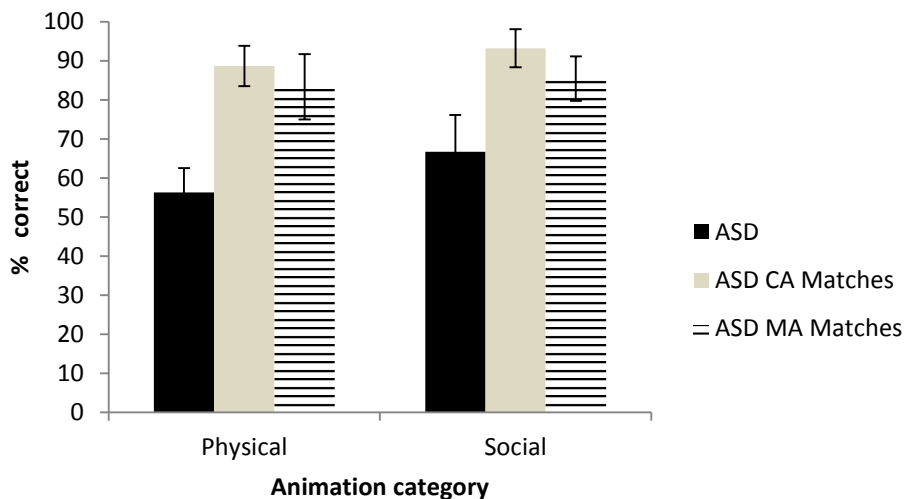


Figure 6.17: Percentages (Out of 4) correct on the MCQs for physical and social animation categories in the ASD group and TD matches in Experiment 5

6.8.3 Results: WS with TD Comparisons

6.8.3.1 Response types

Table 6.16 provides data on the mean number of each type of response in the WS group and TD peers. Response types were analysed in a 2 x 3 (response type x group) mixed design ANOVA, which revealed a main effect of response type ($F(1, 38) = 119.05$, $p < .01$) whereby participants overall gave more physical than social interaction responses. A main effect of group was found ($F(2, 38) = 3.77$, $p < .05$), driven by individuals in the TD CA group giving more of both types of response than MA peers ($p < .05$) and those with WS ($p < .05$). No significant differences were found between the WS group and TD MA peers ($p = .96$). No significant interaction was found between group and response type ($p > .05$).

Table 6.16: Mean number of each response type (Maximum number=8) in the WS group and TD matches in Experiment 5 (Standard deviations in parentheses)

	Physical terms only	Emotion terms	Social labels	Social interaction terms
WS (n=14)	4.86 (1.61)	.36 (.63)	.43 (.51)	2.5 (1.29)
TD CA (n=13)	4.0 (1.29)	.54 (.66)	.31 (.48)	3.15 (.99)
TD MA (n=14)	4.71 (1.73)	.00 (.00)	.79 (.80)	2.36 (1.34)
Total	4.52 (1.54)	.29 (.56)	.51 (.64)	2.66 (1.24)

6.8.3.2 Accuracy

The accuracy of responses to physical versus social animations was analysed in a mixed design 2 x 3 ANOVA (animation category x group). The only main effect found was for group ($F(2, 38) = 7.80$, $p < .01$) whereby those in the TD CA group performed significantly more accurately overall than all other participants, as is outlined in Table 6.17. No significant main effect of condition or significant interaction between condition and group was found ($p > .05$).

Table 6.17: Mean accuracy score (Maximum possible=8) for physical and social animations in the WS group and TD matches in Experiment 5 (Standard deviations in parentheses)

	Physical accuracy score	Social accuracy score
WS	4.86 (1.61)	4.86 (2.25)
TD CA	6.15 (1.07)	7.08 (1.71)
TD MA	4.71 (1.73)	4.07 (2.17)
Total	5.22 (1.61)	5.29 (2.38)

6.8.3.3 Errors

Two separate one way ANOVAS were conducted on each type of error made (MisPhysical and MisSocial). No significant main effect of group was found for MisPhysical or MisSocial errors ($p=.28$; $p=.31$, respectively). As is evident in Table 6.18, groups were comparable as to how many of each error type were made.

Table 6.18: Mean number of mislabelling errors (Maximum possible =4) in the WS group and TD matches in Experiment 5 (Standard deviations in parentheses)

	MisPhysical	MisSocial
WS	.14 (.36)	.86 (1.03)
TD CA	.46 (.66)	.46 (.88)
TD MA	.29 (.47)	1.0 (.88)
Total	.29 (.51)	.78 (.94)

Figure 6.19 demonstrates how, in the WS group as well as with their TD MA matches, a higher proportion of MisSocial errors were made than MisPhysical. This difference was greater amongst those with WS, however. Those in the TD CA group showed less proportional differences between the number of each error type made, with a slight tendency towards giving a higher percentage of MisPhysical errors.

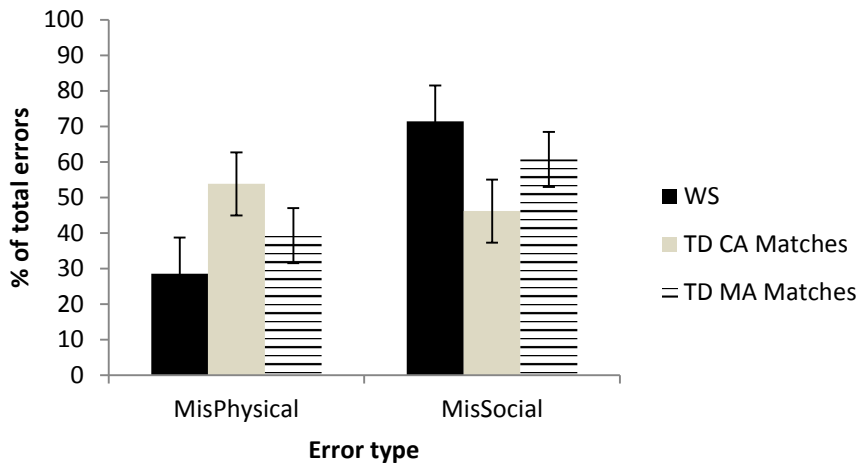


Figure 6.18: Percentages of each type of mislabelling error made (MisPhysical/MisSocial) as a percentage of the total number of mislabelling errors made in the WS group and TD matches in Experiment 5

6.8.3.4 MCQs

Correct responses to the MCQs for each animation category were analysed in a mixed design ANOVA, with group as a between subjects factor. No significant differences were found between correct responses to the MCQs for physical and social animations ($p > .05$). A main effect of group was found ($F(2, 38) = 7.32, p < .05$) whereby those in the TD CA group were found to give significantly more correct responses overall than either other group (Figure 6.20). No significant interaction ($p > .05$) was found between animation type and group.

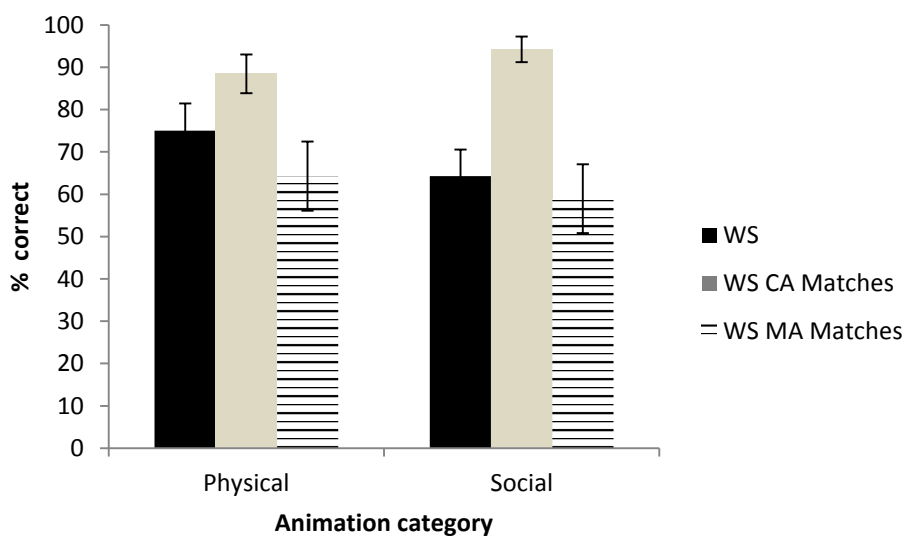


Figure 6.19: Percentages (Out of 4) correct on the MCQs for physical and social animation categories in the WS group and TD matches

6.8.4 Summary of Results

Experiment 5 was designed to explore whether those with WS and ASD would be more likely to give different social and/or physical attributions to ambiguous moving shapes, relative to their TD peers. No differentiating patterns were found between those with ASD and WS (relative to TD peers) as to how many physical versus social interaction responses were given. Overall, in the WS comparison, all participants including TD peers, provided more physical than social descriptions. Differences between the response types were not found in the comparison of age groups or in the ASD analysis. Very few emotion or social labels were given by any individuals overall.

Within the TD group, participants were overall more accurate in giving *appropriate* social than physical responses; the youngest group had overall lower accuracy scores compared to those aged 6.6-9.0 and those aged over 12 years, but no differences were found between the youngest group and those aged 9 years to 11.11, perhaps suggesting that age is not an underlying factor. In the ASD comparison, an interesting trend towards a significant interaction emerged in which individuals with ASD were comparable to TD peers on accuracy for *physical* animations, but had lower accuracy scores than TD CA matches for *social* animations. In the WS group, individuals had lower accuracy scores than CA TD matches for both physical and social animations. This may suggest that, in ASD, the *physical* nature of a scene may elicit better understanding of interactions.

When analysing error *types* across TD age groups, differences only emerged for MisSocial errors, in which those in the youngest group made more of this type of error than those aged 12 years and above. When examining the *proportion* of each type of mislabelling error, those in the youngest group were more likely to mislabel a social animation with a physical label than vice versa. Individuals with ASD made significantly more MisSocial errors than TD MA peers, although it is difficult to draw conclusions from this finding given there were no significant differences between those in the TD CA and MA groups. Proportionally, individuals with ASD had a far higher percentage of total errors for this error type than they did in making MisPhysical errors. Interestingly, the opposite pattern was seen amongst TD groups. No differences were noted between those with WS and TD peers as to how many of each error type were made; bigger proportional differences were, however, seen whereby individuals with WS showed more likelihood of mislabelling a social scene as physical than vice versa, relative to TD CA peers.

Analysis of correct responses to MCQs for physical versus social scenes did not reveal any significant differences between the animation types in any of the groups. However, the youngest group performed significantly less accurately than older groups in the age analysis; both those with ASD and WS were also unable to perform as accurately as their CA peers, and MA peers in the case of those with ASD. This may suggest an overall development with age in *understanding* exchanges and interactions, regardless of social or physical content, and a possible *deficit* in those with ASD.

6.9 Discussion

In order to build up a full picture of the ways in which individuals with WS and ASD attend to, utilise and attribute social and non-social cues, the findings of Experiments 4 and 5 will be considered in tandem. To broadly summarise Experiment 4, there were no striking factors in any of the analyses that appeared to differentiate the two clinical groups from one another, or from their MA peers: Participants showed evidence of being more accurate in identifying missing objects versus faces overall; no evidence of any interplay with the types of cues present in a scene suggestive of heightened allocation of attention to faces was observed in any of the groups. All participants showed a higher percentage of errors in choosing the correct within-category item, demonstrating more of an *understanding* problem rather than choosing the wrong category altogether. Of those errors that were made in which participants did choose the wrong category, no notable proportional differences were observed in individuals with ASD or WS suggestive of a tendency towards choosing one category type over another. The prediction that individuals with WS would be more prone to choosing faces when the correct choice was an object was not borne out.

In Experiment 5, differences were only found between the number of physical versus social interaction terms given in the analysis in which individuals with WS were compared to TD peers; in all groups in this analysis, there were significantly more physical descriptions of the animations given, with overall fewer physical or social descriptions being given by those with WS relative to CA peers. Differences between the response types or groups did not emerge in any of the TD age or ASD comparison analyses.

In terms of accuracy of responses (how closely participants' descriptions matched those of a TD adult cohort), a divide was found in the TD analysis whereby the youngest group overall were less accurate than all older children. A borderline interaction was observed in the ASD comparison in which individuals with ASD were comparable to TD peers for *physical* animations but only at an MA level of accuracy for social animations, suggesting, as predicted, a facilitation of more physical cues in understanding ambiguous scenes. Individuals with WS performed at a level comparable to MA (but not CA) matches for both physical and social animations. In terms of error types, as a proportion of all the errors made, TD individuals in the youngest group were more likely to mislabel social scenes as physical. Individuals with ASD also showed a higher percentage of MisSocial errors than their MA peers with a proportionally far higher tendency towards making MisSocial errors than was seen in either other TD group, in which the pattern was towards making a higher percentage of MisPhysical errors. Individuals with WS made a comparable number of each error type compared to TD peers but also showed a proportionally higher number of MisSocial errors; this goes against the prediction that individuals with WS would make more human attributions to ambiguous stimuli.

It was on the MCQs that the clearest divides between the clinical groups and their TD peers emerged, with individuals with ASD giving significantly fewer correct responses compared to both CA and MA peers for both social and physical animations; those with

WS performed at MA level. No differences were found for MCQ accuracy between social and physical scenes in any of the groups.

6.9.1 Experiment 4

The findings of Experiment 4 are partially in line with the work of Da Fonseca et al. (2009) in that participants overall were more accurate in identifying missing objects than faces. Further, age effects were also found in that the youngest group made more errors than older TD children, suggesting a development in social understanding with age. However, Da Fonseca et al.'s (2009) key finding had been the *different* patterns of result between those with ASD and their TD peers, and it was hypothesised in the present experiment that individuals in the TD population would be better in identifying missing *faces*. This was not found to be the case. It was the case that CA TD matches did give significantly more correct responses to missing faces than individuals with ASD, but this was also true for missing objects.

It could be that better performance for missing objects was driven by fewer subtle differences between the item options in Experiment 4. Missing items for the object condition were typically from different categories, and it was therefore possible to make a judgement based on broader, categorical terms. In the faces condition, subtle differences between emotions needed to be appraised in order to form a decision. The fact that all participants were found to make more understanding versus distractor errors supports the possibility that *within* category judgements were driving poorer performance in the faces condition. This issue of class membership is one that should be controlled for in any future replication. Lacroix et al. (2009) did observe in their study that individuals with WS were poorer in making judgements when stimuli depicted happy faces; no analysis in the present experiment was provided for differences in performance between the emotions depicted, but it is possible that this may have revealed some differentiating trends between clinical and TD groups.

Experiment 4 aimed to build on the Da Fonseca et al. (2009) study by also examining interactions with the types of emotional or neutral cues available in social and non-social scenes. It was predicted that an interaction between accuracy for missing item type and the cues present in the scene would be found in the WS group, given their difficulties in disengaging from faces; this was not found to be the case. No interactions between cue condition and missing item type were found in any analyses. Santos et al. (2008) found in their comparison of WS individuals to TD controls on the same task as later employed by Da Fonseca et al. (2009) with ASD children, that those with WS were better in identifying missing faces versus objects; the prediction that this finding would be replicated in the present study was not borne out. However, that individuals with WS made proportionally more understanding than distractor errors suggests that their lower performance relative to CA TD peers might not be concerned with being 'stuck' on faces, but in making sense of their emotional meaning. The same pattern was found amongst individuals with ASD, perhaps suggesting that, in both disorders, it is an

understanding of the information available in social and non-social scenes that poses a problem rather than difficulties in attending to (ASD) or disengaging from (WS) faces.

The lack of any interaction between cue and missing item type amongst individuals with ASD does stand in line with Riby, Brown, Jones and Hanley (2012b) who have shown that individuals with ASD are not distracted by neutral faces. Remington et al. (2012) have also shown that individuals with ASD are not distracted by faces, regardless of the perceptual load of a central task. It is worth considering that Experiment 4 did not control for the perceptual load of central scenes, nor the proximity of target items to peripheral cues and therefore it may be that the pattern of results shown was being modulated in some way by different demands from one scene to the next. Given Remington et al.'s (2012) findings that the set size of central arrays determined the extent to which those with ASD would devote attentional resources to peripheral stimuli, this might be something worth examining in future; although the same pattern of results was found amongst the TD cohort in the present experiment, the underlying *causes* may have been different.

Experiment 4 points to the possibility that any problems in accurately identifying missing objects and facial expressions stem from difficulties in *understanding* rather than being distracted by faces, in all participant groups. This goes against the hypothesis that TD individuals would have their attention 'grabbed' and sustained by faces over objects. It also stands in contrast to the work of Lense et al. (2011) and Remington et al. (2012) who have shown in WS and ASD respectively that a lack of attention to and problems in disengaging from faces are notable underlying deficits in these disorders. It may, however, be that some interplay between the emotions depicted and accuracy, or in the nature of the objects used as response options, determined the ways in which individuals utilised and made sense of the cues. Examination of these factors with eye-tracking data to assess patterns of attention would illuminate this issue further.

6.9.2 Experiment 5

It was predicted that different patterns would emerge within the different groups in that younger TD children would show a tendency towards making more physical attributions to ambiguous scenes, as would those with ASD relative to TD peers of both MA and CA. Conversely, it was predicted that individuals with WS would make more *social* attributions to scenes relative to peers, regardless of whether they were designed to depict physical or social interactions. This was not, however, found to be the case; in fact, it was only in the WS comparison that any differences in response types emerged, with *all* groups providing more physical descriptions of scenes. This points to the possibility that individuals with WS struggle to deduce and describe social interactions in the same way as TD peers. This similarity with individuals with ASD was not predicted but, given the overlap in SCQ scores between those with WS and ASD in the present study (See Appendix C), it is perhaps not surprising that participants in the two groups behave similarly on these social tasks. Indeed, Van der Fluit et al. (2012) noted in their study that 35% of WS participants met the SCQ criteria for a diagnosis of

autism. Worthy of note is the fact that participants in all groups provided very few emotion labels or labels in which they described social aspects of the scene (such as labelling a combination of shapes as a person, for example), perhaps suggesting that the animacy of the scenes naturally elicited responses revolving around the *interactions*, be they physical or more social. Examples of participant responses are outlined in Appendix B.

Regarding the *accuracy* of participant responses, a very interesting borderline interaction emerged in which individuals with ASD were less accurate for *social* animations only compared to CA peers. In the WS group, accuracy was reduced relative to peers for *both* physical and social animations. This points to the possibility that, in ASD specifically, individuals have difficulty in forming appropriate attributions about the *social* interactions of a scene. Abell et al. (2000) observed in their TPT that children with ASD were as accurate in providing descriptions of the animations as TD matches, but purely physical versus social descriptions were not directly compared in that study. Van der Fluit et al. (2012) noted in their study examining individuals with WS on the SAT that they provided fewer terms indicative of using a theory of mind; it may therefore be the case that a lack of such terms also underpinned the similar performance between physical and social animations in Experiment 5. Whilst the studies outlined in section 6.5.2 all provided detailed analysis of responses to animations, the coding systems used focused on appropriateness and pertinence of descriptions, rather than an analysis of the content of the terms given. Experiment 5 did this in order to pull apart possible divides in the types of information that individuals might focus on.

Although statistical analysis was not conducted on all four response types categorised, it was noted that overall all participants gave fewer emotion and social labels than physical or social interaction terms. This suggests that both individuals with ASD and WS as well as TDs find it difficult to deduce an emotion from ambiguous scenes and do not necessarily need to label the ‘characters’ depicted in order to comment on social interactions that take place. This stands in line with Experiment 1, in which fewer emotion terms were given overall in response to the more ambiguous stimuli but participants would not necessarily need to label an item as a ‘face’ in order to provide an emotion. It may be the case that divides may have been more likely to emerge between the groups had appropriateness (versus accuracy or type) of response been examined: Experiment 6 focussed on the relationship between descriptions of emotion and their appropriateness to context.

Klin (2000) has argued that individuals with autism tend to overuse physical terms as a compensatory strategy for making sense of ambiguous situations. This was found to be the case in Experiment 5 in which individuals with ASD made more MisSocial errors than MA TD participants and proportionally more MisSocial versus MisPhysical errors. Individuals with WS, by comparison, did not significantly differ to TD matches as to how many of each error type they made. This suggests that there is a tendency amongst those with ASD to use the blanket type strategy, suggested by Klin (2000) in defaulting to concrete physical descriptions in cases of uncertainty. This stands in line with the findings of Experiment 1 in that individuals with ASD talk more about the practical

functions of objects compared to peers. Interestingly, no clear age effects were found regarding error types, with only the youngest group making proportionally more MisSocial errors; it is therefore difficult to deduce whether the specific pattern seen in ASD is due to deficit or delay.

One particular area of weakness for both individuals with WS and ASD in Experiment 5 was in correctly answering MCQs to test *understanding* of the animations. Both Abell et al. (2000) and Van der Fluit et al. (2012) observed in their studies that cueing participants as to the content of the depicted scenes improved task accuracy. Despite participants in experiment 5 being provided with clear narratives as to the exchanges and interactions happening in the animations, those in the clinical groups were significantly poorer than TD peers (MAs as well as CAs in the case of those with ASD) in making sense of those narratives to correctly answer MCQs. This is striking given the fact that individuals in the clinical groups gave similar descriptions and terms to those seen in TD adults. It therefore appears as though the key difficulty for both individuals with WS and ASD is in forming an *understanding* of interactions, both social and non-social. Aspects of this will therefore be examined in Experiment 6.

6.10 Summary of Chapter 6

The question of specifically what attracts and has meaning to those with WS and ASD has yet to be deduced; individuals with WS and ASD respectively did not show any heightened or reduced utilisation of faces in Experiment 4, nor any specific patterns of cue use that might define their social behaviours. All participants tended to over-use physical terms to describe ambiguous animations in Experiment 5 and participants in the WS and ASD cohorts were also poorer than TD controls in correctly answering MCQs about the exchanges that were depicted in both social and physical scenes on this task, perhaps suggesting a more general understanding problem. One differentiating profile to emerge, apparently specific to individuals with ASD, was their reduced accuracy for making attributions to *social* scenes and a propensity towards mislabelling social animations as physical. It may therefore be that, in ASD, one area of particular difficulty is in forming an understanding of *social* interactions, in which the default strategy is to misattribute exchanges with more physical descriptions.

One question that has not thus far been explored is what comprehension do individuals with ASD and WS have of broader social contexts? Could it be that difficulties in social-cognitive *understanding* might be one part of a combination of factors that underpin the distinct behavioural profiles seen in ASD and WS? The Social Cognition task (Experiment 6) was designed to explore this.

Chapter 7: Theory of Mind and Social Understanding

7.1 Introduction

The focus of this chapter will be on the domain of higher level social-*cognitive* processing: What cognitive judgements do individuals make about socially relevant information and how do they map these judgements onto formulating emotional understanding of real-life situations? Whilst understanding of the basic emotions (happy/sad/angry/surprised/fear/disgust) can be deduced from facial expressions alone, it is the *appraisal* and understanding of these emotions that comprises social cognition; similarly, complex mental state terms (such as guilt or bewilderment) require considerably more cognitive appraisal. Experiment 6 (the Social Cognition task) was designed to examine the types of social inferences that individuals would make from positive and negative displays.

Thus far (Chapters 4-6), possible differences between social-perceptual versus social-cognitive processes have been explored in typical development, ASD and WS, specifically looking at the utility of faces versus objects and the different meanings that emotions might afford. This chapter will explore further dissociations *within* the social-cognitive domain, focussing on the relationship between emotion understanding and the ability to infer information, and how this might be different in ASD and WS, relative to TD controls.

7.1.1 Social Cognition in Typical Development

Experiments 1-5 suggest that individuals with the neurodevelopmental disorders ASD and WS largely process information from faces in the same way as their TD peers at the perceptual level; the question therefore remains as to what *does* drive the differences seen in everyday social behaviours between these groups? By exploring the typical processes that underpin social cognition, such as the ability to draw social inferences and motivations towards understanding social situations, one might draw comparisons as to where areas of delay or deficit might fall within neurodevelopmental groups.

False belief is the ability to understand that the knowledge another individual possesses is inaccurate, based on new knowledge one has themselves. False belief paradigms have long been used as a method of tapping into the theory of mind (ToM) abilities of individuals: The classic task asks individuals to answer questions about what another person is thinking/what knowledge they have. This tests the ability of individuals to put aside their own internal knowledge and take the perspective of another, based on sources of external information. Baillargeon, Scott and He (2010), in their review of studies examining false-belief understanding in infants, suggest that an awareness of the beliefs of another person can be developed as young as two years of age. They argue the case that the 'classic' experimental design in testing false beliefs, whereby direct questions are asked to participants as to what knowledge another person might have,

taps into a more complex system of understanding that does not develop until 4-5 years. This highlights the importance of using appropriate and accessible methodologies when attempting to explore these more social-cognitive processes.

Baillargeon et al. (2010) have proposed a ‘response account’ of theory of mind: In order to fully comprehend and accurately judge the actions of another person, we must firstly represent their beliefs, select an appropriate response, and then inhibit other responses that pertain to our own knowledge rather than that of the other person. Employing methodologies that simply tap into the first part of this system has shown that infants as young as two years are able to at least *represent* the false beliefs of another, whilst they struggle on more classic tasks requiring all three components. Interestingly, very little research has been carried out to examine the simpler concept of the *beliefs*, rather than false beliefs, of another. Experiment 6 attempts to explore the ways in which individuals with ASD, WS and their TD peers may represent the thoughts and feelings of another person. Specifically, use of an open ended question in Experiment 6, asking participants why a protagonist would be looking at a specific display, allows for a more fine-tuned analysis of the level at which individuals draw social inferences.

Thirion-Marissiaux and Nader-Grosbois (2008) have examined understanding of the beliefs of others in terms of emotional cause and consequence; they have proposed that there are different sub-components to social cognition and that understanding of *causes* versus *consequences* of emotions may involve quite different processes and streams of development. Thirion-Marissiaux and Nader-Grosbois (2008) specifically suggest that ToM is concerned with the understanding of *causes* whereas comprehension of the consequences of emotions underpins real-life social functioning and the ways in which individuals respond to social situations. This theory adds weight to the argument that the relationships between these components might operate differently in neurodevelopmental disorders than they do in typical development. For example, it could be that individuals with ASD and/or WS struggle to form links between deducing the *cause* of an emotion and comprehending *what* emotion might be felt in a certain social situation.

In their examination of these different processes, using a script-based paradigm in which participants were read a social scenario and were asked to choose either a resulting scene or a causal facial expression, Thirion-Marissiaux and Nader-Grosbois (2008) found no differences in typically developing individuals (mean age 4.1 years) between measures, perhaps suggesting an interplay between these components in typical development in young infants. Given that performance on both measures positively correlated with performance on a standardised ToM task, this may be indicative of the importance of both emotion and social understanding in developing a full awareness of the actions and intentions of others.

The link between real-life social behaviour and understanding and utility of social cues is one that is directly relevant when considering the profiles of individuals with ASD and WS. Is there a relationship, for example, between an individual’s social drive to interact with others and their ability to decipher social signals? Pickett, Gardner and Knowles (2004a) have proposed that, in typically developing individuals a ‘Social

Monitoring System' (SMS) becomes activated when belonging needs are not being met, for example, if an individual feels 'left out' from social interactions. This system enables us to pay heightened attention to both positive and negative social cues and therefore adjust behaviour accordingly in order to "navigate the social environment" (Pickett et al. (2004a), p.1096). Pickett et al. (2004a) have examined the relationship between belonging needs and accuracy for interpretation of social cues in a cohort of 98 TD adults. They manipulated social exclusion by informing participants that they would have to work alone on a task either due to there being an unequal number of participants (non-social condition) or because nobody else chose them to work with (social exclusion condition). They then asked participants to complete a questionnaire assessing their need to integrate with others and tested them on a task exploring accuracy in identifying facial emotions and vocal affect.

Pickett et al. (2004a) found that there was a clear positive association between belonging needs and performance accuracy on the experimental tasks; further, that participants in the social exclusion condition reported higher belonging needs on the questionnaire. Pickett et al. (2004a) conclude that it is therefore the case that, in a typical adult population, internal states of social integration motivate attendance to and accurate use of social cues. Examination of the *development* of this relationship across childhood as well as into adulthood would better inform understanding of the link between one's own social drive and an ability to interpret emotions in others.

7.1.2 Social Cognition in Neurodevelopmental Disorders

The fact that Pickett et al. (2004a) posit the SMS as being akin to any homeostatic system, triggered when a set threshold is reached, is also of interest to the clinical field: Might the 'belonging' needs of individuals with WS be much higher than in ASD? Anecdotally, individuals with WS are reported to excessively seek out social contact, perhaps suggesting a heightened need to belong. Biologically and conversely, Stavropoulos and Carver (2013) have shown that reduced oxytocin levels in individuals with ASD correlate with the social motivation to approach others. Most importantly, social motivation has also been shown to mediate accuracy in following and understanding joint attention (Stavropoulos & Carver, 2013), therefore there may be a strong link between social *motivation* and social cognition in both ASD and WS. If there is a link between one's understanding of social cues and one's own drive to integrate socially, this may go a long way to explaining the atypical profiles of those with WS and ASD. Given the hyper-social profile of individuals with WS, it would be expected that they would make more emotional inferences from socially relevant scenes.

A lack of appropriate social interactions in both WS and ASD points to the fact that individuals with these disorders are either not motivated to respond to others in typical ways, or may struggle to *understand* how they are meant to respond. The SMS theory, outlined above, helpfully suggests that these two components of social exchange may well be related. It is therefore important to explore both aspects in individuals with ASD

and WS, in which the social approach behaviours appear to be so different. For example, might it be that there is a *divide* between social drive and social cognition in ASD? It may be that the motivation to approach others, found to be heightened in WS (Frigerio et al., 2006) is reciprocally linked to a poorer *understanding* of social situations. Experiment 6 was designed to test participants' understanding of the motivations of *others* to attend to socially relevant scenes, as well as their understanding of appropriate emotional responses to different social motivations. As the focus of Experiment 6 was on the *understanding* of another's social drive and emotions, rather than a direct examination of the participants' own social motivations, the following literature is on the social *understanding* aspect of social cognition.

7.1.3 Social Cognition in autism

In order to understand the beliefs and desires of another, one must make inferences based on the social cues available. Le Sourn-Bissaoui, Caillies, Gierski and Motte (2009) have explored the relationship between ToM abilities and inferencing skills in participants with Asperger's syndrome, compared to TD controls. This link is an important one to examine given that an understanding of social situations must require some appraisal of why other people behave as they do. Specifically, Le Sourn-Bissaoui et al. (2009) wanted to examine possible differences between pragmatic versus semantic inference-drawing and their relationship to ToM: Semantic inferences being deduced from the verbal context of a situation whilst pragmatic inferences were based on an understanding of another's *actions*.

Participants with Asperger's syndrome (mean age 16.1 years) were found to perform consistently below the level of TD controls matched on CA and VIQ on all measures. All participants were less accurate in drawing inferences pragmatically, such as understanding that a character handing their car keys to another person suggests lending them the car. This difference in performance between pragmatic and semantic understanding was more pronounced in the Asperger's group. Le Sourn-Bissaoui et al. (2009) cite this as evidence for the fact that individuals with Asperger's syndrome, especially, find it difficult to form links between social concepts to infer meanings. The fact that this was a largely verbal task, conducted with a cohort on the autism spectrum diagnosed on the basis of high verbal ability, may have masked some of the true differences in performance between TD individuals and other individuals found to be lower on the spectrum. Indeed, Sivaratnam, Cornish, Gray, Howlin and Rinehart (2012) have shown in their study of ASD children (aged 4-8 years) matched to age and IQ TD controls that clear differences do emerge in terms of accuracy in intention-understanding. Their participants were given a comic-strip style task, therefore removing the verbal component, and were asked to choose which *pictures* were an appropriate ending to a presented story. Two subscales were designed to measure understanding of intent and understanding of emotions. They found that individuals with ASD did perform significantly less accurately than typical matches on the intention understanding component, although no differences emerged in the understanding of emotions. Given the much younger age range of children in the Sivaratnam et al. (2012)

study, and their diagnoses of core autism with poorer verbal functioning than individuals in the Le Sourn-Bissaoui et al. (2009) research, these findings may suggest that there is little development in social understanding from 4 years into adolescence, regardless of the severity of autistic traits.

Experiment 6 aims to build on understanding of social intentions by exploring the ways in which participants with WS and ASD can infer beliefs from *visual* cues without any verbal context. This is important because of the range of verbal functioning seen within and between individuals with ASD and WS, therefore it is important to remove this component so that it is not masking or confounding the underlying understanding of socially relevant information. Experiment 6 will attempt to address the divide between intent and emotion understanding by adding a dimension in which, based on inferences taken from visual cues, participants are asked to deduce the emotional state of a person; examining the mapping of inferences onto attributions about the mental state of another.

Li, Kelley, Evans and Lee (2011) have shown that individuals with ASD (mean age 8.3 years) are able to show an awareness of the knowledge of another, by telling as many white lies and lies for deceit as verbal-MA matched TD peers (mean age 7.3 years). Whilst individuals with ASD struggled to maintain deceitful lies (as to whether or not they had looked at a hidden toy), they were able to acknowledge that they could initially tell the lie and not be found out. Interestingly, no relationship was found amongst the ASD children between their lie-telling ability and performance on a false belief task. This may point to the possibility that lie-telling could be a learned response or, in the case of white lies, confounded with difficulties with 'liking'. Anecdotally, parental reports have suggested that some children with an ASD struggle with the concept of 'favourites' and do not often refer to 'liking' particular items. In typical development, neurological differences between wanting and liking have been shown (Berridge, Robinson, & Aldridge, 2009), therefore it could be the case that these mechanisms are confounded or damaged in different ways in ASD and WS. Understanding of one's own wants and likes is essential in order to extend a ToM to considering the desires of another, therefore problems in this domain might explain some of the difficulties individuals with WS and ASD face. Experiment 6 allows for consideration of this understanding of what another person may want by providing both positive and negative cues typically associated with fears or desires.

Incidences of alexithymia have been reported in individuals with ASD (Hill, Berthoz, & Frith, 2004), where they show a lacking awareness of their *own* internal states and feelings. Research (Szatmari et al., 2008) has also shown that the *parents* of children with autism report a higher prevalence of alexithymia than is seen in the typical population, and that children displaying high incidences of repetitive behaviours tended to have fathers who scored high on the alexithymia scale (Toronto Alexithymia Scale). Therefore it may be that the white lie task tapped more into difficulties in this domain rather than a genuine understanding of social conventions. However, clear difficulties in interpreting subtle aspects of social exchanges, such as the use of irony, have been found in individuals with ASD.

Wang, Lee, Sigman and Dapretto (2006) examined understanding of irony in 18 children with high functioning ASD (mean age 11.9 years) matched on CA and MA to TD controls. Whilst individuals with ASD performed above chance level on the tasks, they were significantly less accurate than TD matches, and showed greater neural activation relative to TD peers in the inferior frontal gyrus; Wang et al. (2006) claim this as being suggestive of more effortful processing in understanding irony, underpinning poorer accuracy. Given that a ToM is necessary in order to fully comprehend irony (knowing that another person does not *mean* what they say), this adds weight to the argument that individuals with ASD may not accurately put themselves into the mindset of another when interpreting socially relevant information.

7.1.4 Social Cognition in Williams syndrome

It could be the case that individuals with ASD are poor in forming social inferences, and this governs their atypical social behaviours. Conversely, if as Pickett et al. (2004a) suggest, there is a relationship between social drive and understanding of social situations, one might expect that the hyper-sociability seen in WS results in better accuracy for interpreting socially relevant information. Van der Fluit et al. (2012) have shown in their examination of 24 children (mean age 12.5 years) with WS that there is a link between the ability to interpret ambiguous social scenes and an individual's own social responses. Participants in their study were asked to complete a standard SAT task (See 6.5.1) and parents filled out measures of social communication and social reciprocity using the SCQ and SRS. A significant relationship was found in which descriptions on the SAT that were more in line with those given by TD children tended to correlate with higher scores in appropriate social reciprocity. This suggests that there is a reciprocal link between the *understanding* of social cues and one's ability to appropriately respond to them in WS.

Understanding of social signals has been explored by Sullivan, Winner and Tager-Flusberg (2011) in their examination of the ability of individuals with WS to understand jokes versus lies. Sixteen adolescents with WS (mean age 12.3 years) were given short verbal anecdotes that ended with the protagonist providing an untruth either as a deliberate lie, or as a joke. Participants were asked to state which it was, and provide an explanation of why. It was found that participants were unable to differentiate between the two, defaulting to 'lie' as a blanket response. Further, when the types of justifications that individuals gave were examined, individuals with WS gave far more explanations comparing the joke/lie to reality rather than any mental state explanation or responses suggesting an understanding of the protagonist's viewpoint. This suggests that individuals with WS struggle to take on board the perspective of another person when making decisions about social scenarios.

Haas and Reiss (2012) offer a review of the WS profile and focus on the fact that, both behaviourally and in neurological terms, individuals with this disorder appear to demonstrate an extreme willingness towards engaging and pleasing others. This seems to work in parallel with a reduced fear response and heightened arousal towards positive

emotional faces, with consistent reports of poor ToM abilities. This suggests that the link between a need for social approval and appropriate decoding of social cues might be damaged in this population. Haas and Reiss (2012) have noted that, in TD children, brain connectivity between brain regions associated with perception and cognition develops gradually across time, therefore it may be that a lack of connectivity in WS results in relatively spared domains at the expense of those that are severely *impaired*.

Sparaci, Stefanini, Marotta, Vicari and Rizzolatti (2012) have made the suggestion that attempting to examine the understanding of complex social intentions in a group with such low levels of intellectual functioning as seen in WS is somewhat counterproductive in pinpointing the root of their problems. They suggest that it is more fruitful to explore, instead, understanding of *motor* intentions as a starting point for pulling apart the possible deficits underpinning a broader social understanding in this group. Sparaci et al. (2012) highlight the importance of examining understanding of motor intentions given that a wealth of literature points to the neurological relationship between one's own actions and the actions of others. In WS, motor movements are typically impaired therefore might it be that comprehending the motor actions of another is also deficient and how might this generalise to more social-cognitive constructs such as emotion understanding?

Sparaci et al. (2012) designed a task in which WS participants (matched to two separate cohorts of TD children on CA and MA, mean ages approximately 13 and 6.5 years, respectively) were asked to state whether an image of an everyday object was being 'touched' or 'grasped' by a human hand and to explain why. Two conditions were devised so that participants were presented with and without contextual cues within the scene. Individuals with WS performed more accurately on the 'why' than 'what' measures. Specifically, they were comparable to MA matches on the why task but were not able to match the performance of CA controls on either measure. The presence of contextual cues boosted performance on the why task in all participant groups.

The findings of Sparaci et al.'s (2012) experiments point to a possible divide in WS between being able to describe and interpret motor actions. This may offer support for a mirror neuron system in which performing motor actions is also impaired in WS; the next step is to explore whether this is *specific* to motor intentions. Experiment 6 aims to extend this work by examining 'what' and 'why' responses to broader social responses in individuals with both ASD and WS.

7.1.5 Summary of Research

Understanding the intentions of others is a crucial aspect of everyday social functioning that requires an awareness of both social and non-social cues, an ability to infer meaning from them, and a relationship between comprehending one's own emotional state in relation to that of others. In typical development, systems are in place so that each of these components work together, developing across time and with social experience. In WS and ASD, aspects of this system may interact differently, making it

difficult for individuals with these disorders to make sense of new situations. The question of precisely which aspects are affected, and to what extent they are explained by delay versus deficit, has yet to be answered.

7.1.6 Experiment 6: Summary and Aims

Given that, based on the experiments discussed thus far, the social-perceptual processes and abilities within those with WS and ASD do not appear to differ in any significant way from one another or from typical development, it is necessary to examine more social-cognitive constructs. This is necessary in order to pinpoint why the social behaviours seen in ASD and WS manifest so differently. Evidently, in real-life daily social exchanges, the behavioural profiles of individuals with ASD and WS seem to vary greatly but neither group shows *appropriate* social behaviours and there are definite overlaps (Lincoln et al., 2007) between these disorders in their use of social gestures and reciprocal chat; a preliminary investigation of the types of conversation that individuals with these disorders have is briefly discussed in section 8.7. It is important to establish in what ways possible overlaps or divides in social-cognition might be driving these behaviours.

Experiment 6 was comprised of 8 displays in which a neutral face in the centre of the screen was shown to be attending to 1 of four positively or negatively valenced socially relevant images. Participants were asked to state which image was being attended to, why it was being attended to, and how that person would feel. Responses were coded under four possible categories: A solely basic description, reference to liking/not liking, use of an emotion term, or taking the perspective of that person. In doing so, experiment 6 aimed to examine social-cognitive *understanding* of socially relevant scenes: What types of inference will individuals make about why a person is attending to a certain display and what *understanding* of emotion will individuals have?

7.2 Experiment 6: Hypotheses and Predictions

Whilst a wealth of studies have examined understanding of *false* beliefs, none have explored the *types* of explanations that individuals with ASD and WS will give in making sense of another person's motivations for attending to socially relevant displays. Similarly, no studies to date have examined the ways in which an *understanding* of emotions might map onto this.

7.2.1 Typical Development

There will be an increase in the number of perspective (versus physical) terms used with age. Older participants will be more accurate in appropriately stating an emotion in line with the explanation given for why an image is being looked at.

7.2.2 ASD and TD Comparisons

Individuals with ASD will provide fewer perspective taking terms for attendance to an image than both CA and MA TD matches; they will be comparable (Sivaratnam et al.,2012) in deducing emotions appropriate to explanations, compared to TD peers.

7.2.3 WS and TD Comparisons

Individuals with WS will provide significantly fewer perspective terms relative to CA but not MA peers (Sullivan et al. 2003). Individuals with WS will also be significantly less accurate in choosing appropriate emotions, relative to CA peers.

7.3 Method

7.3.1 Participants

The same participants as took part in Experiment 1 were recruited to take part in the Social Cognition task (See section 4.3.1); two children with ASD and one with WS declined participation giving a final cohort of 16 ASD and 13 WS participants. Age and NVIQ data for their TD matches is outlined in table 7.1. The ages of the ASD participant group ranged from 8 years 10 months to 14 years 9 months, with a mean of 11 years 11 months. NVIQ scores (assessed using the RCPM) ranged from 9 to 33 (maximum score=36), with a mean of 27. The WS cohort had an age range from 6 years, 9 months to 16 years 4 months; mean age 11 years 7 months. NVIQ scores ranged from 8 to 21 (maximum score= 36) with a mean of 15. Within the ASD cohort, there were 14 males and two females; in the WS cohort there were seven males and six females.

Table 7.1: Age and RCPM data for TD matches for both clinical groups in Experiment 6

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
ASD (16)				
CA Matches*	8.0-15.0	11.2 (2.5)	24-36	31 (3.65)
MA Matches	4.5-13.11	9.5 (2.8)	10-35	27 (6.16)
WS (13)				
CA Matches	6.8-16.6	11.8 (3.2)	22-36	30 (3.45)
MA Matches	3.7-6.7	4.8 (0.9)	9-22	16 (4.23)

*Due to recruitment difficulties, one CA match was missing.

Independent samples t-tests were conducted in order to ensure that there were no significant differences between age and NVIQ between clinical groups and their CA and MA matches, respectively. There were no significant differences found between the mean ages of those in the ASD cohort compared to their CA matches ($t(29) = .10$, $p=.92$) or between those with WS and their CA matches, $t(24) = .01$, $p=1.0$. Similarly, no significant differences were found for the NVIQ scores of those in the ASD and WS clinical groups and their MA matches ($t(30) = .20$, $p=.84$ and $t(24) = .44$, $p=.66$, respectively).

7.3.1.1 TD age

Data from the 57 participants who were assigned as matches for the clinical groups was also analysed by age-group. Participant details for these groups are outlined in table 7.2.

Table 7.2: Age and RCPM data for TD groups split by age in Experiment 6

	Chronological Age		RCPM Raw Score	
	Range	Mean	Range	Mean
Up to 6 years (n=13)	3.7-5.9	4.6 (0.7)	9-22	15 (4.19)
6.0-8.5(n=12)	6.7-8.4	7.5 (0.6)	21-32	27 (3.94)
8.6-11.5 (n=15)	8.8-11.4	9.8 (0.11)	21-35	29 (3.84)
11.6 and above (n=17)	11.6-16.6	13.6 (1.5)	28-36	32 (2.85)

7.3.1.2 TD Gender

Independent samples t-tests were conducted to compare total scores on gaze following, response type and appropriate emotion (See data analysis section for a description of terms) between male (n=26) and female (n=31) participants over the TD group; no significant differences ($p > .05$) were found on any of these measures. The mean age for males was 9 years 11 months, and for females was 8 years 7 months. The mean scores on the RCPM (maximum score=36) were 27 for males and 25 for females. Given the similar NVIQ matches ($t(61)=1.51, p=.14$) and no significant differences in task performance, sex was not considered further for analysis.

7.3.2 Materials and Design

Experiment 6 consisted of eight displays, presented in PowerPoint, depicting a neutral face in the centre of the screen looking at an image presented in one of the four corners of the screen. Figure 7.1 provides an example of one of the displays. All images were non-social in that they contained no people; images were chosen to depict positive and negative scenes in order to elicit a range of emotional responses. Four positive and four negative images were used, randomised across each display so that different images appeared in different combinations and positions. These were balanced such that there were always two positive and two negative images in each display and each image was the 'looked at' item once only. All images were cropped to be the same size (400 x 300 pixels). Each participant was shown the displays in the same order to control for any possible cueing effects that different images might have. See Appendix A for a full list of the images used.

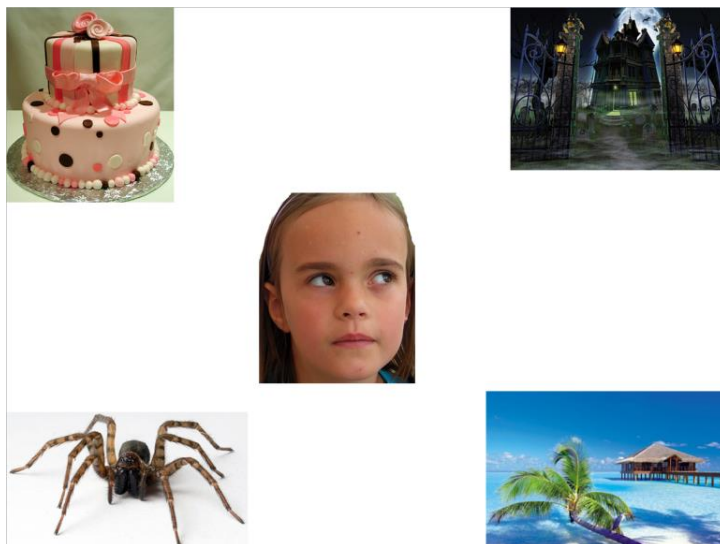


Figure 7.1: Screenshot of one of the scenes on the Social Cognition task

7.3.3 Procedure

Participants were told that they were going to see one display on the screen at a time and would be asked, initially, to state where the girl in the centre of the screen was looking. They were told that they would be asked to briefly describe “what is in the picture she is looking at”. Once participants had given their answer to this first scene, they were given feedback as to what the scene actually depicted, either by the experimenter stating “That’s right, I think it’s X as well” or with a correction such as “She’s looking at this one. What is supposed to be shown here is... Do you see that here?” Once the participant had been provided with feedback, the experimenter then asked “Can you tell me why you think she’s looking at that?” Following this, participants were asked “And how do you think that makes her feel?” Participant responses were audio recorded using a Sony digital recorder and coded after the testing session.

7.3.4 Data Analysis

Initial responses to *which* stimulus was being looked at were coded as either correct or incorrect. Types of response were coded into four categories: A physical term (such as the flower is colourful); use of a preference term (referring to ‘liking’ something); an emotion term, or taking the perspective of another (“she wants to go there because it reminds her of a time when she was on holiday”). See Appendix B for some illustrative examples. For each response given by a participant, physical terms were only scored as 1 if they failed to provide any other type of response. Therefore, this category represented those participants who *only* gave physical terms. For the other categories, a participant would receive a score of 1 for any of the response types they provided. For example, if a participant stated “The girl is excited because she loves cake”, this would be coded for both preference and emotion. This allowed for an exploration of what percentage of the time (over the 8 displays), each participant would use each type of term. This differed from the type of analysis of categories used in Experiment 5 as Experiment 6 was designed as an exploratory task to examine the types of response that individuals would give; Experiment 5, conversely, was theoretically driven. Ten percent of each participant group’s responses were second-rated by an additional experimenter, blind to the hypothesis of the experiment or participant cohort. Reliability was found to be 85% for the entire sample, across all groups.

The appropriateness of the emotion participants gave in response to the question “how does she feel?” were scored as correct or incorrect based on their explanation of why the item was being looked at. For example, if a participant stated that “she is looking at the flower because it’s pretty” and then gave her emotion as being happy, this would be considered a consistent response, whereas an emotion term of angry would be scored as incorrect. This was deemed to be the most reliable method of deducing accuracy, given the wide range of responses that participants could give. Scores for emotion appropriateness were also double-coded at a reliability level of 92%. Separate univariate ANOVAs were run to compare groups for gaze following and gaze appropriateness.

Mixed design ANOVAs were conducted to compare the number of physical versus perspective terms given to items; as with Experiment 5, whilst mean numbers of responses were reported for preference and emotion terms (social labels and emotion terms in the case of Experiment 5), these were not considered to be informative to be included in the main analyses. In comparing physical to perspective taking in the present experiment, parallels could be drawn with physical versus *interaction* terms used in Experiment 5. Mixed design ANOVAs were also conducted in order to examine the interplay between image type (positive versus negative) and the type of response given, with group as between subjects factor.

Mixed design ANOVAs were conducted in each cohort (TD age groups, ASD comparisons and WS comparisons) to analyse whether there would be any interaction between positive versus negative images presented and the types of response (physical/perspective) that participants would give. No significant interactions ($p > .05$, $F < 1$) were found between response type and image category in any of the cohorts. It was therefore not deemed necessary to examine responses to positive versus negative images separately.

7.4 Results

7.4.1 TD Groups

7.4.1.1 Correct Responses: Gaze following

A univariate ANOVA did not find any significant differences between age-groups in terms of correct responses for gaze following, $F(3,57)=1.43$, $p=.24$. Virtually all participants performed at ceiling on this measure, as is evident in Table 7.3.

Table 7.3: Mean number of correct responses to following gaze in Experiment 6, across TD age groups (Maximum score=8; standard deviations in parentheses)

	Mean number correct
Up to 6 years (n=13)	7.38 (1.12)
6-8.5 (n=12)	8.0 (0)
8.6-11.5 (n=15)	7.87 (.52)
11.6 and above (n=17)	7.65 (1.0)
Total	7.72 (.82)

7.4.1.2 Gaze Understanding: Reasons for gaze

The mean number of each of the four response types given when participants were asked to explain *why* an image was looked at are reported in Table 7.4. Because answers could be categorised in more than one way and were therefore not independent, a mixed design ANOVA was only run to compare tendencies towards giving a physical *only* versus perspective taking response (See data analysis section).

Table 7.4: Mean numbers of each response type in Experiment 6, across TD age groups (Maximum number=8)

	Physical terms	Preference terms	Emotion terms	Perspective taking
Up to 6 years	3.0 (2.71)	2.77 (2.28)	.85 (.90)	1.31 (1.44)
6-8.5	3.67 (2.39)	.92 (1.17)	1.25 (.87)	2.75 (2.01)
8.6-11.5	2.47 (1.60)	1.47 (1.55)	2.20 (1.15)	2.27 (1.53)
11.6 and above	1.94 (1.71)	.65 (.70)	1.67 (1.22)	2.79 (2.14)
Total	2.68 (2.14)	1.40 (1.67)	1.67 (1.22)	2.69 (2.14)

As is outlined in section 7.3.4, only physical and perspective terms were considered as these were the types of responses that best represented the contrast between a tendency towards describing exchanges without any social inferences versus demonstrating an understanding of social exchanges. A mixed design ANOVA comparing physical only versus perspective terms (response type x age group) did not find any significant main effect of response type ($p=.86$); there was, however, a main effect of age group ($F(3, 53)=6.43, p<.01$) and a significant interaction between response type and age group, $F(3, 53)=3.89, p<.01$, as is evident in Figure 7.2. Univariate ANOVAs were conducted on each response type separately to examine this interaction further. No significant differences were found between the age groups for the number of physical terms given ($p=.17$). For perspective terms, the oldest group gave significantly more of this response type than those aged under 6 years, as well as those aged 8.6-11.5 years, $F(3, 56)=7.68, p<.01$.

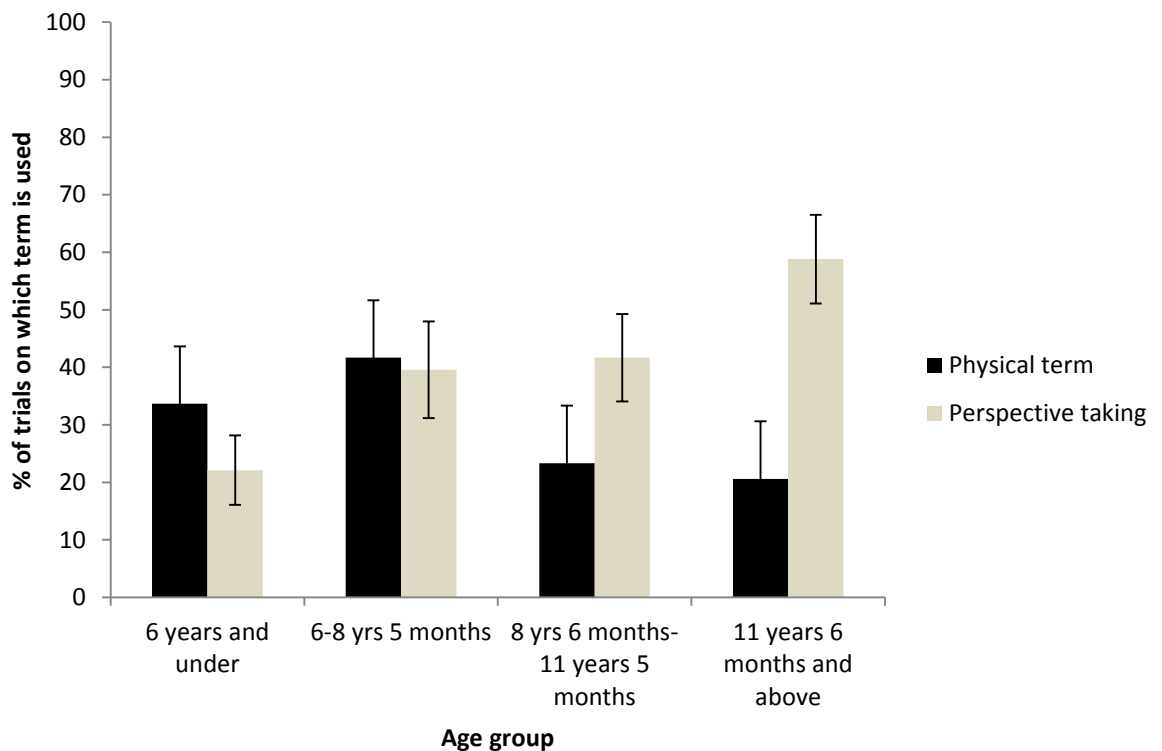


Figure 7.2: Mean percentages of physical versus perspective terms given in Experiment 6, across TD age groups (Maximum number of responses=8)

7.4.1.3 Gaze Understanding: Appropriate Emotion

A univariate ANOVA was conducted to examine differences between the number of correct responses that each age-group gave when providing an emotion appropriate to their gaze understanding response. As is evident in Figure 7.3, no significant differences were found between the groups overall, $F(3, 57)=2.30$, $p=.09$, although there was a marginal tendency towards higher accuracy in the older groups.

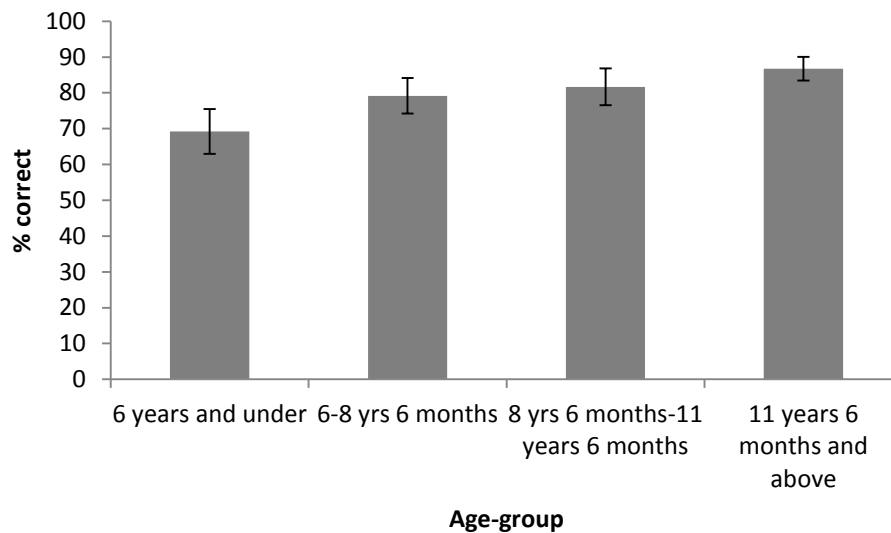


Figure 7.3: Percentages correct for the appropriate emotion measure for TD age groups in Experiment 6

7.4.2 Results: ASD with TD Comparisons

7.4.2.1 Correct Responses: Gaze following

A univariate ANOVA to compare performance for the gaze following measure, with group as a between subjects factor, showed no significant differences between the groups, $F(2,47)=.80$, $p=.46$. Mean number of correct responses are reported in Table 7.5. Worthy of note is the fact that individuals with ASD made no errors in correctly identifying the correct image⁴.

⁴ It is acknowledged that an ANOVA is not the most suitable method of analysis to use in this case due to a lack of variance. However, given its robustness in identifying potential interactions, it was deemed appropriate for this particular analysis.

Table 7.5: Mean number of correct responses to following gaze in Experiment 6, in the ASD group and TD matches (Maximum score=8; standard deviations in parentheses)

	Mean number correct
ASD (n=16)	8.0 (0)
TD CA (n=15)	7.67 (1.05)
TD MA (n=16)	7.81 (.75)
Total	7.83 (.73)

7.4.2.2 Gaze Understanding: Reasons for gaze

The mean number of responses for each type of term used are given in Table 7.6. A mixed design ANOVA was conducted (response type [physical/perspective] x group). There was no significant main effect of response type ($F(1, 44) = .58, p = .45$) or group, $F(2, 44) = 2.39, p = .10$. However, a significant interaction between the two factors was found, $F(2, 44) = 5.92, p < .01$.

Table 7.6: Mean numbers of each response type in Experiment 6, in the ASD group and TD matches (Maximum number=8)

	Physical terms	Preference terms	Emotion terms	Perspective taking
ASD	3.44 (2.0)	1.38 (1.71)	1.19 (.99)	1.50 (1.2)
TD CA	1.93 (1.99)	.93 (1.58)	1.13 (1.06)	4.53 (2.70)
TD MA	2.44 (1.97)	1.50 (1.75)	1.38 (1.15)	3.0 (2.45)
Total	2.62 (2.04)	1.28 (1.66)	1.23 (1.05)	2.98 (2.48)

Univariate ANOVAs were conducted for physical and perspective response types separately in order to explore the interaction between response type and group. No significant differences were found between the groups for the number of physical only terms given ($p = .11$). For perspective terms, a main effect of group was found, $F(2, 46) = 7.40, p < .01$, in which individuals with ASD gave significantly fewer of this type of response than their CA (but not MA; $p = .09$) matches. Figure 7.4 depicts this interaction.

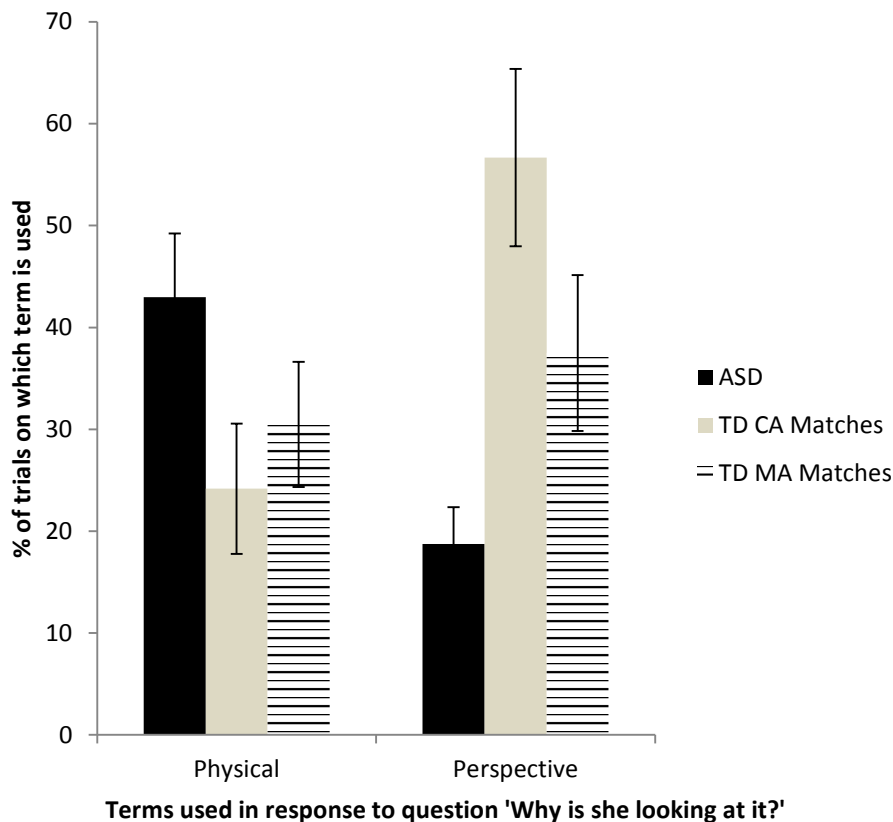


Figure 7.4: Mean percentages of physical versus perspective terms given in Experiment 6, in the ASD group and TD matches (Maximum number of responses=8)

7.4.2.3 Gaze Understanding: Appropriate Emotion

A univariate ANOVA for appropriate emotion, comparing groups, found no significant differences, although there was a trend for individuals with ASD giving a lower percentage of correct responses than their TD peers, $F(2, 47)=2.66, p=.08$. The mean percentage of correct responses for individuals with ASD was 69.5% compared to 85% and 82% for CA and MA TD matches, respectively.

7.4.3 Results: WS with TD Comparisons

7.4.3.1 Correct Responses: Gaze following

A univariate ANOVA to compare performance for the gaze following measure, with group as a between subjects factor, showed no significant differences between the groups, $F(2,39)=1.55, p=.23$; Table 7.7 provides the mean number of correct responses for each group.

Table 7.7: Mean number of correct responses to following gaze in Experiment 6, in the WS group and TD matches (Maximum score=8; standard deviations in parentheses)

	Mean number correct
WS (n=13)	7.15 (1.21)
TD CA (n=13)	7.77 (.60)
TD MA (n=13)	7.62 (.87)
Total	7.51 (.94)

7.4.3.2 Gaze Understanding: Reasons for gaze

The mean numbers of responses for each type of term used are given in Table 7.8. A mixed design ANOVA was conducted (response type (physical/perspective) x group). No significant main effects were found for response type ($p=.14$); group ($p=.10$) or the interaction between factors ($p=.17$).

Table 7.8: Mean numbers of each response type in Experiment 6, in the WS group and TD matches (Maximum number=8)

	Physical terms	Preference terms	Emotion terms	Perspective taking
WS	2.92 (1.55)	1.0 (.71)	1.85 (1.21)	1.46 (1.56)
TD CA	2.54 (2.37)	.92 (.95)	2.38 (1.45)	3.21 (1.88)
TD MA	3.23 (2.56)	2.38 (2.10)	.92 (.96)	1.46 (1.51)
Total	2.90 (2.16)	1.44 (1.52)	1.72 (1.32)	2.05 (1.82)

7.4.3.3 Gaze Understanding: Appropriate emotion

A univariate ANOVA for appropriate emotion, comparing groups, found a significant difference between them, $F(2, 39)=6.71$, $p<.01$. Individuals with WS were significantly less accurate than their TD CA but not MA peers ($p<.01$; $p=.10$, respectively). Percentages of correct responses in the WS group were only at 51% compared to 72.1% and 82.7% for MA and CA matches, respectively.

7.4.4 Summary of Results

No participant groups had any difficulties in following gaze to the item being attended to, or in describing what was in the image presented. Performance on this measure was at ceiling. In terms of the *types* of explanation given as to why the image was being looked at, differences only emerged between the TD age groups for the number of perspective taking (versus physical) terms given, in which older children gave more of this type of term than the youngest group or those aged 8.6-11.11 years, as hypothesised. In the ASD analysis, differences also emerged for the number of perspective taking terms (but not physical) terms given, whereby individuals with ASD

gave significantly fewer than CA but not MA peers. No differences were found between groups or response types overall in the WS analysis.

Accuracy for stating an emotion appropriate to the explanation given was found to be comparable between the age-groups, with individuals with ASD being worse (although not significantly so) than TD peers; this was a somewhat surprising finding, given the expectation that individuals with ASD would show significantly poorer social understanding of displays. However, those with WS did perform significantly less accurately than their TD CA peers on this measure.

Taken together, the findings of Experiment 6 suggest an atypicality, unique to those with WS, in mapping emotions onto a socially relevant context. Individuals with ASD also show less likelihood of taking the perspective of another (relative to CA peers) when making sense of a socially relevant display whilst individuals with WS did not differ significantly from CA or MA peers as to how often they gave perspective terms. This may be suggestive of a tendency to *using* but not understanding such terms in individuals with WS.

7.5 Discussion

The findings of Experiment 6 point to a possible divide between interpretation of the social drive of another and the mapping of appropriate emotions onto this, in WS and ASD. The aspect of social-cognition in which difficulties are shown is different in the two groups: Individuals with WS used comparable numbers of perspective-taking terms compared to TD peers of both the same CA and MA but were significantly less accurate than TD CA peers when providing appropriate emotions. Conversely, individuals with ASD gave significantly fewer perspective taking terms than CA TD peers but did not give significantly fewer accurate descriptions of appropriate emotions. This may therefore suggest difficulties in different components of social cognition between the two groups.

The initial part of Experiment 6 asked participants to follow gaze of the person at the centre of the scene to state which image was being attended to; performance in all groups was at ceiling on this measure. The fact that performance was approaching or at ceiling goes some way to supporting Baillargeon et al.'s (2010) assertion that task methodology can largely determine the apparent performance of younger children. They noted that a spontaneous task design would place fewer demands on the need to simultaneously represent and suppress different belief systems; the present study did, indeed, utilise a spontaneous task design in which participants as young as 4 years were able to perform with high accuracy. The fact that performance was near ceiling verified that subsequent analyses of *interpretations* of the images were based on accurate original classifications. Lobmaier et al. (2008), for example, have shown that judgements about gaze direction can be influenced by the emotional expression of a face; were an expressive face introduced into Experiment 6, it might have teased out

some of these subtle differences between the types of cue that individuals in the clinical groups attend to when following gaze.

Only in the WS group did performance on ability to accurately deduce an emotion based on social understanding drop significantly below that of TD CA (but not MA) peers. Baillargeon et al.'s (2010) response account theory may go some way to explaining this finding: It may be the case that individuals with WS have difficulties with the third component of social cognition, the aspect in which they are required to inhibit their own emotional states to deduce how another person might be feeling. Indeed, the fact that individuals with WS provided more emotion terms than their MA TD peers when explaining social intent suggests a propensity for focussing on emotions, perhaps based on their own internal states. No direct measure of this was taken in Experiment 6 and a future design should incorporate asking participants how *they* feel in response to the images, in order to establish whether this appears to be where the divide occurs.

The fact that individuals with ASD were able to deduce appropriate emotions almost as accurately as their TD peers is in line with the work of Sivaratnam et al. (2011), who have shown comparable levels of performance between ASD children and TD matches on a non-verbal comic strip task. In their study a divide was found between the ability to deduce emotions and evidence of understanding of *intent*; whilst accuracy per se was not measured in Experiment 6 in terms of the explanations that participants gave about why an image was being attended to, it was also found that individuals with ASD gave significantly fewer perspective taking terms than their TD CA peers. Within the age analysis, it was found that the oldest children used more perspective terms, suggesting that these more social-cognitive aspects of social understanding are a product of age and social experience. This lends itself to the possibility that individuals with ASD therefore struggle to make these higher level inferences because of a diminished social experience in everyday life. Individuals with WS, who display hyper-social traits, did not differ from either CA or MA peers as to how many perspective terms they gave, again highlighting the important link between social experience and the understanding of another's social intent (Van der Fluit et al., 2012). However, the number of participants recruited to Experiment 6 was not large enough to conduct an analysis of the *relationships* between understanding the mind of another and understanding emotions. For example, might it be the case that those individuals who were more likely to take on the perspective of another were more accurate in providing appropriate emotions? It would be fruitful to examine this link in a larger sample in future studies, given the heterogeneity seen in ASD and WS.

The role of the type of image presented (positive versus negative) was examined in the present study and was not found to interact significantly with the type of response given by any participants, in line with the findings of Pickett et al. (2004a). It should be noted that Experiment 6 did not attempt to ascertain, as Pickett et al. (2004a) have done, whether or not there are relationships between the internal need to belong of individuals and their attendance and understanding of social cues. Haas and Reiss (2012) have noted a heightened need for social engagement in individuals with WS, but no direct or

standardised measure of this was taken in the present experiment; this would be an informative additional measure to take in a future experiment.

Thirion-Marissiaux and Nader-Grosbois (2008) have suggested that there are two components to social cognition, pertaining to an understanding of causes and consequence; it might be that an understanding of *cause* relates more to emotions and comes later in development, whereas understanding of liking is sufficient to explain somebody's actions. Whilst no statistical analyses were conducted on all of the different response types in Experiment 6, due to the dependence of responses, examination of the mean numbers of each response category revealed some interesting patterns: The youngest group of children gave more preference (liking/not liking) terms than the other TD age-groups, and individuals with ASD gave a similar number of preference terms to their MA matches, whereas individuals with WS gave fewer. This might suggest that young children refer to 'liking' terms as this is the 'consequence' type of social understanding that develops earlier, according to Thirion-Marissiaux and Nader-Grosbois (2008). Individuals with ASD are therefore perhaps delayed in this development, whereas individuals with WS have a more developed social understanding. In further support of this, it was found that individuals with WS gave more emotion terms than MA TD peers, perhaps being indicative of the second component of social understanding proposed by Thirion-Marissiaux and Nader-Grosbois (2008).

Sparaci et al. (2012) have noted a divide amongst WS individuals between the ability to explain what is happening compared to *why*. No differences were found between any groups in any of the analyses for the number of solely physical terms given. This suggests that individuals with both WS and ASD do not default to focussing on the material properties of socially relevant scenes when drawing inferences, above and beyond their TD peers. Sparaci et al.'s (2012) research was focussed on motor actions, however, whereas Experiment 6 was aimed at drawing out more social-cognitive aspects; this does suggest, however, that the divide between 'what' and 'why' may not be as apparent in the non-motor domain.

7.6 Summary of Chapter 7

In conclusion, Experiment 6 begins to highlight a possible divide between the social understanding seen in those with WS and ASD: Whilst individuals with ASD were not significantly less accurate than TD peers in providing appropriate emotions, they tended to use fewer perspective taking terms in explaining the drive of another person; conversely, individuals with WS did not differ significantly from TD peers in the number of these terms used but did show difficulties in providing appropriate emotions relative to TD CA peers.

Together, these results begin to suggest that difficulties in social exchange in WS may be driven by a propensity towards talking about the social intentions (and emotions) of another, unsupported by an understanding of them; in ASD, the problem may lie more

in an inability to take on the perspective of another. In both cases, there appears to be a dissociation between *interpreting* and *understanding* socially relevant information.

Chapter 8: Summary, Limitations and Future Directions

8.1 Summary of experiments

The overarching purpose of the present research was to answer the question of what meanings faces and other socially relevant information have to individuals with ASD and WS. In what ways might the very different social behaviours seen in these neurodevelopmental disorders be underpinned by different profiles in the types of interpretation, understanding and attribution that individuals make of socially relevant contexts, and how might these compare to typically developing peers? Experiments 1-3 were designed to examine the role of perceptual features in the ways in which individuals with ASD, WS and their TD (MA and CA matched) peers would process and accurately deduce emotions from faces. Experiments 4-6 were developed in order to examine the attribution and *understanding* of emotions from socially relevant scenes. The following sections provide a summary of the main findings of each experiment, with interpretations and an evaluation of how possible limitations might have affected results.

8.1.1 Experiment 1: Summary

The ‘What Is It’ (Wii) task was designed as a preliminary exploration of how individuals would spontaneously interpret both real images of faces and ambiguous face-like configurations. Participants were shown images of human and animal faces as well as images comprised of items of fruit and schematic configurations, and were asked ‘what is it?’ Images of objects were also included to reduce practice/boredom effects. Human and animal faces were used in order to examine the possible specificity of the human face in eliciting emotional processing (Tong et al., 2000); fruit and line images were included in order to separate out attention to specific features versus the tendency towards piecing together parts into a whole. Participants’ responses were coded as to whether they initially referred to a face or an emotion when presented with the ambiguous images; further, if they would describe facial features, emotions, or give explanations for an emotion in response to all four image categories.

When examining initial responses to the question ‘what is it?’, individuals with ASD and WS generally gave comparable numbers of ‘face’ responses to line and fruit images as did their TD peers, and in no groups were differences found between the number of ‘face’ responses given to line versus fruit images. All participants gave significantly fewer emotion term responses to fruit images compared to line images; individuals with ASD and WS used this type of term significantly less often than TD CA peers for both image types. That individuals were comparable to TD MA peers might suggest more of a delay than deficit although it is worth noting that the youngest TD group (<6 years) did not give any emotion terms to fruit images.

That individuals in the neurodevelopmental groups did spontaneously describe the line images as a 'face', and did not do this significantly less than those in TD groups, points to the fact that individuals with ASD and WS are able to piece together parts to form a whole. The tendency to do this less than peers when labelling emotions for *fruit* faces suggests that individual features might hold their attention more in cases of uncertainty. Carey and Diamond (1977) have proposed a switch from using features to a configural style of processing at around 8 years of age; there is ongoing debate (Mondloch et al., 2002) as to precisely when this switch might occur. An insignificant main effect of age for the number of 'face' responses given in Experiment 1 suggests that the ability to piece together parts into a whole might be developed as young as 6 years old; further, the fact that different aspects of a face might be used differently in different situations and by different groups is a compelling idea. Might it be, for example, that individuals with ASD and WS default to using individual cues when the demands of a task/everyday situation are more complex? Annaz et al. (2009) have shown that individuals with ASD and WS tend to use a more feature-by-feature processing style, but perhaps this might depend on the exact task design?

An examination of response types to all four image categories revealed some interesting differences between the groups: TD individuals of all ages, as well as individuals with ASD, tended to provide more facial feature descriptions in response to human faces versus fruit or animal, although individuals with ASD provided significantly fewer of this response type overall compared to either CA or MA peers. Tager-Flusberg et al., (2003) have shown that individuals in neurodevelopmental groups often show the same *patterns* of performance but with reduced accuracy. Whilst Experiment 1 did not directly examine accuracy for identifying emotions, fewer responses overall may provide a loose measure of ability to make interpretations about images.

In the WS group, a significant interaction emerged in which individuals with WS did not significantly differ from TD peers as to how many facial feature responses they gave to real-face images, but gave significantly less than both TD CA and MA matches in response to line and fruit images. This divide between the image types in eliciting more descriptions of facial features in WS suggests either a more feature-based processing style (Annaz et al., 2009) or that there is something more salient about *real* faces that facilitate more descriptions of facial features. Golarai et al. (2010) have shown that the FFA in individuals with WS is double the size of typical controls, and hyperactivation is seen in response to human faces specifically. This may underpin a heightened behavioural response to real faces as well, although differences were not found in Experiment 1 between human and animal faces.

Standing in contrast to the possible facilitation of the human face for individuals with WS, the number of *emotion* terms given fell significantly below that of TD CA peers for both human and fruit faces. The youngest group of TD children provided very few emotion terms to human faces, suggesting that individuals with WS are in line with this, being indicative of a possible developmental delay. The fact that the human face failed to elicit many emotion terms but generally gave rise to more descriptions of facial features might suggest a dissociation between perceptual and more cognitive appraisals

of the human face, in both early typical development (under 6 years) as well as WS and ASD (where patterns were also the same as seen in TD peers, but with fewer overall responses).

Overall, few explanations for emotions were given in any of the groups; interestingly, in the ASD group and their TD peers, more of this type of response was given for animal versus fruit faces; this pattern was found for human versus fruit faces in the WS group and their TD peers. It may be the case that the role of experience played a part in this pattern of results, and that individuals in the ASD group (and TD peers) had more experience with pets, possibly drawing on their own experiences to infer and explain emotions depicted in Experiment 1. Schultz (2005) has suggested that experience plays a role in shaping neurology; no measure of this was taken in the present experiment but this would be an important detail to examine in future research.

Object images were included in Experiment 1 in order to reduce practice effects and prevent participants from defaulting to 'it's a face' as a response. An interesting finding emerged, however, in that the youngest children and those in the ASD group provided significantly fewer descriptions of the features than did their peers, and gave significantly more descriptions of the *functions* of objects. The importance of the *subjective* experience of everyday cues and stimuli in shaping our understanding of them must not be underestimated; it might be that individuals with ASD are developmentally delayed in that it is the *utility* of an object that affords the most meaning.

8.1.2 Experiment 2: Summary

The Emotion task (ET) was comprised of the same image categories used in Experiment 1, to examine *accuracy* in interpreting emotions from real and non-face stimuli. Participants were presented with 16 images (4 of each category) depicting four of each emotion (happy/sad/angry/surprised) and were asked to choose (from a choice of 3 emotions) which emotion was depicted. All participants were very accurate on this task with scores at or approaching ceiling, therefore the reliability of these results was treated with some caution.

The same patterns emerged in all participant groups whereby accuracy was overall poorer for line and fruit (compared to human and animal) images. Individuals with ASD and WS were significantly poorer than their CA-matched TD peers in accurately identifying emotions from *human* faces; in the WS comparison, accuracy also fell below that of even MA peers. Skwerer et al. (2006) have previously shown that individuals with WS are less accurate than TD peers in identifying emotions from faces, and that the animacy or more 'real' nature of a face does not buffer against this. However, they also found that a third of their sample *were* comparable to CA matched peers, therefore it could be that an examination *within* the WS group in the present study might also have revealed different patterns in performance. That individuals with WS were less accurate in identifying emotions from human faces in Experiment 2 is, however, in line

with the findings of Experiment 1 in which spontaneous descriptions of emotion were also reduced for human faces relative to peers.

Non-parametric analysis of the data also revealed that individuals with WS and ASD were less accurate in identifying happy and surprised images, relative to both CA and MA TD peers. Baron-Cohen et al. (1993) have shown that individuals with ASD have a particular deficit in recognising surprise in others, therefore the findings of Experiment 2 are in line with this. However, it was expected based on Farran et al.'s (2011) examination of response times for identifying emotions, that individuals with both ASD and WS would show an advantage for happy faces, and that TD peers might be more accurate in identifying anger. However, accuracy and response speed may not necessarily be related and the two different methodologies employed between the present study and that of Farran et al. (2011) might explain the different pattern of results.

8.1.3 Experiments 1 and 2: Limitations

Experiments 1 and 2 were designed to work together to explore the different ways in which individuals with ASD and WS, relative to TD peers, would piece together the parts of real and schematic faces to form interpretations and accurately deduce emotions. Whilst Experiment 1 was designed as a preliminary analysis of the *spontaneous* responses participants would give, and some evidence of global processing emerged given that participants would initially state that ambiguous images (both line and fruit) were a 'face', no systematic manipulation of specific configurations was employed in the present experimental design. Baudouin et al. (2010) have shown that sensitivity to spacing changes develops with age in TD children, therefore the lack of any consistent manipulation of spacing changes in Experiments 1 and 2 might have been a confound, masking possible differences between the groups. Experiment 3 was designed to be a more robust examination of processing styles employed by participants, based on a classic composite face paradigm (Young, Hellawell & Hay, 1987).

Whilst emotion accuracy was examined in Experiment 2, it might also have been informative to look at the interplay between accuracy and response type in Experiment 1 additionally. This would have been especially useful given the ceiling effects seen in Experiment 2, presumably as a result of using a multiple-choice design. It would also have been useful to have examined interactions between the category of image presented and the emotion depicted in Experiment 2; a replication in future might digitally create images so that emotions could be consistently depicted across all image categories to allow for an exploration of this.

8.2 Experiment 3: Summary

Experiment 3 was devised of two parts: Experiment 3a involved participants identifying emotions (Happy/scared/angry) from isolated eye and mouth cues; Experiment 3b employed a classic composite paradigm (Young, Hellawell & Hay, 1987) in order to examine evidence of holistic processing amongst the participant groups, as well as exploring the possible interplay between upper and lower face cues with emotion.

In Experiment 3a, participants were presented with images of either eyes or mouths and asked to identify (from a choice of 3) the emotion depicted. All participants were poorest in identifying scared as an emotion, regardless of the format of presentation. Across TD age groups, no differences were found in accuracy in identifying emotions from eye versus mouth cues. However, in the WS analyses, individuals with WS and their TD peers all gave significantly more correct responses to mouth versus eye cues. There was a borderline tendency towards less accurate performance for mouth cues in the ASD group. Given the very limited number of participants in this group (n=10), these results must be treated with caution.

The lack of any clear differences in facilitation of eyes versus mouth cues between the neurodevelopmental groups and their TD peers goes against previous research by Behrmann et al. (2006b) and Baron-Cohen and Wheelwright (2010) who have shown *reduced* attention to the eyes in individuals with ASD. Further, Lacroix et al. (2009) have shown that performance for isolated eye cues was better amongst individuals with WS than that of mouths, again going against the findings of the present experiment. However, Back et al. (2009) have shown that freezing the information available from mouth cues is as detrimental to individuals with WS as making eye cues unavailable, therefore the exact type of stimuli used might be a factor.

In Experiment 3b, participants were asked to identify (from a choice of happy/scared/angry) the emotions of either the top or bottom halves of faces, presented in aligned and misaligned formats. Better accuracy for misaligned faces is taken to be evidence of holistic processing (Young, Hellawell & Hay, 1987) In all participant groups, accuracy was highest for misaligned faces overall, and also for faces in which the emotion of the *bottom* halves were being identified. Given that no heightened accuracy was observed across the TD groups in identifying emotions from isolated mouth (versus eye cues), this suggests different processes might be at play depending on whether or not other face information is available. However, in the WS group, accuracy for mouth cues was significantly better than for eye cues in Experiment 3a, and this was in line with the finding that accuracy was at only chance level (~33%) when identifying emotions from the *top* halves of faces in Experiment 3b. Perhaps then, in WS uniquely, the same types of strategies are employed when presented with isolated face parts and whole faces?

Individuals with both ASD and WS were only able to give accurate responses at chance level for *aligned* presentations of images in Experiment 3b, perhaps suggesting that they do employ a holistic style of processing that is more negatively affected by the

alignment of face parts than seen in the TD groups. One particularly interesting finding to emerge was that individuals with both WS and ASD were more accurate in identifying happiness from aligned versus misaligned presentations of faces; in TD groups, the opposite pattern was seen, in which accuracy was higher for misaligned happy faces. It is very difficult to reconcile this finding with any previous literature; eye-tracking data would be informative in elucidating patterns of attention in pulling apart why the amalgamation of two conflicting face halves would result in *better* accuracy for depictions of happiness. This pattern was not more pronounced when identifying emotions from top or bottom halves of faces, therefore it cannot be explained by any particular type of cue use. Given that, in Experiment 2, accuracy for identifying ‘happy’ was reduced relative to peers in the WS and ASD groups, it might be possible that this emotion specifically is processed atypically. This is worth further examination in future.

8.2.1 Experiment 3: Limitations

The main limitation in Experiment 3b was the fact that a large number of ASD participants recruited to the study did not wish to take part, leaving a final sample of only 10 participants. Where borderline interactions were found, results might have been more robust given a larger sample size. Further, had more participants taken part, it might have been possible to explore subgroups of participants and possible *within* group differences that might have been underpinning some of the unexpected patterns of results.

Whilst the inclusion of a robust paradigm such as that used in Experiment 3b was important for formally and systematically examining evidence of holistic processing in neurodevelopmental groups, it would have been useful to have included the same emotions as were depicted in Experiment 2, in order to draw links between underlying processes and behavioural performance. ‘Surprise’ was not included in Experiment 3, therefore it is not possible to state whether the lower accuracy for that emotion in Experiment 2 might be underpinned by a less holistic strategy. However, given that the majority of participants were not the same individuals in these experiments, it would not be possible to draw direct comparisons, regardless of the uniformity of individual stimuli.

8.2.2 Summary of Experiments 1-3

Experiments 1-3 point to the fact that individuals with both WS and ASD do use similar strategies when interpreting emotions from faces, but do so generally less accurately than TD CA peers. Some specific atypicalities emerged in which individuals in both neurodevelopmental groups appear to have difficulties in identifying happy and surprised images, perhaps underpinned by a more feature by feature style of processing. Whilst the role of experience (with animals and in using everyday items, for example) was not examined in the first set of experiments, suggestions emerged in which the role

of experience and the *saliency* of particular stimuli might play an important role in the ability to accurately interpret and give social meaning to faces. Experiments 4-6 were designed to examine what *attributions and understanding* individuals derive from socially relevant information.

8.3 Experiment 4: Summary

The Masking task was based on an experiment used by both Santos et al. (2008) and Da Fonseca et al. (2009) with WS and ASD participants, respectively. The purpose of these original experiments was to examine whether individuals in the neurodevelopmental groups would be able to accurately deduce what object or emotionally expressive face was missing from everyday scenes by using surrounding cues. Their findings showed opposite contrasting patterns between individuals with WS and ASD in that those with ASD were less accurate than TD peers in identifying the missing face but were as competent as peers when asked to find the missing objects; individuals with WS were poorer than peers in identifying the missing object, but were as capable in correctly choosing the missing face. Experiment 4 was therefore designed to replicate these findings, with the addition of examining the interplay of what types of surrounding cue were available in the scenes.

Participants in Experiment 4 were presented with 36 everyday scenes in which either a face or object were masked out. A third of the scenes were non-social, in that they only contained objects or scenery and no people; one third had another person in the scene with a neutral expression, providing some type of instructional or descriptive gesture, whilst the remaining third contained a person with a clear facial expression that could be used to derive the missing item or face. Participants were presented with five cartoon response options and were asked ‘what’s missing’. A consistent finding across all participant groups was that accuracy was higher for identifying missing objects compared to faces, regardless of the types of cue available in the scene. Unlike what was found by Santos et al. (2008), this was also the case in the WS group. Accuracy was overall poorer for *both* faces and objects in the WS and ASD groups and over all conditions relative to CA but not MA peers. This therefore suggests that individuals in the neurodevelopmental groups find it difficult to use any types of cue to make inferences about missing content and show possible developmental delay in this area.

It was expected, given the evidence that individuals with WS overly attend to faces and seem to get ‘stuck’ on them (Riby & Hancock, 2009; Doherty-Sneddon et al., 2009) that individuals with WS in the present study would be more likely to make errors in which they chose faces instead of objects as a response. This was not, however, found to be the case, with no notable differences found in the proportions of face versus object distractors chosen in any of the groups. However, overall, very few distractor error types were made, with all participant groups making a higher percentage of errors *within* a category (such as choosing the wrong emotional expression) than in choosing the wrong category altogether. The findings of Experiment 4 therefore failed to identify any possible differences between individuals with ASD and WS that might be

suggestive of the different facilitation of a face or divides between understanding of, versus attention to, particular cues.

8.4 Experiment 5: Summary

The Animation task (AT) was based on an adaptation of the Heider and Simmel (1944) moving triangle animation, in which basic geometric shapes were created to depict possible physical (such as a flower growing) or social (the motions of two characters hugging, for example) movements; participants were asked to watch the animations carefully (four of each type) and provide a narration of what they had seen. Previous research (Klin, 2000; Abell et al., 2000) has suggested that individuals with ASD make far fewer social attributions about ambiguous moving scenes using this type of paradigm than TD peers, instead focussing on the *physical* descriptions of displays. Van der Fluit et al. (2012) have shown a similar profile amongst individuals with WS, in that they fail to provide as many descriptions as TD peers indicating social or perspective-taking type attributions. Previous research has, however employed slightly different scoring indices for coding the types of descriptions that participants provided, therefore Experiment 5 was designed to directly compare the type of spontaneous attributions that individuals would make to physical and social depictions comprised of ambiguous moving geometric shapes (See examples on CD 1).

One prediction made in Experiment 5 was that individuals with ASD would provide more descriptions concerned with purely physical interactions, whereas individuals with WS would show a propensity towards providing more social descriptions of interactions. This was not, however, found to be the case: No differences were found between the number of physical versus social interaction terms used in the ASD analysis compared to TD peers, or across age groups in the TD analyses. In the WS comparisons with TD peers, *all* groups provided more physical versus social interaction descriptions. It was hypothesised that the hyper-social (Dodd et al., 2010) nature of individuals with WS might be underpinned by a tendency towards making excessive social attributions from scenarios, regardless of their social content; whilst this was not found to be the case, the findings of Experiment 5 are in line with what was found in Experiment 1, whereby individuals with WS gave comparable numbers of *feature* descriptions in response to real faces as did TD peers, but struggled to provide more complex (emotion) terms. It could be the case that individuals with WS did not use as many social interaction terms in Experiment 5 due to a lack of *understanding*, although not all of the same participants took part in these two experiments.

The narratives provided by participants were coded for *accuracy* compared to an adult TD sample. Accuracy was not seen to clearly improve with age across the TD groups, and individuals with WS were less accurate than TD CA peers on both physical and social animations. A borderline significant interaction was found in the ASD group, in which individuals with ASD did not differ in accuracy scores for physical animations but were poorer in accurately narrating social animations. This points to the possibility, as Klin (2000) and Da Fonseca et al. (2009) also have done, that individuals with ASD

are better able to deduce meanings and accurately interpret physical scenes and objects, rather than those with more social content. However, individuals with ASD were significantly less accurate than both CA and MA TD peers in answering multiple choice questions about what might happen next in the animations (after being provided with a narrative by the experimenter) and this was the case for both physical and social displays. Therefore, despite more accurate *narratives* in line with TD adults for physical animations, an *understanding* of what those interactions might depict was lacking in the ASD group. Individuals with WS performed at MA (but less accurately than TD CAs) level on this component of Experiment 5. Van der Fluit et al. (2012) found that providing narratives improved performance in their WS cohort, but individuals in the present study were only comparable to very young MA matches.

An examination of the proportions of each type of error made (labelling a social animation with physical labels[MisSocial] or vice versa [MisPhysical]) revealed the same pattern in WS and ASD groups whereby participants with the neurodevelopmental disorders made a far higher percentage of MisSocial errors, whereas TD groups made a higher proportion of MisPhysical errors. The underlying reasons for these similar profiles in WS and ASD might be different; for example, individuals with ASD were overall less accurate in providing narratives for social scenes, therefore perhaps the over-use of physical descriptions is a default strategy in cases of uncertainty. The profile is more difficult to explain in WS, in which no accuracy differences were found between social and physical animations. It may, again, come down to an *understanding* issue; the purpose of experiment 6 was to examine the link between the attribution and understanding of emotions in socially relevant scenes.

8.5 Experiment 6: Summary

The Social Cognition task (SC) was comprised of 8 socially relevant displays in which participants were asked to follow the gaze of a central character (depicting a neutral expression) to state what image she was attending to. All participants were able to do this without difficulty, performing at ceiling. Participants were then asked to explain why the image was being looked at (four images were positively valenced and four were negative, such as a sunny beach compared to a haunted house) and to state how the central character would therefore feel. To be in line with Experiment 5, the same types of responses were compared: Purely physical explanations versus those involving a more social element in which the perspective of the central character was verbalised.

Whilst no differences were found between the TD age groups for the number of purely physical explanations given, individuals in the oldest group gave significantly more perspective-taking terms than those aged 8.6-11.11 or children aged under 6. Individuals with WS did not differ significantly from peers as to how many of either term type they gave, whereas those with ASD gave significantly fewer perspective-taking terms than CA TD peers. Given that in Experiment 5, differences were not found between the numbers of physical versus social descriptions used relative to TD peers in

the ASD group, it is interesting to note that differences did emerge in Experiment 6. Given that different children were recruited to the two experiments, it is impossible to state whether this was due to within subject variability or concerned with some specific facet of the task demands. Kret et al. (2011) have noted how the animacy of socially relevant information might determine the processing strategies used and their efficacy, therefore it might be that individuals with ASD were less inclined to use perspective-taking terms in Experiment 6, where no depictions of animate interactions were provided.

When examining the appropriateness of the emotions given to the explanations for why a scene was being attended to, it was found that no age effects emerged within the TD analysis and individuals with ASD did not make significantly more errors than TD peers. In the WS group, however, individuals were not as accurate as TD CA individuals. That individuals with WS were using similar numbers of perspective-taking terms as TD peers but without mapping appropriate emotions onto these is particularly interesting, and points to a possible divide between *interpreting* and *understanding* socially relevant information.

8.5.1 Experiments 4-6: Limitations and Summary

Due to the timing of recruitment, the participants who took part in Experiments 4/5 and Experiment 6 were largely not the same individuals. A small subgroup of those with ASD, and a larger cohort of the WS individuals did take part in all 3 experiments, but these numbers were not sufficient to conduct any direct analyses comparing patterns of performance across the three tasks. This would have been particularly informative in teasing apart possible differences due to task demands versus underlying atypicalities seen in the groups that might persist *across* the different measures.

In both Experiments 4 and 5, a more fine-tuned analysis of the error types and responses given might have better pulled apart differences that were predicted (but failed to) emerge between the WS and ASD groups, relative to TD peers. It was decided not to employ the detailed and complex scoring indices adopted by Klin (2000) in experiment 5, as the focus of this experiment was on physical versus social descriptions; however, use of a more comprehensive scoring system would probably have better differentiated between the types of profiles seen in neurodevelopmental groups. Similarly, analysis of the types of emotion labelling errors that individuals were making in Experiment 4 might have better revealed *why* individuals with WS did not show the ‘face’ advantage observed by Santos et al. (2008). Regarding Experiment 4, it is also worth considering that the cartoon-like depiction of response options might have affected performance; whilst Santos et al. (2008) also used this method of presentation in their study, Farran et al. (2011) have noted that there is an interplay between the emotions being depicted and the nature of the stimuli (schematic versus real faces) on accuracy in identifying emotions. This interplay was not explored in Experiment 4, and should be considered in future research.

One striking finding in Experiment 6 was the observation that *all* participants in the ASD group accurately identified the image being attended to on 100% of trials. This level of accuracy was not seen in any other groups. Given that part of the diagnostic criteria on the ADOS is poor joint attention, this is a somewhat surprising finding, although lab-based measures of gaze detection (Nation & Penny, 2008) have shown similar accuracy for gaze following in individuals with ASD. This highlights the importance of acknowledging differences between controlled, standardised measures of social perception compared to those seen in everyday behaviours. Whilst following gaze to one of four possible corners of a screen is not joint attention per se, it still suggests that individuals with ASD are able to attend both to a central character and then to the item that person is looking at. That they do this as *accurately* as TD peers is not under debate, based on the finding of Experiment 6; in future, it would be useful to examine whether they do this as *rapidly*, taking a measure of response times. Further, eye-tracking techniques would also be helpful in examining precisely which cues in socially relevant scenes individuals with WS and ASD attend to when devising their explanations. Riby and Hancock (2009) examined one component of this in their study comparing the ‘hotspots’ of individuals with WS and ASD when attending to social scenes, but the relationship between *where* an individual is attending and what use they make of that information has yet to be explored.

To summarise Experiments 4-6, it does not appear to be the case that individuals with WS are overly distracted by faces versus objects, or that there is any particular facilitation of faces in aiding accuracy for identifying missing items in the WS group. All individuals in Experiment 4 were more likely to make errors suggesting difficulties in *understanding* both social and non-social scenes. This difficulty in *understanding* socially relevant information pervaded all three experiments in the WS group, with performance being less accurate than TD CA peers in providing accurate narratives in Experiment 5, and in providing appropriate emotions in Experiment 6. Individuals with ASD tended to show developmental delays for *social* animations exclusively in Experiment 5, and in using fewer perspective terms in Experiment 6. It therefore appears that a possible key difference between individuals with WS and ASD might be in the fact that those with ASD make fewer *interpretations* based on social terms and descriptions, and have more difficulty in making sense of social versus physical information, whereas individuals with WS do use socially complex terms but are lacking in a real *understanding* of them.

Over 6 experiments examining various aspects of processing style, cue use, emotion specificity and the interpretation, attributions and understanding of faces and other socially relevant information, very few differences in the profiles of individuals with WS and ASD have emerged. Indeed, there are more similarities between those with ASD and WS than there are between these groups relative to TD peers. It is therefore important to examine why these overlaps might be occurring, in light of heterogeneity seen within the groups.

8.6 Heterogeneity and Overlaps in autism and Williams syndrome

Given the similar profiles seen on several of the experiments in the present research between those with ASD and WS, possible overlaps in everyday traits were examined in the neurodevelopmental groups. The Social and Communication questionnaire (SCQ) was used in order to formally measure the number of autistic type traits seen in WS. No significant differences were found (See Appendix C) on the total scores of individuals with WS compared to those with ASD; moreover, *all* individuals recruited to Experiments 1, 2 and 6 in the WS cohort for whom SCQ data was available had scores that were above the cut-off (scores above 12) indicating autism. This could suggest that some of the overlapping traits assessed on the SCQ might underlie the similar profiles seen in the present set of experiments. These findings should be treated with some level of caution, however, as the SCQ is designed whereby caregivers are asked to choose a yes/no response to questions such as “Does she/he show a normal range of facial expressions?” In autism, a ‘no’ to this question might be because the child only ever shows one emotion, whereas in WS, it could be that the child shows a vast range of *extreme* emotions, therefore not picking up on these subtle but critical differences. Were a large number of participants recruited to the present research, it would have been useful to look at subsections of the SCQ and their possible correlation to specific tasks.

Lincoln et al. (2007) have shown that there are definite overlaps in the autistic traits seen between individuals with WS and ASD, but this does depend on the particular domain of behaviour being explored; 55% of their WS sample met criteria on the ADOS for a PDD-NOS but only 10% met criteria when examining the purely *social* domain. This highlights how heterogeneous WS is, with certain areas of social function being more atypical than others. Little et al. (2013) have proposed that there might be subgroups of individuals with WS and this is a definite area worthy of future research; it would be interesting to examine subgroups of participants in Experiments 5 and 6, for example, to establish if individuals who were using social terms were the same individuals who better understood the emotions in the tasks.

It was not possible to directly compare individuals with WS and ASD in the present research, given their significantly different NVIQ scores; individuals with WS had consistently lower scores than those in the ASD group. This also meant that TD MA matches for WS individuals were particularly young. This could be problematic given the wide age range (spanning 6.9-17.5, across all participants recruited) in the WS group. Recruiting more participants would have allowed for an analysis of subgroups of ages within the neurodevelopmental groups much like that carried out in the present study in the TD groups. Searcy et al. (2004) have, however, shown that there was no significant relationship between *verbal* IQ and age in a group of WS TD adults, therefore it may be the case that age is not as important in determining performance in individuals with WS. This is in line with the consistent finding across the majority of experiments in the present study that both individuals with ASD and WS did not differ significantly from TD MA peers.

VIQ scores in the present set of experiments were relatively higher (than NVIQ) and significantly exceeded those of individuals with ASD in comparisons conducted between participants recruited to Experiments 1, 2 and 6. Poorer verbal ability amongst the ASD group in Experiment 6 might have played some part in their using fewer perspective taking terms relative to peers; unfortunately, VIQ data was not available for TD participants on that experiment. This difference in VIQ between ASD and WS participants disappeared in those recruited to Experiments 3,4 and 5, however. This again demonstrates how different the verbal profiles within both ASD and WS can be; Jarrold et al. (2001) have demonstrated how VIQ determines performance in other domains across age in WS, whereas visuo-spatial abilities cannot be so reliably used to predict performance in other areas. This complex pattern of abilities within different domains and how they relate make it very difficult to deduce precisely which factors might underlie everyday social behaviours.

The Strengths and Difficulties Questionnaire (SDQ) was used in the present set of experiments in order to ensure that only children who were not reported to have any 'atypical' social or emotional behaviours were recruited into the TD comparison groups. SDQ data was also available for the majority of participants with WS (See Appendix C) therefore differences between the scores were examined for the WS group and their TD peers. Whilst it was expected that TD children would have significantly lower scores than individuals with WS, the degree of difference was considerably striking, with an average score of ~4 across all TD participants compared to an average score of 25 in the WS group. Scores ranged from 18-33 amongst WS participants, again suggesting a lot of individual differences *between* individuals within this population. Unfortunately, subdomain scores were not available for the group of WS participants and no data was available for individuals with ASD; a direct comparison of these would be particularly informative in future for highlighting possible subgroups within and between disorders.

8.7 Conclusions and Future Directions

It is clear that, even *within* the neurodevelopmental disorders ASD and WS, there is a great deal of variation in both verbal and non-verbal IQ, as well as in the types of social behaviours that individuals show. Future research must aim to recruit as wide a sample of participants as possible, in order to examine possible 'clusters' (Little et al. (2013) and subgroups that might better explain the particular social profiles seen in these disorders. It is also evident, based on the six experiments described here, that there are many overlaps between individuals with ASD and WS, with standardised measures such as the SCQ and ADOS (Lincoln et al., 2007) picking up on autistic traits in individuals with WS. Pulling apart precisely in what ways these disorders are similar or different might be a fruitful, albeit challenging, avenue of future research.

The primary aim of the current research was to answer the question of what meaning faces and other socially relevant information have to individuals with ASD and WS; the initial guiding hypothesis was that perhaps there was a neat distinction between the underlying causes of the apparently divergent social behaviours seen in ASD and WS,

such that the differences might be explained by difficulties in social-perception versus social-cognition. However, the consistent theme to emerge from the six experiments comprising this research was that individuals with ASD and WS have considerably more *overlaps* in their social profiles than they do distinctions: Both individuals with ASD and WS tend to attend to individual features in cases of uncertainty when processing information from ambiguous stimuli (Experiment 1) and are poorer than TD CA peers in accurately identifying emotions, especially surprise and happiness (Experiment 2). The *interplay* between emotions and the cues used was not robustly or systematically examined in the present set of experiments; a fine-tuned analysis of these complex relationships would make an informative future study. Similarly, none of the present experiments involved images exploring gaze; as an important part of joint attention, known to be atypical in individuals with ASD, future studies should examine the interplay between gaze direction and social understanding.

Experiments 4-6 were designed to assess atypicalities in the social-*cognitive* domain: What inferences, attributions and understanding would individuals make from socially relevant information, and would faces facilitate or distract individuals in some way (Experiment 4)? The most prominent theme to emerge from these experiments was that individuals with ASD did not seem to use as many socially driven descriptions, with more focus and more accurate performance on physical scenes and information. Individuals with WS, conversely, did not show as many difficulties in using social terms but showed deficits in an *understanding* of emotions and social contexts. Given the heterogeneity seen in the participants recruited to these experiments, with a wide range of both non-verbal and verbal IQ scores and a broad range of atypical behaviours reported by parents/teachers, it may well be that *within*-group differences need further exploration.

The role of experience in modulating both neurological development and the development of social behaviours is an increasingly important area of research. Karmiloff-Smith (1997) and Bachevalier and Loveland (2006) are strong proponents of the view that there is a complex and reciprocal relationship between everyday experiences and the development of specific social-cognitive domains. Preliminary findings in the present study (Experiments 1 and 6) point to the possibility that some of the differences seen between individuals with neurodevelopmental disorders and TD controls might be due to individual personal experiences. Future research should build on this concept by rigorously exploring the relationship between one's own emotions and preferences compared to their understanding of another's. Similarly, the utility and salience of particular cues and their facilitation in helping individuals to understand socially relevant information would be a worthy focus of future studies. A preliminary study (See Appendix D) conducted during the present research used guided conversations to explore the types of experiences and understanding of social situations that children with ASD and their TD peers would report. Topics of conversation were structured to be about the children's hobbies, birthdays or a school trip, with prompted questions designed to elicit conversations; allowing children to talk about activities that they had experienced enabled an examination of the types of experiences and concepts that were most salient to them. A small sample (n=5) of conversations were also

conducted with individuals with WS. Whilst no formal analyses of the conversations has yet been conducted, brief examination of the types of descriptions that children in the different groups gave suggests that individuals with ASD talk less about interactions with peers and focus more on recalling concrete activities and objects; individuals with WS seem to give reports around who was involved in an interaction and how people felt, much in line with TD children. This is an area of future work that may be useful in exploring the role that personal experiences have in an understanding of social situations.

8.8 Summary

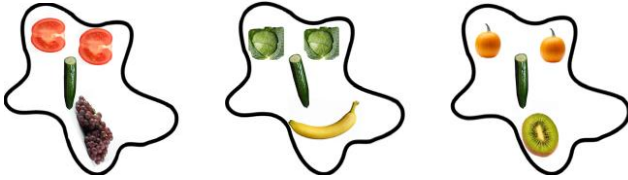
The present research suggests that individuals with WS and ASD, whilst being less *accurate* in interpreting emotions from faces, tend to use similar social-perceptual strategies; individuals with the neurodevelopmental disorders default more to using features only when presented with ambiguous information. In the social-cognitive domain, clearer differences begin to emerge between those with ASD and WS, with individuals in the former case appearing to make less social *interpretations* of socially relevant information, whilst individuals with WS show difficulties in social *understanding*. Future research must attempt to map these possible difficulties in interpreting and understanding social information onto everyday social behaviours, examining the ways in which personal experiences might mediate this link. Might it be, for example, that the cues that are salient to individuals with ASD and WS (i.e.: objects and emotions) can in some way be used to support their understanding of social information? Understanding precisely how the atypicalities seen in ASD and WS might be mediated by personal experiences and heterogeneity within these neurodevelopmental disorders could be the key to mapping these areas of difficulty onto the unique social profiles seen in these groups. Elucidating profiles of where the difficulties lie will allow for applied future research to explore ways in which the relative *strengths* seen in these disorders might be used to support an understanding of the social environment and give more socially *relevant* meaning to the question of ‘What’s in a face’?

Appendix A

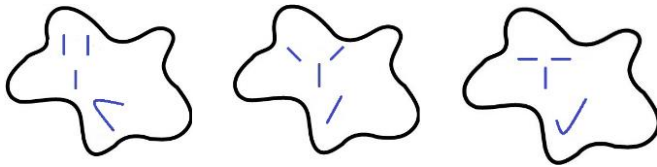
The below sections provide examples of the various images used in experiments 1-6.

All images used in Experiment 1 (What Is It task)

Fruit images



Line images



Human images



Animal images



Object images



Examples of scenes used in Experiment 4 (Masking task)

No social content

What's missing?



Is it...

A



B



C



D



E



Correct response: C

What's missing?



Is it...

A



B



C



D



E



Correct response: E

Neutral content

What's missing?



Is it...

A



B



C



D



E



Correct response: E

What's missing?



Is it...

A



B



C



D



E



Correct response: B

Emotional content

What's missing?



Is it...

A



B



C



D



E



Correct response: A

What's missing?



Is it...

A



B



C



D



E



Correct response: D

Scripts for narratives used in Experiment 5¹

Animation 1:

A cat spots a bird flying up in the sky. The cat follows the bird and sees he lands on a tree. The cat jumps up to try to catch the bird but the bird flies away again.

Animation 2:

A glass ball is on the table and starts to roll off. It lands on the floor and breaks open and the items inside spill out.

Animation 3:

A big cloud is in the sky. It grows bigger and bigger and then it starts to rain. The rain makes a big puddle on the ground.

Animation 4:

A dog is sniffing along the ground. He smells something hidden under the tree so he digs to find what it is. He finds a bone and takes it away.

Animation 5:

The sun is shining and a flower starts to grow. Petals appear and the sun makes it grow more and more.

Animation 6:

A boy and girl wave at each other then run towards each other. They have a big hug.

Animation 7:

Two people are playing tennis. They hit the ball backwards and forwards until one of them cannot hit it back anymore.

Animation 8:

An aeroplane goes down the runway very fast and takes off up into the sky. It goes higher and higher.

Images used in experiment 6 (Social Cognition task)

Positively valenced images



Negatively valenced images



Appendix B

Examples of narratives given in Experiment 5 (For animations 6, 7, 3 and 5)

Williams syndrome participants

Awww. That's so sweet. There were two friends playing and then they hold hands.

He's got a tennis racket and he hit the ball to that one and he hit it down so that means he was cheating.

There was a rose and a cloud and rain shot out.

The sun shined and it made the tree grow, wheee.

Autistic participants

The triangle and the square both together.

They're playing tennis. They were hitting it.

It started to rain. The cloud's red.

A plant, a flower growing and the sun come.

Typical children

A girl and a boy kissing.

They're playing tennis, one of them hits it out and the other one drops the racquet 'coz he's sad.

It was a sunny day with clouds in the sky then it suddenly started raining and there was a flood.

Somebody's planted a flower seed and then the sun comes out and it starts growing.

Examples of reasons given for why an image is being looked at, in Experiment 6 (For the lightening image and beach image)

Williams syndrome participants

Having a bad day. Doesn't have to go to school.
She's afraid.
Can't go outside coz it might hit her.
Looks a bit scary to me.

Because it's good. I love sailing.
She might want to play in the sea.
Making her sad. She won't be allowed to go on holiday.

Autistic participants

Coz it's all thundery. Scary and dangerous.
It has light (makes a thunder sound).
Might make her scared
She's scared. She likes it.

Might wanna go there
It's a beautiful sea.
She's so happy
Might be looking at the blue sky

Typical children

Looking out her window to see if it's thundering
A bit dangerous and she doesn't like how it feels.
Colour and electric sparks. It's so fast, it's capturing so she's looking while she can.
Young children find it frightening but some people find it pretty.

A lovely scene and she probably wants to live there.
She might have been there with her family and it all looks calm and away from everything. She wants to play in the sea.
Makes her relaxed and she wants to swim in that pool. 'I want to go there'.
She'd rather go on holiday than do anything with the other pictures. It's more relaxing to go away than any of the other pictures. She might live in England where the weather is rubbish!

Appendix C

Overlaps and differences between Williams syndrome (WS) and autism (ASD)

In order to examine the within and between group heterogeneity amongst individuals with WS and ASD, various analyses were conducted on the standardised measures of behaviour and IQ. The following sections report the findings of these analyses and these are discussed in more detail in section 8.6. Participants who took part in experiments 1, 2 and 6 (labelled ‘study 1’) were not the same individuals as those who took part in experiments 3, 4 and 5 (‘study 2’), therefore the data has been grouped into these two halves. Whilst some participants declined taking part in some of the experiments, the below data is for all of those *originally* recruited to the tasks, in order to outline the fullest picture of the heterogeneity within groups. Of the individuals with ASD who took part in study 1, six individuals also took part in study 2. In the WS cohort, 9 individuals recruited to study 1 also took part in study 2. For detailed explanations of each measure, refer to the Method section of corresponding experiments.

STUDY 1

Age, Verbal IQ (VIQ) and Non-verbal IQ (NVIQ)

Descriptive statistics for participant ages, NVIQ (maximum score=36, assessed using the RCPM) and VIQ (maximum score=112, assessed using the WISC III) are provided in table C.1. Data for this measure was available for 14 individuals with ASD and 8 with WS. Independent samples t-tests were conducted to compare the groups; no significant difference was found between the ages of the groups [$t(30) = .01, p = .99$]. Significant differences were, however, found between NVIQ [$t(30) = 6.57, p < .01$] and VIQ scores: $t(20) = 6.39, p < .01$. Whilst individuals with WS had lower scores on the NVIQ measure, they had significantly higher scores on the VIQ tasks.

Table C.1: Descriptive statistics for age, NVIQ and VIQ for the ASD and WS groups recruited to study 1 (standard deviations in parentheses)

	CA		RCPM Raw Score		WISC VIQ Score	
	<i>Range</i>	<i>Mean</i>	<i>Range</i>	<i>Mean</i>	<i>Range</i>	<i>Mean</i>
ASD (n=18)	8.1-14.9	10.8 (2.3)	9-31	26.9 (6.0)	9-42	27.21 (9.53)
WS (n=14)	6.9-16.5	10.10 (3.2)	8-21	14.93 (3.63)	37-74	57.13 (12.26)

Social Communication Questionnaires (SCQ)

SCQ data was collected for all individuals with ASD and historical data was available for 13 individuals with WS. Higher SCQ scores are indicative of more autistic traits; a score of above 12 is used to indicate sufficient autistic symptomatology to meet diagnostic criteria. The SCQ was used in the present set of experiments as an inclusion criteria for selection to the ASD group, therefore the mean score in this group was 16.3 (standard deviation 3.91). However, within the WS group, the mean score was not significantly different from those with ASD [$t(29) = .40, p = .69$], with a mean score of 15.85 (standard deviation 2.41). In fact, scores in the WS group ranged from 13-22 compared to 9-23 amongst those with ASD, meaning that every participant with a diagnosis of WS met the criteria for autism.

Strength and Difficulties Questionnaire (SDQ)

The SDQ was administered as an inclusion measure for TD children: Those scoring above the cut-off for atypical behaviours (17 for parent-report and 16 for teacher-report) were excluded from participating in the present set of experiments. SDQs were not administered to individuals with ASD but historical SDQ data was available for 11 of the WS participants. Descriptive statistics for the WS group and their TD matches are provided in table C.2. Due to some teachers/parents declining to complete the questionnaires, data were missing for 4 of each of the TD CA and MA matches.

Table C.2: Descriptive statistics on SDQ scores for the WS group compared to TD matches recruited to study 1 (standard deviations in parentheses)

	SDQ score	
	Range	Mean
WS (n=11)	18-33	25.0 (5.14)
TD CA (n=7)	0-5	3.14 (2.11)
TD MA (n=7)	1-13	6.86 (4.10)

Independent samples t-tests were conducted to compare the WS participants to their TD MA and CA matches, separately. Levenes test of homogeneity of variance was significant for the TD CA comparison, therefore corrected t-values were used. Both comparisons were significant: $t(16) = 7.86, p < .01$; $t(14.34) = 12.54, p < .01$, respectively.

STUDY 2

Age, Verbal IQ (VIQ) and Non-verbal IQ (NVIQ)

Descriptive statistics for participant ages, NVIQ (maximum score=36, assessed using the RCPM) and VIQ (maximum score=112, assessed using the WISC III) are provided in table C.3 Data for this measure was available for 12 individuals with ASD and 6 with WS. Independent samples t-tests were conducted to compare the groups; no significant difference was found between the ages of the groups [$t(28) = .51, p = .29$] or on their VIQ scores: $t(16) = 1.14, p = .27$. A significant difference was found between NVIQ scores, in which participants with ASD had higher scores: $t(28) = 3.48, p < .01$.

Table C.3 Descriptive statistics for age, NVIQ and VIQ for the ASD and WS groups recruited to study 2 (standard deviations in parentheses)

	Chronological Age		RCPM Raw Score		WISC VIQ Score	
	Range	Mean	Range	Mean	Range	Mean
ASD (n=15)	6.5-16.6 (3.3)	11.2	12-34	25.13 (6.17)	10-57	26.83 (13.90)
WS (n=15)	8.0-17.5 (3.4)	12.6	9-31	17.27 (6.22)	12-57	35.67 (18.48)

Social Communication Questionnaires (SCQ)

SCQ data was missing for one participant with ASD and historical data was available for 14 individuals with WS. The mean SCQ score in the ASD group was 17.29 (standard deviation 4.68), with scores ranging from 12-25. Within the WS group, the mean score was 14.79 (standard deviation 3.29), with scores ranging from 6-19. An independent samples t-test found there to be no significant differences between the SCQ scores of the two groups: $t(26) = 1.64, p = .11$.

Strength and Difficulties Questionnaire (SDQ)

SDQ data was available for 13 of the WS participants. Unfortunately, several of the teachers and parents of TD matches declined to fill out the questionnaire, therefore data was only available for five participants in the TD CA group and 11 in the TD MA group. Descriptive statistics are reported in table C.4.

Table C.4: Descriptive statistics on SDQ scores for the WS group compared to TD matches recruited to study 2 (standard deviations in parentheses)

	SDQ score	
	<i>Range</i>	<i>Mean</i>
WS (n=13)	18-33	25.46 (5.55)
TD CA (n=5)	2-4	3.0 (1.0)
TD MA (n=11)	0-7	2.91 (2.91)

Independent samples t-tests were conducted to compare the WS participants to their TD MA and CA matches, separately. Levenes test of homogeneity of variance was significant for both comparisons therefore corrected t-values were used. Significant differences were found between SDQ scores of the WS and MA group: $t(18.72) = 12.73, p < .01$, as well as the TD CA group: $t(13.82) = 14.02, p < .01$.

Appendix D

Drawing task

Preliminary research gathered as part of another project was carried out with a small number (n=5) of participants from the Williams syndrome cohort, each matched on CA and MA to an ASD participant. The mean age of the WS individuals was 12 years, 9 months and the mean NVIQ score was 21.

Participants were asked to talk about their hobbies, a recent birthday party and a school trip in semi-structured conversations. These conversations were coded for whether the predominant response revolved around talking about relationships and/or interactions with others; things that the child had or had not liked; emotions, and descriptions of details/objects at the event. The mean numbers of each type of response are reported in table D.1, below.

Table D1: Mean number of each response type (maximum number=3) on the drawing task (standard deviations in parentheses)

	Relationships	Likes	Emotions	Descriptions
WS	0.8 (0.44)	1 (1)	0 (0)	1.2 (1.10)
ASD CA	0.5 (1)	0.75 (0.96)	0.25 (0.5)	1.25 (0.96)
ASD MA	0.2 (0.45)	0.2 (0.45)	0 (0)	2.6 (0.55)

Due to the small sample size and lack of power, no statistical analysis was conducted on the above data. However, in line with the findings of the main thesis that individuals with ASD focus more on physical descriptions of objects than on social elements, there was an increase in the number of times individuals with ASD gave purely descriptive accounts during conversations. This same pattern was seen, although to a lesser extent, in the WS group. Figures D.1-D.3 provide a pictorial representation of some of the key terms used by individuals with WS and ASD when asked to talk about each topic. Larger words represent more frequent use of that term.

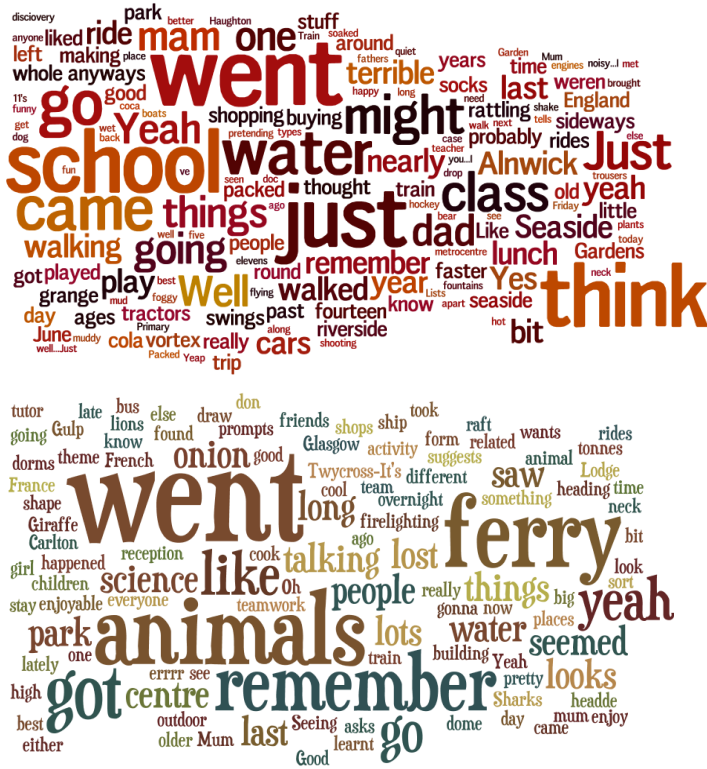


Figure D.1: Wordles of the terms used by individuals with ASD (Top) and WS during conversations about a school trip.

Future research must further explore this type of conversational data as, given a larger sample, it might begin to reveal those aspects of social situations that have the most meaning and relevance to children with ASD and WS.

Appendix E

Information Sheets for parents

TD parents

What meaning do faces have? Processing of emotions from faces.

We would like to invite your child to take part in a research study. Please read this information sheet before deciding whether you would like them to take part. It will explain why the research is being done and what it will involve. If there is anything you are unclear about after you have read this information, please feel free to ask questions. I can be contacted by email or by phone using the contact details at the bottom of the sheet.

Purpose of the study

We are hoping to compare typically developing children like yours to those with Williams Syndrome and Autism: Neuro-developmental disorders that have specific patterns of behaviour. People with Williams syndrome tend to be attracted to faces and social interactions whereas those with Autism appear indifferent to forming social relationships. Recent research has suggested that there may be something about the *meaning* of faces that is represented differently for these two groups. In order to explore this, the current study will look at the ways in which typically developing children process emotions in faces so as to make comparisons with the developmentally atypical groups.

Who are the researchers?

Research will be carried out by Rachel Cole-Fletcher, based at the Institute of Neuroscience at the University of Newcastle. Rachel is currently conducting her PhD and this research will form the basis of her thesis. She will be supervised by Dr. Debbie Riby and Professor Vicki Bruce, both based in the Department of Psychology at the University of Newcastle.

Why have I been asked to take part?

Your child has been selected to be invited to take part in our study because they are developing normally and they are the same age and gender as one of the children who we are studying who has Williams Syndrome/Autism. This will help us to make sure our groups are matched on age so that any differences we may see in the children with Williams Syndrome/Autism are not related to age.

What will the study involve?

For your child, the study will involve:

- Completing some standardised pen-and-paper tasks in order paint a profile of strengths and weaknesses. These should take no longer than 30 minutes in any one session.

- Viewing images of faces or face-like objects (see attached sheet titled 'task images') on a computer screen and being asked what they see or what emotion they think is shown.

What are the benefits of taking part in the study?

We hope that there will be many benefits of this research to the understanding of social interactions for all children as well as to families of children with Williams Syndrome and Autism in particular. The results may provide important information to help professionals in best supporting the needs of those children with Williams syndrome and Autism.

What are the disadvantages of taking part in the study?

We hope that there will be very few disadvantages of taking part in this study. One possible concern may be the time your child will be asked to give to the study for completing tasks. However, we will only work with your child for short durations and they will be able to take short breaks if required; this should ensure that disruption to their normal routines is kept to a minimum.

Do I have to take part in the study?

You do not have to take part in this study. Participation is on a voluntary basis. Should you decide not to take part this will not affect your child's care, treatment or education. If you do take part, keep the information sheet and you will be asked to sign a consent form (see attached). You will receive a copy of the consent form to keep. Your consenting to take part in no way binds your child to participate and either you or they can withdraw without reason at any time.

What will happen to the data?

All information collected from your child will remain confidential. No names will be used throughout the project but all data will be coded with numbers to ensure each child remains anonymous.

What will happen to the results?

The results of this study will be written up in an information document for parents. A copy of this will be made available through your child's school. It will not be possible to identify participants from this or any other document. We are aware that some parents may be very interested in their child's individual results from the measures completed, however due to the research nature of the study, this information cannot be given on an individual basis. As this study is being undertaken as part of a research PhD, the results of this study will also be written up into a final thesis.

Any further questions...

Thank you for taking the time to read this information. Please fill out the attached consent form if you are interested in your child taking part. Should you have any comments or queries, please do not hesitate to contact me using the contact details below.

Parents of children with ASD/WS

What meaning do faces have? Processing of emotions from faces in children with Williams syndrome (WS) and Autism (ASD).

We would like to invite your child to take part in a research study. Please read this information sheet before deciding whether you would like them to take part. It will explain why the research is being done and what it will involve. If there is anything you are unclear about after you have read this information, please feel free to ask questions. I can be contacted by email or by phone using the contact details at the bottom of the sheet.

Purpose of the study

Recent research has suggested that children with WS and ASD have problems processing information across different parts of faces. That is, they do not consider the distances or positions of features but instead focus on the features themselves. This inevitably has an impact on the ability of people with these disorders to appropriately interpret emotions from faces: This is an area consistently found to be a problem for people within these groups, the causes of which warrant further research. However, people with these disorders show very different behaviours in the way that they engage in social relationships, with WS populations favouring social interactions whilst those with ASD seem indifferent to them. Therefore it seems that some factors beyond face processing skills may be operating and this study aims to explore precisely what these factors could be. Is there something about the *meaning* of faces that is represented differently for the two groups?

Who are the researchers?

Research will be carried out by Rachel Cole-Fletcher, based at the Institute of Neuroscience at the University of Newcastle. Rachel is currently conducting her PhD and this research will form the basis of her thesis. She will be supervised by Dr. Debbie Riby and Professor Vicki Bruce, both based in the Department of Psychology at the University of Newcastle.

Why have I been asked to take part?

Families with a child with WS/ASD are being asked to take part in this study. One of the researchers, Dr. Debbie Riby, has close links with the Williams Syndrome Foundation (WSF) and various Autism groups and is involved in ongoing research with them. This project has identified families to take part who have expressed an interest in research through the WSF/North East Autism Society.

What will the study involve?

For your child, the study will involve:

- Completing some standardised pen-and-paper tasks in order to paint a profile of strengths and weaknesses. These should take no longer than 30 minutes in any one session.
- Viewing images of faces or face-like objects (see attached sheet titled ‘task images’) on a computer screen and being asked what they see or what emotion they think is shown.

What are the benefits of taking part in the study?

As this is a preliminary research study, there will be no immediate benefits to participants. We are unable to give families individual feedback on their child's performance. Our hope is that through studies like these, we will learn more about the characteristics of WS and ASD, including those which are not currently well-known. Through disseminating the results of these studies, we aim to increase understanding of WS and ASD among families and professionals, improving the experience for families and children with WS and ASD. We hope that ultimately, such research will provide important information to help in developing interventions for children with WS and ASD.

What are the disadvantages of taking part in the study?

We hope that there will be very few disadvantages of taking part in this study. One possible concern may be the time your child will be asked to give to the study for completing tasks. However, we will only work with your child for short durations and they will be able to take short breaks if required; this should ensure that disruption to their normal routines is kept to a minimum.

Do I have to take part in the study?

You do not have to take part in this study. Participation is on a voluntary basis. Should you decide not to take part this will not affect your child's care, treatment or education. If you do take part, you may keep the information sheet and you will be asked to sign a consent form (see attached). You will receive a copy of the consent form to keep. Your consenting to take part in no way binds your child to participate and either you or they can withdraw without reason at any time.

What will happen to the data?

All information collected from your child will remain confidential. No names will be used throughout the project but all data will be coded with numbers to ensure each child remains anonymous.

What will happen to the results?

The results of this study will be written up in an information document for parents. A copy of this will be made available through your child's school/posted directly to you. It will not be possible to identify participants from this or any other document. We are aware that some parents may be very interested in their child's individual results from the measures completed, however due to the research nature of the study, this information cannot be given on an individual basis. As this study is being undertaken as part of a research PhD, the results of this study will also be written up into a final thesis.

Any further questions...

Thank you for taking the time to read this information. Please fill out the attached consent form if you are interested in your child taking part. Should you have any comments or queries, please do not hesitate to contact me using the contact details below.

What's in a face?



Who are we?

My name is Rachel/Miss Fletcher (depending on school preference) and I am studying at the University of Newcastle. I am working with some other people who are very interested in (and know lots about) faces!

Why are we writing to you?

We would like you to take part in some games all about faces. When children like you look at a face, you are very good at seeing what that person might be feeling and you know how to respond to them. But, for some children, it isn't so easy. Some children can find it hard to get much information from looking at faces and we are trying to work out why. To do this, we need to compare children who have problems understanding the meaning of faces to children your age so that we can see where the differences are. We hope that this will help us to come up with some different ways to help children communicate better when they look at a person's face.

What will you have to do?

We would like you to play some games that will involve you looking carefully at lots of different pictures on a computer screen. The pictures will be of different characters: Some animals, some people and some funny new creatures! As you look at the pictures, we will ask you some questions about what you can see. There are no right or wrong answers-we just want your thoughts and opinions about the characters. We will also ask you to do some quick tasks on paper, similar to the ones you do in the classroom.

Do you have to do it?

Definitely not! Even if you think you would like to take part at the beginning and then you change your mind and want to stop, that's just fine! You can always say no at any time.

And finally...

It is up to you if you want to take part in playing our games. We hope that they will be fun for you and that you will enjoy working with us. We would like to say a big 'thank

you' now whether you decide to join in or not. If you have ANY questions, you can ask an adult to let us know and we can answer them for you.

We hope to see you soon!

Information sheet for WS/ASD participants

What's in a face?



Who are we?

My name is Rachel/Miss Fletcher (depending on school preference) and I am studying at the University of Newcastle. I am working with some other people who are very interested in (and know lots about) faces!

Why are we writing to you?

We would like you to take part in some games all about faces. We are very interested in what children like you see when they look at a face. Some children really love looking at faces, other children don't like to look at them so much. Some children can find it hard to get much information from looking at faces and we are trying to work out why this might be. We hope that, by working together on these games, we can understand better how people are different. We can then come up with some different ways to help children communicate better when they look at a person's face.

What will you have to do?

We would like you to play some games that will involve you looking carefully at lots of different pictures on a computer screen. The pictures will be of different characters: Some animals, some people and some funny new creatures! As you look at the pictures, we will ask you some questions about what you can see. There are no right or wrong answers - we just want your thoughts and opinions about the characters. We will also ask you to do some quick tasks on paper, similar to the ones you do in the classroom.

Do you have to do it?

Definitely not! Even if you think you would like to take part at the beginning and then you change your mind and want to stop, that's just fine! You can always say no at any time.

And finally...

It is up to you if you want to take part in playing our games. We hope that they will be fun for you and that you will enjoy working with us. We would like to say a big 'thank you' now whether you decide to join in or not. If you have ANY questions, you can ask an adult to let us know and we can answer them for you.

We hope to see you soon!

Consent form

What meaning do faces have? Processing of emotions from faces.

I have read the information sheet and/or have had the study explained to me.

I have had the opportunity to ask questions about the study.

I give consent for my child to participate in this study.

I believe my child to be competent to give their own consent and he/she has read the information sheet and has signed the form below to indicate his/her consent.

I understand that I can change my mind at any time or my child can refuse to participate at any time, and that reasons for withdrawal do not need to be given.

Parent/Guardian name: _____

Parent/Guardian signature: _____

Child name: _____

Child signature: _____

Date of birth: _____

Date: _____

Ethical Approval Form

<p>01 June 2010</p> <p>Rachel Cole-Fletcher PhD Student Institute of Neuroscience</p>	 <p>Newcastle University</p>	<p>Faculty Research Strategy Office Faculty of Medical Sciences</p> <p>Newcastle University The Medical School Framlington Place Newcastle upon Tyne NE2 4RH United Kingdom</p>
<p>FACULTY OF MEDICAL SCIENCES: ETHICS COMMITTEE</p>		
<p>Dear Rachel Institute of Neuroscience</p>		
<p>Title: <i>Atypical social exchange in Williams Syndrome and Autism: An exploration of the underlying social-perceptual and social-cognitive mechanisms</i> Application No: 000309/2010 May 2010 to July 2012</p>		
<p>On behalf of the Faculty of Medical Sciences Ethics Committee, I am writing to confirm that the ethical aspects of your proposal have been considered and your study has been given ethical approval.</p>		
<p>The approval is limited to this project: <u>Case 000309 - Atypical social exchange in Williams Syndrome and Autism: An exploration of the underlying social-perceptual and social-cognitive mechanisms</u>. If you wish for a further approval to extend this project, please submit a re-application to the FMS Ethics Committee and this will be considered.</p>		
<p>During the course of your research project you may find it necessary to revise your protocol. Substantial changes in methodology, or changes that impact on the interface between the researcher and the participants must be considered by the FMS Ethics Committee, prior to implementation.*</p>		
<p>At the close of your research project, please report any adverse events that have occurred and the actions that were taken to the FMS Ethics Committee.*</p>		
<p>Best wishes,</p>		
<p>Yours sincerely</p>		
		
<p>Marjorie Holbrough</p>		

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