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**The Use of Global and Contextual Information by Individuals with
Autism**

Beatriz López
University of Durham

Thesis submitted to the University of Durham for the
degree of Doctor of Philosophy

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Abstract

The aim of this thesis was to investigate whether individuals with autism lack a natural drive towards central coherence as predicted by weak central coherence theory (Frith, 1989). To investigate the nature of this difficulty, two main areas of proposed impairment, context (Experiments 1-9) and global processing (Experiment 10), were separated out. In Experiments 1-3 a method was developed to test the ability to use context information in the visual and verbal domains. Results showed that the performance of individuals with autism was facilitated by the provision of visual and verbal context information. Experiment 4 showed that the same children were able to use semantic category information to aid recall. However in Experiment 5 the same individuals had difficulties with a sentence processing task when using sentence context to disambiguate homographs. Experiments 6-9 examined two possible alternative explanations for the difficulties in Experiment 5. The results of these experiments indicated that the difficulties in Experiment 5 were not due to a failure in using context when targets are embedded in the context (Experiment 6). It remains to be tested whether the difficulties are related to the processing of ambiguous information as Experiments 8-9 failed to develop a method to examine this possibility. Having established that the impairment in using context was highly specific to the use of sentence context to disambiguate homographs, Experiment 10 moved away from examining context to study a different measure of central coherence, global processing by use of a face recognition task. The results of this study have confirmed that there is a deficit in the ability to process global information in autism. However further confirmation of a global impairment will be needed by use of non-facial tasks. In summary, the findings fail to support the claim of a general impairment in autism regarding central coherence.

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Declaration

I declare that this thesis has not been presented, in this or any different form to this or any university towards the application of any degree.

Beatriz López

Copyright Statement

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Chapter 1 Historical and theoretical background

Autism is one of the most intriguing syndromes in psychology. Although sixty years have passed since Kanner (1943) first described the syndrome, the exact cause of this syndrome still remains unknown. In recent years however, important changes have taken place in our understanding of this disorder. It is now widely recognised that people with autism have impairments in biological, psychological and behavioural levels of functioning. In recent years therefore, research has been directed towards understanding the nature of impairment at each of these levels in order to answer the question of how these impairments at different levels of functioning might be causally connected to each other (Morton & Frith, 1995; Bailey, Rutter & Phillips, 1996).

This thesis focuses on cognitive impairments at the psychological level. It is nearly thirty years since Hermelin and O'Connor made the proposal that children with autism have a cognitive impairment in the ability to integrate information.



Since their pioneering work, cognitive research in autism has flourished. Hermelin and O'Connor's original ideas have provided the influence for the main cognitive theories that followed, their early work directly influencing the view that children with autism are impaired in their ability to process information for meaning. This view subsequently led Frith (1989) to claim that children with autism have difficulty integrating information into higher-level representations, a problem, that she argued, could be attributed to weakness in 'central coherence'. The view that children with autism were impaired in processing meaningful information also influenced the separate claim that children with autism have a specific difficulty interpreting meaning in relation to people's inner mental states. The authors of this claim, Baron-Cohen, Leslie and Frith (1985), attributed this difficulty to an impaired 'theory of mind', a view that was subsequently been challenged by the executive functioning account of autism (Ozonoff, Pennington & Rogers, 1991).

The rapid development of cognitive research in recent years has left many questions unanswered. Because of the way the theories have been formulated, it has been difficult to test which of the three competing theories; central coherence, theory of mind or executive functioning, is correct in explaining the cognitive difficulties of children with autism. On the other hand, it has also proved difficult to establish if all three theories are correct and that there are independent, complementary cognitive impairments that coexist in people with autism. This makes the overall aim of establishing the exact nature of the psychological

impairment difficult to achieve and makes the goal of connecting psychological with biological or behavioural levels very elusive.

One reason why it has been difficult to establish the exact nature of the psychological impairment may be because there is difficulty in demonstrating the distinctiveness of the cognitive impairment. This particularly applies to the predictions of the executive functioning and theory of mind accounts. Results of research studies that are claimed to provide support for one theory also provide support for the other theory. In addition, impairments in executive functioning and theory of mind may not be distinctive to children with autism but found also in other clinical groups. The research in this thesis therefore focused on the claim made by weak central coherence theory that people with autism have a cognitive profile of strength and weakness. This cognitive profile does appear to be distinctive to autism. It is not easily explained by either of the other theories and to date has not been systematically found in other clinical groups.

The work for the thesis started with an examination of the claim by central coherence theory that there is a distinctive cognitive profile in autism. In particular, a conceptual analysis of the notion of 'central coherence' led to an attempt to specify the concept further in terms of two distinct constructs – contextual processing and global processing, a distinction drawn from research in cognitive psychology. The empirical work started with the question raised by the weak central coherence account as to whether children with autism are impaired in their ability to process context. In establishing across a series of experiments that the impairment in

contextual processing does not constitute a general difficulty but is highly specific to particular task demands, the final empirical investigation tested the claim that children with autism have problems with global processing.

In this first chapter I first set the scene for the investigation of context and global processing by providing background to the cognitive theories of autism, focusing particularly on the claims of weak central coherence theory. I then explain why the study of global and contextual processing became the focus of the empirical investigation in this thesis, dealing with issues of theoretical definition in the current chapter and empirical evidence in Chapter 2. Chapters 3 to 8 report the empirical studies. In Chapter 9 the results of these studies are interpreted in the light of issues of definition and the claims of cognitive theories raised at the outset.

1.1 The emergence of cognitive psychological explanations of autism

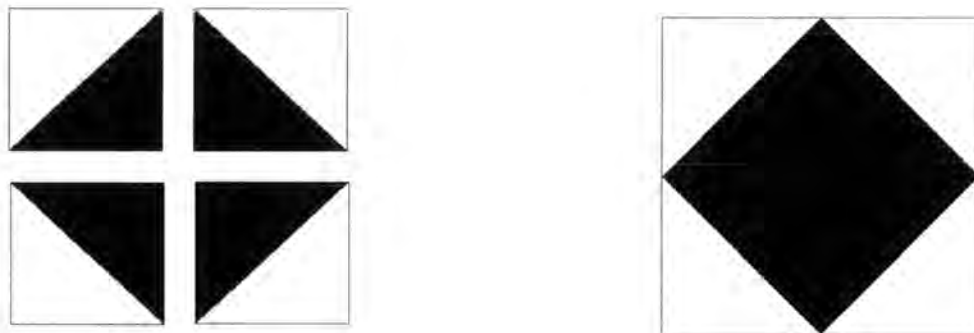
The term autism was originally adopted by Bleuler (1908) to refer to schizophrenic patients with limited relations with the external world and limited interpersonal relations. Although initially this term was used for schizophrenic patients, Leo Kanner in 1943 borrowed the term to describe an entirely distinctive syndrome. Kanner (1943) described 11 cases of children that, although different from one another in some respects such as mental ability, shared a similar pattern. All had language and communication difficulties, social impairments and a insistence of sameness in the environment and repetitive interests.

Kanner's paper has been extremely influential in the study of autism. This paper gave a very detailed and insightful description of the cases, highlighting the three main characteristics of autism and the innate nature of the syndrome. At the time of Kanner's proposal however the predominant approach in psychology was psychoanalysis, thus the initial attempts to explain autism were focused on the affective and not cognitive aspects of the syndrome. Despite Kanner's insight and accuracy in the description of the symptoms, and his suggestion that genetic factors played an important role in autism, research for the following twenty years focused on the explanation suggested by Kanner (1949) in a later paper, that autism was the result of defective parental care. Specifically, he suggested that parents of children with autism were cold and detached and this resulted in an affective impairment for the children. For many years this was the predominant view in psychology. The emergence of behaviourist psychology did not have a great influence in the theoretical approach to autism as behaviourist psychologists focused on the treatment of symptoms and not theoretical explanations.

In the 1960s however there was a dramatic turn in the study of autism. Two factors made possible this change. First, there was a large parental movement against the view that autism was a result of defective parental care. Researchers started to seriously investigate the role of parents in the emergence of autism and found no evidence of a relation between rearing patterns and autism (DeMyer, 1975).

Parallel to this movement a new approach emerged, shifting away from affective explanations to the study of cognition. Serious attempts were made to refine the diagnostic criteria, (e.g. Lotter, 1966; Wing & Gould, 1979), and also to investigate the cognitive abilities of children with autism. Rutter and colleagues, for instance, investigated in the 1960s the children's profiles on intelligence tests and also attempted to describe in detail the clinical features of autism. They found that the performance of children with autism varied significantly across tests. Whilst in some tests, such as the Comprehension test of the Weschler Intelligence Scale for Children (WISC), they performed very poorly, in some others such as the Block Design (see Figure 1.1), children with autism performed extremely well (Lockyer & Rutter, 1970).

Figure 1.1 Example of design and blocks used in the Block Design test (Weschler, 1974),



Also in the 1960s, Beate Hermelin and her colleague Neil O'Connor investigated the perceptual and language abilities of children with autism. These investigations on cognitive abilities revealed that autism was characterised not only by social, language and repetitive impairments but also by the presence of a particular cognitive profile. These studies suggested abnormal processing of information in individuals with autism. For instance, children with autism showed similar recall rates for sentences ('they ate the apple') than random word strings ('went leaf the up') whilst comparison samples show enhanced recall for sentences than word strings (Hermelin & O'Connor, 1967).

Further studies by Uta Frith in the 1970s showed that the particular cognitive style was not restricted to language tasks. Children with autism also had abnormal processing of visual and acoustic information. In one of the studies for instance, Frith (1970b) presented a sequence of coloured beads to a sample of children with autism and a control sample of typically developing children (i.e. blue, red, blue, red, blue, red, blue, blue). The results showed that children with autism learned the sequence quickly, but made mistakes that showed they were influenced by the last elements in the sequence and not by the overall pattern (blue, blue). Typically developing children on the contrary, tended to make errors that reflected an over-generalisation of the overall pattern (blue, red). A different study in which sequences of sounds (i.e., rut-mic-rut-mic) were presented instead of coloured beads provided similar results (Frith, 1970).

Clinical accounts also reported abnormal patterns of processing of sensory stimuli. In particular clinical observations suggested detailed focus processing of incoming sensory information (Ornitz, Guthrie & Farley, 1977; Rimland, 1964). Bearing in mind these results, Hermelin and O'Connor (1970) proposed that individuals with autism have difficulty integrating incoming information. Kanner (1943) had already mentioned in his first description of autism that 'the children read monotonously, and a story is perceived in unrelated portions rather than its coherent totally'.

Following Hermelin and O'Connor's suggestion, Uta Frith carried out a series of studies investigating language and visual processing in autism in the 1980s. In one of these studies she investigated performance of children with autism in a series of verbal tasks (Frith & Snowling, 1983). The results of this study showed that language difficulties in autism were restricted to a difficulty in the use of semantic information in the absence of semantic cues. Specifically they found that children with autism failed to use sentence context information to disambiguate homograph words (i.e. 'tear'). They also had difficulty selecting the right word missing in a sentence according to semantic information. On the basis of these findings, Frith and Snowling argued that individuals with autism have difficulty processing verbal information for meaning.

Additional research in visual perception showed that this difficulty in processing information for meaning was not restricted to language material. Shah and Frith (1983) administered the Embedded Figures test (Witkin, Oltman, Raskin

& Karp, 1971; See Figure 1.2), initially developed to investigate field independence in non-autistic populations, to a sample of children with autism. This task measures the ability to ignore a global visual pattern and focus on the parts in order to find an embedded shape in a picture. Results showed superior performance of individuals with autism relative to a comparison sample. The studies mentioned earlier investigating cognitive profiles in intelligence test in autism also provided evidence of superior featural processing in autism. Individuals with autism tend to have a peak of performance in the Block Design test. This test as the Embedded Figures test also requires the ability to segment a design into its parts.

Figure 1.2 Example of stimuli used in the Embedded Figures test (Witkin et al., 1971).



On the basis of the results from these studies and clinical observation data, Uta Frith (1989) formally proposed a new theory of autism, Weak Central Coherence theory. This theory will be discussed in the next section, together with the two other cognitive theories of autism that emerged at around the same time, the theory of mind and executive function accounts of autism.

1.2 Weak Central Coherence and other cognitive accounts of autism

1.2.1 The 'theory of mind' account

The term 'theory of mind' was first coined by Premack and Woodruff (1978) to refer to the capacity to predict other's behaviour on the basis of inferred mental states. Wimmer and Perner (1983) argued that the most suitable way of testing whether an organism has theory of mind is to assess its capacity to predict another's behaviour on the basis of a false belief. In order to investigate theory of mind abilities in children, Wimmer and Perner designed a false belief test. In this test, children hear a story about a character that leaves an object in a particular location. While this character is absent, the object is transferred to a different location. Children then are asked where the character will look for the object. If they understand false belief, children will predict that the character will look for the object where he/she left it. However, if they do not understand false belief, they will predict that the character will look for the object in the new location. Wimmer and

Perner (1983) found that children only develop this ability at around four years of age. The emergence of the concept of theory of mind opened a whole new field in developmental psychology.

Baron-Cohen, Leslie and Frith (1985) were the first to apply this concept to the study of autism. They argued that autism could be characterised by an inability to understand other people's mental states. When Baron-Cohen, Leslie and Frith administered the false belief test to a sample of individuals with autism they found that individuals with autism consistently failed to solve the task. Furthermore, this inability to solve the task seemed related to autism only and not to a general cognitive handicap as a matched sample of children with learning difficulties were able to solve this task despite their developmental delay. Theory of mind therefore seems to be relatively independent of general intellectual abilities in non-autistic samples.

Later research consistently reported deficits in theory of mind in autism using different paradigms (Baron-Cohen, Leslie & Frith, 1986; Baron-Cohen, 1989a,c). The emergence of the 'theory of mind' theory had a great impact in research in autism and typical development as it provided a theoretical framework from which to draw specific predictions. This account of autism could explain the language and communication difficulties in autism as well as the social interaction impairments, in other words the social deficits in autism. However, autism is characterised also by deficits in the non-social domain. For instance, autism is related to repetitive and perseverative behaviour and abnormal patterns of

perception. These impairments cannot be easily explained by a theory of mind deficit. The two alternative theories of autism, executive function theory (Russell, 1996; 1998; Ozonoff, Pennington & Rogers, 1991) and weak central coherence theory (Frith, 1989) are more successful in accounting for the non-social impairments.

1.2.2 The executive function account

Executive function (EF) is an umbrella term that covers a range of abilities such as attention shifting, set-shifting, inhibition of automatic responses, generation of goal-directed behaviour, holding information on-line in working memory and a series of high-level functions that are controlled by the frontal lobes.

The proposal that individuals with autism have an executive dysfunction is based on the finding that many of the deficits in autism resemble those of brain-damaged patients with lesions to the frontal lobes. Traditional tests of executive function abilities include the Wisconsin Card Sorting Test (WCST) in which participants have to flexibly shift from one card sorting strategy to another. The ability to plan strategies and inhibit prepotent responses, measured by the Tower of Hanoi, are also part of the executive functions.

There is wide evidence for executive deficits in autism. Research has shown that individuals with autism have difficulties in strategic and motor planning, set-shifting, attention shift, generating novel behaviour and working memory among

other components of executive function (see Pennington and Ozonoff, 1996 for a review). However, not all executive function abilities are impaired in autism and impairments also vary as a function of age and IQ level. In addition, EF impairments are not specific to autism as other clinical groups such as schizophrenia, Tourette's syndrome, Attention Deficit Hyperactivity Disorder (AHDH) or Parkinson's disease also present an executive dysfunction (Ozonoff, Strayer, McMahon & Filloux, 1994).

The executive function account has attempted to explain both the social and non-social deficits in autism. Several authors have suggested that the ability to shift cognitive set is linked to social abilities (McEvoy, Rogers and Pennington, 1996; Berger et al., 1993). In addition, it has been suggested that the difficulties experienced by individuals with autism in theory of mind tasks such as the false belief test can be explained by a deficit in disengaging from the salience of reality (Hughes & Russell, 1993). Evidence however shows that individuals with autism are able to disengage from reality when they need to distinguish between reality and the content of a photograph (Leekam & Perner, 1991; Swettenham, Baron-Cohen Gómez & Walsh, 1996) or a map (Leslie & Thaiss, 1992).

The relation between executive functions and theory of mind abilities is an issue of debate in current research. Theorists of the executive function account claim that the difficulties in theory of mind can be explained by an executive dysfunction (Russell, 1996), while theorists of the theory of mind account claim that social impairments in autism can be explained by a theory of mind impairment

(Perner, 2000). This debate has not yet been resolved, thus further research will be needed to establish the relationship between these two abilities. Regardless of which of the two theories may account best for the diagnostic criteria of autism, neither of the two theories attempts to explain the unique cognitive profile found in autism. An alternative theory has been proposed to explain this cognitive profile, weak central coherence.

1.2.3 The weak central coherence account

The weak central coherence account proposed by Frith (1989) was based on evidence from research by Hermelin and O'Connor (1970) and by Frith and colleagues (Frith & Snowling, 1983; Shah & Frith, 1983; Frith, 1970) showing that children with autism have difficulty in integrating incoming information and in processing information for meaning.

Central coherence is the term coined by Frith (1989) to refer to the tendency of the cognitive system to integrate information into meaningful higher-level representations.

“The normal operation of central coherence compels us human beings to give priority to understanding meaning. Hence we can easily single out meaningful from meaningless material. Indeed it goes against the grain to deal with anything meaningless. Despite the processing effort that it involves, we remember the gist of the message, not the message verbatim” (Frith, 1989, p.101).

Frith (1989) claims that in typical cognitive functioning there is a central high-level component, what she terms 'central coherence', that selects what to attend to from the vast amount of information that reaches the perceptual systems. The selection of what is appropriate to attend to is based on the basis of the integration of the information available. Without this high-level integrative component, she argues, the coherence would be weak and attention would be random.

Frith's proposal is that autism is characterised by a certain cognitive style. The particularity of this cognitive style is that individuals with autism, unlike normal populations, do not tend to integrate incoming information in its context, but instead preferentially attend to local information. Unlike the other theories of autism, this theory attempts to explain not only impairments but also the islets of abilities that have been repeatedly found in autism. For instance, this theory predicts relatively good performance in tasks where attention to local information is advantageous, but poor performance on tasks requiring the recognition of global meaning or integration of stimuli in context.

The advantage of WCC theory as opposed to the other two theories is that, to date, no other syndromes have been found to have the distinctive cognitive profile identified by weak central coherence theory. In addition, whereas even when the minority of high functioning children are able to pass tests of theory of mind, it seems that central coherence difficulties are nevertheless still present in these children (Happé, 1996; 1997). This therefore seems to be a cognitive style that is

distinctive to autism. The proposal of a cognitive style with various degrees along a continuum also allows a better explanation of autism as a spectrum of disorder. Finally, this proposal not only explains attentional and perceptual deficits but also the presence of superior abilities in autism in certain tasks.

In spite of the advantages of WCC theory over the other two theories, this theory suffers from a critical problem, namely the poor definition of the concept of central coherence. Although the concept of central coherence is very appealing, accounting for piecemeal processing and islets of abilities that have been repeatedly found in autism, it is 'a very slippery concept to define' (Baron-Cohen & Swettenham, 1997). In the next section I examine in more detail this slippery concept. Issues of theoretical definition are dealt with in the remaining part of this chapter while empirical evidence is discussed in Chapter 2.

1.3 Examining the concept of central coherence

The claim that children with autism have weak central coherence is based on evidence for a distinctive cognitive profile. This profile reveals superior featural processing combined with poor global processing, recognition of the global meaning or poor integration of stimuli in their context. There are two assumptions within this claim that I attempt to address in this thesis. The first is that the existence of superior featural processing presupposes a lack of holistic processing. The second

is that it is assumed that 'global processing' and 'integration of stimuli in context' are one and the same thing.

Taking the first assumption, there is now considerable evidence supporting the claim for superior featural processing but little evidence focusing on the global impairment. The evidence that exists is based mainly on the results of very specific tasks with high cognitive demand, making it difficult to ascertain whether the impairment is due to holistic processing or simply complexity or information load. This thesis therefore specifically focused on whether individuals with autism are impaired in holistic processing.

Taking the second assumption, central coherence has been defined as either the ability to process contextual information or the ability to process global patterns of visual stimuli. It has been assumed that if central coherence is weak, the two abilities would be impaired. However, nowhere has it been demonstrated that these two abilities are one and the same thing. Indeed, research with typical and atypical populations investigate these two abilities separately. The work of this thesis therefore separated out the notion of contextual and global processing. Evidence of difficulties in global and contextual processing will be discussed in Chapter 2 and in Chapters 3 to 8 a series of experiments investigating the ability to process global and contextual information are presented.

Further examination of the concept of central coherence reveals other difficulties that are addressed in the thesis. These difficulties concern the confounding of the definition of central coherence when dealing with the issue of

level and domain of cognitive processing. In the model originally proposed by Frith, (1989), central and peripheral processes were differentiated. Peripheral processes were described as specialised processes, that transform sensations into perceptions with a low degree of interpretation whereas central processes in contrast, were described as processes that interpret information further by integrating the information received from the different peripheral sources. Frith (1989) argued that a weak central coherence impairment would only affect central and not peripheral processes. An example she gives of low-level integration processes by peripheral systems is for instance, that of visual illusions where the illusion is created even before the information is passed on to the central processes. The perception of visual illusions would therefore be no different from that of typical populations according to her initial account. One difficulty here is the failure to specify the boundaries of peripheral and central processes. In subsequent work, Happé (1996) examined the local-global distinction *within* a low level visual task such as the visual illusion task. Despite Frith's earlier prediction, Happé did not find children with autism susceptible to visual illusion, a finding that Ropar and Mitchell (1999) did not replicate. These mixed results leave open the question of how global ability should be interpreted in visual tasks involving different levels of cognitive demand.

To date, the impairment in central coherence is documented using a diverse range of global and contextual tasks, assessing different cognitive abilities (e.g. perception, memory, language) across visual and verbal domains. For instance, weak central coherence has been investigated in tasks testing the ability to use

sentence context to disambiguate a homograph (Frith & Snowling, 1983), to select the right word missing in a sentence (Frith & Snowling, 1983), to facilitate recall of words (Hermelin & O'Connor, 1967), to recall semantic category information (Tager-Flusberg, 1991) and to extract holistic properties of visual stimuli (Mottron & Belleville, 1993). One of the claims of weak central coherence theory is that central coherence is a general property of the cognitive system. It has therefore been assumed that if central coherence is weak in autism, individuals with autism will have difficulties across domains of performance. However, the evidence suggests that studies investigating context processing in the verbal domain (e.g. sentence processing tasks) reveal difficulties whereas studies investigating global and context processing in the visual domain have provided mixed evidence. It would be possible therefore that performance is particularly impaired in the verbal domain. Demonstrating competence in the visual domain in both the ability to process context and global information would seriously damage weak central coherence theory and in particular the definition of central coherence as a general capacity.

1.4 Conclusions

In this chapter a historical perspective of how cognitive theories of autism emerged was presented. The discussion of three current cognitive theories of autism revealed that weak central coherence theory, unlike the other two theories of autism, has the potential to explain the unusual cognitive style characteristic of autism. This

particular cognitive style has been conceptualised by Frith (1989) as a failure to integrate information, manifest by difficulties in processing global, context information and relative good detailed focused processing.

The analysis of the weak central coherence theory of autism revealed that although this theory is important in proposing a cognitive profile that might be distinctive to autism, it suffers from various conceptual difficulties. In an attempt to deal with these difficulties, the work of this thesis concentrates on the proposed impairment in processing global, contextual information, separating out these two notions from each other and attempting to avoid previous difficulties of confounding with respect to the level and domain of processing.

In Chapter 2 a detailed literature review of part/whole processing will demonstrate that superior part processing can be accompanied by a lack of impairment in global processing. Evidence for the assumption that central coherence is a general capacity is also examined by reviewing evidence from studies testing difficulties in the visual and verbal domain at different levels of cognitive processing.

Chapter 2 Contextual and global processing: Evidence from typical and atypical populations

The claim of the weak central coherence theory of autism is that children have a distinctive cognitive profile. This profile includes superior featural processing together with impaired holistic processing. In Chapter 1 it was proposed that the concept of central coherence confounded two notions that refer to holistic processing, that of global processing and contextual processing. In this chapter the evidence in support of difficulties in contextual and global processing will be discussed separately, following the traditional approach of models of typical cognitive functioning and neuropsychological research. As Chapter 1 pointed out, existing research following weak central coherence theory has assumed that performance on visual and verbal tasks can be equated together. As it will be discussed later, evidence for difficulties in the visual domain is scarce and

contradictory. Evidence of contextual difficulties in both visual and verbal domains is therefore examined separately in this chapter.

2.1 Evidence of context processing

In this section the evidence for contextual difficulties in both the visual and verbal domains in autism will be discussed. Context is a very broad concept that includes many different notions. For instance, context can be defined as semantic information within a sentence, simply as semantic information of a word, a situation in which an utterance is produced, as the mutual knowledge that two speakers share about the world, as a visual scene, or the previous wealth of knowledge a person has about the world. It could therefore be argued that there are as many definitions of context as experimental paradigms and theories of context processing. It is very difficult, if not impossible, to empirically manipulate and control the knowledge a person has about the world, or how a person might interpret a situation, or the extent to which speakers are aware of a certain amount of shared knowledge. Thus, in the benefit of clarity, in this thesis 'context' will be operationalised as background knowledge elicited by means of exposure to either a word, sentence or picture. This specific information is provided in an experimental setting.

2.1.1 Evidence from language studies

Language and communication are good examples of the necessity of a central integrating component in the cognitive system. In interpreting utterances, we continually have to select the referent of words or choose the right meaning of polysemic words according to the context. Figures of speech like irony and metaphors are also highly dependent on context. Without the ability to integrate verbal information into meaningful representations, language would become a very difficult and complex task. Understanding language however, is a relatively effortless task as context is taken in to account almost automatically without the need to stop and analyse consciously what might be the referent of a certain pronoun or article.

Evidence in typical populations

There is extensive evidence in typical populations for the tendency to integrate information in its context in language processing. Ambiguous sentences for example tend to go unnoticed and misinterpretations are rare (Hoppe & Kess, 1986) demonstrating that the integration of incoming information is a relatively automatic process. The automaticity of integration processes has also been demonstrated in text processing, where it has been shown that participants tend to automatically integrate the ideas of different sentences and forget the actual sentences (Bransford & Franks, 1971).

A classical paradigm to study the effects of context in language processing is the semantic priming paradigm. In a typical semantic priming task, a word or sentence is presented prior to the presentation of another target word. In these tasks, the primes and targets can be either related or unrelated. Research has consistently shown that related prime words/sentences significantly facilitate word recognition (e.g., Meyer & Schvaneveldt, 1971; Becker, 1980). Priming tasks have also been used to study the role of context in semantic disambiguation. The presentation of a prime word related to one of the interpretations of an ambiguous word, facilitates that interpretation of the word and not the alternative (Simpson, 1984).

Several theories have attempted to account for context effects in language. These theories can be classed into two main categories. Those that postulate that lexical access is independent of other processes and hence independent from contextual influence, namely modular theories (Neely, 1991; Foster, 1989). These theories suggest that contextual information is accessed only after a word has been identified (i.e., post-lexical access). The second cluster of theories postulate that the presentation of a word automatically activates all words related to it, interactive theories. Examples of these latter theories are the automatic spreading model (Anderson, 1976; 1983; Posner & Snyder, 1975b) and the expectancy based priming theory (Becker, 1980; 1985). Empirical research has however provided evidence in support for both types of theories. Hence the debate concerning the precise nature of the influence of context in language processing is still open.

Evidence in autism

Unfortunately, these cognitive theories of language processing have not been applied specifically to the study of autism. The basis for Frith's (1989) suggestion that individuals with autism fail to process information in context came instead from the evidence described in the previous chapter. This evidence indicated a failure to use sentence context to facilitate recall in autism (Hermelin & O'Connor, 1967). Additional evidence of a failure to use sentence context in autism comes from a study by Frith and Snowling (1983) in which they presented sentences containing homograph words to children with autism and two comparison groups matched on reading age. Homograph words are words that have two different meanings and pronunciations (i.e., *bow*). The results showed that children with autism tended to give the more frequent pronunciation of the homographs regardless of the context in which they were presented whereas the control samples tended to give the context-appropriate pronunciation. In a second task, participants had to select a word out of three possible options to complete the missing word in a sentence. It was found that children with autism were less accurate than the comparison samples in selecting the appropriate word to complete the sentences. They did however choose words from the correct syntactic class. Frith and Snowling therefore argued that there is not a general language impairment in autism but that impairments are restricted to the use of semantic information. This was further confirmed by the results from other tasks investigating syntactic processing where children with autism performed as comparison samples (Frith & Snowling, 1983).

The results of the homographs task were later replicated in two studies by Happé (1997) and Jolliffe and Baron-Cohen (1999). Further evidence of difficulties in the use of sentence context to disambiguate information has been also found by use of an ambiguous sentences task in which individuals with autism fail to select the right interpretation of the ambiguous sentences according to context information (Jolliffe & Baron-Cohen, 1999).

Contextual difficulties in autism are not restricted to the use of sentence context. In a second experiment, Hermelin and O'Connor (1967) investigated if children with autism would have difficulties even when syntactic information was removed. They presented lists of unrelated words (i.e., bear, cup, pencil, brown, three) and a list of words containing two semantic categories (i.e., three, red, four, five, green, blue) to the same sample of children. They found that although both groups of children had similar recall rates for the two lists, the comparison group, and not children with autism tended to recall the words of the same semantic category together (i.e., three, four, five, red, green, blue). Thus they concluded that children with autism have difficulties not only with sentence processing but even at the more basic level of processing semantic category information.

This conclusion has been confirmed in a later study by Tager-Flusberg (1991). Tager-Flusberg presented two lists to children with autism and two comparison groups. One list contained words of the same semantic category (i.e., animals) and the second list contained semantically unrelated words. Results showed that whilst the recall rate was higher for the related than the unrelated list in

the two comparison groups, children with autism had similar recall rates for both lists. This finding, according to Tager-Flusberg reflects an inability to use semantic information to aid recall in autism.

In contrast, research has shown that the ability to process single word meaning is intact in autism. Frith and Snowling (1983) found that children with autism are as susceptible as typically developing children and children with dyslexia to the Stroop effect (i.e., they find it harder to name the colour of the ink, namely 'blue', when the word presented is 'red' than when presented with a string of Xs). Eskes, Bryson and McCormick (1990) also found normal interference effects in a Stroop task using concrete and abstract words. Thus Happé (2000) has suggested that individuals with autism can process single words for meaning but have greater difficulty making meaningful connections between words.

In summary the evidence suggests that the language difficulties experienced by individuals with autism are the result of a specific impairment related to the ability to integrate information in its context. This deficit is demonstrated by a failure to use semantic category information in memory tasks and failure to use sentence context to disambiguate homographs, select missing words in a sentence or facilitate recall.

It has been assumed that the contextual difficulties in autism are present in the visual and verbal domain (Frith, 1989; Happé, 2000), it would be therefore predicted that individuals with autism would fail to integrate not only verbal but also visual information in its context.

2.1.2 Evidence from visual studies

Evidence in typical populations

Research in visual perception in typical populations has demonstrated that visual information also tends to be integrated in its context. The evidence comes from a wide range of studies in which the influence of context is assessed by use of object identification or eye movement paradigms. These studies show that objects are better identified when presented in or after an appropriate contextual than when presented in or after inappropriate contextual scenes (e.g., Palmer, 1975; Biederman, Mezzanotte & Rabinowitz, 1982). Similarly eye movement studies have found shorter gaze for objects consistent with a visual contextual scene than for objects inconsistent with the visual scene (e.g., Friedman, 1979; Rayner & Pollatsek, 1992). These findings have been interpreted as demonstrating that the context in which an object is presented influences the accuracy, and speed of object identification.

Several models, based on the principles of the models of language processing, have been proposed to account for the influence of context in object processing. These models can be classed into two categories, models that propose that object identification is isolated from expectations derived from scene knowledge and models that propose that visual processing is influenced by expectations derived from scene knowledge.

An example of the first type of model is the functional isolation model that postulates that bottom-up visual analysis is sufficient to discriminate objects (Hollingworth & Henderson, 1998). Context effects, it is argued, occur because of later influences of scene constraint. The second type of model proposes that the presentation of a scene or object automatically activates information related to it. Examples of this type of model are the perceptual schema model (e.g., Boyce, Pollatsek, & Rayner, 1989; Metzger & Antes, 1983) and the priming model (e.g., Bar & Ullman, 1996). These models propose the memory representation of a scene type (a schema or frame) contains information about the objects and spatial relations between objects that form a type. The early activation of this schema facilitates the subsequent perceptual analysis of schema-consistent objects.

Evidence in autism

Very little research has been carried out to investigate the ability to process visual information in context in autism. Evidence for weak central coherence in the visual domain in autism has been drawn instead from studies investigating featural processing. It is however important to directly investigate if individuals with autism are able to process visual information in context. A failure to find an impairment in context or global processing in the visual domain would challenge the notion of a general impairment in autism related to weak central coherence.

A study by Pring and Hermelin (1993) suggests that, contrary to WCC theory, individuals with autism are able to use semantic visual information to aid

recall. In this study they presented two different sets of pictures. One set contained pictures of objects of the same semantic category (i.e., musical instruments). The second set contained pictures or objects with similar shapes (i.e., light bulb, pear...). They found that children with autism, like comparison samples, had higher recall rates for the semantic related set than the structurally related set. They argued that this finding indicated intact semantic processing of visual stimuli in autism. This result contrasts with findings showing a failure to use semantic information to aid recall in verbal tasks (Tager-Flusberg, 1991). This would suggest the presence of a domain specific difficulty in autism in the ability to use context.

A study by Jolliffe (1997) however has found evidence for abnormal context processing in the visual domain in autism. In this study participants had to choose which of the pictures in a set was incongruous with the rest (i.e., bucket, man, ladder, window, suitcase). In a second task, participants had to select what was the incongruous object on a contextual scene (i.e., a squirrel on a beach). High-functioning individuals with autism had difficulties in both tasks relative to control participants. Specifically, they had difficulties deciding which was the incongruous object.

It is difficult to explain the different results from the studies of Pring and Hermelin (1993) and Jolliffe (1997) regarding a deficit in autism to process visual information in context as the tasks used in both studies are very different in nature. The first study tests the ability to use semantic category to aid recall whilst the second investigates the ability to assess the appropriateness of an object in a

contextual scene. Further research using specific context tasks should be carried out to ascertain the presence of contextual difficulties in autism in the visual domain.

As argued earlier, evidence for weak central coherence in the visual domain has been mostly drawn from studies looking at part/whole processing. This evidence will be reviewed in the next two sections in relation first to evidence of superior part processing and second, to evidence of a specific global impairment.

2.2 Evidence of part/whole processing

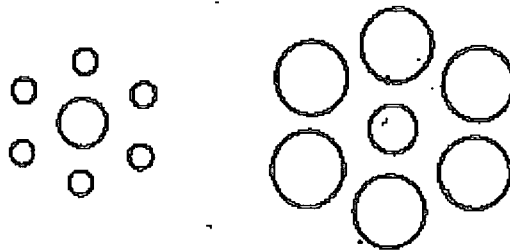
2.2.1 Evidence of attentional local bias in autism

Research in visual perception has provided evidence supporting the view that the cognitive system perceives the world hierarchically, that is, that the cognitive system tends to integrate parts into wholes. This proposal dates back to the early part of the last century when Gestalt psychologists proposed that perception of wholes is not the simple addition of its component parts (Koffka, 1935). Gestalt theorists argued that the cognitive system automatically integrates the different parts of a display into a global configuration. They proposed that although the system tends to integrate the parts automatically it is also possible, to perceive the separate parts.

Typical examples of automatic integration of parts into wholes are visual illusions. In these figures, the perception of the parts is biased by the global

configuration. For instance, in the Titchener circles (Figure 2.1 below), despite the two central circles being the same size, people tend to perceive the circle surrounded by small circles as bigger than the circle surrounded by big circles. When global information is removed however, people have not difficulty perceiving the circles as the same size.

Figure 2.1 Titchener visual illusion.



A test that has been also commonly used to test the claim that the cognitive system tends to automatically integrate parts into wholes is the Embedded Figures test. This test involves finding a hidden shape (i.e., triangle) among a larger meaningful drawing (i.e., a pram). The difficulty of this test for normal populations has been ascribed to the overwhelming 'predominance of the whole' (Gottschalldt, 1926). Hence, good performance in this test depends on the ability to focus on detail and ignore the global picture. Research in autism has demonstrated that children with autism are more accurate and faster than matched control children on the

Embedded Figures test (Shah & Frith, 1983). The fact that children with autism perform extremely well on this test has been taken as evidence of a local attentional bias.

Several studies carried out before Frith's proposal (1989) consistently showed that children with autism show a peak of performance in the Block Design test of the Weschler Intelligence Scales for Children (for a review see Happé, 1994). In this test subjects have to reconstruct a design by putting together individual blocks. In order to do so, participants have to be able to break up the line drawings of the design into parts. It has been argued that this test is measuring the same skill as the Embedded Figure test, that is, the ability to segment a picture into its parts and ignore the whole outline.

In a later study, Shah & Frith (1993) set out to investigate whether superior performance in this type of test by individuals with autism is due to a general superior spatial ability or a specific ability to segment wholes in parts. In their study, they not only presented the standard version of the test but they also made two spatial transformations (obliqueness and rotation) and introduced a condition in which they presented the design segmented into its parts. They predicted that if children with autism have general superior spatial ability, they would be superior not only in the standard condition but also in the spatial transformation conditions. In contrast, if superiority in this test is due to superior ability to segment a picture in its parts, they would be superior in the standard condition only, and the presentation of segmented designs would not enhance their performance to the same extent as in

typically developing children. Results showed that children with autism were superior only in the standard condition. Furthermore, the segmentation of the design significantly helped the control sample but not children with autism. This result confirms that the superior performance of children with autism in this task is the result of superior ability in segmenting objects into its parts and not general superior spatial abilities.

The empirical evidence reviewed so far has referred to visuo-spatial tasks with a certain degree of complexity. Originally, Frith (1989) had predicted that the integration difficulties in autism would lie at the more complex level. Happé (1996) however investigated the possibility that a local bias would also be present in autism at more basic levels of perception. To investigate this possibility she presented visual illusions such as the Titchener circles (Figure 2.1) to a sample of children with autism matched on verbal mental age with typically developing children and developmentally delayed children. She introduced a condition in which brightly coloured plastic strips were added over the original drawings. This variation was introduced to help children to segment out the parts of the picture relevant for the decision. She predicted that children with autism would not succumb as much as control groups to visual illusions because of their tendency to focus on parts of the objects. In addition it was predicted that providing brightly coloured strips would only help the control sample and not individuals with autism. Results showed that children with autism were less likely to succumb to the illusions. Furthermore, the control samples were significantly better at the segmented condition while children

with autism seemed not to be aided by this segmentation. These findings show that whereas control samples need an external aid to segment an object into its parts, children with autism seem to do it spontaneously. These results also seem to support the claim that autism is characterised by a local bias in autism even at low levels of perception, contrary to the claim made by Frith (1989) that weak central coherence would only be apparent in higher-level tasks.

Despite the initial success in finding evidence to support the claim of a local bias in autism, recent studies have failed to find evidence of superior performance in tasks such as the visual illusions or the Embedded Figures test (EFT). Two different studies have failed to replicate superior performance in the Embedded Figure test thus shedding doubt over Shah and Frith's findings and the existence of a local bias in autism. The first study by Brian and Bryson (1996) did not find any difference in performance in the Embedded Figure test between control samples and a sample of individuals with autism and pervasive developmental disorders (PDD). As the results of Brian and Bryson (1996) could be explained by sampling selection, because of the inclusion of participants with pervasive developmental disorders, Jolliffe and Baron-Cohen (1997) used a combined sample of people with autism as well as Aspergers syndrome. They predicted that in a sample of high functioning adults with a strict diagnosis of autism they would be able to replicate Shah and Frith's findings. Surprisingly, they also found like Brian and Bryson, that individuals with autism were not more accurate in the EFT test than the control samples. However, an analysis of the reaction times showed that autistic individuals

were actually faster at finding the embedded figures. Hence, although with a more subtle measurement, they concluded that their results supported, at least partially, Frith's claim.

A recent study by Ropar and Mitchell (1999) has also failed to replicate Happé's findings with visual illusions. They found that children with autism were as susceptible to visual illusions as the comparison samples. Thus, this study did not provide evidence of superior processing of parts. In a later study however, Ropar and Mitchell (2001) reported that performance on visual illusions is not related to performance to other visual tasks such as the EFT or Block Design. More importantly, the performance on each of the visual illusions did not correlate with performance in other illusions. It seems therefore that visual illusions are a unique type of stimuli and might not be the best way of testing local bias at low levels.

In summary, although there are some mixed findings, the weight of the evidence supports Frith's (1989) suggestion that autism is characterised by a local bias. Several studies find a peak of performance in the Block Design test (Lockyer & Rutter, 1970; Venter, Lord & Schopler, 1992). This peak has been confirmed to stem from an ability to segment pictures and not general superior spatial ability as demonstrated by two findings (Shah and Frith, 1993). Regarding the evidence from the Embedded Figures test, Brian and Bryson's (1996) failure to find superior performance in autism results can be explained by the nature of the sample used in the study. Jolliffe and Baron-Cohen's (1997) results have confirmed the original findings of Shah and Frith (1983) of superior performance of individuals with

autism in this test relative to comparison groups. The results from the visual illusions tasks in contrast have provided mixed evidence. However, this task examines low levels of integration which according to the original proposal (Frith, 1989) should be spared in autism. More importantly visual illusions seem to be a unique type of stimuli as performance in this task does not correlate with performance in other visuo-spatial tasks.

It has been assumed that the attentional local bias in autism is the result of an inability to perceive wholes (Happé, 1999; Happé, 2000). However, as discussed in the previous chapter, the presence of a local bias does not necessarily mean the existence of a global impairment. It is therefore of great importance for the definition of WCC to establish whether there is a global impairment in autism.

2.2.2 Evidence of global processing deficits in autism

Systematic research into part-whole perception started with a series of studies by Navon (1977). Navon designed a task in which stimulus patterns with local letters were nested within a global letter to test part-whole processing in normal populations (see Figure 2.2). The identity of the large and small letters could be the same (compatible condition) or be different (incompatible). He found that normal adults were faster at recognising large rather than small letters, a phenomenon he labelled as 'global advantage'. He also found that when participants were asked to report the identity of the small letter in the incompatible condition,

the identity of the large letter interfered, slowing down reaction times and leading to increased errors. However, when reporting the identity of the large letter, there were no interference effects from the smaller letters in the incompatible condition. This effect is referred to as the 'global interference effect'. Based on these results, Navon proposed the 'global precedence' model. According to this model, global information is processed faster and before local information. That is, the cognitive system first processes the outline of objects and it is only later, if necessary, that it processes local information.

Figure 2.2. Example of stimuli used in the Navon task in the compatible (a) and incompatible (b) conditions.

a)	H H H H H H H H H H H H H H H H H	b)	S S S S S S S S S S S S S S S S S
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Several studies have attempted to test global perception in autism by use of the Navon task. According to WCC theory, it would be predicted that the lack of a natural drive to process information globally in autism would result in a lack of 'global advantage' in the Navon task. That is, individuals with autism would not be

faster identifying the big letter rather than the small letters in the compatible condition. Secondly, if individuals with autism do not process global information faster and before local information, they would also fail to have 'global interference' effects in the incompatible condition, according to Navon model. As Frith (1989) proposes that autism is characterised by a local bias, a reversal of effects, that is 'local advantage' and 'local interference' effects, would therefore be expected in autism.

In 1993 Mottron and Belleville conducted the first of a series of studies exploring performance in the Navon task by individuals with autism. In this first study they administered the Navon task to a savant draughtsman with autism. Contrary to expectations, it was found that the autistic draughtsman presented a global bias (i.e. he was faster and more accurate when identifying the large letter than small letters). However, in the incompatible condition, unlike the comparison group, he did not show a global interference effect. In fact, he did not show any preference for either level in this condition.

As a result of these findings, Mottron and Belleville (1993) proposed an alternative theory: the hierarchisation theory. According to this theory, people with autism do not have any advantage for either local or global levels of processing. What Mottron proposes is that impairments in information processing are related to the interaction between the local and global levels and not to a preference of part over whole processing.

Another study by Ozonoff, Strayer, McMahon and Filloux (1994) however showed evidence for neither WCC theory nor the hierarchisation theory. They administered the Navon task to a sample of high functioning adolescents with autism. The results showed that there were no differences in the way people with autism processed local and global levels in relation to the control samples. Like the control sample, the autistic sample had global advantage and global interference effects. These findings did not confirm either weak central coherence predictions of a local bias and local interference effect nor Mottron's predictions of global bias but no interference effects. Results suggested that, on the contrary and at least in relation to this task, people with autism do not differ in terms of global/local processing from comparison samples.

Jolliffe and Baron-Cohen (1997) suggested that a difference in the methodology used in these two studies could explain the contradictory results. According to them 'Ozonoff et al. failed to replicate Mottron et al. findings, but this was probably because they used an exposure time far too long to bring out this subtle effect'. Jolliffe and Baron-Cohen argued that local/global bias effects are too subtle to be detected, at least by this task, by long exposure times. Therefore it seems that the exposure times used in the study by Ozonoff et al. were too long to detect any difference between the autistic and comparison samples.

Plaisted, Swettenham and Rees (1999) however proposed a theoretically more interesting alternative explanation of these contradictions. In Ozonoff's study they used what it is known as the *selective attention procedure*. That is, participants

are asked to concentrate on only one level at a time (i.e. decide whether the small or the large letter was an 'H' or a 'S'). On the other hand, in Mottron study, participants had to find a specific letter ('H' or 'S') in either the local or global level. This is known as the *divided attention procedure* because participants have to attend to both levels at the same time. They argued that this difference in methodology could be the explanation for the contradictory results.

In this study, Plaisted et al. (1999) tested both procedures in the same sample using the long exposure times used by Ozonoff et al. (1994). Results confirmed that for Ozonoff's procedure adults with autism responded faster to larger rather than small letters (i.e. global advantage) and when the identity of the letters differed, the larger letter slowed down the response time to the small letter (i.e. global interference) but the small letters did not interfere with the processing of the large letter. With Mottron's procedure however, adults with autism presented the opposite pattern, they responded faster to small letters (i.e. local advantage) and the identity of the small letters slowed down reaction times for the larger letter (i.e. local interference).

Plaisted et al. (1999) argued that this was confirmation of weak central coherence in autism. In particular they argued that global processing is intact in autism but that it only operates when cues are provided to focus the attention on one level only. They suggest that inhibitory mechanisms that operate upon the local information do not operate automatically in autism but must be primed. However,

this explanation does not explain why when directing attention to the local level participants, still had global advantage and interference effects.

In summary, there is mixed evidence regarding the Navon task. Whilst Mottron et al. (1993) found global advantage but no interference effects, Plaisted et al.'s study could not replicate these findings and found instead a local bias and local interference as predicted by WCC theory. Using the selective attention task however Plaisted et al. replicated Ozonoff et al. findings of typical global bias and interference effects.

To further complicate the picture, a very recent study by Mottron et al. (1999) using the divided attention procedure (i.e. attention not being focused in either local or global level) found global advantage and global interference effects in a sample of children and adolescents with autism. These findings contradict Plaisted et al. (1999) results showing local advantage and local interference effects using the divided attention procedure. They also contradict their own earlier study that showed no interference effects. Furthermore, they did not find global advantage in the control sample!

There is reason to believe that the Navon task is not a reliable procedure to test global and local processing. Lamb and Robertson (1989) have found evidence that global advantage and interference effects are 'by no means universal'. Changes in factors such as discriminability, sparsity, size or brightness can reduce or even reverse the effects. Therefore, it is difficult to reach a conclusion regarding the

results on the Navon task because it is unlikely that all the studies employed stimuli that were equivalent in all these features.

The only study using the Navon task that seems to reach a reliable conclusion is that of Plaisted et al. (1999). They used exactly the same stimuli and time exposure but two different procedures and found differences in performance. Therefore, it is reasonable to conclude that there is something about the nature of the procedure that affects whether stimuli are processed globally or not. One clear difference between both versions is that in the selective attention procedure participants are overtly primed by the instruction to attend at only one level. They conclude that 'global processing is intact in autism...but operates only under conditions of overt priming'. It is interesting to note that even when they are cued to attend to the local level, they still show global advantage and preference. An important implication of this study therefore is that the provision of external cues to attend to only one level enhances normal global processing, regardless of whether the cue is to attend to the local or global level.

In addition to the methodological problems inherent to the Navon task, there are also theoretical issues of concern. In particular, recent research has shed doubt over the model of global precedence postulated by Navon (1977). Navon argued that the explanation to the global interference effect is that the global level is processed faster and before the local level. Therefore the model predicts that global interference effects are necessarily a consequence of a global advantage (i.e. faster processing of global levels).

In contrast, research in neuropsychology using brain-damaged patients has shown that these two effects are independent (Lamb & Robertson, 1989; Lamb Robertson & Knight, 1990). Some patients show a local advantage (i.e., they process faster the small letter), but still exhibit global interference effects, that is, in the incompatible condition, the processing of the big letter slows down response times to the small local letter. Thus, according to these results, the global interference effect is not due to the global level being processed faster and before the local level. Robertson and Lamb (1991) propose that there are three separate mechanisms, one that processes global information, one that is in charge of processing local information and an independent mechanism that integrates the information of the two levels. They argue that the three mechanisms can be selectively impaired and that integration deficits can co-exist with either normal global bias or local bias.

This insight into the processing of parts and wholes might have important implications for weak central coherence theory. It has been assumed that the presence of a local bias in autism is a consequence of a global impairment. Most of the evidence in which Frith based the suggestion of a global impairment in autism came from studies using the Block Design, Embedded Figures test and clinical observations of good featural processing. These studies however show that children with autism are good at processing parts not that they have difficulty processing the whole. According to Navon 'global precedence' model, the presence of a local bias would imply a deficit in global processing. However, according to Lamb and

Robertson's (1991) model, a local bias can co-exist with normal global interference, hence the issue is no longer as simple as first thought. Studies using the Navon task have failed to give reliable evidence to either confirm or refute the claim of a global impairment in autism. It is therefore of the most importance to directly examine the extent to which children with autism are able to process visual arrays globally.

2.3 Conclusions

The first chapter identified several problematic aspects of the definition of central coherence. The first problem concerned the confounding of two different notions of central coherence, the notion of global processing and the notion of contextual processing. Context is usually operationalised as the background information, either of a sentence, word or picture provided in an experimental setting. Global processing, in contrast, refers to the ability to extract holistic properties of a visual pattern. Weak central coherence theory makes the claim that both global processing and the ability to process information in context are impaired in autism. As there is no evidence that these two abilities are one and the same thing however, evidence for each ability was reviewed separately.

The literature review for contextual difficulties in autism revealed that individuals with autism have difficulty processing information in context, at least in the verbal domain. Children with autism have difficulty with the use of verbal context as shown by the failure to use sentence context to disambiguate homographs

(Frith & Snowling, 1983; Happé, 1997), and the failure to use information about sentences to facilitate recall (Hermelin & O'Connor, 1967). There is even failure to use semantic category information to aid recall (Tager-Flusberg, 1991).

Evidence for a global impairment in autism comes from studies investigating the ability to process parts of visual patterns. Several studies have demonstrated superior performance of part processing in autism (Shah & Frith, 1983; 1993; Jolliffe & Baron-Cohen, 1999). These findings have been taken as evidence for an inability to process patterns of stimuli globally and thus weak central coherence. However, good featural processing does not directly demonstrate that there is a global impairment in autism. Most of the evidence for a global impairment in autism comes from studies using the Navon task. The evidence from these studies is contradictory, whilst some studies find typical global processing (Ozonoff et al., 1994), other studies find that individuals with autism have a tendency to process parts over wholes (Mottron & Belleville, 1993). The problem with the evidence drawn from the studies using the Navon task, is that this task has been shown to be very susceptible to small changes in procedure so no conclusions can be made from these studies. No definite conclusions can therefore be drawn about the presence of a global impairment in autism.

The second problem concerned the issue of domain and level of processing. It has been assumed that central coherence is a general component of the cognitive system and thus if impaired all areas of cognition will be affected. However, the literature review revealed that evidence of contextual difficulties in the visual

domain is scarce and contradictory. Whilst one study shows that individuals with autism are able to use semantic information (Pring & Hermelin, 1993) another study shows difficulties in selecting the incongruous object in a set or visual contextual scene (Jolliffe, 1997). Hence, the assumption that there is a general impairment regarding context processing in autism needs further confirmation.

The literature review also revealed that research to date has also failed to define the specific level of cognitive processing at which difficulties in autism arise. Evidence suggests that in verbal contextual tasks, the difficulty lies in making meaningful connections between words (Tager-Flusberg, 1991; Hermelin & O'Connor, 1976). In visual contextual tasks however, children with autism seem to be able to make connections between objects in terms of semantic category information (Pring & Hermelin, 1993). The attempts to establish if there are difficulties at low levels of perception have provided mixed evidence. However, although there is some evidence for failure at low levels (Happé, 1996) the evidence seems to indicate that central coherence as operationalised in terms of global processing, is intact at low levels of perception (Ropar & Mitchell, 1999).

Demonstrating intact abilities in autism to process visual patterns of stimuli globally would seriously damage the notion of WCC in autism, especially if no evidence was found either of an impairment in the use of visual context information. It has been assumed that the tendency to draw information together is a general property of the cognitive system that if impaired will affect performance in all areas of cognition, such as verbal or visual processing. If individuals with autism had an

impairment restricted to the verbal domain, the notion of central coherence would have to be redefined in terms of a specific language impairment. Having weak central coherence in one domain only would imply that integration mechanisms could be selectively impaired.

The aim of the experiments reported in the next two chapters was to investigate the difficulty in using visual (Experiment 1 and 2) and verbal (Experiment 3) context to facilitate object and word identification. Performance on these tasks was compared to performance in two tasks traditionally used to evaluate weak central coherence in autism, the semantic memory task (Tager-Flusberg, 1991; Experiment 4) and the homographs task (Happé, 1997; Experiment 5). Experiments 6, 7, 8 and 9 investigated possible explanations for the failure of children with autism to use sentence context information (Experiment 5). As the series of experiments testing ability to use context demonstrated only a very specific rather than a general impairment in contextual processing the final experiment tested the ability to use global processing in a new task designed to test the ability to extract holistic properties from a visual pattern, (Experiment 9). These experiments are reported in chapters 3 to 8.

Before presenting these studies I include a note about methodology. In research investigating weak central coherence theory, there is a tendency to develop diverse new paradigms instead of using well-established paradigms drawn from the study of cognitive psychology. In this thesis I attempt to follow existing cognitive models of perception and use established paradigms in order to be able to compare

performance of children with autism with norm data from non-autistic populations and avoid the difficulties of interpretation that arise from studies using new developed paradigms. Thus the majority of empirical studies reported in this thesis were based on paradigms already established with non-autistic populations except with the exceptions of Experiment 4 and 5 which used traditional tasks from research within the WCC account.

Chapter 3 Can children with autism use visual context information to facilitate object identification?

It has been claimed that 'individuals with autism fail to integrate information in its context' (Frith, 1989). Although there is wide evidence for an impairment in the verbal domain regarding the ability to process information in context, the evidence from visual tasks is still not clearly established. A new method was therefore devised to examine the ability of children with autism to use visual context information to facilitate object identification. This new visual context task was based on a paradigm developed by Palmer (1975). Two empirical studies are reported in this chapter. The first study tested the modified visual context task in a non-autistic population of adults. In the second study the modified task was administered to children with autism and typically developing children to examine their ability to use visual context information to facilitate object identification.

Since Frith's (1989) original claim that people with autism lack a natural drive towards central coherence there has been increasing interest in this proposal as an explanation for the perceptual and cognitive difficulties of people with autism. A key contribution of the proposal is the claim that individuals have a unique profile of perceptual and cognitive abilities in which superiority in processing of local, featural information is contrasted with inferiority in processing global and context information. Evidence for this pattern has been examined with respect to low-level visual processing (Ropar & Mitchell, 1999; Happé, 1996; Plaisted, Swettenham & Rees, 1999), high level visuo-spatial processing (Shah & Frith, 1983; 1993; Brian & Bryson, 1996), semantic memory (Tager-Flusberg, 1991) and sentence processing (Hermelin & O'Connor, 1967; Happé, 1997; Jolliffe & Baron-Cohen, 1999).

The weak central coherence account of autism is wide ranging in its scope of application, yet the empirical evidence for this proposal is still not clearly established. On the one hand there is considerable evidence to support the claim that children with autism have enhanced ability to discriminate features (Shah & Frith, 1983,1993). On the other hand there are contradictory findings as to whether this ability occurs alongside impairment in global processing. Some studies do show evidence of deficits in the ability to process global information (Hermelin & O'Connor, 1967; Frith & Snowling, 1983; Happé, 1997; Jolliffe & Baron-Cohen, 1999), whereas other studies show no differences between individuals with autism and non-autistic populations in global tasks (Ropar & Mitchell, 1999; Brian & Bryson, 1996; Plaisted, Swettenham & Rees, 1998; Pring & Hermelin, 1993; Ramondo & Milech, 1984).

These contradictory findings may be best understood by examining the way that global processing has been conceptualised across different perceptual and cognitive tasks. The impairment in global processing has been interpreted both in terms of a conceptual semantic deficit, or context deficit, and in terms of a failure to extract holistic perceptual properties as demonstrated by studies of visuo-spatial processing. Evidence that specifically relates to the failure in using context information rests almost exclusively with studies of verbal processing. For example individuals show impairments in the recall of semantically related words (Tager-Flusberg, 1991; Hermelin & O'Connor, 1967). They are also impaired in the use of context information when reading homographs in a sentence processing task (Frith & Snowling, 1983; Jolliffe & Baron-Cohen, 1999). The results of these studies are considered to demonstrate impairment in the ability to 'integrate information in context', due to difficulties in forming meaningful connections between different items (Happé, 2000). On the other hand evidence for a deficit in the ability to extract holistic properties of visual patterns of stimuli is contradictory. Whilst some studies provide evidence for a global impairment (Mottron & Belleville, 1993; Plaisted, Swettenham & Rees, 1999), other studies have provided evidence of intact global processing abilities in autism (Ozonoff, Strayer, McMahon & Filloux, 1994).

It is well known clinically that individuals with autism have superior non-verbal skills relative to verbal skills. An obvious question, given that global processing difficulties have been demonstrated mostly in verbal tasks, is whether the global impairment proposed by the weak central coherence explanation is simply a reflection of difficulties in processing complex verbal stimuli rather

than a general difficulty in global processing. The next section presents a review of the evidence for an impairment in the ability to use visual context information.

3.1 Use of context in visual processing tasks

Happé (2000) has argued that in visual tasks 'people with autism can process single objects for meaning but have greater difficulty making meaningful connections between objects' (p. 210). The evidence for the suggestion of intact processing at single object level, she argues, comes from two studies looking at visual processing in autism. The first study by Ameli, Courchesne, Lincoln and Grillon (1988) reports that adults with autism have better recall rates for meaningful objects than for abstract shapes. The second study reports two different experiments (Pring & Hermelin, 1993). In one experiment, children were presented with sets of pictures. Some sets contained pictures of objects of the same semantic category (i.e. musical instruments) and other sets contained pictures of objects with similar shapes (i.e. pear, light bulb). It was found that children with autism, as with the control sample, tended to remember better the objects from the semantically related set than the objects from the structurally similar set. In a second experiment, Pring and Hermelin, presented children with sets of three pictures (i.e., wineglass, bottle and tulip). The pictures could be sorted by either structural similarity (i.e., wineglass with tulip) or by semantic category (i.e., bottle with wineglass). They found that children with autism, as with the control sample, also tended to pair together

pictures of objects on the basis of semantic information rather than on the basis of the shape (i.e., they paired the bottle with the wineglass and not with the wineglass with the tulip). In an unpublished study Ropar (2000) has further confirmed that individuals with autism tend to pair objects on the basis of semantic information.

Happé (2000) has suggested that these experiments provide evidence of intact processing at single object level. There are two problems however with this interpretation. The first problem is that the tasks used by Pring and Hermelin require the ability to connect objects on the basis of semantic information, that is the tasks are not evaluating single object processing but integration processes (i.e., integration on the basis of semantic relations). Hence, Pring and Hermelin's findings cannot be taken as evidence for intact single object processing but rather as evidence of intact semantic processing in autism.

Second, Tager-Flusberg's (1991) semantic memory task described earlier, also requires the ability to connect stimuli, in this case words, on the basis of semantic relations. Hence, it would be expected that children would show either difficulty or competence in both Pring and Hermelin and Tager-Flusberg tasks. Specifically, whilst the Pring and Hermelin study using a visual task found that children with autism are able to use semantic information of objects to aid recall, Tager-Flusberg has found an impairment in the use of semantic information of words to aid recall in a verbal semantic memory task. These results would suggest that there is a discrepancy in the ability to connect items of information between the visual and verbal domain in autism.

In contrast, Jolliffe (1997) has found that individuals with autism are poor at spotting the incongruous object in a scene (i.e. a squirrel on a beach). In the same study she found that individuals with autism were also poor at selecting which objects should go together to form a coherent scene (i.e., a man, a bucket, a window, a ladder and a suitcase).

Based on this evidence, Happé (2000) has suggested that individuals with autism ‘...have greater difficulty making meaningful connections between objects’. As discussed above, the study by Pring and Hermelin also examined the ability to make meaningful connections between objects and have failed to find difficulties in autism.

3.2 Developing a new method to test the use of contextual information

The aim of this study was to investigate further the ability of children with autism to integrate and use visual contextual information. To do this a different methodology was required in order to test the extent to which individuals with autism make use of visual contextual information. Pring and Hermelin’s (1993) study examined only the ability to connect objects on the basis of semantic information and not the ability to use visual context information as such. Jolliffe’s study on the other hand, examined the ability to identify an incongruous object and not directly the ability to use visual contextual information. Therefore to investigate directly the extent to which

children with autism may use visual contextual information we looked for an alternative methodology that would allow a direct comparison between the performance of children when context was provided and in the absence of context. An additional aim was to find a task that would be easily adapted to a verbal format to compare performance in the visual and verbal domains.

The literature review revealed several paradigms that have been developed to test the extent to which the provision or absence of context information influences object identification in non-autistic adult populations. The advantage of these paradigms is that they provide an exact measure of the extent to which visual context information facilitates object identification. Thus these paradigms would allow the investigation of the extent to which children with autism are able to use visual context to improve performance, in this case, facilitate object identification.

Research investigating the influence of visual contextual information on perception started with a pioneering study devised by Palmer in 1975 to investigate the effect of visual context on object identification. The method used by Palmer was originally inspired by studies of language processing showing that words are easier to identify when presented after appropriate contexts and more difficult when presented after inappropriate contexts (Tulving & Gold, 1963). Palmer argued that visual perception processes would be similar to language processing and thus predicted that object identification would be facilitated by appropriate contextual scenes and hindered by inappropriate contextual scenes.

In order to test these two hypotheses, Palmer developed a paradigm in which visual contextual scenes (i.e. the picture of a kitchen) were presented for 2 sec. These contextual scenes were followed by the brief presentation (20, 40, 60 or 120 msec.) of an object. The object could be either likely to appear in that scene in everyday life (i.e. toaster) or unlikely to appear in that scene (i.e. drum). As a control condition Palmer presented the same objects preceded by a neutral visual scene, which consisted of a black frame. Thus there were three conditions: appropriate, neutral and inappropriate contextual scenes.

Participants had to both name the objects and fill in a 5-point rating scale stating how confident they were in their responses. Results showed that, as expected, contextual scenes influenced the accuracy and confidence of object identification. Unfortunately, although a main effect of context is reported, Palmer did not report the pair-wise comparisons to confirm specifically the hypotheses that appropriate contextual scenes facilitate identification and inappropriate scenes hinder identification of objects.

This pioneering research was followed by a series of studies trying to determine which specific mechanisms facilitate the influence of contextual scenes in object identification. These studies have confirmed Palmer's prediction that appropriate contextual scenes facilitate object identification (Biederman, Mezzanote & Rabinowitz, 1982; Boyce & Pollatsek, 1992; Hollingworth & Henderson). In a comprehensive literature review, Henderson and Hollingworth (1999) conclude that 'there is sufficient converging evidence to support the general conclusion that consistent scene context facilitates the identification of objects'. The evidence that inappropriate visual contextual information also

interferes with object identification is less clear. In contrast to the evidence for verbal contextual information, empirical evidence for the presence of interference effects in visual context tasks has been contradictory. Although most of the studies find a trend suggesting a negative effect of inappropriate scenes on object identification, this trend fails to yield significance in most cases (e.g., Boyce, Pollatsek & Rayner, 1989). Most importantly, neither of the current theories accounting for the influence of context in object identification would predict the presence of interference effects in object identification tasks. These theories assume that the presentation of contextual scenes activates objects related to the scene (Biederman, 1981; Friedman, 1979). These theories however do not propose that the presentation of contextual scenes inhibits the activation of objects unrelated to that contextual scene.

Although Palmer's paradigm offered a technique to test children's use of visual contextual information, it was not the only paradigm that was potentially suitable. One of the most common paradigms used to examine context influence in object identification is the object detection paradigm (Biederman et al, 1982). In this paradigm a word (i.e., 'mixer' or 'chicken') is presented prior to a contextual scene which contains the target object (i.e., a mixer in inappropriate trials or chicken in appropriate trials). It has been repeatedly found that participants are faster at detecting the target objects when they are presented in appropriate than in inappropriate contextual scenes. The adequacy of this paradigm to evaluate contextual influence has been recently challenged (Hollingworth & Henderson, 1998). One of the major concerns is that in this paradigm the word labelling the object may automatically generate expectancies

of the kind of contextual scene (i.e., for the mixer, a kitchen). Slow reaction times in inappropriate trials therefore might be the result of the expectancy drawn from the word and not from the expectancies drawn from a visual context. Thus, Hollingworth and Henderson (1998) argue that this paradigm is not testing how visual contextual scenes might affect object but the effects of verbal primes on object identification.

Another common research method is the recording of eye movements. In this type of paradigm participants are instructed to memorise visual scenes. It is assumed that the amount of time the participant focuses on each object when memorising a visual scene reflects the amount of time necessary to identify the objects. It has been found that participants focus less time on appropriate than inappropriate objects. Thus it has been argued that appropriate contextual scenes facilitate object identification. Hollingworth and Henderson (1998) have argued however that the amount of time the participant focuses on the object might reflect the time taken for the participant to memorise an object and not the time taken to identify the object. In addition, the recording of eye movements in children, especially children with autism may be problematic. Due to the methodological problems of the paradigms mentioned above, in this study Palmer's (1975) original paradigm was used to assess children's sensitivity to visual context information.

Palmer's paradigm had not previously been used with children. In order to adapt the task for the use of children, and in particular children with autism, three major changes were needed. First, participants in Palmer's study had to name the object and also rate how confident they were of their response in a

five-point rating scale. It was felt that children with autism could have difficulty understanding how to fill in a confidence rating scale. To obtain a more objective dependent measure, it was decided to rely instead on reaction time measures. Many other studies using other types of paradigms have used this measure successfully (e.g., Biederman, 1972; Boyce, Pollatsek & Rayner, 1989; Boyce & Pollatsek, 1992) but this response measure has not previously been applied to the Palmer procedure. In addition to the recording of accuracy measures therefore, a voicekey attached to the computer was employed to measure the time from the onset of the object to the participant's response.

Palmer presented the target objects for very short times of either 20, 40, 60 or 120 msec. A study by Teunisse (1996) revealed that children with autism have difficulty recognising visual stimuli presented for less than 1000 msec. As reaction times were to be recorded, the objects were presented instead for a maximum of 3000 msec., or until participants responded.

Finally, Palmer used a between-participants design. Due to restrictions in the access to participants with autism it was necessary to use a repeated-measures design. The main advantage of using a between-participants design is that the same object can be paired with different contextual scene and thus it is possible to test the differential effects of each type of contextual scenes in the same object. Using a within-participants design on the other hand, may be problematic as the repeated presentation of the same object, each time paired with a different contextual scene, may influence participants' responses. To avoid the effects of repeated presentation of the same objects, a new complete set of stimuli was therefore created by selecting sets of triplets of objects

matched in terms of complexity and familiarity. Once these triplets were created, each object of the triplet was randomly assigned to a condition to ensure that any difference between contextual conditions might not be explained by differences in the complexity or familiarity of the different objects. Given the changes in procedure, it was necessary to first test the new task with a group of non autistic adults.

3.3 Testing the modified visual context task with non-autistic adults

EXPERIMENT 1

In order to test if the adaptation of Palmer's procedure in response measure, design and stimulus presentation were successful, the new procedure was first tested with a group of typical adults before giving the task to children with autism. It was predicted that, as found by Palmer using accuracy measures, appropriate visual contextual scenes would facilitate object identification. Specifically it was predicted that adults would identify faster and more accurately objects that were preceded by appropriate contextual scenes. On the basis of previous research, no interference effects of inappropriate contextual scenes were predicted.

Participants

The participants were seventeen undergraduate students of the University of Kent.

Design

The experiment had a repeated measures design. The within-subject factor was the type of context that preceded each object: *Appropriate context* (A), *Neutral* (N), and *Inappropriate context* (I). The dependent variable was the time taken to name the objects and the accuracy of the responses.

Materials and apparatus

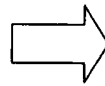
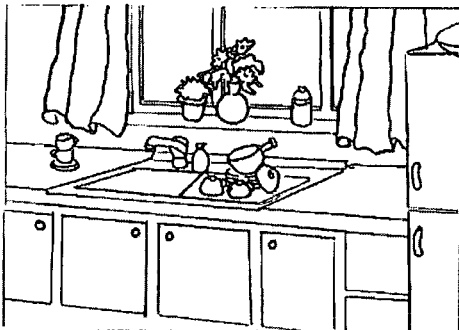
Eight triplets of objects were selected from the standardised set of pictures created by Snodgrass and Vanderwart (1980). Within each triplet, the objects were matched on familiarity, complexity and image agreement to ensure that any differences in reaction times between conditions were due to the effects of the contextual scenes and not to differences in the characteristics of the objects. Once the triplets were constructed, the objects were assigned randomly to one of the three conditions so that each of the objects in one condition had a match in the other two conditions.

Each object was then paired to a contextual scene. For the *appropriate context condition*, 8 objects were paired with visual scenes in which the object would be very likely to appear in everyday life (i.e. Kitchen-Jug). For the *inappropriate condition*, eight objects were paired with visual scenes in which the object would not be likely to appear in everyday life (i.e. Office-Lemon).

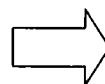
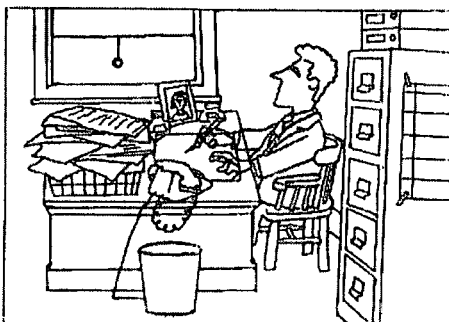
The remaining eight objects were paired to the same neutral scene, *neutral condition*. Thus in total the experiment consisted of 24 trials. Neutral contextual scenes as in Palmer's original design consisted of a black rectangular frame only (14 x 10 cm.). The contextual scenes were selected from children's books or drawn by the experimenter (see Figure 3.1 for examples of contextual scenes and objects).

Figure 3.1. Examples of contextual scenes and objects used in the visual context task.

Appropriate Condition:



Inappropriate Condition:



The objects and contextual scenes were black drawings over a white background. All the scenes were drawn within a black rectangular frame of 14cm x 10cm. Contextual visual scenes did not contain the target object.

Reaction times were measured from the presentation of each object to the acoustic onset of the participant's verbal response by means of a voicekey attached to the computer. All stimuli were presented in a Macintosh Computer and the experiment was run using Superlab software.

Procedure

Participants were tested individually in a quiet room at the University. Each participant was given 24 trials composed of the same sequence as in Palmer's original study except for the change in the time exposure of the target object that was 3000 msec. instead of 20, 40, 60 or 120 msec. The sequence thus was as follows: a) presentation of the contextual scene for 2000 msec.; b) a delay of 1300 msec. and c) the presentation of the target object for a maximum of 3000 msec., or until the student responded. Unlike Palmer's procedure, participants were not informed of the existence of the three different conditions or the nature of the experiment. The trials were presented in a random order. Participants were instructed to name only the objects and not the contextual scenes.

Results

Scoring criteria

Responses were scored as correct if the most common name for the object or a synonym was given. Those responses that were not correct (i.e.

'apple' for 'strawberry') or referred to a higher semantic category (i.e. 'fruit' for 'strawberry') were scored as incorrect, and therefore excluded from the data.

Accuracy Data

It was not possible to analyse error data as overall performance was at ceiling. Ten participants made no errors, three participants made one, two participants made two and another two made three errors. Of these, three were of objects in the appropriate condition, three in the neutral condition and seven in the inappropriate condition.

Analysis of RT Data

All correct trials were included in the analysis. The mean reaction times for each condition are summarised in Table 3.1.

Table 3.1. Mean reaction times and standard deviations across conditions in Experiment 1.

		Appropriate	Neutral	Inappropriate
RT	Mean	842.09	959.75	1015.98
	SD	151.47	191.09	210.24

A one-way ANOVA on the mean RT scores revealed a significant main effect of context ($F(2,32) = 14.477$, $p = .001$), indicating that participants were faster at identifying objects when these were presented after an appropriate context than when presented after an inappropriate context ($t(16) = -5.76$,

$p=.001$) or a neutral context ($t(16)=-4.70, p=.001$). The difference between inappropriate and neutral context was not significant ($t(16)=-1.353, p=.195$).

Discussion

The aim of the present study was to ensure that the adapted visual context task based on Palmer's original paradigm was suitable to test contextual influence in object identification. If this task was suitable for the assessment of contextual influence, it would be predicted that appropriate contextual scenes would facilitate object identification.

The results of the present study confirmed that appropriate contextual scenes facilitate object identification, and it can thus be assumed that the adaptation of the task was successful. As predicted, participants were faster at identifying objects after the presentation of appropriate contextual scenes than after inappropriate or neutral contextual scenes.

An additional aim of the study was to investigate the sensitivity of the new measure of reaction time. This was necessary since this measure has not been used previously with Palmer's paradigm. The analysis of the reaction time data showed a significant main effect of context and significant facilitation effects of context thus confirming that the effects of contextual scenes on object identification can be measured with reaction times using this paradigm. In fact, this was the only measure that could be used in the statistical analysis due to ceiling effects in terms of accuracy. The ceiling effects in this study are likely to

be explained by the extended exposure times. Whilst Palmer presented the objects for either 20, 40, 60 or 120 msec., in this study objects were presented for a maximum of 3000 msec. so participants had more time to identify the objects.

In relation to Palmer's prediction that inappropriate visual contextual scenes may hinder recognition, neither this study nor previous research have found evidence to support the claim (Boyce et al, 1982). Existing theories such as the perceptual schema model (Biederman, 1981), or the priming model (Friedman, 1979) explaining the influence of context on object identification, suggest that the presentation of contextual scenes primes the stored representations of schema-consistent object types, thus facilitating the identification of objects. This activation however does not interfere, at least to the same extent, with the identification of inconsistent objects, and thus inappropriate contextual scenes do not produce interference effects. A closer look at the mean reaction times suggests that inappropriate contextual scenes interfere to some extent with object identification as the mean reaction times for the inappropriate condition were higher than for the neutral/control condition. This study employed a quite small sample ($n=17$) and thus it is possible that with a larger sample this difference would become significant. Regardless of this possibility, the results showed that facilitation effects are larger than interference effects, thus providing further evidence for these two theories of object identification.

The purpose of this study was to confirm that the adaptation of Palmer's task could be used to measure the influence of context on object identification.

The results confirmed that the new method was successful as appropriate contextual scenes facilitated object identification. This task was therefore regarded as suitable for the evaluation of children's sensitivity to contextual visual information.

3.4 Are typically developing children and children with autism sensitive to visual context?

EXPERIMENT 2

In the present experiment a sample of children with autism and a comparison sample of typically developing children were tested using the revised context task methodology to investigate the extent to which children with autism make use of contextual visual information. Although Palmer's paradigm has not previously been used with children, there is evidence that prior presentation of pictures of related objects facilitate object identification in children as young as six years of age (McCauley, Weil & Sperber, 1976). McCauley et al. presented a picture naming task to six and eight year olds in which objects to be named were preceded by either related or unrelated objects. For instance, the picture of a hat was preceded by either a coat (related) or a butterfly (unrelated). They found that both groups of children were faster naming the objects that were preceded by related objects than those preceded by unrelated objects.

It was therefore predicted that the typically developing children would be sensitive to contextual visual information. That is, they would be faster and more accurate identifying objects after appropriate contextual scenes than after neutral or inappropriate contextual scenes.

In relation to autism, it was predicted that, if children with autism have weak central coherence, they would fail to use visual contextual information to facilitate object identification. An interaction between group and context was therefore expected, with typically developing children showing greater accuracy and speed in naming objects than children with autism after appropriate contextual scenes were presented.

Method

Participants

Fifteen high functioning adolescents with autism (AD: 1 girl, 14 boys) took part in the study. Thirteen children were recruited from a range of special schools in Kent, England. The remaining two children had taken part in a previous project, thus their parents were contacted directly. All had received a diagnosis of autism by experienced clinicians using the guidelines of standard criteria as DSM-III, DSM III-R (APA, 1987), or ICD-10. The children were matched to a sample of sixteen typically developing children (TD: 5 girls and 11 boys) on the basis of chronological age (CA). Participants' IQs were measured using four subtests of the Weschler Intelligence Scale for Children - Revised (WISC-R; Weschler, 1974; Information, Vocabulary, Block Design and Object

Assembly). Following Ozonoff et al (1994), these four subtests were chosen because they load most highly on the verbal comprehension and perceptual organisation factors of the WISC-III-R (Weschler, 1974). Participants' characteristics are summarised in Table 3.2 below.

Table 3.2. Mean chronological age (CA), verbal IQ (VIQ), performance IQ (PIQ) and full score IQ (FIQ) of participants across groups.

N	Group		CA	VIQ	PIQ	FIQ
16	TD	Mean	14:4	94.12	102.87	98.75
		SD	0:10	19.31	18.25	16.20
15	AD	Mean	13:10	83.53	93.80	87.13
		SD	2:4	28.11	20.64	24.93

Neither CA, FIQ, VIQ nor PIQ were significantly different in the two groups ($t(29) = .859, p = .397$; $t(29) = 1.548, p = .132$; $t(29) = 1.230, p = .229$; $t(29) = 1.299, p = .204$, respectively).

Design

A mixed design was employed. The within-participants factor was context with three levels: Appropriate (A) vs. Neutral (N) vs. Inappropriate (I) and the between-participants factor was group with two levels: Children with autistic disorder (AD) vs. typically developing children (TD). The dependent measures were reaction time and accuracy.

Materials and apparatus

The same materials as in Experiment 1 with adults were used in this experiment. All stimuli were presented in a Macintosh laptop computer and the experiment was run using Superlab software.

Procedure

The same procedure as in Experiment 1 was employed. Participants were tested individually in a quiet room either at their school or home. The children were told that they would see a series of pictures on the computer screen, some depicting visual scenes and some single objects. Their task was to name the objects and not the scenes. Before the proper experiment began participants were given three training trials to ensure they understood the procedure. The contextual scenes for these trials were a 'Garden', a 'Post Office' and a 'Room'. The objects chosen were 'Cap', 'Bottle' and 'Button'. During these trials the experimenter pointed to the objects that the child had to name. Only if the child understood the procedure, was the proper experiment started. All children understood the procedure by the end of the training session.

Results

Scoring criteria

The same scoring criteria as in Experiment 1 was employed. One trial in the appropriate condition of the visual task had to be excluded from the analysis

as none of the children in either group named it correctly. All children mistook a 'nail file' for either a 'knife' or a 'pen'. As none of these objects appear usually in a 'bathroom' the trial was deleted from all analyses.

Analysis of Accuracy data

Five trials had to be excluded from the analysis due to equipment malfunction (less than 1% of the total number of trials). Of these, four trials were of AD children and one of the TD group. Due to the missing trials, raw data were converted into proportion scores for the purpose of analysis. Table 3.3 below summarises the proportion of accuracy responses for both groups across conditions. As can be seen, there seems to be a ceiling effect as both groups had high rates of accuracy in identifying the objects. This ceiling effect may have influenced the results of the analysis; the data however were not significantly skewed which provides some guarantee for the results of the analysis.

Table 3.3. Proportion of accurate responses and standard deviations across contextual conditions in Experiment 2.

N	Group		Appropriate	Neutral	Inappropriate
16	TD	Mean	.944	.885	.871
		SD	.075	.096	.107
15	AD	Mean	.911	.836	.757
		SD	.107	.121	.158

Although the two groups of children did not differ significantly in terms of IQ levels and chronological age (CA), the children had not been individually matched. Full IQ scores (FIQ) and CA were therefore introduced in the analysis as covariates to test the extent to which these variables were related to the group differences for the dependent variable. Neither of the two measures covaried significantly with either overall performance (CA: $F(1,27) = .001$, $p = .973$; FIQ (1,27) = 2.323, $p = .163$) or the context factor (CA: $F(2,54) = 1.408$; $p = .259$; FIQ: (2,54) = 1.192, $p = .312$), thus they were removed from the analysis.

The data were therefore analysed by means of a mixed ANOVA with group as the between participants factor (TD vs. AD) and context as the within-participants factor (appropriate vs. neutral vs. inappropriate). The analysis of the accuracy data revealed that there was a significant main effect of context ($F(2,58) = 9.632$, $p = .001$). Pair-wise comparisons using Bonferroni adjustment for family-wise errors indicated that the provision of an appropriate context facilitated accuracy in the identification of objects as compared to providing a neutral ($p = .010$) or an inappropriate context ($p = .001$). The comparison between providing a neutral context and providing an inappropriate context was not significant ($p = .340$).

The interaction between group and context was not significant ($F(2,58) = 1.464$, $p = .240$) indicating that, in terms of accuracy, both groups of children were affected by the context to the same extent. Further analysis revealed that both samples had significant context effects independently (AD: $F(2,13) = 6.472$, $p = .005$; TD: $F(2,14) = 4.845$, $p = .025$). The main effect of group

was significant ($F(1,29) = 5.459, p = .027$), indicating that typically developing children were more accurate than children with autism at identifying objects.

Analysis of RT Data

One of the disadvantages of using a voicekey is that it records any first sound after the stimuli onset. Although every attempt was made to avoid the recording of sounds different from the child's response, in some cases this was not possible. The experimenter was behind the child at all times to ensure that the response recorded was the child's verbal response and not any other sound. In those cases where a sound different from the child's was recorded, the trial was removed from the analysis of RT data.

Twenty-three trials in total were deleted for the above mentioned reasons (3% of the total number of trials). Of these, 13 trials were of children with autism, the remainder from the TD children. Table 3.4 shows mean RT on correct trials to appropriate, neutral and inappropriate trials for each group.

Table 3.4. Mean reaction times and standard deviations for accurate responses across conditions in Experiment 2.

N	Group		Appropriate	Neutral	Inappropriate
16	TD	Mean	937.04	1056.93	1087.63
		SD	178.51	185.67	164.64
15	AD	Mean	987.3	1024.26	1060.60
		SD	245.63	229.5	259.86

As in the analysis of the accuracy data, Full IQ scores (FIQ) and CA were introduced in the analysis as covariates to correct for differences between the groups on these measures. Neither of the two measures however covaried significantly with either overall performance (CA: $F(1,27)=3.002$, $p=.095$; FIQ($1,27$)= 2.154 , $p=.154$) or the context factor ($F(2,54)=2.062$, $p=.137$; FIQ($2,54$)= 1.169 , $p=.318$), thus they were removed from the analysis.

A mixed ANOVA was conducted on these data, with context (appropriate vs. neutral vs. inappropriate) as a within-subjects factors and group (AD vs. TD children) as a between-subject factor. The analysis revealed a significant main effect of context ($F(2,58) = 6.267$, $p=.003$). To further investigate the context effect, pair-wise comparisons using Bonferroni adjustment to correct for family-wise errors were carried out. These comparisons showed that children were faster at identifying objects when these were preceded by an appropriate context than when preceded by a neutral ($p=.029$) or an inappropriate context ($p=.003$). The comparison between the neutral and inappropriate contexts, as in the study with adults, did not yield significance ($p=.999$). The interaction between context and group did not yield significance ($F(2,58)=1.019$, $p=.367$; respectively). Further analysis however revealed that only TD children showed context effects ($F(2,14)= 12.062$, $p=001$); AD children in contrast did not show evidence of context effects in terms of RT ($F(2,13)= .794$, $p=.473$). Unlike in the analysis of accuracy data the group main effect did not yield significance ($F(1,36)=.002$, $p=.963$). AD children were as fast as TD children in identifying objects.

Discussion

It was predicted, according to weak central coherence theory, that children with autism would fail to use visual contextual information to facilitate object identification. Specifically, a significant interaction between context and group was predicted as a result of greater context effects in typically developing children than in children with autism.

The results of this study failed to support this prediction. Instead, the results showed that children with autism were faster and more accurate at identifying objects after an appropriate contextual scene than after either neutral or inappropriate contextual scenes. Moreover, children with autism used visual contextual information to aid object identification to the same extent as typically developing children as revealed by the non significant interaction between group and context. It could be argued that there is some indication that children with autism are less able in using contextual information as separate analysis for each group revealed that AD children only showed context effects for accuracy data and not for RT data. There are two reasons however to question this possibility. First, the overall interaction did not yield significance and therefore there is no statistical evidence that the context effect sizes are different for each group. Second and most important, the power of the statistical analysis was over 85% which suggests that the absence of an interaction effect is not due to a statistical flaw of the analysis.

Although the expected interaction between group and context was not found, the analysis of a main effect of group was found for accuracy of

responding. Children with autism made more errors overall in naming objects than TD children. The higher frequency of errors cannot be explained by differences in either IQ or chronological age as neither of these measures covaried significantly with overall performance. The group difference cannot be explained by semantic difficulties in the autism group either. The analysis of the type of errors children made revealed that errors could be grouped in two main categories. Visual errors, where children failed to identify the object (i.e. they said 'spade' instead of 'broom') and semantic errors, where children produced a word semantically related to the target object (i.e. 'bikini' for 'vest') or a word that referred to the higher-level category (i.e. 'insect' for 'fly'). The majority of errors in both groups were visual errors (TD: 68.08%; AD: 68.11%), followed by semantic errors (TD: 31.92 %; AD: 31.89%). This analysis suggests that the difficulty AD children exhibit in this task is not due to a semantically related impairment.

It is difficult to explain why children with autism made more errors, especially when considering that IQ scores, did not influence accuracy of responses as shown by the ANCOVA. It might still be possible that the higher rate of errors is due to lower IQ scores in the AD group. Even though the IQ scores were not significantly different in the two samples, the verbal subscales used to measure IQ did not include a vocabulary test as only two of the five verbal subtests of the WISC were presented to the children. Hence, the higher rate of errors might be due to limited vocabulary in the autistic sample. Regardless of this possibility, the analysis of errors demonstrates that the naming difficulty experienced by children with autism is not related to a semantic

impairment as shown by the similar pattern of types of error in the two samples. An alternative explanation for the group difference might relate to the fact that there was a ceiling effect in terms of accuracy which would have inflated or distorted the difference between the two samples.

The results of this study indicate that, over and above the naming difficulties, children with autism are able to use visual contextual information to aid object identification. This finding fails to support weak central coherence theory, which proposes that the impairment to use contextual information is present in both the visual and verbal domain.

These results appear to refute the unpublished finding by Jolliffe (1997) showing a difficulty judging whether an object is incongruous in a visual scene (i.e., squirrel in a picture of a beach) or which is the odd object in a set of pictures (i.e., a bucket, a man, a window, a ladder and suitcase). However, Jolliffe's task required individuals to make an evaluation of appropriateness that might be much more difficult than the current task. Also the current task depended on facilitation of appropriate context rather than interference by inappropriate contexts.

The results are more difficult to reconcile with other previous evidence showing that children with autism have difficulty connecting words on the basis of meaning in a verbal task. A study that is particularly relevant to the discussion of these results is that of Tager-Flusberg (1991). She read two lists of words to young children with autism and two comparison groups. One contained semantically related words (i.e., a list of animals) and the other contained unrelated words (i.e. a list of words pertaining to different semantic categories).

The two comparison samples recalled more items from the semantically related list than the unrelated list. Children with autism however, had similar recall rates for both types of lists indicating a failure to use semantic information to aid recall. One would therefore expect that individuals with autism would also fail to use visual contextual information to aid object identification in a task involving connecting pictures on the basis of meaning.

A possible explanation is that children with autism might not be able to use context information when verbal stimuli alone are presented. Although it has been assumed that there is a general difficulty in autism, the contextual difficulty might be restricted to the verbal domain and not apply when visual information is presented. It is important for the definition of WCC to establish that context difficulties in autism are not language specific as it is proposed that central coherence is a central component of the cognitive system that applies to both the visual and verbal domain. To investigate potential differences in performance in the visual and verbal domains, an adaptation of the visual context task was made so that the stimuli were presented in a verbal format without pictorial information being available. This study is presented in the next chapter.

Chapter 4 Can children with autism use verbal context to identify and recall words?

The findings reported in the previous chapter contradict the weak central coherence theory prediction that individuals with autism fail to process information in its context. This claim has been supported by studies using verbal tasks (e.g. Hermelin & O'Connor, 1967; Frith & Snowling, 1983) and visual tasks (Jolliffe, 1997). The results of Experiment 2 and a study by Pring & Hermelin (1993) however, show competence in autism in the use of visual information to aid recall and object identification.

In the present chapter an adaptation of the visual context task used in Experiment 2 was developed to investigate the ability of children with autism to use verbal contextual information to aid word identification. To adapt the visual context task for this purpose, each contextual scene was substituted for the word that best described that scene (i.e. the school scene was substituted by the word 'school').

The pictures of the objects were substituted by the most common word used to refer to each of the objects (i.e. the picture of a 'jug' was substituted by the word 'jug'). The resulting verbal context task highly resembled single-word semantic priming tasks which have been used to test context effects in word identification. This literature is reviewed in the section below.

4.1 Use of verbal context in single word semantic priming tasks

There is large body of evidence from adult and developmental studies showing that presentation of prime words facilitate word identification (e.g., Meyer & Schvaneveldt, 1971; Becker, 1980). Furthermore, unlike in visual context tasks, there is sound evidence indicating that the presentation of unrelated or inappropriate word primes hinders word identification (Fischler & Bloom, 1979; Neely, 1976). Simpson (1984) has however suggested that there is a trend across studies for the size of the facilitation effect to be larger than the interference effect, although this difference invariably fails to reach significance in any individual study.

Priming effects appear early in development. One study has reported priming effects in children as young as 6 years of age (Radeau, 1983). Moreover, it appears that priming effect sizes are larger in younger children than in adults. Initially, it was thought that a larger priming effect in younger children was the result of children being more sensitive to context effects than adults. This illusory effect however has been suggested to be due to larger overall reaction times

(Chapman, Chapman, Curran & Miller, 1994). That is, the larger overall reaction times in children artificially inflate the difference between conditions.

Although there are no studies to date investigating verbal priming effects in children with autism, Tager-Flusberg (1991) has provided evidence of a difficulty using verbal contextual information to aid recall in autism in a single word semantic memory task. On the other hand Experiment 2 and the study by Pring and Hermelin (1993) provide evidence of competence in the use of context information in the visual domain. It was thus predicted that if the difficulty in autism was restricted to verbal material only, children with autism would fail to use verbal context information to aid word identification. In contrast, if children with autism are competent in the use of context regardless of whether stimuli are presented verbally or visually, they would be able to use verbal information to aid word identification.

4.2 Are children with autism sensitive to verbal context in a semantic priming task?

EXPERIMENT 3

In this study the same two samples of children from Experiment 2 were tested using the adapted verbal context task. If the difficulty with context is restricted to the verbal domain, an interaction between group and context would be expected with only typically developing children showing facilitation and

interference effects. Alternatively, if children with autism are competent in the use of verbal context, both groups of children would show large interference and facilitation effects, although the facilitation effect would be larger than the interference effect (Simpson, 1984).

Method

Participants

The same participants as in Experiment 2 took part in this experiment. To avoid practice effects from Experiment 2, the study was carried out 4-7 months after the earlier experiment.

Design

The same mixed design was used. The within-participants factor was context: Appropriate (A) vs. Neutral (N) vs. Inappropriate (I). The between-participants factor was group: Children with autistic disorder (AD) vs. typically developing children (TD).

Materials

In order to keep the materials as close as possible to the visual context task, the words chosen for this experiment were those that best described the pictures used in the visual context task. For instance, the picture of a kitchen was substituted

by the word 'Kitchen'. The 'Nail file' object could not be described in a single word, thus this object was substituted in the verbal task by the word 'Brush'. For the neutral condition trials, before presenting the target word a series of five X's were presented. All stimuli were presented in capital letters.

Procedure

Children were tested in a quiet room at either their school or home. The same procedure as in the visual task was followed. Three training trials were used to ensure that children understood the task before the commencement of the experiment. These training trials were the same as the ones used in the visual task but presenting words instead of pictures. Thus the priming stimuli used for the training trials were the words 'Garden', 'Post Office' and 'Stairs' and the targets were "Bottle", 'Cap' and 'Button'. All children understood the task by the end of the training trials. This task was presented at least four months after the visual context task.

Results

Accuracy data

An exploration of the accuracy data revealed that the data were significantly skewed in all conditions due to ceiling effects in both groups (see Table 4.1 below for summary of results). None of the attempted transformations (e.g., logarithmic,

square root, and inverted transformations) could correct the distribution of the data, thus no further analysis was carried out on the accuracy data.

Table 4.1. Proportion of accurate responses and standard deviations across conditions and groups.

N	Group		Appropriate	Neutral	Inappropriate
16	TD	Mean	.992	.992	.925
		SD	.032	.032	.199
15	AD	Mean	.992	1.00	.925
		SD	.030	.00	.113

Reaction time data

Due to the problems with the use of a voicekey, twenty-one trials needed to be removed from the analysis (2.84 % of the total number of trials). Seven were of children with autism and 14 of typically developing children. The reaction time data from one TD child was not collected due to equipment malfunction and therefore only the data from fifteen TD children were included in the analysis. A summary of the results is shown in Table 4.2.

As in previous analysis, Full IQ scores (FIQ) and CA were introduced in the analysis as covariates to correct for differences between the groups on these measures. CA did not covary significantly with either overall performance

($F(1,26)=.439$, $p=.513$) or context ($F(2,52)=.432$, $p=.651$). FIQ however covaried significantly with both overall performance and context and was thus kept in the analysis ($F(1,26)= 5.810$, $p=.023$; $F(2,52)= 14.075$, $p=.000$, respectively).

Table 4.2. Mean reaction times and standard deviations across conditions and group in Experiment 3.

N	Group		Appropriate	Neutral	Inappropriate
15	TD	Mean	624.76	676.00	713.62
		SD	107.18	152.86	179.72
15	AD	Mean	617.60	715.27	744.40
		SD	108.52	138.66	171.18

The data were analysed by means of a mixed ANCOVA with context (appropriate vs. inappropriate vs. no context) as a within-subjects factors and group (AD children vs. TD children) as a between-subject factor and FIQ as a covariate. The statistical analysis revealed a significant main effect of context ($F(2,54)=19.908$, $p=.001$). Pairwise comparisons using Bonferroni adjustment to correct for family-wise errors revealed that children were faster at recognising words when preceded by an appropriate context than when preceded by a neutral ($p=.002$) or an inappropriate context ($p=.001$). The comparison between the neutral and inappropriate context also yielded significance ($p=.002$).

Neither the interaction between context and group nor the main effect of group were significant ($F(2,54)=1.292, p=.283$; $F(1,27)=.029, p=.867$ respectively). Children with autism were as fast as typically developing children at identifying words and they were affected by contextual information to the same extent. Also, and most importantly both groups showed evidence of a contextual effect when data were analysed separately for each group (AD: $F(2,13)=6.514, p=.011$; TD: $F(2,13)=8.413, p=.005$).

Discussion

This study tested whether a context deficit would be found for individuals with autism when information was presented in the verbal domain only. Results showed that children with autism were as sensitive to verbal contextual information as typically developing children. Both groups had similar facilitation effects in that words preceded by a related prime were identified faster than words preceded by a neutral prime. Also both groups had similar interference effects in that words preceded by inappropriate primes were identified less rapidly than words preceded by neutral primes. The results of Experiment 2 and Experiment 3 therefore provide evidence that children with autism take account of context whether or not pictorial information is provided. It is possible that the presence of a ceiling effect in Experiment 2 as well as Experiment 3 might have influenced the results. However,

priming studies using similar methodology to the one used in these studies also report ceiling effects as accuracy in these studies is also very high. Moreover these studies usually rely primarily on reaction times rather than in accuracy data (e.g. Boyce & Pollatsek, 1992; Meyer & Schvaneveldt, 1971). Therefore there is no reason to believe that context effects in Experiment 2 and 3 or the lack of difference between the two groups in terms of the size of the effect are a result of flawed data. Thus it can be concluded that the results fail to provide evidence to support Happé's (2000) suggestion that in autism 'single word/object meaning is intact while connections between items are weakened'.

Unlike Experiment 2, children with autism were as accurate as TD children at correctly identifying words. This result could have been due to the practice effects from presentation of the same words that they named earlier from pictures. The time delay between testing sessions however makes this unlikely. More likely is that the task in this experiment did not involve searching for a word but simply reading it, and therefore this task was less demanding. Despite an overall improvement in both accuracy and speed for both groups between the two experiments, the context effects remained.

Given the results for this study, the question to be addressed is why children with autism are able to use verbal contextual information in this task when there is evidence supporting a deficit in the use of verbal contextual information from a single word semantic memory task (Tager-Flusberg, 1991). One possibility is that children with autism do have difficulty connecting single words on the basis of

meaning, but only in tasks that involve making connections between subordinate and superordinate category information. This could be due to an alternative explanation such as failure to organise information hierarchically.

An examination of the evidence for impairment to use semantic category information in semantic memory tasks has however revealed mixed findings. Only two studies have found evidence for a difficulty in integrating words on the basis of semantic category information in single word tasks (Tager-Flusberg, 1991; Hermelin & O'Connor, 1967). In contrast two other studies have failed to find a deficit in use of semantic category information (Ramondo & Milech, 1984; Pring & Hermelin, 1993). This evidence will be reviewed in the next section.

4.3 Use of verbal context in memory tasks in autism.

Research into the ability of children with autism to integrate verbal information to aid recall started in the late 1960s. The purpose of this research was to evaluate general language abilities rather than the ability to integrate information. It was not until 1989 that Frith integrated the evidence from these studies to formulate weak central coherence theory. In a seminal study Hermelin and O'Connor (1967) showed that whilst children with learning disabilities had better recall rates for sentences (i.e., 'We went to town') than for random word strings (i.e., 'Some that a went'), children with autism had similar recall rates for sentences and word strings.

In a second experiment Hermelin and O'Connor evaluated the extent to which the difficulty children with autism had with the sentence task was due to an impairment in semantic processing. They presented word strings instead of sentences. The strings could contain unrelated words (i.e., glass, hand, cow, pot, cup, meat, spoon, place) or words that belonged to two categories (i.e., colours and numbers; blue, three, red, five, six, white, green, eight). The results showed no differential performance between autism and non-autism groups for the number of items recalled from each list. However, children with learning difficulties, and not children with autism, tended to reorganise the material so that related items were recalled together.

The difficulty to use syntactic and semantic information to enhance sentence recall has been confirmed in later studies by Frith (1969) and Wolff and Barlow (1979). In the latter study, although there was a significant interaction, the children with autism showed a significant improvement for sentences if to a lesser extent than the control sample. One study however has failed to find differences between autistic and control samples. Fyffe and Prior (1978) found that children with autism who had high memory spans had similar enhanced recall for sentences than a comparison group. In a second experiment, where they presented standard sentences and anomalous sentences, it was also found that children with autism performed worse when recalling anomalous sentences than correct sentences. It is possible that although children with autism have a difficulty processing sentences, this difficulty

disappears when memory develops. That is, the ability to integrate words into sentences might depend on general memory skills in autism.

Ramondo and Milech (1984) have argued that the difficulty with sentences experienced by children with autism is related to a specific difficulty in processing syntactic information and not semantic information. In this study Ramondo and Milech manipulated the syntactic structure and meaningfulness of word strings. The word strings could be meaningful and well structured (i.e., Last week we all went by train to see the big farm), meaningless and well structured (i.e., Last six we all went by tree to see the big box), meaningful but badly structured (i.e., red, white, blue, green, cat, bird, dog, horse, train, car, bus, boat), or meaningless and badly structured (i.e., week went see big last the all to train we farm by). The meaningful but badly structured strings resembled those used by Hermelin and O'Connor (1967) since they included words from colours, animals and vehicles. The results showed that when the material was well structured typically developing children performed significantly better than children with autism. Children with autism however performed as well as children with learning difficulties. Regarding the semantic component, all groups of children improved to the same extent when the material was semantically related. This latter finding suggests that children with autism are as able as the comparison groups in using semantic information to aid recall.

In summary, most of the studies have found difficulties with sentence processing in autism. It is not clear however to what extent the deficit is specific to

autism. Ramondo and Milech did not find differences between children with autism and children with learning difficulties regarding recall for sentences and the studies by Frith (1969) and Wolff and Barrow (1979) failed to include a learning disability group as a comparison sample. Hence it is not possible to conclude from these studies if the deficit is specific to autism.

Regarding the semantic component, although Ramondo and Milech (1984) suggest that semantic processing is intact in autism, Hermelin and O'Connor (1967; Experiment 2) have found evidence for a semantic deficit in autism. In an attempt to investigate if there is a deficit in autism related to the encoding of semantic information, Tager-Flusberg (1991) designed a semantic memory task in which the syntactic component was removed. This task involved the processing of semantic relations between single words in order to facilitate recall. She presented two types of lists to children with autism, typically developing children and developmentally delayed children. One list contained semantically related words (i.e., animals) and another list of unrelated words drawn from different semantic categories. She found that the two comparison groups recalled more words from the semantically related list than from the list that contained unrelated words. Children with autism however showed similar recall rates for both types of list. This result has been taken as evidence indicating an inability to use semantic information to aid recall (Tager-Flusberg, 1991; Happé, 2000).

In the same study, Tager-Flusberg (1991; Experiment 2) used a cued recall task to investigate the extent to which children with autism could use semantic cues.

She provided children with two types of cues, rhythm cues (target: fox; cue: box) or semantic cues (target: cherry; cue: fruit). The results showed that children with autism were as able as the comparison groups to use semantic cues. This finding replicated the results of Boucher and Warrington (1976) who also found that children with autism are able to use semantic cues. Tager-Flusberg therefore concluded that the difficulty children with autism have with semantic information is related to retrieval and not encoding processes. Specifically, she argues, it is not that children with autism do not process semantic information but that they fail to use it to aid recall.

The results from Tager-Flusberg (1991) and Hermelin and O'Connor's (Experiment 2) studies indicate that there is a deficit in autism related to the ability to use semantic information. This evidence together with the evidence showing that children with autism have similar recall rates for sentences than random words (Hermelin & O'Connor, 1967; Frith, 1969; Wolff & Barlow, 1979) has been taken as evidence of an integration deficit in autism (Happé, 2000).

Tager-Flusberg's results are based on the comparison of only two word lists (i.e., a list of animals and a list of unrelated words) containing only twelve words each, which is insufficient material on which to base firm conclusions. Hermelin and O'Connor's results, on the other hand, provide only indirect evidence of a deficit as children with autism had similar recall rates to LD children for both types of lists. In contrast, the findings from Experiment 3, the results of Ramondo and Milech (1984) and the results of Pring and Hermelin (1993), using a visual task,

have also failed to find a deficit in autism related to semantic processing. Thus it may be possible that semantic processing is intact in autism and Tager-Flusberg results are due to confounding variables.

To further explore children's with autism ability to use semantic information to aid recall, the task originally developed by Tager-Flusberg was administered to the same children as in Experiments 2 and 3. To increase the number of stimuli, Tager-Flusberg's task was adapted to include an additional set of lists. In addition, to investigate potential differences in performance in the visual and verbal domains, a new visual condition was devised in which objects were presented instead of words.

4.4 Can children with autism use semantic information to aid recall of words and objects?

EXPERIMENT 4

The first aim of this study was to confirm the presence of difficulties in autism in the use of semantic information to aid recall. An additional aim of the study was to investigate if the difficulty in autism in using semantic information to aid recall is confined to verbal semantic memory tasks. To achieve this aim an adapted version of Tager-Flusberg's task was used which included a visual condition as well as the original verbal stimuli used by Tager-Flusberg. If the difficulty

children with autism experience with semantic category information is confined to the verbal domain, they should show poorer recall of semantically related information only in the verbal condition but not in the visual condition.

Method

Participants

The same participants as in Experiment 2 and 3 took part in the experiment. This experiment was administered in the same session as Experiment 3.

Design

A mixed design was used with two within-participants factors, modality (visual vs. verbal) and list (semantically related vs. unrelated) and one between-participants factor, group (children with autism vs. typically developing children). The dependent measure was the number of words recalled correctly from each list.

Materials

Half the stimuli were the same as those used by Tager-Flusberg. One list contained words drawn from different categories (*apple, brown, cabin, drum, farm, elephant, lamp, onion, pencil, pot, shirt, thumb*). The semantically related list contained words from the same semantic category (*bear, cow, giraffe, horse, lion,*

monkey, pig, rabbit, racoon, sheep, turtle). Tager-Flusberg reported that she matched the words in these two lists approximately for frequency.

In order to increase the number of stimuli, another pair of lists was added to the procedure. Of these, one list contained words of vehicles (*bike, boat, bus, car, helicopter, motorbike, plane, roller skate, sledge, train, truck, wagon*). The other list contained words from different semantic categories (*birds, biscuits, booklet, drink, gentlemen, hill, seven, sugar, tonic, toothpaste, word, yellow*). The words of these two lists were individually matched on frequency on the basis of the Celex lexical database (Baayen, Piepenbrock & Gulikers, 1995).

To further explore potential differences in performance between the visual and verbal domain in autism, a new visual condition was added to the original procedure. Four sets of pictures were used in the visual condition each containing twelve pictures of objects. The two semantically related sets were the same lists of animals and vehicles used in the verbal condition. The unrelated sets contained pictures from different semantic categories (Animal matched list: *axe, barrel, harp, kite, mushroom, rolling pin, spinning top, suitcase, thimble, trumpet, watering can, windmill*; Vehicles matched list: *brush, coat, flute, fork, racket, scissors, screwdriver, tie, toaster, trousers, violin, whistle*). The pictures of the unrelated sets were matched individually to the semantically related sets of pictures on the basis of familiarity and complexity. All the pictures were taken from the standardised set of pictures created by Snodgrass & Vanderwart (1980). The pictures were presented one at a time in a laptop computer.

Procedure

All children were tested in a quiet room at either their school or home. The administration of this task was part of a wider battery of tests investigating other aspects of perception. Following Tager-Flusberg's procedure, a practice set of four simple words (*pin, cat, tea, wall*) or four objects (*flower, frog, sock, star*) was used to familiarise the child with the task. Half of the children in each group received the verbal condition first and the other half received the visual condition first.

The session began with the experimenter explaining the task to the child. For those children starting with the verbal condition the experimenter told them: "I will read a list of words, and when I'm done, you have to repeat the same words, or at least as many words you can remember from the list I read. You don't need to repeat them in the same order". After these instructions, the experimenter read the words of the practice trial in a monotone voice. All children understood the aim of the task after this single trial.

For the visual condition the instructions were the same except that they were told they would see a series of pictures on the screen of the laptop and once the presentation was over they had to recall as many objects as they could. After the instructions the practice trial was conducted. Again, all children understood the task after this first practice trial.

Once the practice trial was completed, the child was presented with one test list. The order of the lists was counterbalanced within each modality condition

across participants. The items from each list were presented in random order at a rate of one word/object every two seconds. The experimenter recorded all the words that were correctly or incorrectly recalled by the child.

Results

The number of correctly recalled items from the two semantically related and the two unrelated lists of each modality condition were added for the purpose of analysis. A summary of results broken down by modality and group is shown in Table 4.3.

Table 4.3. Mean number of items recalled from related and unrelated lists in the visual and verbal conditions (Maximum = 24).

N	Group		Visual Condition		Verbal Condition	
			Related	Unrelated	Related	Unrelated
16	TD	Mean	14.37	9.62	14.12	9.93
		SD	1.99	1.89	2.06	1.84
15	AD	Mean	11.80	7.67	11.33	8.20
		SD	4.10	2.16	3.52	2.18

As can be seen, although AD children had lower recall rates in all conditions, both groups of children performed better in the related than unrelated conditions for both the visually and verbally presented lists. To test if the difference between semantic conditions was statistically significant an ANCOVA with modality (visual vs. verbal) and list (related vs. unrelated) as within-participants factors, group as a between participants factor and FIQ and CA as covariates was conducted on the data. Neither FIQ nor CA covaried significantly with either context or overall performance thus they were removed from subsequent analysis ($F(1,27)=1.020, p=.322$; $F(1,27)=2.538, p=.123$ respectively).

The analysis revealed a significant main effect of list ($F(1,29)= 108.39, p=.001$) indicating that children recalled significantly more words from the semantically related lists than from the unrelated lists. Unlike Tager-Flusberg's study, the interaction between list and group was not significant ($F(1,29) = 1.152, p=.292$).

The main effect of modality was not significant ($F(1,29)= .009, p=.927$), nor was the interaction between modality and list ($F(1,29)= 2.301, p=.998$), indicating that the provision of related material improves performance on the visual and verbal domains. Furthermore, the interaction between modality, list and group was non-significant ($F(1,29)= .159, p=.693$), providing further evidence for semantic processing in both the verbal and visual domain in autism.

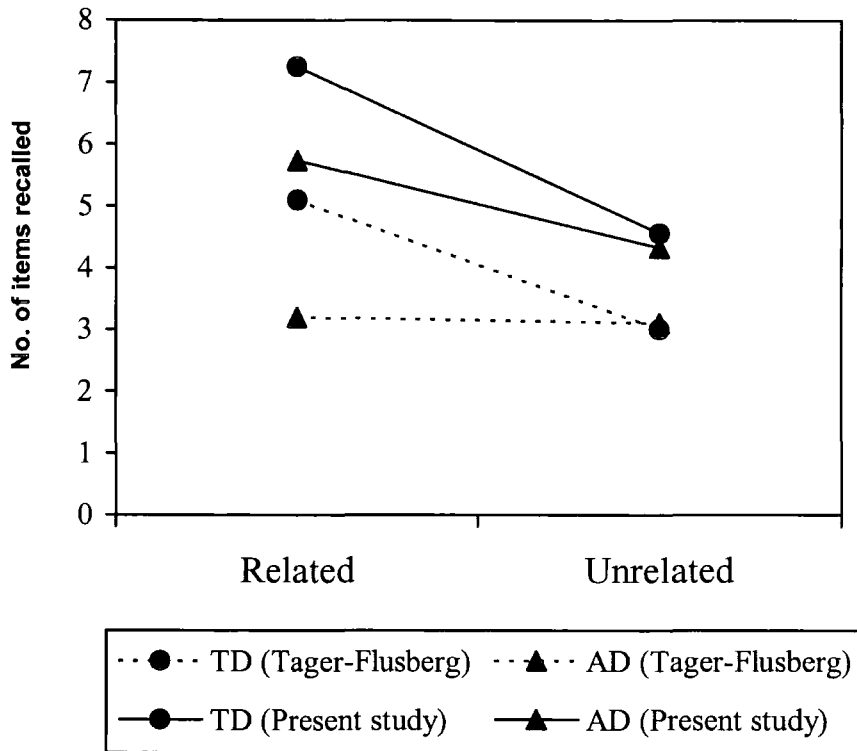
Post hoc t- tests carried out separately for each group and condition revealed that both groups recalled more words from the semantically related lists than the unrelated lists in both modalities (TD: Verbal $t(15)= 10.108$, $p=.001$; Visual $t(15)= 7.84$, $p=.001$; AD: Verbal $t(14)= 4.68$, $p=.001$; Visual $t(14)= 4.11$, $p=.001$).

The main effect of group was significant as, overall, typically developing children recalled more items than children with autism ($F(1,29)= 10.071$, $p=.004$), indicating that there is a memory deficit in autism.

The results of this study are at odds with those found by Tager-Flusberg. To directly compare the results from both studies a separate ANOVA was conducted on the data from the two original lists only (i.e., animal and matched unrelated list). Figure 4.1 shows a comparison between the results of the present study and the original study of Tager-Flusberg. As can be seen, the results of the present study regarding the original lists show a similar pattern to those in Tager-Flusberg's study, except that the children in the present study had overall higher recall rates, as would be expected due to the higher chronological age of participants.

The results of the statistical analysis matched those of Tager-Flusberg. Specifically, there was a significant main effect of list ($F(1,29)= 52.45$, $p=.001$) and a significant interaction between group and list ($F(1,29)= 4.858$, $p=.036$), indicating that AD children were less sensitive to semantic information than TD children, since AD children had similar recall rates for both lists. The main effect of group only approached significance ($F(1,29)= 3.587$, $p=.068$).

Figure 4.1. Comparison between Tager-Flusberg results and the results of this study including the original lists of animals and matched list only (Maximum=12).



However, if there was a difficulty in the use of semantic relations to aid recall this effect would be observed in any type of list. The only comparison that showed a significant group by list interaction was the original animal verbal list. In neither of the other three comparisons this interaction did yield significance (Vehicles verbal list: $F(1,29)=.054$, $p=.818$; Vehicles visual list: $F(1,29)=1.401$, $p=.246$; Animals visual list: $F(1,29)=2.485$, $p=.126$). In sum, the results from this



study provide no evidence of an impairment in autism related to the ability to use semantic relations.

Discussion

The evidence regarding the existence of a semantic memory impairment in autism is contradictory. On the one hand, Tager-Flusberg (1991) has found that children with autism fail to use semantic information to aid recall. In contrast, two other studies using more than one semantic category, have failed to find a group difference in the number of items recalled from the semantically related and unrelated lists (Ramondo & Milech, 1984; Hermelin & O'Connor, 1967). Also, a study by Pring & Hermelin (1993) suggests that any difficulties in Tager-Flusberg's task are overcome when visual information is provided. The aim of this study was to confirm the presence of a difficulty in using semantic information in memory tasks. Secondly, the study aimed to investigate potential differences in autism in the use of visual and verbal semantic information.

The results of this study indicate that, as in Experiment 3, children with autism are able to integrate words on the basis of meaning and they do so to the same extent as TD children. Both groups of children showed enhanced performance for semantically related lists. In relation to modality, children with autism showed evidence of connecting semantically related items in both the visual and verbal

domain. Thus, Experiments 2, 3 and the present study, all provide evidence that the ability to connect items on the basis of meaning is intact in autism in both the visual and verbal domains.

The analysis of the original lists (i.e. animals and matched list) matched Tager-Flusberg's results showing a significant interaction between group and condition. To explore if the results for the original list were related to the specific semantic category used, an ANOVA including semantic category (i.e., animals vs. vehicles) was conducted. These analyses showed that neither semantic category nor the interactions between semantic category and type of list or group were significant ($F(1,29)=.072, p=.791$; $F(1,29)=.627, p=.435$; $F(1,29)=.722, p=.403$, respectively). Furthermore, in the visual condition the comparison of the animal list did not yield a significant group interaction, as it would be expected if the deficit was related specifically to the animal category. The only comparison that showed a significant group by list interaction was the original verbal list. None of the other lists (vehicles visual and verbal and animals visual) produced significant interactions between group and type of list. Thus it can be concluded that the results from this study do not support the claim for impairment in the ability to use semantic relations to aid recall.

It is difficult to explain why the original lists produce an interaction effect indicating a failure in autism to use semantic information. The only differences between the original and new lists was that the original lists were matched approximately on frequency (as reported in Tager-Flusberg, 1991) whilst the new

lists were individually matched exactly on frequency and, in the case of pictures, individually matched on familiarity and complexity. It is thus possible that the failure to match words carefully results in confounding findings, though it is difficult to explain why the frequency matching would have an effect in the recall processes of children with autism or TD children. It could be that the words included in the animal lists were more frequent than in the unrelated list and this would result in an additional advantage for TD children which are more sensitive to word frequency effects.

The children with autism in Tager-Flusberg's study had, on average, a verbal mental age of five years, although their chronological ages were around eleven years of age. The typically developing children had a mean chronological age of four and a half. The children used in this study had an average age of fourteen years, and due to high IQ levels, similar mental ages. It could be argued that the difference in results is due to differences in the age of participants. However, despite being older, the performance of children with autism was similar to the children in Tager-Flusberg's study on the original lists. Hence, this explanation can be ruled out. If we had used only the original lists we would have found the same results as Tager-Flusberg.

It is still possible that there is a developmental delay in semantic processing in autism. To confirm the existence of an impairment in younger children with autism it would be necessary to conduct a study with young children using a wider range of material, and not just the original set used by Tager-Flusberg. The reason

for including an additional set of lists was that it was felt that Tager-Flusberg's conclusions were based a set of stimuli far too small to be statistically reliable. The pattern of results in this study has confirmed that performance varies depending on the set of stimuli. For this reason it seems especially important to use a wide range of stimuli when investigating the ability to process semantic relations.

Regarding modality of presentation, children with autism showed evidence of semantic processing in both the visual and verbal domain. Thus, Experiments 2, 3 and the present study provide evidence that the ability to use semantic relations is intact in autism in both the visual and verbal domains. None of the three studies provide evidence supporting the claim that individuals with autism fail to process information in its context, as Frith (1989) suggested since at least they are able to integrate stimuli on the basis of semantic information.

Children with autism had in general lower recall rates than TD children, confirming previous findings showing a general memory impairment in autism (Boucher & Warrington, 1976). Over and above this impairment though, children with autism were able to use semantic information to aid recall to the same extent as TD children.

4.5 Conclusions

None of the three experiments reported so far in this dissertation provide evidence supporting the claim that individuals with autism fail to process

information in context, as Frith (1989) has suggested. Individuals with autism are no different than typically developing children in their ability to integrate stimuli on the basis of semantic information, whether information is presented visually or verbally and whether connections are based on items within semantic categories or objects associated with familiar everyday locations.

Tager-Flusberg's and Hermelin and O'Connor's (1967) results have been often cited as evidence of an impairment in autism in the ability to integrate information in context (Brian & Bryson, 1996; Happé, 2000; Happé, 1999; Happé, 1997). As previously argued earlier, Hermelin and O'Connor's task only provides indirect evidence as children with autism had similar recall rates to children with learning difficulties. The results of Experiment 4 indicate that Tager-Flusberg's findings are due to the inclusion of a small set of stimuli rather than a deficit in the use of semantic information to aid recall.

The remaining evidence for failure to integrate context information comes from sentence processing tasks in which semantic connections between items is made across multiple stimuli. Two different types of task have been used, memory tasks and the homographs task. In memory tasks the recall rates of sentences ('They went to the theatre') vs. word strings ('School run the on girl') are compared. The evidence from these studies is contradictory. Research has shown that typically developing children benefit to a greater extent than children with autism from the presentation of sentences (e.g., Frith, 1969; Wolff & Barlow, 1979). It is not clear however to what extent the deficit is specific to autism. Hermelin and O'Connor

(1967) found that children with learning difficulties benefit to greater extent by the provision of sentences than children with autism. In contrast Ramondo and Milech (1984) failed to find differences with a learning difficulty sample and, in another study, it was shown that the deficit was related to low memory span (Fyffe & Prior, 1978).

The studies using the homographs task have consistently demonstrated that individuals with autism experience difficulties with the use of sentence context to disambiguate homographs. This task not only involves sentence processing but also the ability to process ambiguous information. In the homographs task, originally developed by Frith and Snowling (1983) children have to read sentences aloud. Each of these sentences contains a homograph word, which are words that have two different pronunciations (i.e. 'tear'). The sentence can be consistent with the frequent pronunciation of the homograph (i.e. 'There was a big tear on her cheek) or the rare one (i.e. 'There was a big tear on her dress').

Several studies have found that children with autism fail to use contextual information to disambiguate homographs (Frith & Snowling, 1983; Happé, 1997; Jolliffe & Baron-Cohen, 1999). Specifically, it has been found that individuals with autism tend to give the most frequent pronunciation of the homograph regardless of the context. To explore if the same children with autism used in the previous studies have difficulty in a sentence context task which involves making connections across multiple items, the homographs task was administered to the same two samples of children. The results of this study are presented in the following chapter.

Chapter 5 Can children with autism use sentence context to disambiguate homographs?

The results reported so far in this dissertation have failed to provide evidence of an impairment in autism in the use of verbal and visual context information in single words/objects tasks. As discussed in the previous chapter, most of the evidence of an impairment in autism in the ability to use contextual information comes from studies using sentence processing tasks, such as the homographs task. The homographs task, originally developed by Frith and Snowling (1983), is a sentence processing task in which connections between items are made across multiple stimuli. This task additionally involves the ability to process ambiguous stimuli.

Homographs are words that have two different pronunciations (i.e., 'tear'), where one of the pronunciations is more frequent than the other. The aim of Frith and Snowling's task is to evaluate the extent to which participants make use of sentence context information to disambiguate homographs. If participants use the context they would give the same amount of frequent and rare

pronunciations. If, on the other hand, participants do not take into account contextual information they would tend to give the most frequent pronunciation regardless of the context in which the homograph is embedded. Happé (1997), Jolliffe and Baron-Cohen (1999) and in an earlier version of the task, Frith and Snowling (1983) found that individuals with autism tend to give the most frequent pronunciation regardless of the context. This finding has been taken as evidence of an impairment in the use of context in autism.

An additional finding reported by Happé (1997) is the effect of the homograph position in the sentence. If children are sensitive to context, they will tend to perform better when the homograph is placed towards the end of the sentence, since sentence context is available. Happé found that children overall were more accurate when the homographs were placed towards the end of the sentence than when it was presented at the beginning of the sentence. However, the influence of the position of the homograph in the sentence had a greater impact in typically developing children than in children with autism. This finding provides additional evidence for a context difficulty. In contrast, Jolliffe and Baron-Cohen failed to find the same position effect. Unlike Happé's study with children, Jolliffe and Baron-Cohen tested adults with autism and Asperger's syndrome and a comparison sample of non-autistic adults. They argued that adults' 'reading ability and experience enables them to read ahead and thus perform similarly irrespective of the position of the homograph'. Thus, the position in which the homograph is placed in the sentence seems to have an impact early but not later in development.

The aim of Experiment 5 was to replicate Happé's (1997) and Jolliffe and Baron-Cohen's (1999) findings using the same design, material and procedure in order to explore if the same children that have no difficulties in making connections between single items such as in Experiment 2 and 3, would have difficulty making connections across multiple items.

5.1 Do children with autism read homographs in context?

EXPERIMENT 5

Experiments 2, 3 and 4 showed that children with autism take account of context information when connecting single items on the basis of meaning. In order to investigate if these children have difficulty with a sentence task that involves connecting across multiple items, the same sample of children was tested on Frith and Snowling's (1983) homograph task. If children with autism have difficulty using sentence context to disambiguate homographs, they should give the most frequent pronunciation of the homographs regardless of the context. It was also predicted that children with autism would be less sensitive than typically developing children to the position of the homograph in the context sentence.

Method

Participants

The same participants as in Experiment 2, 3 and 4 took part in this experiment.

Design

The experiment had a mixed design with two within-participants factors: pronunciation (frequent vs. rare) and position of the homograph (before context vs. after context). The between-participants factor was group (children with autism vs. typically developing children).

Materials

Four homograph words were used in the experiment (tear, row, bow and lead). Although previous studies have used an additional homograph word, *read*, the two different pronunciations of this word, unlike the other homographs, depend on syntactic and not semantic context. As there is evidence of spared syntactic abilities in autism (Bartolucci, Pierce, Streiner & Eppel, 1976; Frith & Snowling, 1983) this word was excluded from the original design to avoid confounding effects.

The stimuli consisted of sixteen sentences, the same as in Happé's (1997) original study except for the four sentences containing the word *read*. None of the sentences referred to mental states or were social in nature. As in Happé's study, there were four types of sentences: frequent pronunciation and homograph

before sentence context (FB), frequent pronunciation and homograph after sentence context (FA), rare pronunciation and homograph before sentence context (RB) and rare pronunciation and homograph after sentence context (RA). Examples for each condition are shown in Figure 5.1.

Figure 5.1. Examples of sentences used in the homographs task.

Frequent pronunciation before context (FB):

‘There was a big tear on her cheek’.

Frequent pronunciation after context (FA):

Molly was very happy but on Lily’s cheek there was a big tear’.

Rare pronunciation before context (RB):

‘There was a big tear in her dress’.

Rare pronunciation after context (RA):

‘The girls climbed over the hedge. Mary’s dress was spotless, but in Lucy’s dress there was a big tear’.

A pre-test list of thirteen single words including the four homographs words (*bow, light, lead, bank, tear, nail, row, palm, read, letter, bat, glasses ball*) was used to evaluate participants’ ability to read the target words. Only one child (in the autism group) gave the two pronunciations of each of the homographs. All children gave the most frequent pronunciation of ‘bow’ and all except two children (one AD and one TD) gave the most frequent pronunciation

of 'row'. The two pronunciations of the other two homographs ('tear' and 'lead') were more evenly distributed. All pre-test words were presented on a single card. Each sentence was presented on a different card one at a time.

Procedure

All children were tested in a quiet room in either their school or home. The pre-test words were always presented first. Children were told that they would see a list of words that they were to read aloud. All participants read this list without difficulty. All sentence cards were shuffled before the administration of the test to ensure random order presentation. After the pre-test was completed the experimenter told participants that they would be given cards containing a single sentence each and that they had to read them aloud. The experimenter then handed one card at a time to the child. The experimenter recorded the pronunciation of the homograph, any reading mistakes and any self-corrections regarding the pronunciation of the homographs. As in Happé's (1997) study, children were not alerted to the special status of the homographs to ensure the evaluation of the spontaneous processing style.

Results

Scoring Criteria

Following Happé's (1997) and Jolliffe and Baron-Cohen's (1999) scoring criteria, trials in which participants corrected themselves were regarded

as correct (self-corrected score). The first pronunciation attempt (initial score) was also recorded and this more stringent score is also reported below.

As with the data reported in Jolliffe and Baron-Cohen study, the data were severely positively skewed (see Table 5.1 for summary of results). This skew was not corrected by logarithmic transformation thus non-parametric tests were employed and the median is reported instead of means. The use of non-parametric tests does not allow the investigation of interactions between conditions, thus the amount of frequent pronunciations given by the two groups was analysed separately from the effects of the position of the homograph in the sentence.

Table 5.1. Median of homographs pronounced context appropriately (Maximum = 4)

N	Group		Frequent Pronunciation		Rare pronunciation	
			Before	After	Before	After
16	TD	Median	3.50	4.00	3.50	4.00
		SD	.79	.97	.86	.62
15	AD	Median	4.00	4.00	1.00	2.00
		SD	1.98	.59	1.58	1.52

Analysis of Frequent and Rare Pronunciations

Self-corrected scores: To test for the effect of pronunciation frequency, the scores for the two frequent conditions (before and after) were combined in a

composite score (F). The scores for the two rare conditions (before and after) were also combined in a single score (R). The median and range of the two composite scores are given in Table 5.2.

Table 5.2. Median of frequent and rare context appropriate responses, including self-corrections, across groups (Maximum=8).

N	Group		Frequent	Rare
16	TD	Median	7.50	7.00
		SD	1.48	1.26
15	AD	Median	8.00	4.00
		SD	1.39	2.94

As can be seen, whilst TD children gave roughly the same amount of rare and frequent pronunciations, AD children tended to give the most frequent pronunciation regardless of the context. Two Mann-Whitney tests were performed using these combined scores to compare the two groups. These tests revealed that whilst there were no differences in the amount of frequent context appropriate responses given by the two groups ($U=114.5$, $p=.830$), there was a significant difference in the number of context appropriate rare pronunciations ($U=49.5$, $p=.004$). AD children gave significantly less context appropriate rare pronunciations than TD children. This was the case whether the homograph was placed before or after the context (RB: $U=54.0$, $p=.008$; RA: $U=52.5$, $p=.006$).

Furthermore, there was a significant difference in the number of rare and frequent context appropriate pronunciations given by the AD group ($Z=-2.595$,

$p=.009$) but not in the TD group ($Z= -.214$, $p=.831$). These analyses confirm that AD children tend to give the most frequent pronunciation regardless of context.

Initial scores: The analyses using the initial pronunciation only, produced similar results to the analysis of self-corrected scores. Children with autism gave significantly fewer rare responses than TD children (AD mean: 3.27 (2.65); TD mean: 5.62 (1.36); $U=52$, $p=.006$). Within-subject analysis also showed that AD children, but not TD children, gave significantly more frequent than rare responses (AD frequent mean: 6.93 (1.39), rare mean: 3.17 (2.65), $Z= -2.925$, $p=.003$; TD frequent mean: 6.19 (1.33), rare mean: 5.62 (1.36), $Z= -1.276$, $p=.202$).

Analysis of Position of the Homograph in the Sentence

Self-corrected scores: To test for the effects of the position of the homograph in the sentence (before or after the context), the frequent and rare scores were combined into a single score for the before condition (B) and the after condition (A). The median and range of these two scores are shown in Table 5.3.

As can be seen, both groups had more correct responses when the homographs were placed after the sentence context than when placed before although the effect was only marginally significant in the TD sample (AD: $Z= -.236$, $p=.018$; TD: $Z=-1.778$, $p=.075$). These results are very surprising as they suggest that children with autism benefit from the provision of context information to the same extent than TD children, if not to a greater extent.

Table 5.3. Median number of context appropriate pronunciations, including self-corrections, when homographs were placed before and after the sentence context (maximum=8).

N	Group		Before	After
16	TD	Median	7.00	8.00
		SD	1.36	1.22
15	AD	Median	5.00	6.00
		SD	1.44	1.71

Two Mann-Whitney tests were performed to compare the performance of the two groups. These tests revealed that TD children were more accurate than children with autism both when the homographs were placed before ($U=50.5$, $p=.005$) and after the context ($U=67.5$, $p=.037$).

Initial scores: As can be seen in Table 5.4, when accounting only for initial scores, the impact of the position of the homograph in the sentence was larger for TD than AD children. The statistical analysis confirmed this observation. Although both groups improved significantly when the homographs were placed after the sentence context, the difference seemed larger for the TD group (AD: $Z= -2.027$, $p=.043$; TD: -3.128 , $p=.002$). Unfortunately, the interaction could not be investigated by use of a parametric test.

Table 5.4. Median and range of initial context appropriate responses when the homographs were placed before and after the sentence context (maximum=8).

N	Group		Before	After
16	TD	Median	5.00	8.00
		Range	1.36	1.44
15	AD	Median	4.0	3.00
		Range	1.36	1.77

Two Mann-Whitney tests were performed to compare performance between the two groups in relation to the position of the homographs in the sentence. These tests revealed that the two groups were not significantly different when the homograph was placed before the sentence context ($U= 99.5$, $p=.423$). When the homograph was placed after the sentence context however there was a significant difference in accuracy between the two groups ($U= 67.0$, $p=.024$). TD children were more accurate than AD children when the homograph was presented after the sentence context.

Discussion

The aim of this study was to explore if the same children that were able to use contextual information in single-item tasks such as the ones used in Experiments 2 and 3 would have difficulty using contextual information when a task (i.e., homographs task) demands making connections across multiple

stimuli. On the basis of previous research (Happé, 1997, Jolliffe & Baron-Cohen), it was predicted that children with autism would tend to give the most frequent pronunciation, indicating a failure to use contextual information. It was also predicted that the position of the homographs in the sentences would have a greater impact in TD than AD children.

The results of this experiment support the evidence of Frith and Snowling (1983), Happé (1997) and Jolliffe and Baron-Cohen (1999), showing that children with autism are impaired in using sentence context in a homograph task. Whereas typically developing children gave the pronunciation most appropriate to the context of the sentence, children with autism did not adapt their pronunciation to sentence context and gave the most frequent pronunciation for the homograph. Given the proficiency shown by the same children with autism in our earlier experiments, it appears that difficulties in processing context information are specific to particular characteristics of this task.

The analysis of the effect of position of the homograph using the more stringent initial score revealed that children in both groups gave more context-appropriate pronunciations when the homograph was placed at the end rather than at the beginning of the sentence. The effect of position was, as predicted, larger in TD children than AD children. This result is consistent with Happé's findings, although her results were based only on self-corrected rather than initial response. In the present study there was no evidence for position for self-corrected responses in the typically developing group but there was for AD children. This was because the typically developing group made a large number of self-corrections that cancelled out the position differences revealed by their

initial score. Typically developing children made 34 corrections to their initial responses. Twenty-nine (85%) of these were made when homographs were placed before the context. In contrast, children with autism made 15 corrections, 6 (40%) of which were made when the homograph was placed before the sentence context.

Although the results help to identify the difficulty in autism as specifically related to ambiguous information within a sentence context, alternative explanations for the results are possible. An obvious explanation is that children with autism simply lack knowledge of the rare pronunciations of the homographs. In this study and in the studies of Happé (1997) and Jolliffe and Baron-Cohen (1999), children's specific knowledge of rare homographs was not tested. However, in one study by Snowling and Frith (1986) subjects were informed that each word had two possible meanings and were given training in the alternative use of each word. Performance for all children improved following training but children with autism did not show any greater improvement than non-autistic children. This result is not sufficient evidence to rule out the possibility that children with autism might be less familiar with low frequency words, and especially with ambiguous homograph words at the outset. Further studies are needed in which the effects of training are assessed against baseline knowledge and using stimuli that are controlled in terms of both frequency and ambiguity.

Children with autism made fewer self-corrections. This could be explained by either lack of knowledge of the rare pronunciation or lack of access to the two alternative pronunciations simultaneously or, alternatively, by lack of

self-monitoring. Despite the lack of self-correction however, children with autism still gave more correct responses when the homograph was presented after rather than before the sentence, suggesting that children with autism may be capable to some extent of using sentence context. On balance then, the claim of a failure to take account of sentence context is best described, not as an absolute impairment, but relative only to the ability of typically developing children.

5.2 Conclusions

The weak central coherence account of autism makes the proposal that children with autism are impaired in processing information in its context. This difficulty in making use of context has been attributed to a problem with forming meaningful connections between semantically related items (Happé, 2000). To date, however, the evidence in support of this claim has rested mainly on the results of verbal tasks involving either recall of semantically related words or reading of sentences. As individuals with autism are known to have good visuo-spatial ability, the aim of the current research was to investigate whether they would be able to make use of context when information was presented in the visual domain.

Experiment 2 used an adaptation of Palmer's (1975) visual perception task to assess the influence of contextual scenes in object identification. For context information to have a facilitative effect on performance, children needed to link a visually presented contextual scene with an object that was either

typically or untypically associated with that scene. Results showed that children with autism were as able as the comparison group to use visual contextual information to facilitate object identification. Surprisingly, Experiment 3 showed that the ability to take account of appropriate context was not confined to pictorial information but was also found when verbal information alone was presented.

Both these experiments suggest that children with autism can make meaningful connections between items. The results were unexpected in the light of evidence that children with autism have difficulty with a semantic memory task in which words are connected by means of their superordinate category (Tager-Flusberg, 1991). This evidence is often cited as providing support for the weak central coherence account (Happé, 2000; Brian & Bryson, 1996). To examine the discrepancy between our findings and those of Tager-Flusberg (1991), the original semantic memory task was given to the participants of Experiment 2 and 3. In addition, another set of stimuli was added in order to include more than one semantic category. The results of this replication showed that, contrary to previous findings, children with autism did use semantic category information to aid recall when several categories were used. The earlier reported results seem to be confined to the particular set of stimuli employed in the original study.

Experiments 2 to 4 therefore failed to support the case for weakness in central coherence. Individuals with autism performed like non-autistic samples and were sensitive to context and in general were also sensitive to semantic category information, regardless of whether the information was presented

visually or verbally. Since these tasks require the integrating of single items on the basis of meaning, it is possible, in contrast to the suggestion by Happé (2000), that meaningful connections between words and objects are not weakened in autism, at least when tested in single word/picture tasks.

The replication of the homographs test in Experiment 5, however, did provide evidence of a deficit in the use of contextual verbal information in autism. Children with autism, as in previous studies, failed to give context appropriate pronunciations and instead tended to give the most frequent pronunciation of the homographs. The results of this study however provided evidence for some sensitivity to context in children with autism as they were more accurate when the homographs were placed after the sentence context. There are several alternative explanations for the difficulty children with autism experience with this task.

The first is that, as predicted, the ability to make meaningful connections between single items is intact, whereas ability to integrate multiple or higher level items of information within sentences is impaired for children with autism. This explanation has been earlier suggested by Brian and Bryson (1996). If children with autism have specific difficulty in making connections across multiple items of information, it will be important to understand how this difficulty relates to the proposed problem with context. Further research should identify whether people with autism have difficulties in making connections across multiple visual stimuli.

An alternative explanation however, is that children with autism simply lack familiarity with rare forms of homograph words. In a previous study

Snowling and Frith (1986) administered the standard task and in a later session they provided training of the two meanings or pronunciations of the homographs immediately before presenting the homograph task. Results showed that children with autism did not make significantly greater improvements in performance between the first and second session compared with non-autistic children. However, this is the only study to date that has failed to find an impairment in the homograph task by children with autism. This finding suggests that when children are provided with training, that they are assisted in accessing the rare form of homograph word. The results from Experiment 5 indicating that children with autism perform better when homographs are presented after rather than before the sentence suggests that children can make use of context to aid access of rare pronunciation and meaning. However, they are less able to do this than children in the comparison group. What is not clear is whether children with autism are less familiar with the rare forms of homographs than other children or whether they are aware of both meanings but fail to access them without a cue or training.

Another alternative for the view that children with autism have difficulties in integrating multiple items of information is the hypothesis that children may have difficulty with processing ambiguous stimuli in which two representations need to be held simultaneously. This hypothesis would predict that it is the ambiguity that creates the problem for children with autism rather than the context. If it is the case that the central difficulty for children with autism is with processing ambiguity rather than with processing sentence context, it is likely that children will have difficulty not only with processing

ambiguous words in a sentence but also with processing ambiguous visual information in general.

If the difficulty with processing ambiguous information is independent of context, this problem would be equally well explained by both theory of mind and executive function explanations of autism. For example, the ability to represent an alternative interpretation is considered to require metarepresentational ability (Perner, 1991) and is a hallmark of 'theory of mind'. The ability to shift between alternatives is also proposed as a critical element of executive function ability (Russell, 1998; Pennington & Ozonoff, 1996). There is some reason to predict that difficulty with ambiguity might not be independent of context however. Happé (1997) found that performance on the homograph task is not associated with performance on theory of mind tasks. This result suggests that these tasks have different task demands. It is possible that the sentence context in the homograph task might be important in addition to the problem with ambiguity. The possibility that children might have difficulty with ambiguous information will be investigated in Chapter 6 by use of an ambiguous figures task.

In relation to the above suggested difficulty to hold two representations simultaneously, children with autism might have difficulty integrating information when this is presented simultaneously. In the contexts tasks presented earlier in this dissertation (Experiments 2-4), the information to be integrated was presented sequentially. That is, the context was presented first and targets followed. In the homographs task however, contextual information and targets were presented simultaneously.

Most of the evidence supporting the notion of weak central coherence comes from studies using tasks in which information is presented simultaneously. For instance, Jolliffe's visual context tasks (1997), the Embedded Figures test and the Block Design task all present the context or global patterns alongside the targets. Children with autism might have difficulty representing both the global/context and the local information simultaneously. If this is the case, they would have more difficulty to use context information when this is presented with the target than when presented prior to targets. This possibility is explored in the next chapter by adapting the visual context task to present the targets embedded in the contextual scenes.

Chapter 6 Can children with autism use context in an embedded context task?

The results of Experiments 2, 3 and 4 showed that children with autism do not appear to have difficulty in using context information in either the visual or verbal domains in tasks using single words or objects. However in Experiment 5 it was found that these children did have difficulties using sentence context to disambiguate homographs. These findings fail to support the claim that children with autism have general difficulty in integrating information in its context as predicted by weak central coherence theory.

One conclusion from these experiments is that children with autism have specific difficulty with complex verbal tasks involving the disambiguation of words within sentences. However it is difficult to reconcile the evidence from the visual context task with Jolliffe's (1997) findings. In Jolliffe's tasks participants had to choose which object was incongruous with the rest in a set (i.e., ladder, bucket, window, man, suitcase) or alternatively which was the incongruous object on a visual contextual scene (i.e. a squirrel in a beach). In the

visual context task, children with autism were able to use context information of scenes to facilitate object identification. In Chapter 3 it was argued that Jolliffe's task required individuals to make an evaluation of appropriateness that might be much more difficult than the current task, which merely tested accuracy and time to name object. Also the visual context task depended on facilitation of appropriate context rather than interference by inappropriate context.

There is however an alternative explanation. In the visual context task, as in the verbal context and semantic memory tasks, context and targets were presented sequentially. In contrast, in Jolliffe's tasks the stimuli were presented simultaneously. In the homographs task, targets and context information were also presented simultaneously. Most of the evidence supporting the notion of context difficulties in autism comes from studies using tasks in which the stimuli are presented simultaneously (i.e., homographs task, Jolliffe's visual tasks, ambiguous sentences, the gap test). The only paradigms used to investigate integration problems in autism using sequential presentation of stimuli are the visual context task presented in Chapters 3 and 4, the semantic task presented in Chapter 4 and a task measuring memory for sentences versus memory for words (i.e., Hermelin & O'Connor, 1967). In all these tasks, except the latter one testing memory for sentences, individuals with autism seem to be able to integrate the stimuli and use semantic information to enhance performance.

Another source of evidence of weak central coherence in autism comes from studies using visuo-spatial tasks, such as the Block Design or Embedded Figures test. Several studies have provided empirical evidence suggesting that individuals with autism are more proficient than TD children at processing parts

of objects in these tasks (Jolliffe & Baron-Cohen, 1997; Shah & Frith, 1983, 1993). All these studies have also used tasks in which the global and local information are presented simultaneously.

The superiority in these tasks has been ascribed to a failure to process the global information. According to the global precedence model, proposed by Navon (1977), global information is processed faster and interferes with the processing of local information. A lack of global precedence therefore would result in no interference effects of the global level in the processing of the parts. This model can therefore explain why children with autism are superior in these tasks. As a result of a global impairment, the performance of children with autism, unlike TD children, is not affected by the global picture.

The global precedence model however has recently been questioned in light of more recent research in neuropsychology (Robertson & Lamb, 1991). In particular it has been argued that a lack of global interference does not necessarily involve a global impairment. In a recent study, Robertson, Lamb and Knight (1990) found that patients with lesions in the right posterior temporal regions showed enhanced performance for global information than for parts, although the same patients lacked global interference effects due to a deficit in the integration of information from the local and global levels. Thus the lack of interference of the global picture in tasks such as the Embedded Figures test cannot necessarily be taken as evidence of a global impairment. The results of this task could be explained by an inability to hold the representations of the local and global levels simultaneously and not an inability to process global information. Similarly, when having to process information in context, children

might have difficulty in representing the context when information is presented simultaneously despite their ability to integrate information when presented item by item, such as in the visual and verbal context tasks presented earlier in this dissertation.

Two different theories of autism propose that the ability to hold two representations simultaneously is impaired in autism, theory of mind and executive function theories. For example, the ability to represent alternative interpretations is considered to require metarepresentational ability (Perner, 1991), an ability that is impaired in autism (Baron-Cohen, Leslie & Frith, 1985, 1986). The ability to shift between alternatives is also proposed as a critical element of executive function ability (Russell, 1998; Pennington & Ozonoff, 1996). Autism is also characterised by executive impairment (Ozonoff, Pennington & Rogers, 1991; Hughes & Russell, 1993). Thus, if the difficulty was constrained to contextual tasks requiring the integration of simultaneous representations, any of these two theories could equally explain the contextual difficulty in autism.

To investigate the possibility that the difficulty in autism might be related to the inability to integrate information when presented simultaneously, and not to a general difficulty to integrate information in context, the same visual context task reported in Experiment 3 was administered to the same children. A new condition was added to the design in which the objects were presented superimposed in the contextual scenes. If children with autism have difficulty in integrating stimuli presented simultaneously, they would not benefit from the

provision of contextual scenes to identify objects when these are superimposed in the context.

6.1 Are children with autism sensitive to visual context when objects are embedded in a contextual scene?

EXPERIMENT 6

The aim of this experiment was to investigate if children with autism have difficulty integrating information that is presented simultaneously in contrast to information presented sequentially. To do so, the visual context task was adapted to include two conditions. In one condition the contextual scenes were presented prior to the objects, as in Experiment 2. In the other condition, embedded condition, the objects were superimposed in the contextual scene. If children with autism have an inability to process context information when presented alongside the targets, they would fail to use contextual scenes to identify objects only in the embedded condition.

The embedded condition highly resembled the Embedded Figures test, although in the present task objects are only superposed in the scene and not embedded in the picture. In the Embedded Figures test individuals with autism show enhanced perception of parts relative to non-autistic populations. It was therefore predicted that, regardless of the ability of children with autism to use contextual information to facilitate object identification, children with autism would show enhanced performance in the embedded context task relative to the

comparison group. That is, children with autism would be faster overall than the comparison group at identifying objects in the embedded condition, regardless of whether they used contextual information to facilitate object identification or not as this task, like the Embedded Figures test require the ability to focus on a part of a picture

The sequential condition was similar to Experiment 2, except for the substitution of some objects and the highlighting of the outline of the objects (see materials section for details). The administration of a similar task twice to the same samples is problematic as it might lead to practice effects. However, it was important to compare performance between the embedded and sequential conditions and it was not possible at this stage to recruit two other samples of children. To minimise the practice effects this experiment took place 4 to 7 months after the administration of the standard visual context task. As a precaution, before analysing the data, performance in the sequential task was compared to the performance in Experiment 2.

Method

Participants

The same participants as in previous experiments took part in this study. The administration of this experiment took place 4 to 7 months after the administration of Experiment 2.

Design

The experiment had a mixed design with context (appropriate vs. neutral vs. inappropriate) and type of presentation (sequential vs. embedded) as within participants factors and group (children with autism vs. typically developing children) as the between-participants factor. The dependent measures were reaction time and accuracy. The order of the sequential and embedded tasks was counterbalanced across participants.

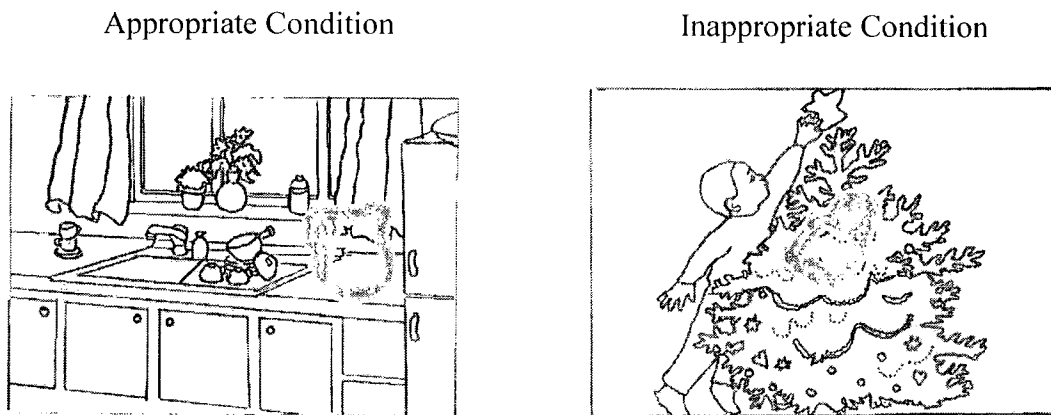
Materials

The same materials as in Experiment 2 were used in this study except for some substitutions. The object 'nail file' was replaced by a 'brush' because in Experiment 2, this object proved problematic as none of the participants named it correctly. Consequently the objects for the other two conditions (i.e., lettuce and strawberry) matched in terms of familiarity and complexity to the 'nail file', were replaced for a 'guitar' in the inappropriate condition and 'hat' in the neutral condition.

In the embedded condition, the objects were superimposed approximately in the middle of the contextual visual scene. This scene contained a number of objects and it was difficult to decide which item to name. In order to make clear for the children which object to name, the outline of the target objects in both the embedded and sequential conditions were accentuated. This had the effect of highlighting the object against its background. The same treatment was given to all targets in both conditions (see Figure 6.1 for examples

of stimuli). A pilot study with adults revealed that this alteration made no difference in reaction times, accuracy or in the context effects.

Figure 6.1 Examples of stimuli used in the embedded context task.



Procedure

All the children were tested in a quiet room. In the embedded condition, children were told that they would see a series of pictures in the screen and that they would have to name the highlighted object. The pictures containing the contextual scenes and the objects were presented for a maximum of 3000 msec. or until the child responded. Three training trials were administered before the task to ensure that children understood the instructions. In the training trials, the experimenter pointed to the object the child had to name. All children understood the task after the training trials. The same procedure as in the visual context task (Chapter 2) was followed for the sequential task.

There was a break between the administration of the embedded and sequential tasks in which distractor tasks were administered to the children. The order of administration of the two tasks was counterbalanced across participants.

Results

Most of the materials used in the sequential task had been presented previously to the children in Experiment 2. To test for practice effects prior to the analysis of the data, the results of the sequential condition were compared to the results of Experiment 2. No differences were found in performance on the two tasks or in the context effects, thus it can be assumed that there were no practice effects.

Accuracy data

The data for all children were included in the analysis. Due to the problems linked to the voicekey twelve trials (1.53% of total trials) had to be excluded from the analysis. Of these, 4 were of TD children and 8 of AD children. The data was therefore converted into proportion scores (see Table 6.1 for summary of results).

An ANCOVA was performed on the proportion scores with FIQ and CA as covariates. This analysis revealed that CA did not covary significantly with performance ($F(1,27) = .497, p = .487$). FIQ however covaried significantly with both overall performance ($F(1,27) = 8.06, p = .008$) and context ($F(2,56) = 5.143, p = .009$).

Table 6.1. Mean proportion of accurate responses and standard deviations in Experiment 6.

N	Group		Sequential			Embedded		
			A	N	I	A	N	I
16	TD	Mean	.929	.790	.814	.894	.682	.786
		SD	.10	.09	.12	.09	.18	.15
15	AD	Mean	.899	.721	.759	.867	.681	.685
		SD	.09	.11	.12	.11	.16	.19

The results of the ANCOVA revealed a significant main effect of context ($F(2,56) = 7.432, p = .001$). Pairwise comparisons indicated that children were more accurate at identifying objects in the appropriate than in the neutral ($p = .001$) or inappropriate conditions ($p = .001$). As in Experiment 2, the comparison between the neutral and inappropriate conditions did not yield significance ($p = .390$). The interaction between context and group was not significant ($F(1,27) = .011, p < .989$) indicating that AD children were as sensitive to the context as TD children.

The main effect of task did not yield significance ($F(1,28) = .036, p = .851$) nor did the interaction of task and context ($F(2,56) = 1.375, p = .261$) or task and group ($F(1,27) = .014, p = .905$). The 3-way interaction between task, context and group was not significant either ($F(2,56) = 2.128, p = .129$), indicating that, contrary to predictions, children with autism were as able as TD children at

using contextual visual information regardless whether this information was presented before or alongside the target object.

Accuracy levels, unlike in Experiment 2 were similar for both group of children ($F(1,28)= 1.317, p=.261$).

Reaction time data

Due to equipment malfunction, the data of two children, one from the AD group and one from the TD group, had to be excluded from the analysis, leaving the sample of TD children with 15 participants and the sample of AD children with 14 participants. Thirty-seven trials (2.48%) were also excluded from the analysis, of these 21 were of AD children and 16 of TD children. A summary of the results is shown in Table 6.2.

Table 6.2. Mean reaction times and standard deviations for each condition across groups in Experiment 6.

N	Group		Sequential			Embedded		
			A	N	I	A	N	I
15	TD	Mean	935.2	1043.5	1024.5	1135.3	1255.2	1247.8
		SD	255.1	206.3	241.1	210.4	247.56	312.8
14	AD	Mean	864.1	1010.8	1030.4	1070.3	1038.1	1177.8
		SD	233.3	153.8	201.1	189.6	182.5	315.9

As in previous analysis FIQ and CA were introduced in the analysis as covariates. Neither FIQ nor CA were significantly associated with either overall performance or context ($F(1,25) = .054, p = .818$; $F(1,25) = .119, p = .733$, respectively), thus they were removed from the analysis.

An ANOVA with context and task as within-participants factors and group as a between participants factor was performed on the data. This analysis revealed a significant effect of context ($F(2,54) = 9.977, p = .001$). As in the analysis of accuracy data, pair-wise comparisons showed that the provision of an appropriate context facilitated identification of objects as compared to the neutral ($p = .007$) or inappropriate conditions ($p = .001$). The difference between the inappropriate and neutral conditions did not yield significance ($p = .667$).

Unlike the analysis of the accuracy scores, the main effect of task was significant ($F(1,27) = 19.491, p = .001$). Reaction times were slower for the embedded task than for the sequential task regardless of the group as the interaction between task and group was not significant ($F(1,27) = 1.501, p = .231$).

Neither the interaction between group and context, the main effect of group nor the 3-way interaction between context, group and task yielded significance ($F(2,54) = 1.306, p = .279$; $F(1,27) = 1.143, p = .294$; $F(2,54) = 2.105, p = .132$, respectively). These results confirm the findings for accuracy scores, indicating that children with autism are as sensitive to context when this is presented alongside the target object than when presented prior to the target object.

Discussion

It was predicted that children with autism would have difficulty integrating context information and targets when presented simultaneously, as a result of an inability to hold two representations in mind. If the contextual difficulties in tasks such as Jolliffe's context task were the result of this impairment, children with autism would fail to use contextual information in the embedded condition and not in the sequential condition. The comparison between performance in the sequential task and the simultaneous task showed that both groups had similar context effects in both tasks. Children with autism, as TD children, were faster and more accurate at identifying objects when these were either embedded or presented after an appropriate contextual scene than when the contextual scene was not appropriate. Therefore, the prediction that the difficulty integrating stimuli is related to tasks in which stimuli are presented simultaneously was not supported.

In the introduction of the chapter, it was argued that the difficulty experienced by individuals with autism in the homographs task or Jolliffe's visual tasks could be explained by an inability to integrate information presented simultaneously. The results of this study seem to indicate that individuals with autism are as able to connect items of information when presented simultaneously than when presented sequentially, although further research will be needed to confirm this finding. It is still possible that poor performance in the homographs task is the result of difficulties in the processing of ambiguous stimuli and not solely a contextual difficulty. This possibility will be explored in

the next chapter. In relation to Jolliffe's tasks, it is also possible that the failure to select the incongruous object in a set or contextual scene (i.e., Jolliffe's visual context tasks) is the result of advanced requirements of these tasks related to the notion of inappropriateness.

Both groups of children were slower in the embedded than in the sequential task. A possible explanation for the enhanced performance for the sequential task could be that children might have improved at identifying objects in the second presentation of the sequential task. However, the comparison of performance in the sequential task and Experiment 2 did not yield significance. Alternatively these results might be the result of an additional difficulty in identifying objects in the presence of background information. Further research will be needed to ascertain the effects of providing context information alongside targets in object identification.

It was predicted that as the embedded condition highly resembled the Embedded Figures test, children with autism would show enhanced performance in this condition relative to non-autistic populations, regardless their ability to use contextual information. Children with autism in contrast were as fast as TD children in the embedded condition. A possible reason for the failure to find enhanced performance for parts in this task relative to the comparison group is discussed in the following section.

6.3 Are children with autism really superior in the Embedded Figures test?

EXPERIMENT 7

The most highly regarded evidence for weak central coherence in autism, comes from the use of the embedded figures test (Witkin, Oltman, Raskin & Karp, 1971) and the block design test (Weschler, 1974). Several studies have shown that in both the Embedded Figures test (EFT) and the Block Design (BD) individuals with autism show superior performance as compared to matched samples (e.g., Shah & Frith, 1983; 1993). According to the findings from these studies using both the EFT and the Block Design, children with autism should have been faster than TD children in Experiment 6 when identifying objects embedded in a contextual scene. Children with autism however were as fast as TD children. It is difficult to explain why in this task, but not in the EFT or Block design, which share a similar format, TD children are as fast as children with autism. One possible explanation lies with the nature of the stimuli. In both the EFT and the BD, the global pattern needs to be broken up into meaningless parts. The parts in Experiment 6 in contrast, constituted meaningful objects (i.e., a 'jug').

There is some evidence showing that when provided with a meaningful global pattern TD children are as good as AD children in segmenting a given design. Pring, Hermelin and Heavey (1995) investigated the effects of providing meaningful and meaningless patterns of stimuli in an autistic and a typically

developing sample. They adapted the Block Design task so there was a condition in which the pattern was meaningful (i.e. a scene taken from a children's book) as well as the standard meaningless/geometrical condition. They found that individuals with autism were faster than non-autistic individuals at copying the patterns only in the meaningless/geometrical condition. In the meaningful condition they were as fast as the comparison group. Pring, Hermelin and Heavy (1995) also compared the performance of artistically talented individuals with autism and non-autistic individuals. The results for the artistically talented individuals showed that the comparison sample were as fast as individuals with autism in the meaningless condition but talented non-autistic individuals were faster than autistic people in the meaningful condition.

They concluded that the ability to segment pictures underlies artistic talent, an ability that is shared by both non-autistic and AD artistically talented individuals. However, only talented non-autistic individuals are able to use the additional meaningful information to facilitate performance in this task as shown by their superior speed in completing the meaningful designs.

Experiment 6 resembled the meaningful condition in that the visual contextual scene constituted a meaningful picture and the task required the ability to focus on a part of the picture. It is therefore possible that the failure to find superior speed in AD children relative to TD children might be due to TD children using the additional meaningful information. If children with autism had only superior performance in tasks where the pictures are meaningless, such as in Pring, Hermelin and Heavey's (1995) study, this could have important implications for the definition of WCC theory. No longer the superior ability in

tasks such as the EFT or the BD should be interpreted in terms of a general tendency to focus on parts, that is a local bias, but superior ability to process meaningless material.

Experiment 7 investigates if the superior performance of children with autism in the BD or EFT is due to superior ability to segment pictures into meaningless parts and not to general superior ability to process parts. It was predicted that if they have a general superior ability to process parts, they would be faster and more accurate than TD children in finding a shape embedded in a picture even when the shape depicted was a meaningful object. If the ability is restricted to the segmentation into meaningless parts, as Pring et al's results suggest, the two groups should have similar reaction times.

Method

Participants

The same participants as in previous experiments took part in this experiment.

Design

The experiment had a between-groups design. The independent variable was group (AD vs. TD children) and the dependent variables were reaction time and accuracy.

Materials

Six geometrical shapes were employed: Square, diamond, large circle, small circle, triangle and cylinder. All the shapes depicted a meaningful object in a picture (i.e. a circle was a Christmas decoration). These shapes were embedded in ten different pictures (See Figure 6.2 for examples of stimuli). Three other visual scenes were employed as training trials, a 'garden' (cylinder), a 'post office' (diamond) and an 'office' (cylinder).

The pictures containing the visual scenes were the same as used in Experiment 2 but adapted to contain the shapes. For instance, the diamond shape was inserted as a kite in the picture depicting a beach or a triangle was inserted as a hat in the picture of a children's party. The reaction times were recorded with a stopwatch.

Figure 6.2. Examples of stimuli used in the Meaningful Embedded Figures task.



Procedure

Children were tested in a quiet room at either the school or home. The same procedure as in the standard Embedded Figures test was used. The children

were told: ' I am going to show you some pictures and some shapes. Your task will be to find the shape in the pictures. I will show you first the shape and then the picture where to find the shape. The shapes are always up-right so you don't need to tilt the card over. The shape in the picture is identical to the sample I will be giving you. We are going to practice first with three pictures'. There were then showed one shape (cylinder) followed by the presentation of a picture depicting a visual scene (a 'garden' where the cylinder was a post in the fence). This training trial was followed by another two practice trials with different shapes and scenes. Once the child understood the purpose of the task the proper experiment commenced.

The trials were presented in random order. The shapes were always shown before the pictures. If the child had difficulty to find the shape, he/she was encouraged to keep searching until found. Children were asked to point at the location where the shape was in the picture.

Results

All children found the embedded shapes, thus only the reaction time data were analysed. The reaction times for each picture were combined in a total mean score. A pre-screening of the data revealed an outlier in the AD group who had a mean reaction time 2 standard deviations above the mean for the AD group. The data for this child were therefore excluded from the analysis. The results of the remaining children are summarised in Table 6.3.

Table 6.3. Mean reaction times in seconds and standard deviations across groups in Meaningful Embedded Figures task (Experiment7).

N	Group	Reaction Times	
16	TD	Mean	2.84
		SD	1.41
14	AD	Mean	4.92
		SD	3.67

A t-test was performed on the mean reaction times to test for differences in speed between the two samples. The Levene's test assessing the assumption of equal variances was significant ($F=8.298$, $p=.008$) thus the t-test for equality of variances not assumed is reported. TD children tended to find the embedded shapes faster than AD children although this difference only approached significance ($t(16.333)=-2.00$, $p=.062$).

Discussion

The aim of this study was to test, by use of an adapted version of the Embedded Figures test, whether children with autism would show superior performance in comparison to TD children. In this adapted task the shapes to be found depicted meaningful objects and not parts of objects as in the standard embedded figures test. The results showed that children with autism were not faster than the comparison group at finding the embedded shapes. Moreover

there was a trend for TD children being faster. These results confirm the findings of Pring, Hermelin and Heavey (1995), indicating that when meaningful material is provided TD children are as fast as children with autism in the Block Design.

It is difficult however to draw firm conclusions from this study because of the lack of a control task with a meaningless condition. It would have been ideal to administer the standard EFT to this same sample to compare children's performance in the two tasks, however this was not possible due to time limitations. We have some evidence that the sample of children with autism had a local bias from the scores in the Block Design sub-test of the WISC. Only eight out of the fourteen of the children with autism (57.14%) had the full WISC administered, six of these children (75%) had peak scores in this test. It is not possible to draw any conclusions for the other six children as there is only one other non-verbal subtest to compare performance with. None of the TD children had the full administration of the WISC.

The performance of the six children with peak scores in the BD did not differ from the sample of TD children (AD mean=2.61 (.75); TD mean=2.84 (1.4); $t(20)=.376$, $p=.715$). That is, these children did not have superior performance in the meaningful embedded figures test as would be expected from their superior performance in the Block Design test. The number of participants however is too small to draw any definite conclusions.

The present experiment was an exploratory study. Further research with a control for meaningless stimuli will thus be needed to confirm the extent to which the local bias in autism is confined to meaningless material. Superiority of feature processing only in tasks containing meaningless material could have

important implications for the definition of central coherence. No longer should weak central coherence be defined in terms of a local attentional bias, but by a difficulty to process information for meaning. This was the original definition proposed by Frith (1989), however later developments in research in the area led to the assumption that failure to process for meaning and preference for part processing were part of the same underlying mechanism.

6.4 Conclusions

Experiment 6 (embedded context task) investigated the possibility that the difficulty children with autism experience with the homographs task might be due to an inability to integrate several pieces of information when presented simultaneously. Results showed that even when information was presented simultaneously, children with autism use contextual information to facilitate object identification. The next chapter investigates an alternative explanation to account for the difficulties children with autism have with the homographs task. This explanation relates to potential difficulties in the processing of ambiguous information in autism.

Chapter 7 Does context influence the interpretation of ambiguous figures?

Experiments 2 to 4 showed that children with autism were competent in making use of both visual and verbal context information. They did however have difficulty using contextual information to disambiguate homograph words (Experiment 5). It was argued that children with autism might have experienced problems with the homographs task because in this task, the contextual information is presented alongside the target stimuli and not sequentially and/or because this task requires the processing of ambiguous stimuli.

Having established that children with autism did not find it more difficult to integrate information in its context when the targets were embedded in the context, the next study investigated the question of ambiguity. The present chapter reports two studies which develop a paradigm designed to investigate the influence of context in the identification of ambiguous figures.

7.1 Perception of ambiguous figures

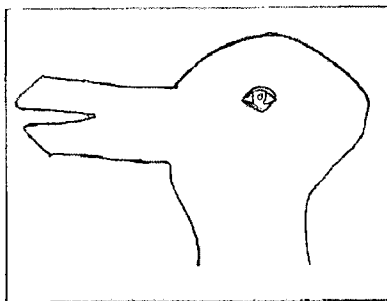
Ambiguous figures have been used to investigate two different areas of cognitive functioning, perceptual processes and the ability to switch between two representations. The first area of investigation has examined the extent to which attention to certain aspects of the figure affects the interpretation of the figure. In this type of research participants' attention is drawn to critical aspects of the figure. For instance, for the duck/rabbit figure (see Figure 7.1) attention is drawn to either the ears of the rabbit or the beak of the duck. It is assumed that if there are bottom-up perceptual processes, attention to a critical feature (i.e., ears) will increase the likelihood of forming that interpretation of the figure (i.e., rabbit).

Attention has been manipulated in different ways by use of letter detection tasks in which the letters are presented in the same position as the critical feature (Tsal & Kolbert, 1985) and also by positioning the fixation point on the location of the critical feature (Goolkasian, 1987). A more direct approach has been to present a drawing of the critical feature or a biased version of the figure prior to the presentation of the ambiguous figure (Goolkasian, 1987). Overall the results of these studies have shown that focusing attention to critical features increases the likelihood of interpreting the figure in a certain way. This finding suggests that the formation and maintenance of a given interpretation is achieved by allocating attention to a focal area. To date no studies have investigated whether the presentation of contextual scenes prior to presentation of an ambiguous figure

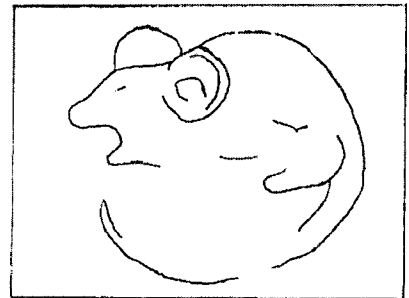
would facilitate the interpretation of the figure in the same way as a contextual scene facilitates object identification.

The second area of investigation concerns the ability to reverse from one of the interpretations of the figure to the alternative interpretation. This ability has been related to executive function (Ricci & Blundo, 1990; Meenan & Miller, 1994) and to theory of mind (Gopnik & Rosati, 2001).

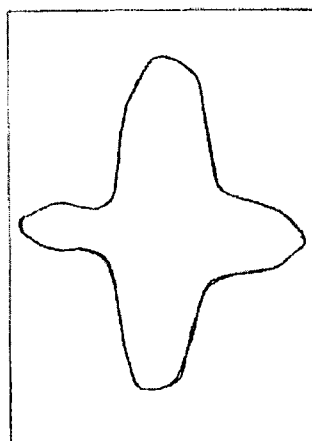
Figure 7.1. Examples of figures used in Goolkasian's (1987) and Tsal and Kolbert's (1985) studies.



a) Duck/Rabbit Figure



b) Man/Mouse Figure



c) Bird/Plane Figure

Patients with damage in the frontal lobes have special difficulties to switch from the first interpretation they make of the figure to the alternative (Meenan & Miller, 1994). It has been suggested that individuals with autism have an executive dysfunction (Russell, 1996; Pennington & Ozonoff, 1996) and, in particular, difficulties in shifting attention and cognitive shifting (Courchesne et al., 1994). Moreover, individuals with autism have been reported to show difficulty in the inhibition of prepotent responses (Ozonoff, Pennington & Rogers, 1991). Ambiguous figures like homograph words have one interpretation that is more frequent than the other (Goolkasian, 1987). It is therefore reasonable to argue that the difficulty experienced by children with autism might be related to a difficulty in processing ambiguous material, either related to a difficulty to shift between interpretations or an inability to inhibit the most frequent response.

Ambiguous pictures and objects have been used also to investigate the ability of children to hold two different representations. Children acquire the ability to distinguish appearance and reality between the age of three and five years (Flavell, Green & Flavell, 1986). This ability to hold two representations has been suggested to underlie theory of mind abilities (Perner, 1991). In order to solve the traditional theory of mind tasks such as the false belief task the child needs to take in account the representation of the real world state and the belief held by the other person. Gopnik and Rosati (2001) found that typically developing children who could solve theory of mind tasks, and therefore were able to hold two representations, were more likely to reverse ambiguous figures. Children with

autism have theory of mind deficits (Baron-Cohen, Leslie & Frith, 1985, 1986; Leslie & Frith, 1988) thus it would be expected that they would also show difficulty in the ability to reverse ambiguous figures.

Bearing in mind that both executive function and the theory of mind accounts provide explanations for the ability to process ambiguous figures and that children with autism have impairments in these two domains, it would be expected that individuals with autism would have difficulties processing ambiguous material regardless of whether they have difficulty with context.

The aim of this study was to investigate if the difficulty experienced by children with autism in using context information in the homographs task is related to the processing of ambiguous material. There are no tasks in either the adults or child literature testing whether context information facilitates the disambiguation of ambiguous figures although there are tasks that test whether focusing attention on a critical feature increases the likelihood of giving a particular interpretation. These tasks however would not enable the investigation of the precise effects of an impairment in the processing of ambiguous material in the use of context. Rock, Gopnik and Hall (1994) have developed a paradigm that has been widely used with children. This paradigm however is based on a structured interview that investigates children's ability to reverse ambiguous figures and not the extent to which contextual factors affect the interpretation. Hence this paradigm is not suitable for the evaluation of the effects of context in the identification of ambiguous figures. The first stage, before testing the ability of children with autism or typically

developing children, was to construct a method for testing the influence of context on the interpretation of ambiguous figures.

7.2 Developing a method to investigate the influence of context in the interpretation of ambiguous figures

EXPERIMENT 8

Children with autism benefit from the provision of contextual scenes when identifying objects as shown in Experiment 2. It was decided therefore to adapt this paradigm to investigate the effects of context on the identification of ambiguous figures. If children with autism do not have difficulty processing ambiguous visual information in context, they should use context information to disambiguate ambiguous figures. Alternatively, if they have a problem with ambiguity they would fail to use contextual information to disambiguate the figures as they fail to use context information to disambiguate homographs.

This new context task followed the same format as the visual context task presented in Chapter 3. That is, a contextual scene was presented followed by a target picture and participants had to name the picture. In this case however, the pictures were ambiguous figures that could be interpreted in two ways.

The contextual scenes needed to be adapted to facilitate each of the interpretations of the figures. Before running the experiment with children therefore,

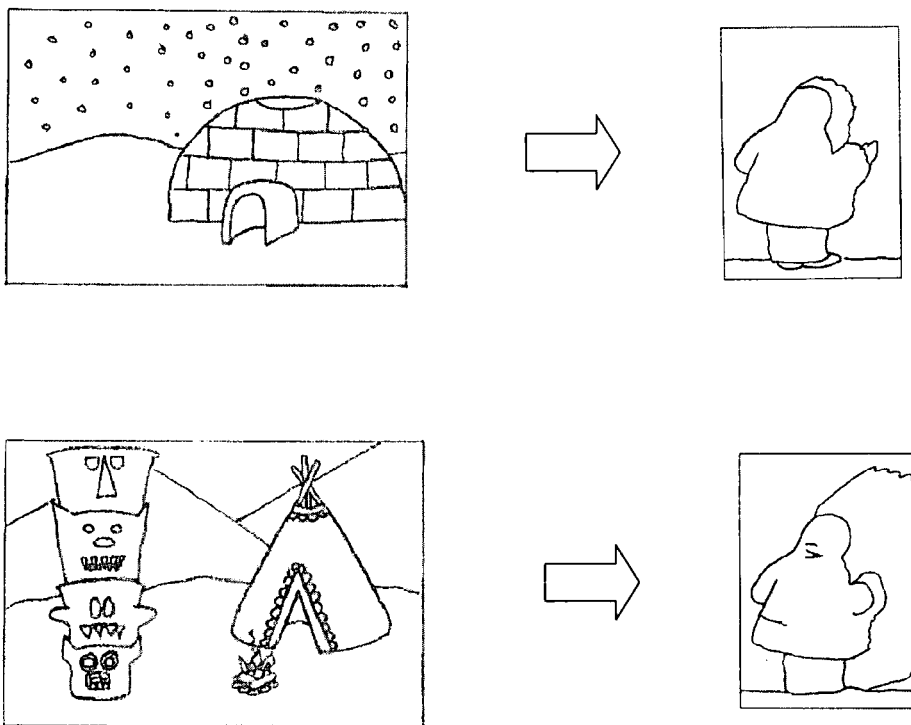
it was necessary to assess whether each of the new contextual scenes would in fact facilitate each of the interpretations. The first stage was to test if the contextual scenes drawn for each of the figures were sufficiently related to each of the interpretations, allowing the method to work like the object identification paradigm of Experiments 1-2.

To complete this stage, the ambiguous figures were manipulated so that they were no longer ambiguous. For instance, for the Indian/Eskimo, the experimenter drew two figures, one looking more like an 'indian' and the other looking more like an 'eskimo' (see Figure 7.2). These biased figures were paired to the contextual scenes drawn by the experimenter. In the case of the 'eskimo' for instance, the experimenter drew a scene depicting an 'igloo' and for the 'indian' a scene containing a 'wigwam'. The design also included, as Experiment 2, a neutral condition and an inappropriate condition. In the latter condition the contextual scenes were paired to the opposite biased version of the figure. For instance, the scene depicting the 'igloo' was paired to the 'indian' and the scene containing the 'wigwam' was paired to the 'eskimo'. This method was then tested with a group of adults.

An additional aim in testing this method with adults was to explore performance for each of the figures. Three of the ambiguous figures, and their corresponding biased versions, had been used in previous studies. Four figures however had not been used before in research and thus it was necessary to assess the extent to which these figures were easy to identify.

It was predicted that if the contextual scenes were appropriately related to each interpretation of the figure, they would facilitate the identification of the biased figures relative to the neutral and inappropriate conditions. As in Experiment 2, no interference effects of inappropriate scenes were predicted .

Figure 7.2. Examples of biased figures and contextual scenes used in the present study.



Method

Participants

Forty-five undergraduate students took part in this pilot study.

Design

To avoid presenting the same figures three times to each participant, each paired with a different contextual scene, a between-participants design was adopted. The independent variable was the type of context (appropriate vs. neutral vs. inappropriate). The dependent variables were naming accuracy and reaction times.

Materials

There was a total of seven ambiguous figures. The Bird/Plane, Mouse/Man and Duck/Rabbit figures were taken from a previous study by Goolkasian (1987; see Figure 7.1). The remaining figures, Indian/Eskimo, Old/Young Woman, Saxophonist/Woman and 13/B were taken from textbooks. The biased versions of these figures were taken from Goolkasian in the case of Mouse/Man, Duck/Rabbit and Bird/Plane. For the other figures the experimenter drew two biased versions for each figure, each emphasising the features of one of the interpretations. Fourteen biased figures were therefore used. These figures consisted of black drawings against a white background. All were approximately 10 x 14 cms. The contextual scenes were also drawn by the experimenter. None of the scenes contained the target

picture. Examples of the biased figures and contextual scenes used are shown in Figure 7.2

In the appropriate condition, the contextual scenes were paired with the appropriate biased figure (i.e. the 'igloo' was paired with the biased 'eskimo'). In the inappropriate condition, the contextual scenes were paired with the inappropriate biased figures (i.e., the 'igloo' was paired with the biased 'indian'). In the neutral condition the biased figures were paired with a black frame as in the replication of Palmer's experiment reported in Chapter 3.

Procedure

All participants were tested individually in a quiet room in the University. Participants were randomly assigned to either the appropriate context condition inappropriate or neutral context conditions. In the appropriate and inappropriate conditions, participants were told that they would see a series of pictures. Some of these were complex visual scenes, and some others depicted just a single picture. They were instructed to name the single pictures but not contextual scenes. They were also instructed to give specific names and not simply 'a man' or 'a boy'.

Participants in the neutral condition were told that they would see a series of pictures, each preceded by the presentation of a black rectangle. They were also asked to name the pictures and try to give specific names.

In all conditions, participants were asked not to respond if they could not identify the figure. Both accuracy of naming and reaction time were recorded. The pictures were presented in random order.

Results

Scoring criteria

Responses were coded as correct if the participant gave the correct name (i.e. Indian) or a name that could be used to describe the figure (i.e., Man's face). Non responses (i.e. the participant did not respond) were coded as incorrect.

Analysis of accuracy data

Nine trials (1% of the total number of trials) had to be excluded from the analysis due to interruptions or equipment malfunction. The accuracy scores were therefore converted into proportion scores. Results are summarised in Table 7.1.

Performance, unlike in Experiment 1 with non-autistic adults, was not at ceiling. Hence the accuracy data could be analysed by means of a one-way ANOVA. This analysis revealed a significant effect of context ($F(2,42)= 10.196$, $p=.001$). Pairwise comparisons using the Tukey procedure revealed that participants were more accurate in the appropriate condition than in the neutral ($p=.016$) or inappropriate conditions ($p=.001$). As in Experiment 1, the comparison between the neutral and inappropriate condition did not yield significance ($p=.283$).

Table 7.1. Mean proportion accuracy scores and standard deviations across contextual conditions in Experiment 8.

	Appropriate (n=15)	Neutral (n=15)	Inappropriate (n=15)
Mean Accuracy	.85	.74	.68
SD	.11	.08	.12

To directly assess the effects of the contextual scenes, an item by item analysis was performed. This analysis consisted of a repeated-measures design in which the mean accuracy score for each figure was compared across conditions. That is, the analysis tested if the figures were more accurately identified when paired to the appropriate context than when paired to a neutral or inappropriate context. A repeated measures ANOVA revealed a significant context effect ($F(2,26) = 9.535, p = .001$). The pairwise comparisons showed that figures were easier to identify when paired to appropriate contextual scenes (Mean = .85, SD = .17) than when paired to a neutral scene (Mean = .74, SD = .26; $p = .030$) or inappropriate scene (Mean = .68, SD = .23; $p = .000$). The comparison between the neutral and inappropriate conditions did not yield significance ($p = .998$).

The second aim of the study was to explore performance for each of the figures that had not been used in research. Table 7.2 below shows the percentage of participants that correctly identified each of these figures.

Table 7.2 Percentage of participants that correctly identified the new ambiguous figures.

Figure	Total
Indian	78
Eskimo	89
Saxophonist	70
Woman	52
13	98
B	96
Old Woman	42
Young Woman	70

As can be seen on the table most of the figures were correctly identified by the majority of participants. The figures that were most difficult to identify were the old woman, and the woman (saxophonist/woman). The old woman, although difficult to identify in the neutral and inappropriate conditions, was fairly easy to identify in the appropriate context condition (Old, 93%). Only about half of the

participants correctly identified the woman in any of the conditions. The alternative interpretation of this figure was easy to identify in all the conditions hence this figure was also kept in the design.

Analysis of reaction times data

All correct responses were included in the analysis to avoid biases introduced by trimming the data. As in previous experiments the use of a voicekey resulted in some trials missing. There were a total of 78 trials missing which accounted for 12.38% of the total number of trials. The mean reaction times for correct trials are presented in Table 7.3 below.

Table 7.3. Mean reaction times and standard deviations across contextual conditions in Experiment 8.

	Appropriate (n=15)	Neutral (n=15)	Inappropriate (n=15)
Mean RT	1410.72	1387.28	1632.33
SD	318.63	293.34	322.12

A one-way between participants ANOVA showed that the context effect was not significant ($F(2,42)=2.824, p=.071$). Unlike in Experiment 1, appropriate scenes did not increase the speed of identification of the figures.

An item by item analysis on reaction times using a one way repeated measures ANOVA revealed a significant effect of context ($F(2,26)=4.257, p=.025$). Pairwise comparisons revealed that biased figures were identified slower when presented after an inappropriate condition than after a neutral condition ($p=.042$). That is, there was a significant interference effect. Neither of the other two other comparisons yielded significance (Appropriate vs. Neutral, $p=.999$; Appropriate vs. Inappropriate, $p=.243$). Contrary to expectations and to the results of the accuracy data, the provision of contextual scenes did not facilitate the speed of identification.

Discussion

The aim of this study was to test the materials for a new method aimed at investigating the effect of context on the interpretation of ambiguous figures. At this stage in the development of the method, ambiguous figure stimuli were not used but instead a biased version of the figures were used to test with a set of contextual scenes in order to see whether these materials would operate well in the object identification paradigm used in Experiment 2. It was predicted that if the contextual scenes were appropriate they would facilitate the identification of the biased figures.

The results showed that the set of contextual scenes did facilitate the correct identification of the figures when contrasted with neutral or inappropriate contexts. This facilitation occurred whether the data was analysed across participants or

across figures. Participants in the appropriate condition were more accurate than the participants in the other two groups. Similarly, the biased figures were identified more accurately when paired with appropriate contextual scenes than when paired with the other two types of scenes.

This study aimed to explore also the patterns of performance for the biased figures that were not used in previous studies. The exploration of the results showed that most of the figures were identified by the majority of participants. Two of the figures, the old woman and the woman had low rates of identification. The old woman was correctly identified by the majority of participants in the appropriate condition and the counterpart of the woman figure was also identified by most participants.

In terms of reaction time data, the results are quite difficult to interpret. It was predicted that participants would be faster in the appropriate condition than any of the other two conditions. Contrary to this expectation, the analysis revealed that participants responded similarly in the three context conditions. It is difficult to explain why in the standard version of the task participants' speed of identification of standard objects improves when appropriate scenes are provided but it does not when the objects are substituted by biased figures. Moreover, the item analysis revealed that figures were identified more slowly when paired with the inappropriate than when paired with the neutral scenes, that is there was a significant interference effect. The figures however were not identified faster when paired with appropriate scenes, in other words there was no significant facilitation

effect. Accuracy scores and reaction times usually show the same effects. That is, if participants are more accurate in a given condition they tend to be also faster. The results of this study however show that participants are more accurate in the appropriate condition but not faster. Also, the results showed that participants are slower in the inappropriate condition relative to the neutral condition but they are not less accurate.

As in the final study the crucial measure was the interpretation given of the figure and not the time taken to identify the figures, the results of the time reaction data are not as relevant as the accuracy data. The aim of this experiment was to evaluate if the set of scenes developed for the final study would be suitable to elicit a particular interpretation of an ambiguous figure. If they were, the scenes should facilitate the identification of the biased versions of the figures relative to neutral or inappropriate scenes. The results of this study have confirmed the suitability of the scenes as participants were more accurate identifying the figures when these scenes were presented prior to the figure than when inappropriate or neutral scenes were presented.

Having established that the contextual scenes devised for the final study with ambiguous figures facilitate the identification of biased versions of the figures, the second stage of the study was to present the figures in an ambiguous form. Again a group of adult participants was used to test this stage of the method design and this experiment is presented next.

7.3 The influence of visual contextual scenes in the interpretation of ambiguous figures

EXPERIMENT 9

The present study investigated whether the contextual scenes tested in Experiment 8 would influence the interpretation of the same figures when presented in an ambiguous form. If the scenes can facilitate the identification of biased versions they should also facilitate particular interpretations of the ambiguous figures. A similar design as Experiment 1 and Experiment 8 was used except that ambiguous figures were presented instead of objects or biased figures. The design of this experiment however did not include an inappropriate condition but two appropriate conditions were presented instead. In Context A condition, the contextual scenes of one of the interpretations were presented (i.e., a picture of an airport for the bird/plane figure). In the other context condition (Context B) the alternative contextual scenes were presented (i.e., the picture of a nest for the bird/plane figure). The third condition consisted of the presentation of a neutral context (i.e., black frame) followed by the ambiguous figure.

Unlike in previous experiments, the targeted measure, was the interpretation of the ambiguous figures, that is, the name given (i.e., whether people saw an Indian or an Eskimo) and not reaction times. The interest was whether children with autism

would give context appropriate names for the ambiguous figures and thus reaction times were not as important as accuracy scores.

Goolkasian (1987) has shown that the presentation of critical features (i.e., the ears of the duck/rabbit) or biased figures before ambiguous figures significantly increases the probability of a particular interpretation. Therefore it was predicted that the presentation of contextual scenes prior to the ambiguous figures would affect participants' interpretation of the figures. For instance, it was predicted that presenting the picture of an airport would increase the proportion of participants naming the bird/plane figure as plane relative to the proportion of plane responses in the no context condition.

Method

Participants

Sixty undergraduate students took part in the experiment.

Design

As the figures needed to be presented three times, one for each condition, a between-participants design was adopted. The independent variable was the type of context (Context vs. No context). The dependent variable was the interpretation of the figure the participant made. Twenty participants in the context condition received a set of contextual scenes appropriate to one of the interpretations of the ambiguous figures (i.e., the nest for the bird/plane) hereafter this condition will be

named Context A condition. Another twenty participants in the context condition, namely Context B, condition received the other set of contextual scenes appropriate for the alternative interpretations (i.e., the airport for the bird/plane). A final group of twenty participants received the ambiguous figures paired with the neutral context scene. The participants were randomly assigned to each of the conditions.

Materials

Seven ambiguous figures were used in the experiment. These ambiguous figures have two interpretations each. Three of the figures were used in previous studies (Goolkasian, 1987) these were the Mouse/Man, Duck/Rabbit and the Bird/Plane (See Figure 7.1). The other four figures were taken from textbooks. Saxophonist/Woman, 13/B, Eskimo/Indian and the Young woman/Old woman (see Figure 7.3). The same contextual scenes as in Experiment 8 were used. The ambiguous figures were black drawings over a white background they all were approximately 10 x 14 cms.

The contextual scenes were presented for 2000 msec. This was followed by an interval of 1300msec. after which the ambiguous figure was presented for a maximum of 3000msec. or until the participant responded. The ambiguous figures and contextual scenes were presented randomly within each condition. Participants were asked at the end of the experiment if they had seen any of the figures before and if so which ones.

Figure 7.3. Examples of ambiguous figures used in Experiment 9.

a) Thirteen/B



b) Indian/Eskimo



c) Saxophonist/Woman



d) Old/Young woman



Results

Scoring Criteria

Responses were coded as valid if the participant gave the correct name for any of the two interpretations of each figure (i.e. Indian or Eskimo) or a name that could be used to describe either of the interpretations (i.e., Man's face). Responses that could not be applied to any of the interpretations were coded as other.

Analysis of data

As in Goolkasian's (1987) study the data for each figure were analysed separately. There were two main reasons for separating the analysis for each figure. First, Goolkasian's study showed that while some figures were significantly affected by the stimuli presented prior to the ambiguous figure (i.e., a critical feature or a biased figure) the interpretation of other figures was not affected by prior stimuli. Second, as Goolkasian's study shows, ambiguous figures have one interpretation more frequent than the other. Therefore it is important to compare the proportion of people that give a particular interpretation with the likelihood of that interpretation being given when no context is provided. Thus, as in Goolkasian's study, the responses were analysed by means of chi-square tests carried out separately for each figure.

Sixty trials (14% of the total number of trials) had to be excluded from the analysis because either participants gave two names of the figure or, in most cases, participants gave a name that could be applied to either interpretation. Of the sixty trials, 30 corresponded to the indian/eskimo as about half of the participants name this figure 'man'. Table 7.4 shows the percentage and number of participants that gave context appropriate responses for each of the figures. As can be seen in the table none of the contextual scenes significantly changed the likelihood of giving a certain name relative to the no context condition.

Table 7.4. Number of interpretations given of the ambiguous figures in each context condition. Percentages are given in brackets.

Bird/Plane Figure				
Response	Nest	No Context	Airport	Chi-square
Bird	8 (47%)	8 (40%)	8(44%)	$\chi^2(2)=.193, p=.908$
Plane	0 (0%)	0 (0%)	0 (0%)	
Other	9 (53%)	12 (60%)	10 (56%)	
Duck/Rabbit Figure				
Response	Pond	No Context	Hunter	Chi-Square
Duck	18 (95%)	20 (100%)	19 (100%)	-
Rabbit	1 (5%)	0 (0%)	0 (0%)	-
Other	0 (0%)	0 (0%)	0 (0%)	
Mouse/Man Figure				
Response	Mousetrap	No Context	Office	Chi-square
Mouse	17 (85%)	15 (79%)	11(65%)	$\chi^2(2)=2.199, p=.333$
Man	2 (10%)	4 (21%)	5 (29%)	$\chi^2(2)=2.230, p=.312$
Other	1 (5%)	0 (0%)	1 (6%)	

(Continued)

(cont.)

Indian/Eskimo Figure				
Response	Wigwam	No Context	Igloo	Chi-square
Indian	5 (42%)	4 (57%)	5 (46%)	$\chi^2(2)=.436, p=.804$
Eskimo	6 (50%)	2 (28%)	6 (54%)	$\chi^2(2)=.986, p=.611$
Other	1 (8%)	1 (15%)	0 (0%)	
Saxophonist/Woman Figure				
Response	Rock Band	No Context	Art Gallery	Chi-square
Saxophonist	15 (79%)	10 (62%)	7 (44%)	$\chi^2(2)=5.073, p=.079$
Woman	2 (11%)	4 (25%)	6 (37%)	$\chi^2(2)=3.54, p=.170$
Other	2 (10%)	2 (13%)	3 (19%)	
13/B Figure				
Response	Numbers	No Context	Letters	Chi-square
13	18 (90%)	18 (95%)	19 (95%)	-
B	2 (10%)	1 (5%)	1 (5%)	-
Other	0 (0%)	0 (0%)	0 (0%)	
Old/Young Woman Figure				
Response	Fireside	No Context	Dance	Chi-square
Old	8 (53%)	12 (63%)	9 (53%)	$\chi^2(2)=.490, p=.783$
Young	4 (27%)	7 (37%)	5 (29%)	$\chi^2(2)=.449, p=.799$
Other	3 (20%)	0 (0%)	3 (18%)	

There were some figures that proved to have a strong bias towards one of the interpretations. The duck/rabbit for instance was interpreted as a 'duck' by all participants in the neutral condition and also by those participants receiving the context appropriate to the rabbit interpretation. Similarly, none of the participants interpreted the figure bird/plane as a 'plane' in neither the neutral condition nor in the condition when an airport was presented beforehand. Only 5% of participants interpreted the 13/B figure as a 'B' in both the context condition and the letter context condition. In these cases it was not possible to carry out statistical analyses. The data for the remaining figures were analysed by a series of 2 x 3 Chi-Square tests. None of these analyses yielded significance (see Table 7.4).

Discussion

It was predicted that the provision of contextual scenes prior to the presentation of ambiguous figures would influence the way participants interpreted the figures. This prediction was not supported by the results of this experiment. Participants tended to give the most frequent interpretation of each figure regardless the context in which they were presented. These results are quite surprising as previous studies have shown that the presentation of a critical feature or a biased figure influences the way in which ambiguous figures are interpreted (Goolkasian, 1987).

A difference between homographs or ambiguous words and ambiguous figures, is that in the case of words, individuals know that the word has two different meanings or pronunciations. Research has shown that when participants do not know that a figure is ambiguous they fail in most cases to realise that there are two different interpretations (Rock & Kurt, 1992). When they are informed of the two alternative interpretations however they do not have problems reversing from one to the other. Maybe if participants had been aware of the two interpretations, the probability of giving context appropriate names would have increased significantly. If they had realised that the bird/plane, for instance, could be seen as a 'plane', then maybe they would have named the figure as 'plane' significantly more when paired with the 'airport' scene.

To explore this possibility, the percentage of participants that were familiar with each of the figures was calculated. Thirty-two participants were familiar with the old/young woman (65.33%) and approximately one third were familiar with the indian/eskimo (39%). The numbers for the indian/eskimo were too small to carry out any statistical analyses. Table 7.5 summarises the number of participants that gave each of the interpretations for the old/young woman figure of those participants that were familiar with this figure. Although the numbers for this figure are also quite small to allow any definite conclusion, exploratory analyses were carried out on this data. This analysis revealed that even when aware of the alternative interpretation, participants failed to give context appropriate responses.

These results thus indicate that knowledge of the ambiguity of the figures was therefore not a determinant factor for the use of context.

Table 7.5. Number and percentages (in brackets) of participants that gave each of the interpretations of the old/young woman figure when familiar with the figure.

Old/Young Woman Figure				
Response	Fireside	No Context	Dance	Chi-Square
Old	6 (75%)	8 (53%)	6 (55%)	$\chi^2(2)=1.134, p=.567$
Young	2 (25%)	7 (47%)	5 (45%)	

How can we explain then the failure to bias the interpretation of ambiguous figures by use of contextual scenes? Several studies have reported that alternative interpretations of ambiguous figures are accompanied by distinctly different patterns of fixation (Ellis & Stark, 1978). Tsal and Kolbet (1985) argued that if participants look at different locations of the figure when seeing the different interpretations, then focusing the attention of participants in those locations would induce a certain interpretation. This prediction was confirmed in their study and also by Goolkasian (1987) in a later study. Thus what is important in determining which interpretation is given is where in the picture participants focus their attention and not in which context are the figures presented. Ambiguous figures as shown in this study are

particularly resistant to context influence, what seems crucial in the perception of ambiguous figures is the focus of attention.

The question to be addressed then is why objects, words or ambiguous words and not ambiguous figures are processed in context. In this study participants were not aware of the nature of the figures except in a few cases, hence they should have treated the figures as standard objects. The pilot study testing the contextual scenes demonstrated that these contextual scenes facilitated the identification of biased figures, hence they should have facilitated the identification of the figures relative to the no context condition. Even when participants were aware of the ambiguity however, they failed to use context information and nevertheless gave the most frequent interpretation. These results contrast with those found in the homographs task where typically developing children when aware of the two meanings of a word, use the context to select the context appropriate pronunciation.

It is evident from this study that ambiguous figures are processed in a different way than either standard objects or ambiguous words. Thus this type of stimulus seems not suitable to investigate the interaction of context and the processing of ambiguous material.

The aim of the studies presented in this chapter was to develop a paradigm to investigate if children with autism are able to process ambiguous information. If children have difficulty holding two representations, as predicted by either the theory of mind account of autism or the executive function theory, individuals with autism should have difficulty processing not only homographs but also with

ambiguous visual stimuli. Unfortunately, Experiment 9 revealed that ambiguous figures are particularly resistant to context influence and hence alternative paradigms using different stimuli will have to be developed to investigate this issue further. It is not possible therefore to make any conclusion regarding a deficit in the processing of ambiguous information in autism.

Chapter 8 Can children with autism use global information of faces?

So far this dissertation has examined the ability of children with autism to process and use context information. The findings from the empirical studies reported earlier in this dissertation have failed to find a general deficit in the ability to use context information. Contextual difficulties in contrast seem to be restricted to the use of sentence context information to disambiguate homographs.

In Chapters 1 and 2 it was argued that failure to find difficulties to integrate information in the visual and verbal domains would have important implications for the notion of WCC as it could no longer be defined in terms of a general deficit but as a specific language impairment. 'Global processing' has been used to refer to both the ability to extract holistic properties of visual patterns of stimuli and the ability to process information in context. These concepts can be considered to be distinct as the ability to use context, as defined as the ability to use background knowledge, might be possible without the ability to extract holistic information or relate parts to the whole and vice versa.

When the work of this thesis started, there was no definite evidence of an impairment in the ability to extract holistic information whereas there was evidence for difficulty in using context information. The results of this dissertation suggest a very specific difficulty confined to complex verbal stimuli and in particular with using sentence context to disambiguate meaning.

It is not possible however to conclude that the global-context difficulties in autism are restricted to high level sentence processing. To confirm that weak central coherence is confined to the processing of complex verbal stimuli, it is first necessary to determine whether children with autism are able or not to process global patterns of stimuli.

It has been repeatedly reported that individuals with autism have superior perception of object parts compared to non-autistic populations. This finding has been demonstrated in a number of different tasks such as the Embedded Figure test (Shah and Frith, 1983) or the Block Design test (Shah and Frith, 1993). A common assumption held by researchers within the WCC account is that the presence of a local bias in autism is due to a failure to process global patterns of stimuli (Happé, 1999; Happé, 2000). However, as discussed in Chapter 1, superior featural processing does not necessarily mean there is a lack of global processing.

Global processing has also been investigated by use of the Navon task. However, these studies have not provided conclusive evidence of a global impairment in autism. An alternative source of evidence for a global impairment comes from studies using face processing tasks. Faces are processed on the basis of featural and holistic information (Tanaka & Farah, 1993). In this chapter the

evidence for global impairment is first reviewed and a study is then presented of use of global processing to identify faces.

8.1 Summary of evidence of global impairment in autism

Evidence for impaired global processing in autism has been largely drawn from performance on the Navon task (Navon, 1977). In the traditional Navon task participants are shown larger letters made up from smaller letters, where these have the same (i.e. compatible condition) or a different identity to the large letter (i.e., incompatible condition). When typically developing children or adults are asked to report the identity of the large letter in the incompatible condition, the identity of the small letter interferes, slowing down reaction times and leads to increased errors (Navon, 1977). When reporting the identity of the large letter, however, there is no interference from the small letters. This effect is referred to as the “global precedence effect”. In the compatible condition, non-autistic populations are faster identifying the large rather than the small letters. This effect has been known as ‘global advantage effect’.

The predictions from central coherence are that, as a result of a global impairment, children with autism would have local interference and local advantage effects in this task. Several studies have investigated the performance of autistic populations in this task with mixed results. Mottron and Belleville (1993) found that children with autism had local interference effects but neither local or global advantage. On the basis of these findings, Mottron argued that the

impairments in autism are related to the interaction of the local and global levels and not to a preference for features. A later study by Ozonoff et al (1994) however found neither evidence for WCC theory nor for Mottron's proposal. In this study the results showed that contrary to predictions, individuals with autism showed typical global interference and advantage effects.

Plaisted and colleagues (1999) argued that these contradictory findings could be explained by difference in the methodology used in the different studies. The Navon task has two different administration procedures. In the first procedure, selective attention procedure, participants are asked to focus on one level at a time and decide whether the small or large letter is a 'H' or a 'S'. This was the procedure used by Ozonoff et al. (1994). In contrast, in Mottron and Belleville (1993) study a second procedure was used, the divided attention procedure. In this procedure participants are asked to find a specific letter ('H' or 'S') in either the local or global level.

To test if the differences in procedures were the cause of differences in results, Plaisted et al (1999) administered the two versions of the task to the same population of individuals with autism. Results for the selective attention task replicated Ozonoff et al findings. Individuals with autism showed global advantage and interference effects. The results of the divided attention procedure showed in contrast local advantage and interference effects. Plaisted et al concluded that the results provide evidence of weak central coherence. Specifically, they argued that global processing is intact in autism but needs to be primed by focusing attention to either the local or global levels.

A recent study by Mottron and colleagues (1999) however has failed to find local advantage and interference effects by use of the divided attention procedure. They found on the contrary, that individuals with autism and not the comparison group showed global advantage and interference effects. As discussed in Chapter 2, the Navon task has inherent methodological problems. Changes in factors such as the brightness, sparsity or size of the stimuli can reduce or even reverse global advantage and interference effects (Lamb & Robertson, 1989). It is therefore difficult to draw any conclusions regarding the presence of a global impairment in autism from these studies. Another source of evidence of global processing abilities comes from studies using face recognition tasks.

8.2 Evidence of global impairment by use of face recognition tasks

Face processing, unlike other types of visual processing, involves both holistic (whole) and featural (parts) processing (Tanaka and Farah, 1993). A classical paradigm used to demonstrate the importance of holistic information is the inversion paradigm where faces are presented up-side down. It has been shown that non-autistic adults are more disrupted by the inversion of faces, and thus the removal of holistic information, than by the inversion of other types of stimuli such as bridges or houses (Tanaka & Farah, 1993; Donnelly & Davidoff, 1999). The dominance of holistic processing over featural processing in face recognition has also been demonstrated by use of a different paradigm in which features are presented either within a face or in isolation. Non-autistic adults are

more accurate at recognising features presented within a face than isolated features (Donnelly & Davidoff, 1999) a finding that suggests that additional holistic information facilitates the recognition of features.

According to WCC theory, individuals with autism have difficulty processing patterns of stimuli globally. It would be therefore predicted that children with autism, as a result of the global impairment, would fail to process holistic information of faces. Specifically, Happé (1999) has predicted that people with autism would use only featural and not holistic information to recognise faces.

If children with autism fail to process holistic information of faces, they should be less affected than comparison samples by the inversion of faces. Two studies have found that children with autism are less affected than comparison samples by the inversion of faces. Langdell (1978) for instance, investigated the ability of children with autism to recognise faces that were presented either upside down or up-right. He found that children with autism were better than the comparison group in the inverted condition although they were affected to some extent by the inversion of faces.

Similar results have been found by Hobson, Ouston and Lee (1988) also using an inversion paradigm. Hobson et al. presented identity and expression matching tasks in which the photographs were presented either up-right or upside-down. They found that children with autism were better than controls at recognition of both expression and identity when faces were inverted. Their performance however deteriorated to some extent when the faces were inverted.

The results from these two studies have been taken as evidence of a global impairment in autism as they show that children with autism are not as affected as comparison groups by the disruption of holistic information although they are affected to some extent. A study by Teunisse (1996) however has shown that these results might be due to a developmental delay rather than to a specific deficit in autism to process holistic information of faces.

In typically developing children, the ability to process faces holistically is a late developing process. Specifically it has been shown that inversion effects increase steadily from the age of 6 to the age of 10 when inversion effects are comparable to the ones found in adults (Carey & Diamond, 1977). Teunisse (1996) has found that adults with autism show an equal inversion effect for faces as comparison groups. Thus the failure to show similar inversion effects to comparison samples in Langdell and Hobson et al's studies might be due to a developmental delay rather than to a specific deficit in the processing of holistic information.

Despite the evidence of abnormal inversion effects in autism, at least at an early age, it is difficult to make any conclusions regarding the extent to which holistic processing is impaired in autism. Children with autism do have inversion effects to some extent. It is not possible to conclude whether these effects are the result of the removal of the holistic information or the removal of featural information, as both types of information are disrupted by the inversion of faces.

Another method of testing holistic processing of faces is by using the composite effect paradigm (Young, Hellawell & Hay, 1987). In this paradigm participants have to recognise the upper or bottom half of a composite face made

up of two different faces. When the upper and bottom parts of the composite face are aligned, and thus a new holistic representation is created, recognition is more difficult than when the halves are not aligned- although this effect appears only for faces in up-right orientation. This effect is known as the composite effect. This paradigm provides a more subtle and precise measure of holistic processing as the featural information remains intact. Any effects in performance using this paradigm can thus be only attributed to the presence of a new holistic representation.

Teunisse (1996) administered this task to the same sample of adults with autism. The results were quite surprising. Although individuals with autism showed inversion effects in the first experiment, in this second experiment they did not show composite effects. Adults with autism were better than non-autistic adults at recognising halves of faces even when the two halves were aligned and thus a new holistic configuration was created. These results suggest that holistic information is not automatically processed in individuals with autism.

The results however can be interpreted in terms of superior processing of parts. The composite task, as the embedded figures test, investigates the ability to process parts of a visual pattern and not the ability to perceive a global pattern. Thus the same criticism can be applied to this task. Individuals with autism when required to do so, might be very good at disengaging from the global information but this does not necessarily mean that they are unable to process the holistic configuration.

Two further studies have looked at holistic perception of faces by presenting faces at differing angles. The rationale behind these studies is that by

changing the orientation of the face, featural cues are removed (i.e. features do not look the same any more). Therefore, participants have to rely on holistic information in order to make a decision. The results from these two studies have provided mixed evidence. Whilst a study by Gepner, De Gelder and Schonen (1996) have failed to find differences between children with autism and two comparison groups, a study by Davies, Bishop, Manstead and Tantam (1994) has found evidence of a global impairment in facial and non-facial visual processing.

The study by Gepner et al (1996) included, as part of a wider battery of facial recognition tests, a task in which participants had to sort a set of faces into groups of three, according to identity. Each trio of photographs consisted of a full front face, a profile and a three-quarter view. Results showed that the performance of children with autism was lower than those of typically developing children matched on non-verbal mental age, however they did not differ from Down's syndrome children or the typically developing children matched on verbal mental age. Hence this study has failed to provide evidence for an impairment in holistic processing in autism.

A study by Davies, Bishop, Manstead and Tantam (1994) on the other hand has provided evidence of a deficit not only in holistic processing of faces but also of a difficulty in processing global patterns of non-facial stimuli. This study included a battery of tests testing face recognition at different angles, emotional expression recognition, identity recognition and finally two control tasks with non-facial stimuli. These control tasks were designed to test holistic perception in non-facial stimuli. The sample comprised two groups of children with autism, a high functioning (HFA) group and a low functioning (LFA)

group. These two groups were individually matched on verbal mental age (VMA) to a control sample of handicapped children and another sample of typically developing children.

Results showed that the LFA children did not differ to their controls in any of the tasks. Again it seems that results shed doubt about the existence of a configural deficit in autism. However, holistic processing of faces only appears in typical development at around 6 years of age and it increases steadily until 10 years of age when holistic processing fully develops. The sample of LFA children and their controls had a VMA of 7. Thus neither the comparison group, nor children with autism, may have yet developed properly holistic processing. The results of the HFA sample on the other hand support the prediction that children with autism have difficulty processing holistic information as they had lower scores than the control samples in all the facial tasks. Furthermore, these results confirm that the deficits in holistic processing are not restricted to facial stimuli.

It is difficult however to ascertain the extent to which children with autism are able to process faces holistically as by presenting faces in different angles, not only featural information is removed but holistic information is also disrupted to some extent. To fully confirm a deficit in holistic processing, it would be necessary to compare directly the effect of providing or not providing holistic information.

8.3 Selecting a paradigm to investigate holistic processing in autism

In the previous two sections, the evidence for a global impairment in autism has been discussed. The studies using the Navon task have provided mixed findings. Whilst some studies show normal global advantage and interference effects in individuals with autism (Ozonoff et al., 1994; Mottron et al., 1999), other studies have found either local advantage or local interference effects (Plaisted et al., 1999; Mottron & Belleville, 1993). There is reason to believe that the Navon task is very susceptible to small changes in procedure, such as changes in the size or sparsity of the stimuli (Lamb & Robertson, 1989). Thus no reliable conclusions can be made from these studies about the ability to process global patterns of stimuli in autism.

Regarding the evidence from facial recognition tasks it is also difficult to reach any definite conclusion. Although in general studies seem to indicate less sensitivity in autism to the removal or disruption of holistic information, none of the studies have directly tested the extent to which individuals with autism are able to use this information.

It is necessary therefore to find an alternative paradigm. There is one paradigm in the face recognition literature that provides a measurement of the direct effect of providing holistic information to the identification of features. Davidoff and Donnelly (1990) have suggested that if faces are processed holistically the recognition of features should be better if they are presented within a complete face than when presented in isolation. To test this suggestion

they designed a paradigm in which participants were presented with a picture of a target face followed by two stimuli. In some trials, the stimuli consisted of two complete faces differing only by one feature. Alternatively, trials consist of two isolated features (i.e. two noses, two eyes or two mouths). In the complete face trials, participants have to decide which of the two faces matches the target face. In the feature trials, participants have to decide which of the two features belonged to the target face. Results have shown that non-autistic adults recognise features better when they are presented within a complete face than when presented in isolation. This effect has been named 'complete face advantage' (CFA). The presence of CFA, Donnelly and Davidoff argue, indicates that adults rely on holistic information to recognise features and faces.

This paradigm has been also used with typically developing children (Donnelly and Hadwin, submitted). As studies using inversion paradigms show, typically developing children do not use holistic information of faces until approximately 10 years of age. Young children are as accurate recognising features in isolation than within a face.

Plaisted et al. (1999) have shown that the provision of cues focusing the attention of individuals with autism in one level, either global or local, enhances global processing in individuals with autism. A manipulation of the CFA paradigm also allows an exploration into the effect of cues in face processing. Donnelly and Davidoff (1999, Experiment 5) showed that by presenting a cue immediately before the target face to inform participants of the feature on which to base their matching decision (i.e. 'Look at the nose') facilitated, but did not

qualitatively change, performance in both complete face and feature trials (Donnelly and Davidoff, 1999).

It was therefore decided to use this paradigm to test the extent to which children with autism are able to use holistic information to identify features. Using this paradigm in addition allowed the investigation of the impact of cueing on face processing.

8.4 Are children with autism able to use holistic information of faces?

EXPERIMENT 10

In this study the complete face advantage paradigm developed by Donnelly and Davidoff (1990) was administered to a sample of children with autism and a sample of TD children matched on chronological age. The experiment consisted of two tasks. In the first task, the cued task, a cue was presented immediately before the target face to inform participants of the feature on which to base their matching decision. In the uncued task, no cue was provided. The uncued version of the face task is very demanding for children as shown in previous studies (see Donnelly & Hadwin, submitted). Therefore following Donnelly and Hadwin procedure, the cued task was always presented first to familiarise children with the task. If cues focusing attention in one level, enhance global processing in individuals with autism as shown by Plaisted et al,

(1999), then similar cues may serve to facilitate holistic face processing in this population.

With respect to the proposition that individuals with autism have a global impairment, if individuals with autism showed a CFA in both the cued and the uncued task, this would reflect a capacity to process faces holistically. This finding would question the assumption drawn from weak central coherence that autism is characterised by a global impairment. In contrast, failing to find an effect in the uncued task and finding an effect only when attention is focused on one level, would support the notion of weak central coherence theory by demonstrating that individuals with autism were able to process holistic information in faces only when cues were provided.

The current paradigm also allows an independent test of a second prediction from central coherence theory. If individuals with autism have a preference for processing parts, that is a local bias, then they should show superior performance in the current task when matching isolated features, relative with the control sample.

Method

Participants

Seventeen high functioning adolescents with autistic disorder (AD) took part in the study. Fourteen of these children took were the same as in Experiments 2-7. Three more children with autism were recruited from a range of special schools. All had received a diagnosis of autism by experienced

clinicians using the guidelines of standard criteria as DSM-IV (APA, 1994), DSM III-R (APA, 1987), or ICD-10 (WHO, 1990). Participants' IQs were measured using four subtests of the Weschler Intelligence Scale for Children - Revised (WISC-R; Weschler, 1974; Information, Vocabulary, Block Design and Object Assembly). Following Ozonoff et al (1994), these four subtests were chosen because they load most highly on the verbal comprehension and perceptual organisation factors of the WISC-III (Weschler, 1974).

The control group consisted of a group of seventeen typically developing (TD) children approximately matched on chronological age to the autism. Thirteen of these children were the same as in Experiments 2-7. The remaining four children were recruited from a local school. The groups did not significantly differ in chronological age (CA: $t(32)=.997$, $p=.326$), verbal IQ (VIQ: $t(32)=.865$, $p=.364$), performance IQ (PIQ: $t(32)=1.807$, $p=.080$) nor full scale IQ (FIQ: $t(32)=1.382$, $p=.177$). Table 8.1 summarises participant characteristics for both groups of children.

Table 8.1. Chronological age (CA), Verbal IQ (VIQ), Performance IQ (PIQ) and Full Scale IQ (FIQ) mean scores of participants in Experiment 10.

N	Group		CA	VIQ	PIQ	FIQ
17	TD	Mean	13:08	90.65	103.71	96.53
		SD	0:11	16.40	18.01	15.31
17	AD	Mean	13:02	84.18	92.29	87.18
		SD	1:07	26.13	18.81	23.33

Design

A mixed design was employed. The within-subjects factors were stimulus type (complete face vs. feature) and cue (cued vs. uncued). The between subject factor was group (children with autism vs. typically developing children). The dependent measure was the number of correct responses.

Materials and apparatus

The same stimuli as in Donnelly and Davidoff (1999) were used in the present study. There were two types of stimuli: complete faces and features. For the complete face condition a set of six target faces was formed in which the features of eyes, nose and mouth were varied, keeping all other aspects of the face constant. The feature condition comprised three examples of eyes, noses and mouths.

In complete face trials, the target was presented alongside a second face that was identical except for the replacement of one feature. No distractor face was the same as any other target face. In feature trials, a feature (eye, nose or mouth) presented previously in the target face was presented alongside a distractor feature (eye, nose or mouth respectively). Targets were presented to either the left or right of distractors. There were thirty-six complete face and thirty-six feature trials. An example of a complete and a feature trial is shown in Figures 8.1a and 8.1b.

Figure 8.1a Examples of stimuli used in the complete face condition.

COMPLETE FACE CONDITION

1. Participants were presented with:



2. After a short delay (500ms) they were then presented with:



3. The participant then had to select the face from Step Two that matched that from Step One. The two faces differed in only one feature.

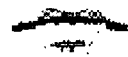
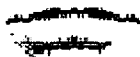
Figure 8.1b Examples of stimuli used in the feature condition

FEATURE CONDITION

1. The participants were presented with:



2. After a short delay (500ms) they were then presented with:



3. The participant then had to choose the feature that belonged to the face in Step One.

In the cued condition, prior to the presentation of the faces, cues were presented in the centre of the screen for 1000 msec. The cues presented read: 'Look at the eyes', 'Look at he nose' or 'Look at the mouth'. The stimuli and the cues were presented in a Macintosh Laptop computer using Superlab software.

Procedure

Children were taken individually to work in a quiet room. Following the procedure of Donnelly and Hadwin (submitted) the sequence of presentation of stimuli in the cued task was as follows: a) presentation of the cue for 1000 msec., b) a delay of 500 msec., c) presentation of the target face for 500 msec., d) a delay of 500 msec., e) presentation of two items.

Participants had to decide which of the two faces (complete condition) or features (feature condition) matched the face presented before by pressing one of two keys in the keyboard -"a" for the item on the left, or "l" for the item on the right.

The uncued condition was administered after completion of the cued condition and followed exactly the same procedure except that no cues were provided prior to the presentation of target faces.

Results

One sample t-test confirmed that responses were above chance level for all conditions across both groups. The mean accuracy scores for each condition are presented in Table 8.2 for both the TD and AD groups.

Table 8.2. Mean accuracy scores and standard deviations in the cued and uncued conditions in the face recognition task. (Maximum =36)

N	Group		Cued		Uncued	
			Complete	Feature	Complete	Feature
17	TD	Mean	28.71	26.59	23.12	21.06
		SD	4.44	3.62	3.02	3.05
17	AD	Mean	25.82	22.12	21.71	21.47
		SD	4.03	4.26	3.16	3.28

CA and FIQ scores were not significantly different in the two groups. However, as individual matching had not been used and, as previous research shows, that CFA is related to chronological age in TD children (Donnelly & Hadwin, submitted), these variables were included as covariates in the analysis of the data.

A three-way mixed repeated measures ANCOVAs was therefore run with stimulus type (complete face vs. feature) and cue (cued vs. uncued) as within participants factors, group (AD vs. TD) as a between participants factor and CA and FIQ as covariates.

Results showed a significant interaction of CA and stimulus type ($F(1,30)=5.152, p=.031$) replicating Donnelly and Hadwin's finding indicating a relation between CFA and CA. CA however did not have a significant effect in overall performance ($F(1,30)=.021, p=.885$). FIQ was significantly related to overall accuracy scores ($F(1,30)= 9.635, p=.004$) and interacted significantly

with cue ($F(1,30)=5.026$, $p=.033$), indicating that the ability to use cues effectively depends on the IQ level.

The analysis revealed a significant main effect of stimulus type ($F(1,30)=4.650$, $p=.039$) indicating that children were more accurate when recognising complete faces rather than isolated features. A significant interaction was found between cue and group ($F(1,37)=4.203$, $p=.049$), indicating that cues enhanced performance significantly more in TD children compared with AD children.

Neither the main effect of cues nor the main effect of group yielded significance ($F(1,30)=.592$, $p=.448$; $F(1,30)=2.588$, $p=.118$, respectively). The interaction between cue and stimulus type was not significant either ($F(1,37)=.405$, $p=.529$).

Finally, there was a significant three-way interaction between cue, type of stimulus and group ($F(1,30)=5.408$, $p=.027$). To further investigate the source of the three-way interaction, a further two-way ANOVA was run for each group separately with cue (cued vs. uncued) and type of stimulus (complete face vs. feature) as within-subjects factors. The covariates were not included in this analysis because none of them interacted significantly with group, indicating that IQ and CA had similar effects on performance for both groups.

The cue x stimulus type x group interaction is explained by a significant interaction of stimulus type and cue in the AD sample ($F(1,16)=15.733$, $p=.001$) but not in the TD group ($F(1,20)=.004$, $p=.950$). *Post-hoc* tests to explore the source of this interaction revealed that only when given a cue were children with autism more accurate in the complete face condition ($t(19)=4.722$, $p=.001$). In the uncued condition, AD children showed no difference between the complete

face and the feature conditions ($t(19)=.260$, $p=.798$). TD children on the other hand were more accurate in the complete face compared with the feature condition for both the cued and uncued conditions ($t(20)=2.680$, $p=.016$; $t(20)=2.582$, $p=.020$ respectively).

The two-way ANOVAs for each group also showed a significant main effect of stimulus type in both groups (AD: $F(1,16)= 7.374$, $p=.015$; TD: $F(1,16)= 10.440$, $p=.005$), indicating that overall both groups were more accurate in the complete face condition than the feature condition. The effect of cues was significant in both groups (AD: $F(1,16)=8.310$, $p=.011$; TD: $F(1,16)= 43.005$, $p=.001$), indicating that children were more accurate in the cued than uncued conditions.

Discussion

The main aim of this study was to establish whether there is an impairment in autism in holistic processing of faces. If children with autism use holistic information of faces, they would find the recognition of features easier when presented within a face than when presented in isolation. The results showed that, at least regarding the uncued condition, children with autism failed to use holistic information of faces to aid feature identification. They were as accurate in recognising features in isolation than when presented within a face. This result contrasts to that found for the TD children, even when IQ and age were controlled for. Typically developing children showed better recognition of features in complete face trials in both the cued and uncued conditions.

An additional aim of the study was to confirm Plaisted et al's findings that the use of cues for focusing attention in one level enhances global processing in autism. The results showed that the use of cues is critical in generating holistic processing of faces in individuals with autism. It was only when cues focusing the attention on a particular feature were provided that individuals with autism showed greater accuracy in recognising faces than isolated features, that is global processing. Therefore both this study and Plaisted et al study show that individuals with autism have an impairment in the processing of global patterns of stimuli in the absence of cues. However this impairment can be overcome by the provision of cues focusing attention to one level.

This result, however, needs to be interpreted with caution. In this study cues enhanced global processing of both AD and TD children so it is not a specific effect of autistic samples. Cues also enhance global processing in non-autistic adults (Donnelly & Davidoff, 1999) and in young TD children (Donnelly & Hadwin, submitted). More importantly, typically developing children 6 to 10 years old also show global processing only when cues are provided (Donnelly & Hadwin, submitted). Although in this study cues had a differential effect in AD and TD children, the results of the children with autism are similar to those found in Donnelly and Hadwin study for young TD children. Thus the effects of cues in holistic processing of faces are not specific to autism. The similar performance of AD children and young typically developing children points to a developmental delay in holistic face recognition in autism. Only a study investigating the effects of cues in adults with autism would clarify if the cues

have a differential effect in autism. That is, if adults with autism can process faces holistically only when given cues.

Children with autism benefited from the provision of cues but only in the complete face condition whilst the performance of TD children was enhanced by cues in both the complete face and feature conditions. One explanation for this pattern of results may be that children with autism did not use the information about cues effectively and thus they did not focus their attention on the relevant feature. Cues seemed to have merely alerted their attention in a non-specific way. This result provides additional support to previous evidence showing that alerting children with autism by non-specific cues facilitates other types of behaviours that otherwise are impaired, such as gaze-following (Leekam, Hunnisett & Moore, 1998) or symbolic play (Gould, 1986; Lewis & Boucher, 1988).

Independently from the effects of cues, the results of this study confirm that individuals with autism do not spontaneously use holistic information when processing faces. Traditionally, it has been assumed that the presence of a local bias is a result of a deficit in global processing. So far research had investigated the ability of individuals with autism to process parts. It was thus necessary to test the ability to use global information in autism to confirm the existence of a deficit in global processing.

Although other studies had already confirmed the presence of a deficit in the use of holistic information in face recognition tasks (Langdell, 1978; Hobson et al, 1988; Davies et al, 1994), these studies had used paradigms in which either the featural or global information was distorted precluding any definite

conclusion. The present study has confirmed a deficit, or at least a developmental delay, of global processing of faces in autism by use of a facial task in which recognition of faces can be directly compared to recognition of features. This study has also confirmed that cues enhance global processing although this effect seems not to be restricted to autism.

Face processing is a very particular type of visual processing. It will be therefore necessary to confirm this deficit and the effects of cues focusing attention to one level by use of other non-facial tasks in which the actual use of the global configuration is tested.

In relation to the presence of a local bias, the results of this study failed to find confirmation for previous evidence suggesting superiority in the recognition of parts in autism. If children with autism are superior at recognising parts of objects, they should also be more accurate than TD children at recognising features in isolation. Children with autism on the contrary were no better than TD children in the uncued condition and significantly worse in the cued condition. The results of the cued condition can easily be explained by the failure of AD children to use cues effectively relative to the TD sample. However if children with autism had a local bias, they should be better than TD children at recognising features in the uncued condition.

In Chapter 6 it was argued that superiority for parts in autism might be restricted to the segmentation of pictures into meaningless parts and not general ability to segment pictures in its parts. The parts in this study, as in Experiment 9, were identifiable objects, in this case features. Thus the failure to find superior performance in these two tasks might be evidence for superior identification of

parts in autism only when parts are meaningless. The confirmation of superior featural processing only for meaningless material would have important implications for the definition of WCC. Confirmation for this suggestion would indicate that individuals with autism do not attend preferentially to features of objects, that is a local bias, but that they have superior ability to segment a picture into meaningless parts when required.

Chapter 9 Summary of findings and discussion

In Chapter 1 it was argued that the concept of central coherence as it is currently defined is problematic for two main reasons. The first is that it is assumed that superior featural processing presupposes a lack of global processing. The second is that it is assumed that global and context processing are one and the same thing. This thesis has attempted to address these two issues by investigating separately the ability to process context and global information and by concentrating on the investigation of global and contextual processing instead of examining featural processing. In addition, the thesis also examined the assumption that context and global processing is a general property of the cognitive system by testing the ability to use context across visual and verbal domains.

In this chapter a summary of the empirical findings is first presented. This is followed by a discussion of their significance to our understanding of the issues of context and global processing in autism and to the question of whether children with autism lack central coherence.

9.1 Summary of findings

The first study investigated whether children with autism are able to use visual context to facilitate object identification. A visual context task was developed in Experiment 1 to test the influence of contextual scenes on object identification. This paradigm was administered to children with autism and a comparison sample of typically developing children in Experiment 2. The results showed that children with autism were as able as the comparison group to use visual context information. Both groups of children were faster and more accurate identifying objects that were preceded by appropriate contextual scenes than at identifying objects that were preceded by either neutral or inappropriate contextual scenes.

To explore if competence in the use of context was confined to tasks where stimuli were presented visually, in Experiment 3, we adapted the visual context task by presenting words instead of objects and contextual scenes. The results of this task showed that children with autism were as able as the comparison group to use verbal context information to aid word identification. Both groups were faster at identifying words preceded by related words than words preceded by either unrelated words or a series of Xs.

The results of Experiments 2 and 3 failed to provide support for weak central coherence in autism in either the visual or verbal domains. These results were difficult to reconcile with evidence showing difficulties in the use of verbal context information in a single word semantic memory task originally developed by Tager-Flusberg (1991). In Experiment 4 this task was adapted to include a

visual condition and additional set of lists to double the amount of stimuli. The results of this replication showed that although the original lists produced a similar effect to that found by Tager-Flusberg, none of the other set of lists provided evidence of an impairment in the use of visual or verbal semantic category information to aid recall. Children with autism benefited to the same extent as TD children from the presentation of semantically related material. It was concluded that Tager-Flusberg's results were confined to the particular set of stimuli employed in the original study and not a deficit in autism in the ability to use semantic information to aid recall.

Experiments 2, 3 and 4 therefore failed to support the case for weakness in central coherence. Individuals with autism performed like non-autistic samples and were sensitive to context and semantic category information, regardless of whether the information was presented in visual picture form or purely verbally. The aim of Experiment 5 was to investigate if the children with autism in the previous experiments would show difficulty in the use of sentence context information to disambiguate homographs despite their ability to use context information in single word tasks. The results of this study replicated previous findings (Happé, 1997; Jolliffe & Baron-Cohen, 1999). Children with autism tended to give the most frequent pronunciation of the homographs regardless of the context in which they were presented. Children with autism seem to have specific difficulties with the use of sentence context to disambiguate homographs.

It was argued that the different pattern of performance between the homographs task and the tasks used in Experiments 2-4 could be explained by

either a difficulty in integrating information that is presented simultaneously or a difficulty processing ambiguous stimuli. The first of these alternatives was investigated in Experiment 6. In this study the visual context task used in Experiment 2 was adapted so that the objects were embedded in the contextual scenes. The results of this study indicated that children with autism are as able to use context information when this is presented previously or as background to targets objects. Thus the difficulty children with autism have with context tasks where the target is embedded in the background (i.e., Jolliffe's visual context task) is not likely to stem from difficulty in simultaneous processing of information.

The embedded task used in this study was very similar in format to the Embedded Figures test in that both test the ability to identify a part. It was thus predicted that children with autism would be faster than TD children at identifying objects (i.e., parts) in this condition regardless of their ability to use context information. This prediction was not supported by the data. Experiment 7 explored if the failure to find enhanced performance in the embedded condition was due to the nature of the stimuli used, namely the parts depicting meaningful objects (i.e., objects) and not meaningless parts as in the Embedded Figures test. In this experiment an adapted version of the Embedded Figures test was developed in which the shapes to be found consisted of identifiable objects (i.e., a circle was a Christmas decoration). Results showed that children with autism were as fast as TD children at finding the shapes. The failure to include a control condition with the standard EF test precludes any definite conclusion. However, the results suggest that superiority for parts in autism might be

restricted to the segmentation of pictures in meaningless parts and not to superior general ability to process parts. This result will need to be confirmed in future research.

The second proposal for the difficulty with the homographs task, namely that children with autism have difficulty processing ambiguous stimuli was investigated in Experiment 8 and 9 by developing a method to examine the influence of context in the disambiguation of ambiguous figures. This method was based on the paradigm used in Experiments 1 and 2. Experiments 8 and 9 provided tests of the method with typical adults participants. Experiment 8 aimed to test if the contextual scenes selected for the final study were sufficiently related to each of the interpretations of the ambiguous figures. The results of this study showed that they were significantly related and thus were appropriate to elicit each of the interpretations.

Experiment 9 examined if the prior presentation of these contextual scenes would increase the probability of giving a particular interpretation of the ambiguous figures. Unfortunately, the results of this study showed that ambiguous figures are particularly resistant to context effects leaving the hypothesis of difficulty in the processing of ambiguous stimuli to be tested.

The final study moved away from examining the influence of context to study a different measure of central coherence in order to clarify if the competence of children with autism applied not only to context but also to global processing. For this study, the ability to process global information in faces was chosen because faces are processed both in terms of holistic and featural information. Experiment 10 had three main aims. The first aim was to examine if

children with autism would be able to process faces globally. Secondly this study aimed to replicate Plaisted et al findings that cues enhance global processing in children with autism. Finally this study aimed to explore if children with autism would fail to show superiority in the processing of parts when these constitute meaningful objects (i.e., features).

The results from this study confirmed the presence of a global impairment in autism, at least regarding the processing of facial stimuli. This global impairment was overcome by the use of cues focusing attention to features. The effects of cues however might not be specific to autism as they also enhance global processing in young typically developing children and adults. In relation to the presence of a local bias, as predicted, children with autism did not show enhanced processing of parts relative to the comparison group as the parts were meaningful objects (i.e., features), indicating that there is not a general local bias in autism, but this is restricted to the processing of meaningless materials.

9.2 Do children with autism fail to use contextual and global information?

Following the distinction between context and global processing raised in Chapter 1 and throughout the thesis, the analysis of impairments in context and global processing are discussed separately.

9.2.1 Context processing in autism

Given the results presented in this dissertation, it is not possible to conclude that there is a general deficit in autism in processing context information. Experiments 2, 3 and 4 failed to find contextual difficulties in the autism group. The replication of the homographs test on the other hand has provided evidence of a deficit in the use of sentence context information to disambiguate homographs. Children with autism, as in previous studies, failed to give context appropriate pronunciations and instead tended to give the most frequent pronunciation of the homographs. Results however provide some evidence of sensitivity to context in autism, as shown by the superior performance when homographs were placed after the sentence context than when placed at the beginning of the sentence.

It seems therefore that context difficulties in autism are restricted to specific tasks. The homographs task is particularly taxing for children with autism. This task differs from the other contextual tasks used in the dissertation in that it involves sentence processing and the processing of ambiguous stimuli. Thus the difficulty experienced by children with autism might stem from an inability to process sentence context or an inability to process ambiguous stimuli. Brian and Bryson (1996) have suggested that the ability to make meaningful connections between single items is intact in autism, whereas ability to integrate multiple items of information within sentences is impaired. There is evidence for difficulties in sentence context processing in autism in studies using memory tasks in which the recall of word strings is compared to the recall of

sentences (Frith, 1969; Wolff & Barlow, 1979; Hermelin & O'Connor, 1967). It is unclear however the extent to which the deficit in sentence processing is specific to autism. One study failed to find differences with a sample of children with learning difficulties (Ramondo & Milech, 1984), two studies failed to include a learning difficulty group (Frith, 1969; Wolff & Barlow, 1979) and another study found that this ability is related to memory span and not to autism (Fyffe & Prior, 1978).

The remaining evidence for a deficit in the ability to integrate multiple items of information within sentences comes from the homographs studies and a study by Jolliffe and Baron-Cohen (1999). The tasks employed in Jolliffe and Baron-Cohen's study are the homographs task, a different task examining the ability to disambiguate ambiguous sentences and a task examining the ability to draw inferences to connect two sentences. The first two tasks involve the ability to process ambiguous stimuli. The ability to process ambiguous information has been related to executive function abilities (Ricci & Blundo, 1990; Meenan & Miller, 1994) and also to theory of mind abilities (Gopnik & Rosati, 2001). This is so because the ability to shift between alternatives is proposed to be a critical element of executive function ability (Russell, 1998; Pennington & Ozonoff, 1996). Also, the ability to represent alternative interpretations is considered to require metarepresentational ability (Perner, 1991), a hallmark of 'theory of mind'. If either executive function or theory of mind are impaired, as is the case in autism, it would be expected that individuals with autism would perform poorly in tasks such as the homographs task or ambiguous sentences. The results

from these studies could therefore be equally explained in terms of weak central coherence or in terms of an executive function or theory of mind deficit.

An alternative interpretation of the results of the homographs task is that children with autism might lack familiarity with rare forms of homograph words or have difficulty accessing these words. Neither the replication presented in this dissertation neither previous studies have tested if the children were familiar with the two interpretations of the homographs. Thus it is possible that children give the most frequent pronunciation simply because they are not aware that there is an alternative pronunciation. There is evidence showing that when children are instructed in the two pronunciations and meaning of the homographs, children with autism are as able as comparison samples to use sentence context to disambiguate homographs (Frith and Snowling, 1986). It is possible therefore that the difficulty individuals with autism experienced with this task is due to lack of familiarity with homographs words and not contextual difficulties.

Given the range of different interpretations for the results of the homographs task, it is not possible to conclude that the difficulty experienced in the homographs task is due to a context processing impairment in autism. The difficulty could stem from an inability to process ambiguous information, explained by either theory of mind or executive function deficits or lack of familiarity with rare pronunciations, explained by language acquisition impairments. Even if the difficulty were to be related to the integration of multiple items of information within a sentence, as suggested by Brian and

Bryson (1996), it is not clear that this difficulty is specific to autism, as shown by Ramondo and Milech (1984).

In view of the different alternative explanations, the main priority for future research is to establish the extent to which the difficulty experienced by individuals with autism in the homographs task stems from contextual difficulties. As discussed above, it is difficult to tell whether the difficulty experienced by children with autism is due to the ambiguity of the word or to the sentence context. Future research should attempt to separate these two components of the task.

A possible way to investigate this issue would be to adapt the verbal priming task used in Experiment 3 by including another condition in which instead of presenting single words the primes consist of sentences. To examine the effects of ambiguity, target words could consist of homographs or non-ambiguous words. If children with autism have a specific difficulty with using sentence context, they will fail to have priming effects in the sentence priming task but not in the single word priming task. This result would support the WCC account. Alternatively, if the difficulty is related to ambiguity, they would fail to have priming effects for the ambiguous targets and not for the non-ambiguous targets regardless whether the primes were single words or sentences. This result would support the alternative theories of autism and therefore the existence of context difficulties in autism would be challenged. To ascertain the extent to which children with autism have difficulties with other ambiguous words, it would also be useful to include in this design homophones which are words with two meanings but one pronunciation.

There is some reason to predict that difficulty with ambiguity might not be independent of context however. Happé (1997) found that performance on the homograph task is not associated with performance on theory of mind tasks. This result suggests that the homograph task involves additional cognitive demand. It is possible that the sentence context in the homograph task might be important in addition to the problem with ambiguity.

In Chapter 1 it was argued that a problem of weak central coherence theory is the lack of specificity in the level at which central coherence operates. Frith (1989) claimed that central coherence only operates at high levels of integration. She failed however to specify the precise level at which individuals with autism fail. Happé (2000) attempted to solve this lack of definition by suggesting that connections between items are weak in autism whilst single object/word processing for meaning is intact in autism. Although this issue has not been addressed directly in this thesis, Experiments 2, 3 and 4 indicate that, contrary to Happé's suggestion, children with autism are able to connect words and objects on the basis of meaning. Specifically, these experiments demonstrate that children with autism are no different than typically developing children in their ability to integrate stimuli on the basis of semantic information, whether information is presented visually or verbally and whether connections in meaning are based on items within semantic categories or objects associated with familiar everyday locations. In view of these results, the level at which impairments manifest in autism need to be revised.

Chapter 1 also identified a problem with the definition of central coherence as a general property of the cognitive system and subsequently the

assumption that individuals with autism have difficulties in both the visual and verbal domains. The literature review presented in Chapter 2 revealed a lack of empirical evidence for difficulties in the visual domain. This thesis attempted to confirm the presence of weak central coherence in the visual domain by investigating the ability to use context in visual tasks and the ability to process global patterns of stimuli. Experiments 2 and 4 failed to find confirmation for contextual difficulties in the visual domain. Children with autism however did not show difficulties in the verbal versions of these tasks either. As argued above, the findings from Experiments 2, 3 and 4 suggest that the ability to connect words and objects on the basis of meaning is intact in autism. It seems that contextual difficulties in autism are restricted to making connections across multiple items of information within a sentence. If this suggestion is confirmed in future research, it would be important to investigate if this difficulty also applies to the processing of non-verbal information.

This issue could be investigated by, for example, a task testing the ability to make connections across multiple items of visual information that are not related to each other but when put together make a coherent visual scene. Establishing whether context difficulties are restricted to the processing of verbal information is important to allow a better definition of WCC. If it is confirmed that individuals with autism only fail to process context information of sentence, the notion of WCC should be redefined in terms of a specific language impairment rather than a general deficit.

9.2.2 Global processing in autism

Having established that contextual difficulties in autism are specific to certain tasks, possibly sentence processing tasks, the question is whether children with autism are able to process global information. Traditionally it has been assumed that contextual difficulties are accompanied by an impairment in the ability to process visual patterns of stimuli globally. However, as discussed in Chapter 1, global and context processing might be independent cognitive abilities. Thus the final study of the thesis investigated the ability of children with autism to process global patterns of stimuli. In particular this study examined children's ability to process faces globally.

The results of Experiment 9 have confirmed the existence of a global impairment in autism. Evidence for the claim that individuals with autism fail to process global information have been drawn mainly from evidence showing that individuals with autism are superior than comparison groups at processing parts. For instance, they are superior in the Embedded Figures test (Shah & Frith, 1983). Happé (2000) has suggested that this superiority does not stem from superior ability in disengaging from the global picture but a specific impairment to process global information.

There is however equivocal evidence for global difficulties in autism. Most of these studies have used the Navon task (Navon, 1977). As discussed in Chapter 2, this task has proved to be very sensitive to procedural changes (e.g., Lamb & Robertson, 1989) and thus no evidence can be drawn from these studies. Most importantly, neuropsychology research has shown that superior

performance for parts does not necessarily mean the existence of a deficit to process visual information globally (Lamb & Robertson, 1989). It was thus necessary to find confirmation that superior featural processing in autism is accompanied by a global impairment.

The results from the face recognition task have confirmed the presence of a deficit in global processing. Thus there is evidence of difficulties in both the processing of context information (homographs task) and global processing, as predicted by weak central coherence theory. The combination of these two impairments would suggest that global and context processing are one and the same thing, as assumed by researchers within the weak central coherence account. However, as discussed above, the results from the homographs task might be explained by difficulties different from a contextual impairment. Similarly the failure to process faces globally cannot be taken in itself as definite evidence for a general global impairment in autism.

It has been assumed that face processing difficulties in autism stem from a difficulty to process faces holistically. However, according to Hobson's (1993) affective deficit theory, the difficulties in face perception in autism might stem from the social nature of the stimuli. Thus it is possible that the difficulty with the face recognition task is related to a difficulty to process facial stimuli and not to a difficulty in global processing. Further research will need to investigate the ability to process non-facial stimuli globally to confirm the presence of a global impairment in autism. Confirming the presence of a global impairment would also confirm the presence of difficulties in the visual domain and hence the

notion of central coherence as a general ability that applies to both the visual and verbal domains.

The pattern of performance of children with autism is similar to that of young typically developing children, indicating a possible developmental delay and not a specific impairment. The development of the ability to process faces holistically is a long process that it is only developed at about 10 years of age (Carey & Diamond, 1977). Holistic processing of faces is therefore a complex, high-level ability. The context studies reported in this dissertation have shown that children with autism only have difficulties with high-level tasks, such as the homographs task. It is therefore possible that similarly, the ability to process global information might be only impaired at higher levels. A study by Ropar and Mitchell (1999) has indeed confirmed that global processing is intact in a task requiring low levels of integration, such as the visual illusions. Specific research should attempt to establish the precise level at which central coherence is manifest in global processing.

An additional finding from the face recognition study is that global impairments can be overcome by use of cues focusing attention to the local level. This finding confirms the results of Plaisted et al (1999) also showing enhanced global processing when attention is focused to either the local or global levels. This finding has important implications for educational strategies in autism. It is still not clear however, the precise manner in which cues facilitate global processing. Results show that children with autism have difficulty using information from cues. Despite this difficulty however they seem to benefit from the focusing of attention to one level. Interestingly, even cues that focus

attention on the local level enhance global processing. This is a very counterintuitive and interesting finding. If children with autism had a preference for local processing, it would be expected that this local bias would be strengthened by local cues. Understanding how the provision of cues enhances global processing could facilitate the understanding of the difficulties in autism to process patterns of stimuli globally.

In Chapters 1 and 2 it was argued that it is problematic to assume that superior featural processing is the reflection of a global impairment is problematic. Thus to demonstrate the presence of weak central coherence it is necessary to find evidence for a global and/or contextual impairment. Research within the weak central coherence account has instead tended to investigate featural processing in autism. This research has provided wide evidence of a local bias in autism as demonstrated by superior performance relative to comparison groups in tasks such as the Embedded Figures test or the Block Design. Experiments 6, 7 and 10 have however failed to find superior performance for processing of parts in children with autism relative to controls. One possible explanation for these results is that whilst in these three studies the parts to be either identified or found depicted either objects or facial features, in the standard Embedded Figures test or the Block Design, the parts are usually abstract shapes although in some cases the parts depict geometrical/meaningful shapes.

One way in which weak central coherence was originally defined is in terms of the ability to process for meaning. Specifically, Frith (1989) initially claimed that individuals with autism are 'less captured by meaning'. As a result,

she claimed, children with autism tend to process incoming information independent of context or the global configuration. Later developments in research have re-interpreted this claim in terms of a general preference for the processing of featural, local information. The results from these studies and the study by Pring, Hermelin and Heavey (1995) have however confirmed the existence of a general local bias in autism. It is possible that superior part processing may be restricted to the segmentation of global patterns of stimuli into meaningless shapes, such as the ones usually depicted in the Block Design or EFT, which would indicate that, as Frith suggested, superior performance stems from being less captured by meaning. It would be interesting to compare performance of individuals with autism in the items of the EFT that entail meaningful parts (e.g. triangle) and performance in trials in which parts are meaningless.

9.3 Do children with autism lack central coherence?

There is still some evidence of a difficulty to process context information that remains uncontested. A study by Tager-Flusberg (1981a) for instance has shown that individuals with autism fail to use semantic context/knowledge in language comprehension. Frith and Snowling (1983) have also found evidence of impairments in the ability to use sentence context to select the missing word in a sentence or to use text information to select the correct word missing in the text (Frith & Snowling, 1986). These studies however only provide evidence for a difficulty in processing complex, high-level verbal stimuli which could be

explained in terms of a language impairment or an impairment in the ability to integrate verbal complex information in context. The results reported in this thesis have provided some evidence for difficulty in the processing of global visual information, specifically global facial information. This difficulty however might be related to a more general, face perception impairment. Evidence for contextual difficulties in the visual domain is scarce and contradictory (Pring & Hermelin, 1993, Jolliffe, 1996) thus further research will be needed to confirm the presence of global and contextual difficulties in autism.

Until the precise nature of the contextual/global difficulty in autism is established, it will be difficult to first, ascertain whether central coherence is weak in autism and second, to define the relation of this impairment to other cognitive deficits in autism (i.e., theory of mind and executive function). In the introduction to this thesis it was argued that the way in which cognitive theories of autism have been formulated, makes it difficult to establish which of the three competing theories, central coherence, theory of mind or executive functioning, accounts best for the cognitive difficulties of children with autism.

A clear example of this difficulty is the issue of ambiguity. The strongest evidence for weak central coherence comes from studies employing the homographs task which involves the processing of ambiguous stimuli. Yet difficulties in ambiguity processing can be equally explained by a theory of mind or executive deficit. Hence it is difficult to specify which of the three cognitive impairments in autism are responsible for the psychological difficulties in autism or whether these are complementary deficits.

In Chapter 1 it was argued that a clear advantage of weak central coherence theory was in its power to explain a cognitive profile that is distinctive to autism while the theory of mind and executive function accounts have difficulties in establishing the distinctiveness of the impairment as evidence that is claimed to provide support for one theory also provides support for the other theory. The results of this thesis and the interpretation of the literature suggests that the cognitive profile might not be as distinctive as first described. The traditional view of superior featural and inferior global context processing may no longer be supported. Nevertheless, a different formulation of the cognitive problems of children with autism might emerge from the observation that certain impairments such as difficulty in processing ambiguous stimuli are common across the three theories. Further theoretical development of the cause of such difficulty might in turn facilitate the task of relating cognitive deficits to behavioural and biological deficits.

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