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Episodic Memory, “Theory of Mind”, and Temporally Extended Self-Awareness in Autism Spectrum Disorder

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Declaration

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Abstract

The primary aim of this thesis was to establish the cause(s) of the diminution of episodic memory that is evident amongst individuals with autism spectrum disorder (ASD). The main hypothesis was that impaired “theory of mind” (ToM) and temporally extended self-awareness are precursors to this diminution. An additional aim was to consider whether some individuals with ASD use their linguistic knowledge of complement syntax as a compensatory, non-ToM strategy to pass false belief tasks. A sample of 93 children/adolescents with ASD and 69 comparison children/adolescents without ASD was tested on a battery of tasks aimed at assessing the cognitive functions of interest. Episodic memory was assessed using a self-other source memory task and ToM was assessed using location change and unexpected contents false belief tasks as well as a see-know task. Temporally extended self-awareness was assessed using the delayed self-recognition paradigm and, finally, complement syntax was assessed using a memory for complements task. The data were presented as a series of experiments each aimed at addressing a specific research question. The results indicated that episodic memory, as indexed by self-other source memory, was subtly impaired in children/adolescents with ASD. Semantic memory, as indexed by A' (item discrimination), was attenuated in children/adolescents with low-functioning, but not high-functioning, ASD. Individuals with ASD demonstrated the enactment effect (superior memory for self-performed, rather than other-performed, actions) to the same extent as those without ASD. Participants with ASD were significantly less likely than comparison participants to pass the delayed self-recognition task and, even when passing, required more prompting than comparison participants who passed. This suggests individuals with ASD have impaired temporally extended self-awareness. Lexical knowledge, but not complement syntax, was related to false belief task performance, irrespective of diagnostic status. These findings thus speak against the hypothesis that individuals with ASD use linguistic strategies to “hack-out” solutions to false belief tasks. Finally, metarepresentational ability, assessed with the Smarties false belief task, was related to episodic (source) memory, particularly source memory for other-performed actions. It was concluded that ToM difficulties contribute to the episodic memory difficulties experienced by individuals with ASD.

List of Abbreviations

AS	Asperger Syndrome
ASD	Autism Spectrum Disorder
BPVS	British Picture Vocabulary Scale
CA	Chronological Age
CELF	Clinical Evaluation of Language Fundamentals
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders IV
DSR	Delayed Self-Recognition
FB	False Belief
HFA	High-Functioning Autism Spectrum Disorder
HFC	High-Functioning Comparison
LD	Learning Difficulties
LoF	Level of Functioning
LFA	Low-Functioning Autism Spectrum Disorder
LFC	Low-Functioning Comparison
MLD	Moderate Learning Difficulties
MSR	Mirror Self-Recognition
PDD-NOS	Pervasive Developmental Disorder (Not Otherwise Specified)
PPVT	Peabody Picture Vocabulary Test
SP	Selection Processor
TD	Typically Developing
ToM	Theory of Mind
ToMM	Theory of Mind Mechanism
TROG	Test for Reception of Grammar
VIQ	Verbal Intelligence Quotient
VMA	Verbal Mental Age

CHAPTER 1: Literature Review

1.1 INTRODUCTION

This chapter reviews theory and evidence relating to episodic memory and associated concepts in both typical development and autism spectrum disorder (ASD). It begins by introducing the notion of different "types" of memory, with reference to "memory systems theory". This is followed by a discussion of some of the key empirical findings which have informed our understanding of the developmental trajectories of the memory systems responsible for long-term retention of information. Throughout, there is a strong emphasis on the development of the episodic system, which is thought to depend upon a series of cognitive prerequisites, including certain representational capacities, self-awareness, and temporal understanding. Research relating to the development of these prerequisites is discussed, as well as the relationship of these prerequisites to memory functioning. The discussion then moves on to consider ASD, which appears to involve a specific problem with episodic memory. The typical profile of memory functioning in ASD is considered and, finally, a theoretical position, grounded in the work on typical development, is set out in an attempt to explain why episodic memory is selectively impaired in ASD.

1.2 MEMORY SYSTEMS

Experimental evidence, including neuropsychological data from individuals with acquired or developmental amnesia (e.g., Mayes, Holdstock, Isaac, Hunkin, & Roberts, 2002; Tulving, 2002; Vargha-Khadem, Gadian, Watkins et al., 1997), suggests that memory cannot be conceived of in terms of a single cognitive faculty – there are clear, dissociable "types" of memory. *Memory systems theory* is one approach which acknowledges the complexity of the nature of memory, recognising that it takes a number of distinct forms[1]. According to Tulving (1985, pp.386-87):

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[1] Memory systems theory may be contrasted with processing accounts which also distinguish between different "types" of memory (see Gardiner, in press).

> Memory systems are organised structures of more elementary operating components. An operating component of a system consists of a neural substrate and its behavioural or cognitive correlates. Some components are shared by all systems, others are shared only by some, and still others are unique to individual systems.

Schacter and Tulving (1994) have proposed that humans possess five such functionally distinct, but interactive, neuro-cognitive memory systems: (1) the perceptual representation system; (2) the procedural system; (3) the working memory system; (4) the semantic system; and (5) the episodic system. Their theory suggests that the perceptual representation system represents "raw" cognitive and perceptual information at a basic pre-semantic level (Faran & Ben Shalom, in press). The procedural memory system underlies perceptual, behavioural, and cognitive skills, or "know-how", and certain types of conditioning and priming. Procedural learning characteristically occurs through gradual, incremental processes, requiring repeated exposure to learning experiences. Both the perceptual representation system and the procedural system involve implicit, non-conscious processes, whereas the semantic, working memory, and episodic systems involve explicit, conscious processes. The working memory system allows the temporary storage, processing, and manipulation of information (Baddeley & Hitch, 1974). The semantic and episodic systems are of particular interest for the purposes of this thesis, however, and further discussions will therefore focus primarily on the functions of and developments in these systems.

In brief, the semantic system is responsible for the storage of factual information and general knowledge, whereas the episodic system is thought to be responsible for personally experienced event memories. More specifically, episodic memories may be defined as "multifeature representations in which numerous different kinds of information – spatial, temporal, contextual, and so forth – are bound together with the individual's awareness of personal experiences in subjective time" (Schacter & Tulving, 1994, p.28). So whereas episodic memories are recollections of personally experienced events that occurred at a particular place and time, semantic memories are factually based and devoid of spatial or temporal context.

The episodic and semantic systems are highly interdependent, however. The episodic system is thought be "built on top" of the semantic system, being the most recently evolved of the five memory systems (Tulving, 2002). The episodic system depends upon input from the semantic system at the point of encoding, in that information is fed from the semantic system into the episodic system. In terms of storage, information may either be retained in just one system or both systems simultaneously. Finally, retrieval from either system can occur independently, such that a given piece of information stored in both systems could be retrieved either episodically or semantically (Tulving, 2001).

Semantic and episodic memory are not only distinguishable in terms of informational content but also, critically, in terms of the conscious experience associated with retrieval: they are said to be retrieved with *noetic* (knowing) and *autonoetic* (self-knowing) conscious awareness respectively (Wheeler, Stuss, & Tulving, 1997). These two discrete types of retrieval are generally referred to as *knowing* and *remembering*, which also correspond closely to the notions of *familiarity* and *recollection* (Mandler, 1980). These two types of consciousness are considered to have their own distinct phenomenological feels, or what philosophers (e.g., Dennett, 1991) refer to as *qualia*. One is said to be experiencing autonoetic consciousness if one is focusing attention directly onto one's own *subjective* experience and one is said to be experiencing noetic consciousness when one is thinking *objectively* about something that one knows (Wheeler et al., 1997, p.335).

This distinction has been operationalised in the *remember-know paradigm* (Tulving, 1985), a task which requires participants to make judgments about the phenomenology of their memories. Typically, in the task, participants are presented with a list of words to study and are later given a recognition test and asked whether they actually "remember" a recognised test item – being able to recollect something specific that they experienced at study – or just "know" that it was present – perhaps having a feeling of familiarity with the item. These judgements are thought to reflect, and therefore distinguish between, the two different types of conscious awareness. The former is indicative of autonoetic consciousness and episodic retrieval, whereas the latter is indicative of noetic consciousness and semantic retrieval.

It is autonoetic consciousness that truly distinguishes episodic memory from other forms of memory. Its importance is highlighted by studies of so-called *episodic-like* memory (Clayton & Dickinson, 1998) – memory for "what", "where", and "when" – which is evident in a number of non-human animals, to which one would be unlikely to ascribe self-consciousness (Babb & Crystal, 2005; Dere, Huston, & Silva, 2005; Eacott, Easton, & Zinkivskay, 2005; see Suddendorf & Corballis, in press, for a review). For example, the behaviour of scrub jays suggests that they have memory for spatiotemporal contextual information – they seem to show memory for *what* type of food they have cached, *where* it was cached, and *when* it was cached (Clayton, Griffiths, Emery, & Dickinson, 2001). Episodic-like memory evidently shares certain characteristics of episodic memory proper (i.e., information about spatiotemporal context) and, on the basis of early definitions (Tulving, 1972), may have been classified as episodic. However, the types of behaviour exhibited by scrub jays, for example, do not provide evidence for autonoetic conscious awareness and would not, therefore, satisfy the criteria of more recent conceptualisations of episodic memory (e.g., Tulving, 2002). Autonoetic conscious awareness, which implicates awareness of the self, is the key concept than distinguishes episodic-like memory from true episodic memory.

Autonoetic consciousness spans awareness of subjective experiences in the present and future, as well as the past (Wheeler et al., 1997). It is what underlies the capacity for *mental time travel* (Suddendorf & Corballis, 1997), which involves either mentally projecting oneself into the past to *re-experience* an event or mentally "projecting oneself into the future to *pre-experience* [italics added] an event" (Atance & O'Neill, 2005, p.127). Evidence, to be outlined below, suggests that children under the age of about 4 years are unable to engage in such mental time travel, most likely because they have not developed a capacity for autonoetic consciousness. The following section will summarise relevant empirical work on the development of long term memory, considering procedural, semantic, and episodic memory developments.

1.3 MEMORY DEVELOPMENT: EMPIRICAL EVIDENCE

The maturational status of each memory system appears to determine the differential mnemonic abilities of infants, toddlers, and preschoolers. Implicit, procedural forms of memory are shown to be operational even before birth, yet explicit semantic memory does not emerge until around 6 to 9 months of age, and episodic memory, by far the most complex and sophisticated system, only emerges in the fourth or fifth year of life.

1.3.1 Procedural Memory

A number of experiments, which have shown neonates to demonstrate memory for information encoded whilst they were still foetuses, suggest that procedural memory begins to function during the prenatal period. DeCasper and Spence (1986), for example, asked mothers to read aloud a given passage of prose twice daily during their third trimester of pregnancy. Three days after birth, memory was measured using a non-nutritive sucking technique whereby babies could control the operation of an audio tape by varying the rate at which they sucked on a pacifier. Babies heard one recording when they sucked at a low rate and another when they sucked at a high rate. Using this method, it was found that babies showed a preference for the recording of their own mother's voice over a female stranger's voice, and for the specific passage that they had heard during pregnancy over a novel passage. This preference indicates that the babies distinguished between old and new stimuli and may be taken as evidence of procedural learning (given that the learnt stimulus was experienced repeatedly).

It is well established that infants show novelty preference and are able to learn through classical and operant conditioning from the first few months after birth (see Rovee-Collier & Gerhardstein, 1997). The mobile conjugate reinforcement technique has been particularly well studied. In this paradigm, the infant initially learns the contingency between a foot-kick and the movement of a mobile which is attached to their foot by a ribbon. After a delay, the experimenter measures whether baseline kicking rate increases in the presence of the mobile as a consequence of the previous operant conditioning. It has been found, for example, that infants as young as 2 months old can retain such procedural information for delays of up to three days. Across a number of experiments, utilising the mobile paradigm, Rovee-Collier and her colleagues have introduced various manipulations which have brought to light a number of important patterns of performance. Firstly, as infants get older they are able to encode information more rapidly – they require briefer periods of initial exposure to the mobile to learn the contingency. Secondly, they are able to store information for longer periods as they get older and, finally, they are able to retrieve information with less specific cues – whereas the youngest babies need to see an identical mobile in order to remember the foot-kick contingency, older babies will increase their kicking rate in the presence of a similar but not identical mobile.

1.3.2 Semantic Memory

Deferred imitation is one of the earliest expressions of semantic memory. A number of studies have adopted tasks based on this non-verbal method of assessing semantic memory. The typical procedure involves an infant observing an experimenter performing a novel action, usually involving various props. There is no immediate opportunity for the infant to perform the action and, hence, no opportunity for procedural learning to take place. Successful performance on the task involves the infant imitating the previously observed action sequence after a specified delay. By 6 months of age, infants can imitate these types of actions after a delay of 24 hours (Hayne, Boniface, & Barr, 2000) and by 14 months of age they are able to do it after a period of 4 months (Meltzoff, 1995).

Deferred imitation clearly relies on some form of explicit memory since it involves learning on the basis of a single experience, with no opportunity for practice, and requires infants to recreate an action from memory by using a stored mental representation. Although deferred imitation could be mediated quite readily by the episodic system (as it probably would be in adults), it cannot be assumed that this is the case for young infants. The semantic system would be sufficient, given that retrieval is aided by the provision of a number of contextual semantic cues (i.e., the props and the experimenter).

Semantic memory appears to undergo qualitatively similar developments to those which occur in procedural memory. That is, with increasing age, information is encoded more rapidly, retention is longer, and retrieval is less reliant on very specific contextual cues (Hayne et al., 2000). Children first *verbally express* semantic memory for the past at around 18 months of age, but these verbalisations tend to be sporadic and fragmentary (Nelson & Fivush, 2004). However, by the age of 3 years, they can give detailed and accurate, generalised script-based accounts of routine events such as going to a birthday party (Nelson, 1986). It is somewhat later that children start to recall specific, individual events, which more closely resemble episodic memories.

1.3.3 Episodic Memory

As explained above, autonoetic consciousness is the most distinctive characteristic of episodic memory. Thus, the age at which episodic memory emerges would be most accurately determined by ascertaining the age at which children manifest autonoetic awareness. Unfortunately, it is not possible for young children to reliably report the phenomenology of their memories, as required for the remember-know paradigm. Preschool children cannot verbally distinguish between the concepts of "remember" and "know" (Johnson & Wellman, 1980). In fact, Brainerd, Holliday, and Reyna (2004) argue that introspective reports may not be reliable until early adolescence. One is therefore obliged to seek more indirect sources of evidence for episodic memory in children, such as developmental changes in memory for unique events and memory for contextual detail (source memory).

Between the ages of 2 and 3 years, children begin to talk to others about specific personally experienced events (see Fivush, 1997, for a review). For example, Hamond and Fivush (1991) assessed memory for family trips to Disneyworld amongst preschoolers. The children were aged between 2 years 9 months and 4 years 6 months when they visited Disneyworld. Memory for the trip was then assessed either 6 or 18 months later, through the use of a standardised interview including both open-ended and structured questions. Although, there were no effects of age or retention interval on the amount of information recounted by the children, older children were able to recall more detail and gave more information spontaneously.

Although such expressions of memory for specific events superficially resemble episodic memories, these early verbal reports require a substantial amount of support/scaffolding from the adult conversation partner. The necessity of such scaffolding is indicative of reliance on semantic memory retrieval: the adult provides the structure for the event memory which cues the child to "fill in the gaps" with their semantic knowledge of the event. In the absence of such scaffolding, until the age of around 4 years, children's recall of unique, non-routine events is fragmentary, disorganised, and lacking in temporal or causal structure (e.g., Pillemer, Picariello, & Pruett, 1994). So, once again, these mnemonic abilities are not necessarily indicative of episodic remembering. The invariance in the *amount of information* recounted by the children of different ages in Hamond and Fivush's (1991) study suggests that children were able to compensate using semantic memory, which is known to be established long before age 2 years 9 months, the age of the youngest children who took part. The key difference was in the amount of scaffolding required across ages. This suggests that the older children were better able to retrieve episodic trace information independently. Children appear to become progressively more proficient at encoding/retrieving episodic trace information during the preschool years, requiring fewer and fewer cues in memory conversations. Only by about 4 years of age are children able to retrieve episodic trace information to produce spontaneous, self-cued verbal reports of specific events (Nelson & Fivush, 2004; Perner & Ruffman, 1995; Wheeler et al., 1997).

A second line of evidence relating to the development of episodic memory is obtained from studies of *source monitoring*. Episodic memories, by their very nature, include details of the contextual information associated with the learning episode (e.g., who performed an action; whether an event was real or imagined; in what modality/modalities the event was experienced). Episodic remembering may, therefore, be used for the purposes of source monitoring – that is, identifying the conditions under which a memory was acquired (Johnson, Hashtroudi, & Lindsay, 1993). Wheeler et al. (1997, p.338) argue that tasks of source monitoring require a "rememberer to contemplate some past personal event directly as it was subjectively experienced" and therefore rely upon episodic memory. Indeed, there is some corroborating evidence, obtained from studies of adults, that source monitoring engages the episodic memory system and entails autonoetic consciousness. Perfect, Mayes, Downes, and Van Eijk (1996) found that typically developing adults made significantly more accurate source judgements about items which they claimed to have "remembered" seeing at study than about items which they claimed to have "known" were seen at study. Furthermore, it appears that episodic memory and source monitoring engage the same underlying brain regions (i.e., the frontal lobes; Johnson et al., 1993).

Developmental studies of source monitoring generally show improvements between the ages of around 3 to 8 years (see Roberts, 2002, for a review). Recognition memory, by contrast, remains fairly constant during this developmental period (e.g., Lindsay, Johnson, & Kwon, 1991). There are also developmental differences in competence according to the specific type of source monitoring under consideration. Johnson et al. (1993) have distinguished between three types of source monitoring: *internal* (e.g., judging whether one actually performed an action or merely imagined performing that action); *external* (e.g., judging which of two individuals performed an action); and *internal-external* (e.g., judging whether it was oneself or another person who performed an action). According to their model, source judgments are made on the basis of *memory characteristics,* which are established at the point of encoding, including perceptual, spatiotemporal contextual, semantic, affective, and cognitive dimensions. This framework suggests that memories from different sources are distinguished from one another because they differ qualitatively or quantitatively in terms of each of these dimensions.

In an early study, Foley and Johnson (1985) tested 6-year-olds, 9-year-olds, and adults on a task involving all three types of source monitoring; internal, external, and internal-external. Participants were asked to perform, imagine performing, or observe another person performing designated actions, such as clapping hands, tracing a shape, or touching one's elbow. Overall, it was found that the three groups showed similar levels of source discrimination for the actions in the external and internal-external conditions but the 6-year-olds showed a significant disadvantage on the internal condition. In a similar experiment, Foley, Johnson, and Raye (1983) asked 6-year-olds, 9-year-olds, and 17-year-olds to either repeat words aloud, imagine repeating words aloud, or listen to another person repeating words aloud. Again all groups performed at similar levels on internal-external and external source monitoring tasks but 6-year-olds showed a significant disadvantage when required to make internal (say/imagine saying) source judgments.

It is generally found that internal-external source monitoring develops prior to external source monitoring, and internal source monitoring, which develops last and is most difficult even for adults (e.g., Hashtroudi, Johnson, & Chrosniak, 1989). It is possible that internal-external source monitoring is easier/earlier developing because internal and external sources are particularly distinct in terms of their memory characteristics (Johnson et al., 1993). If the source is of internal origin, the memory may be more likely to include kinesthetic perceptual information and details of the thoughts and feelings that were being experienced at the time the memory was encoded, whereas if the source is of external origin, the memory will be associated with a greater degree of externally perceived visual and auditory information. It is possible that internal source monitoring is later to develop because it involves introspection and, perhaps, a greater degree of autonoetic awareness than other forms of source monitoring[2]. If source monitoring, in general, is mediated by the episodic system then poor source memory in young children may be attributed to difficulties in mentally re-experiencing past episodes to make judgments about the sources of memories.

A number of other types of memory test are also thought to rely on episodic recollection. For example, Perner and Ruffman (1995) aimed to assess developmental changes in episodic memory by comparing relative levels of performance on free versus cued recall, which are thought to differentially tax the episodic and semantic systems (Tulving, 1985; Wheeler et al., 1997). It was argued that whereas free recall relies heavily on episodic recollection, cued recall can be achieved more readily through semantic processes. They found that both cued and free recall was better amongst 6-year-olds than among 3-year-olds. However, this improvement with age was found to be significantly more marked for free recall than for cued recall (Experiment 3). Naito (2003) also found greater improvements in free recall than cued recall between children aged 3 to 6 years, although no inferential statistics were reported. These results may be taken as further evidence for improvements in episodic remembering during this developmental period.

In a recent experiment, Perner, Kloo, and Gornik (in press) have taken a novel approach to assessing episodic memory in children. In their experiment, children were shown 24 picture cards which they were asked to name. They were then asked to look at and place 12 of these cards into a box under two different conditions. They were later asked to recall which pictures they had put in the box. In the "direct-experience" condition, the children had direct perceptual experience of the to-be-recalled picture cards. In the "indirect-information" condition, they were blindfolded whilst they placed the cards in the box. In this condition, children were later shown a video or PowerPoint presentation of the cards which they had put in the box (showing the pictures only, not the child performing the action). These two conditions were intended to capture the distinction between *remembering* through previous experience of the past and indirectly *knowing* about the past. So, although in the indirect-information condition it might be possible to episodically remember watching the video/PowerPoint presentation, it would not be possible to remember the experience

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[2] One other possibility, that applies to least some studies (e.g., Foley et al., 1983), is that the certain internal source monitoring tasks ask the participant to imagine saying something and hence rely on the capacity for *inner speech*, which does not appear to develop until around age 7 years (Diaz & Burke, 1992).

of placing particular cards in the box. Participants included children with ages ranging from 3 years 7 months to 5 years 11 months. It was found that there were no age effects on recall accuracy for the indirect-information condition but there were significant improvements with age in the direct-experience condition. It was suggested that memory improved for the older children in this condition because they had gained episodic memory competence which allowed them to encoded episodic trace information. Without direct experience (in the indirect-information condition), no such episodic trace information could be encoded and therefore no advantage could be gained for the older children.

Thus far, this review has focused on episodic remembering – past-oriented mental time travel – but the episodic memory system is thought to span future as well as past personal experiences. Indeed, *future-oriented mental time travel* or *episodic future thinking* appears to develop during the same developmental period as episodic remembering. When considering evidence regarding future oriented thinking, it is important, once again, to bear in mind the episodic-semantic distinction. Whereas semantic future thinking involves knowing about the future on the basis of established scripts (sufficient for certain types of planning), episodic future thinking involves autonoetically projecting oneself into the future (Atance & O'Neill, 2005).

In one study, which aimed to assess episodic future thinking, Atance and Meltzoff (2005) presented children with photographs of different locations. For each photograph, they asked the child to pretend that they were going on a trip to that location, to choose 1 out of 3 (photographic depictions of) objects to take with them, and to explain their choice. One example involved a picture of a sunny desert. In this case, the children were then presented with photos of some sunglasses, some soap, and a seashell, and were asked, "Which one of these do you need to bring with you?" In order to give the correct response, "sunglasses", the child would have to anticipate the possibility of the sun getting in their eyes. Children aged 4 and 5 performed significantly better than 3-year-olds and their explanations involved a greater number of references to the future and uncertainties. The authors interpreted this developmental pattern as reflecting changes in the capacity for episodic future thinking, arguing that responses could not be based on semantic future thinking and script knowledge because the situations with which the children were presented were novel, requiring the child to project themselves into an imagined future situation. It could be argued, however, that the task was measuring the more general ability to project oneself into an *imagined* situation, rather than an *imagined future* situation, as such. After all, the children were not led to believe that they would actually be going on a trip to the desert, for example.

In a more ecologically valid study, Suddendorf and Busby (2005) also found that 4- and 5-year-olds, but not 3-year-olds, were able to show the kind of forethought that is indicative of episodic future thinking. Children were shown one room which, in the experimental condition, contained a puzzle board and, in the control condition, was empty. They were then taken to a second room which contained lots of toys and were allowed to play for five minutes. They were then shown four items: a paint brush; a coin; some crayons; and the puzzle pieces to match the board in the first room. Children were then told that they were going back to the first room and asked to select one of the items to take with them. Both 4- and 5-year-olds but not 3-year-olds were found to be more likely to select the puzzle pieces in the experimental condition than the control condition. The children appeared to be using their episodic memories of seeing the puzzle board in the first room in order to project themselves into this imagine future situation. Suddendorf and Corballis (in press) have argued that this ability to use episodic memories to guide behaviour in anticipation of the future is the key evolutionary function of the episodic memory system.

Another, somewhat more contentious, task that has been used to assess episodic future thinking, specifically future-oriented *prudence,* is the "delay of gratification" paradigm. Thompson, Barresi, & Moore (1997) and Moore, Barresi, & Thompson (1998) used a version of this paradigm in which children were offered a choice of 1 sticker now or 2 stickers later. They found that whereas 3-year-olds tended to choose immediate gratification (1 sticker now), older children were able to delay gratification (choosing 2 stickers later). Although this task may index the capacity for considering one's future self, there is clearly a central role for inhibitory control, an executive skill which is known to develop during the pre-school period (Carlson & Moses, 2001). Therefore, it is not precisely clear what the task is measuring – these two possible components have not thus far been disentangled. On the other hand, inhibition may be intrinsic to *all* future oriented thinking because it involves disengaging from one's current reality in order to think about the future (Atance & Meltzoff, 2005) and this could apply equally to thinking about past states of self.

1.4 PREREQUISITES OF EPISODIC MEMORY: THEORETICAL ACCOUNTS OF ITS DEVELOPMENT

The episodic system is clearly the most sophisticated of the memory systems, involving far more than the basic processes of encoding, storage, and retrieval. Autonoetic consciousness is, arguably, *the* defining feature of episodic memory. Accounting for the development of episodic memory must, therefore, involve a central role for autonoetic consciousness. Autonoetic consciousness is itself thought to depend upon a number of interrelated cognitive abilities and the emergence of episodic memory therefore depends upon prior developments in each of these areas. A number of possible underlying pre-requisite abilities for episodic memory have been proposed, including self-awareness, representational skills, and temporal cognition. The following sections will outline the hypothesised contributions of these various factors.

1.4.1 Development of the Self

Wheeler et al. (1997, p.334) state that, "only through the sophisticated representation of self can an individual autonoetically recollect personal events from the past and mentally project one's existence into the subjective future." This theoretical position is echoed throughout the majority of the developmental literature (e.g., Howe & Courage, 1993; McCormack & Hoerl, 2001; Nelson & Fivush, 2004; Povinelli, Landau, & Perilloux, 1996; Welch-Ross, 1995). Theories of the development of episodic memory have tended to focus particularly on *autobiographical* episodic memory. By definition, autobiographical memories are those which constitute an individual's personal history[3]. Autobiographical memory is considered to be core to a sense of self, to personal identity. As Wilson and Ross (2003, p.137) put it, "we are what we remember." Equally, however, self-awareness has been identified as a pre-requisite for, as well consequence of, episodic autobiographical memory: the relationship appears to be bidirectional. However, before explaining the role of self-awareness in episodic memory development, it is necessary to discuss the concept of self-awareness itself.

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[3] Clearly much of our autobiographical knowledge – for example, knowledge of where one was born – is semantic in nature. However, the majority of authors use the term autobiographical memory to refer to episodic forms of recollection.

The intuitive assumption that we each possess some kind of unitary core self – something akin to a soul – has given way, in psychology at least, to theories proposing various delineations of the self (e.g., James, 1890; Lewis, 1995; Neisser, 1988; Rochat, 2003). For example, the most widely accepted distinction is between the self as the subject of experience – the *"I"* – and the self as the object of experience – the *"me"* (James, 1890). However, Neisser (1988) has developed a more elaborate taxonomy claiming that there are five forms of self-awareness[4]: ecological; interpersonal; conceptual; private; and temporally extended. Ecological and interpersonal self-awareness are perceptually based and early developing, together constituting implicit self-awareness (corresponding to James' notion of the "I"). The former entails perception of the body in relation to objects and events in the physical environment, whereas the latter entails perception of the self in relation to others in the social environment. Conceptual, private, and temporally extended self-awareness are later maturing and representationally based, underpinning explicit self-awareness (the "me"). Conceptual self-awareness occurs when the self becomes the object, rather than merely the subject, of thought. It entails having a concept of "me", comprising a set of beliefs about the self. Private self-awareness refers to explicit, conceptual awareness of aspects of the self not accessible to others (e.g., awareness of internal mental states). Finally, temporally extended self-awareness is also conceptual but involves an additional temporal dimension, thereby endowing individuals with a sense of continuity in personal identity through time. These various types of self-awareness are thought to be interrelated/interdependent, in that, for example, implicit forms of self-awareness serve as a foundation for explicit self-awareness. Nevertheless, each of these dimensions follows its own ontogenetic trajectory, evolving throughout development particularly during early childhood, as outlined next.

1.4.1.1 Implicit Self-Awareness: The Ecological and Interpersonal Selves

A considerable amount of evidence suggests that infants are endowed with rudimentary ecological and interpersonal self-awareness soon after birth (Rochat, 1995). For instance, 24-hour-old neonates show significantly more rooting responses (orienting towards perioral cheek stimulation) when they receive external stimulation

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[4] The term "awareness" is used loosely here and does not necessarily imply *conscious* awareness.

from an experimenter's hand than when they are "self-stimulated" by the experimenter moving the infant's own hand to their cheek (Rochat & Hespos, 1997). Such selective responsiveness demonstrates self/non-self discrimination and, therefore, a degree of ecological self-awareness. That newborns will learn to suck on a pacifier at a specific rate in order to see or hear a pleasant stimulus such as a picture or their mother's voice (e.g., DeCasper & Fifer, 1980; Siqueland & DeLucia, 1969), shows that they can also exert control over their behaviour, revealing that they have a sense of "agency" – a critical hallmark of the ecological self (Gibson, 1995; Neisser, 1995). Agency involves implicitly distinguishing between self-caused and environmentally-caused changes in perceptual experience. It involves perceiving oneself as the centre of control of one's own action-generated experiences and detecting one's responsibility for particular changes in perceptual experience (Russell, 1996).

Interpersonal self-awareness is clearly evident among 2-month-olds. Infants of this age readily engage in "protoconversations" with their caregivers (Murray & Trevarthen, 1985) – mutually regulated, coordinated interactions involving turn-taking and imitation of vocal, facial, and gestural expressions (Trevarthen & Aitken, 2001) – that show clear awareness of the self in relation to another. That babies exert control in these social exchanges indicates a clear sense of agency in the interpersonal domain also.

1.4.1.2 Explicit Self-Awareness: The Conceptual, Private and Temporally Extended Selves

Only in the second year of life do children become reflexively – conceptually – self-aware. A number of concurrent developments, including the emergence of self-conscious emotions, personal pronoun use, and a set of explicit beliefs about the self, are considered to be expressions of conceptual self-awareness. However, mirror self-recognition (Gallup, 1970) is widely regarded as the litmus test of conceptual self-awareness. In the classic form of the mirror self-recognition paradigm (Amsterdam, 1972), a familiar adult surreptitiously marks the child's face with brightly-coloured pigment, under the pretence of wiping their face clean. The experimenter then assesses the child's response to their reflection. Touching the mark is generally thought to indicate the presence of a self-concept and, indeed, it appears to imply at least a basic conceptual knowledge of one's typical facial appearance (but see

Hobson, 1990; Loveland, 1986, 1993; and Mitchell, 1993, 1997, for alternative explanations). Studies reliably show the mean age of success in this task to be 18 months, with a proportion of infants showing it at 15 months and most showing it by 24 months (Anderson, 1983; Courage, Edison & Howe, 2004; Lewis & Ramsey, 2004).

Blushing, shy smiling, gaze aversion, and preening are taken to be expressions of embarrassment and pride, both of which are examples of self-conscious emotions. Even the earliest studies of mirror self-recognition noted these reactions among 21- to 24-month-olds when they were confronted with their reflections (Amsterdam, 1972). Unlike earlier emerging basic emotions, such as fear and joy, self-conscious emotions involve cognitive support and necessarily involve a self-concept, since they are emotions *about* the self (Lewis, 1994; Lewis, Sullivan, Stanger, & Weiss, 1989; Tracy & Robins, 2004; but see Hobson, Chidambi, Lee, & Meyer, 2006). They are thought to involve self-evaluative processes, whereby one's representation of self is compared to a socially defined standard. Thus, in the case of pride, one has exceeded accepted standards and in the case of embarrassment, one has violated those standards.

Given that referential use of language is thought to imply conscious awareness (Dennett, 1978b; Perner & Dienes, 2003), the use of personal pronouns to refer to the self is the least controversial marker of conceptual self-awareness. For example, using the terms "my" and "mine" to denote ownership, which occurs at about 2 years of age (Fasig, 2000), implies a concept of self. Moreover, appropriate use of the terms "me" and "you" signifies a sophisticated explicit differentiation of self and other, suggesting that the child represents self and other as distinct individuals. Only individuals who make such an explicit distinction can use the terms correctly because, unlike proper names, their meanings shift according to who is speaking – the speaker is always "I" or "me" and the listener is always "you" (Bates, 1990). For example, if a parent and child were to look into a mirror together, the parent would say, "that's you", whilst pointing to the child's reflection, not, "that's me", and yet by 22 to 24 months toddlers can correctly label their own mirror image as "me" (Courage et al., 2004; Lewis & Ramsey, 2004). Thus, when toddlers begin using these terms, one can confidently infer that they have a self-concept to which they are referring.

Overall, the available evidence suggests that explicit self-awareness in the form of the conceptual self is first apparent in typically developing children between 15 and 24 months. However, the conceptual self undergoes considerable elaboration over time. Its development involves the gradual acquisition of a set of beliefs about the self; knowledge of personal characteristics, features and traits (e.g., Neisser, 1997). Children increasingly produce self-descriptive statements, indicative of a self-concept, from the age of about 24 months (Stipek, Gralinski, & Kobb, 1990). In its earliest stages, the self-concept consists mainly of beliefs about physical traits and abilities (e.g., "I have brown hair," "I can skip"), only later extending to psychological and social traits (e.g., "I'm shy," "I have lots of friends") (Damon & Hart, 1988). Thus, ecologically grounded elements of conceptual self-awareness are earlier to develop than interpersonally grounded elements.

Private self-awareness emerges somewhat later than basic conceptual self-awareness. It involves conceptual awareness of private experiences – of one's own mental life. It thus relies on "theory of mind" (ToM), which is defined as the ability to impute mental states to self or other (Premack & Woodruff, 1978). Children come to appreciate the nature of mental states such as desires, intentions, and beliefs between the ages of around 3 to 5 years, and their ability to attribute these states to self and other appears to develop in parallel (Gopnik & Meltzoff, 1994). Thus, the development of a ToM endows the child with the kind of introspective self-knowledge that characterises private self-awareness, allowing them to go beyond simply *having* private experiences to include the additional awareness *that* they have them.

Temporally extended self-awareness also emerges at around 4 years of age. It involves awareness of the relations between present, past, and future states of self. It is essentially awareness of one's place in, and continued existence through, time. Povinelli et al. (1996) were the first researchers to develop a task to investigate this form of self-awareness. They introduced a temporal component into the traditional mirror self-recognition test to create the *delayed self-recognition* (DSR) paradigm. During the task, experimenter and child were filmed playing a game in which the child was praised by patting them on the head. Whilst praising the child, the experimenter covertly placed a large sticker on top of their head. After a delay of three minutes, the pair watched the recording and the child's response was assessed. The test is designed to establish whether the child understands the causal relation between this "past self" represented on the television screen and their "present self" who is watching the recording. Reaching for the sticker is taken as evidence for a temporally extended concept of self (but for alternative explanations see Suddendorf, 1999; Zelazo, Sommerville & Nichols, 1999; and Chapter 4). Most 4-year-olds, but few 3-year-olds, can locate the sticker on their head in this task (Lemmon & Moore, 2001; Povinelli et al., 1996; Povinelli & Simon, 1998; Suddendorf, 1999; Zelazo et al., 1999).

1.4.1.3 The Role of Self-Awareness in Episodic Memory Development

The question of how these developments in self-awareness relate to the emergence of episodic memory will now be addressed. A number of researchers have argued for a causal link between self-awareness and episodic memory, agreeing that *explicit* self-awareness must be involved, since autonoetic awareness necessitates directing attention onto a mental representation of the self. However, there is controversy over the *level* of explicit self-awareness required.

Howe and Courage (1993; Howe, Courage, & Edison, 2003) have claimed that the emergence of conceptual self-awareness, as indexed by mirror self-recognition, is the critical developmental precursor for remembering personally experienced events. They argue that the self-concept functions as an organising structure in memory and accomplishing mirror self-recognition denotes the point in development at which the self is sufficiently elaborate to act as such an organising structure. Thus, mirror self-recognition sets the lower limit for autobiographical memory: although children will not necessarily encode events as personally experienced, it is at least possible for them to do so. Over time, the self-concept gains complexity and the more complex it becomes the more likely it is to serve as an organising framework. Harley and Reese (1999) attempted to test Howe and Courage's hypothesis and found that early mirror self-recognising children introduced more new information into memory conversations with their mothers at 32 months than did late self-recognisers. Unfortunately, memory *accuracy* was not measured and the observed differences could simply be attributable to differences in the ability of children to elaborate on the conversation.

The most fundamental problem with Howe and Courage's hypothesis is that it fails to account for the asynchrony between mirror self-recognition and the onset of true episodic autobiographical memory. As stated above, studies reliably show children to recognise themselves in mirrors at a mean age of 18 months (Anderson, 1983; Courage et al., 2004; Lewis & Ramsey, 2004), but it is not until many months later that children begin to episodically remember autobiographical events without external support and cueing. These earlier forms of recall are indicative of reliance upon semantic memory. It seems that the mirror self-recognition task simply does not capture the kind of self-awareness involved in autonoetic remembering.

Wheeler et al. (1997, p.335) suggest that “autonoetic consciousness affords individuals the possibility to apprehend their subjective experiences.” This seems to imply private self-awareness, since it involves focussing attention directly onto private experiences. Evidence that episodic memory depends upon private self-awareness has been provided by studies which have found relationships between performance on ToM tasks and episodic memory tasks (Naito, 2003; Perner & Ruffman, 1995; Perner et al., in press). These studies are described below in section 1.4.2, which considers the development of representational abilities and their impact on episodic memory.

Wheeler et al. (1997) also highlight the temporality thought to be intrinsic to autonoetic consciousness. They argue that episodic retrieval involves the understanding that “the self doing the [re] experiencing now is the same self that did it originally” (Wheeler et al., 1997, p.349). This seems to require a concept of self that is extended in time and is represented as such. The likely role of temporally extended self-awareness is supported by studies showing relationships between delayed self-recognition and episodic memory. Welch-Ross (2001) found that children who demonstrated delayed self-recognition provided significantly more new information (as measured by ratio of memory responses to placeholders), indicating greater episodic recall, in mother-child conversations about past events than children who did not show delayed self-recognition. Similarly, Lemmon and Moore (2001) tested children aged between 3.5 and 4 years on delayed self-recognition and a task which involved remembering the temporal order of events in a sticker finding game (memory for temporal order is thought to rely on episodic memory; Wheeler et al., 1997). Performance on the tasks was found to be significantly correlated even after controlling for age.

Thus, autonoetic awareness would seem to involve elements of both private and temporally extended self-awareness. It seems unlikely that these high level forms of self-awareness are necessary for mirror self-recognition.

1.4.2 Development of Representational Abilities

Certain representational abilities constitute the second of the likely developmental prerequisites of episodic memory. Changes in representational abilities are relevant not only in terms of their direct role in the development of autonoetic consciousness and episodic memory but also indirectly, in terms of the developments in self-awareness that were described above. According to Perner's (1991) representational theory of mind, prior to 18 months of age, infants are limited to primary representations which faithfully model the currently perceived state of affairs. Representational skills post 18 months, however, reach a new level of sophistication, with an emerging capacity for secondary representation which allows the child to hold in mind multiple, even contradictory, representations of the world, which can be differentiated from and compared to a primary representation of reality.

It has been suggested that conceptual self-awareness relies upon this capacity for secondary representation (Asendorpf, Warkentin, & Baudonnière, 1996; Perner, 1991; Suddendorf & Whiten, 2001). Thus, in the case of mirror self-recognition, the 18-month-old is able to hold in mind a stable representation of their typical facial appearance (no mark) and compare it to a veridical, primary representation of their currently perceived reflected image (marked). The infant must recognise the discrepancy between these two representations and use this information to initiate appropriate behaviour – that is, trying to remove the mark. Prior to the transition from primary to secondary representation, perceptions of self are in a state of constant flux, and self-representations are largely online. At this stage, stable characteristics cannot be attributed to the self and, therefore, there can be no enduring concept of self. Primary representations, although sufficient for ecological and interpersonal self-awareness, are not adequate for conceptual self-awareness.

The next stage in the development of representational skills – that is, the emergence of metarepresentational ability – allows children to experience private and temporally extended self-awareness. According to Perner (1991), metarepresentations are essentially representations of representations *as* representations. They provide the apparatus that allows children to conceptualise mental states such as beliefs and desires *as* varieties of mental state. Metarepresentations are what underlie "theory of mind" and, hence, private self-awareness. Temporally extended self-awareness is also thought to rely upon metarepresentation, because it involves understanding present, past, and possible future self-representations *as* (alternative) representations of the same temporally extended, coherent self (Perner, 2001; Povinelli, 2001).

The development of metarepresentational ability also directly affects children's capacity for autonoetic awareness. Because autonoetic awareness involves focussing attention on one's own mental states, Perner (2000, 2001; also see Nelson & Fivush, 2004; Perner & Ruffman, 1995; Welch-Ross, 1995; Welch-Ross, 2001) has claimed that episodic memory development is highly dependent on this representational achievement. His account is derived from *higher-order-thought* theories of consciousness (Armstrong, 1968; Rosenthal, 1986). According to such theories, a first-order mental state is conscious *only* when that mental state is, itself, the content of some higher-order representation. Perner and Dienes (2003, p.70) offer the following example to illustrate this argument:

> If we are consciously aware of this pencil lying on the table, then we are also consciously aware that we are seeing the pencil lying there. It never happens that we can genuinely claim being consciously aware of it and at the same time deny being consciously aware of whether we see it, just dream of it, know it by touch, want the pencil to be there, and so on.

Thus, one can only be consciously aware of remembering something when the mental state of remembering is, itself, the content of a higher-order representation. Higher-order thoughts are essentially metarepresentations of one's own mental states (Carruthers, 1996). Episodic remembering involves the explicit understanding that what is being brought to mind (the mental *re*-experience) is a *mental representation* of a past experience – that is, the memory is represented *as* a memory and recognised as such. Without metarepresentation, there is no awareness of the propositional attitude (i.e., "I remember that...") assumed in relation to the information held in mind. It is metarepresentation that underlies the distinction between noetic and autonoetic awareness. Thus, without metarepresentation, memories would involve (semantic) knowing rather than (episodic) remembering as shown below in (i) and (ii) respectively.

(i) I went to the shop and bought milk.
(ii) [I remember that] I went to the shop and bought milk

Perner (2000) also argues that it is crucial for one to represent the fact that one's memory was caused by direct experience of an event – that is, one has to understand that one's current mental state of remembering derives from a past mental state of experiencing. Representing the causal origin of a memory is termed *causal self-referentiality* (Searle, 1983, cited in Perner, 2000) and entails recognising the memory "as something formerly experienced" (Ebbinghaus, 1885, p.1, cited in Perner, 2001).

Thus, episodic memory requires both a capacity for metarepresentation and an understanding of causal self-referentiality. The ability to metarepresent is typically measured using *false belief* ToM tasks (e.g., Wimmer & Perner, 1983) and understanding of causal self-referentiality, argues Perner (2001), is measured using tasks which assess understanding of the relationship between perception and knowledge. *See-know* tests, for example, assess children's understanding that visual access to information is a way of gaining knowledge of that information (Wimmer, Hogrefe, & Perner, 1988).

Perner and Ruffman (1995) found that children's performance on see-know tests was related to free recall (which is thought to rely primarily on episodic memory), even after controlling for cued recall (which is thought to rely more heavily on semantic memory) and receptive vocabulary, supporting the hypothesis that the ability to represent the experiential origin of knowledge is necessary for episodic remembering. Furthermore, Naito (2003) found that source memory (also thought to index episodic memory) was significantly correlated with performance on an unexpected contents false belief task (Perner, Leekam, & Wimmer, 1987), consistent with the suggestion that metarepresentation is necessary for episodic memory.

The episodic memory experiment by Perner et al. (in press), described above (which included "indirect-information" and "direct-experience" conditions), also included a battery of ToM tasks, including two location change false belief tasks, a see-know test, and a modality specific test (O'Neill, Astington, & Flavell, 1992), in which children had to predict whether they would need to see or feel an object in order to determine the colour or weight of that object. They found that children with high ToM competence, as determined by a composite score, performed significantly better in the direct-experience condition, which was thought to index episodic memory, than in the indirect-information condition. The pattern was reversed for children with low ToM competence. In a second (replication) experiment, the false belief tasks were replaced with the "when-did-you-learn" test (Taylor, Esbensen, &

Bennett, 1994) and the same pattern of results was observed. The authors took these findings as evidence that ToM and episodic memory development are related. This interpretation must be qualified, however. The source of knowledge ToM test, which required children to explain how they knew something (through direct observation or testimony), and the when-did-you-learn test, in themselves, probably rely on the capacity for episodic memory, since they are essentially both types of source monitoring test. The relationship could have been due to the fact that "ToM competence" was at least partially indexing episodic memory competence.

1.4.3 Development of Temporal Cognition

Certain developments in temporal cognition are also thought to be prerequisites of episodic memory because, unlike (timeless) semantic memories, episodic memories involve explicitly thinking about the past. Fairly young children have a concept of the basic past-present-future distinction. This is evident from the fact that children are able to comprehend and use tense correctly to describe past and anticipated future events by the time they are 2.5 years old (e.g., Weist, 1989). Friedman (1990) argues, however, that their sense of the past (and the future) is somewhat undifferentiated and that they experience "isolated islands of time" (p.89), without any concept of where these islands lie relative to each other. It is not until children are somewhat older that they are able conceive of events as having occurred at particular points in a time-line which runs from past to future. *This* is what is required for episodic memory.

McCormack and Hoerl (1999, 2001) suggest that episodic memory relies on *temporal decentering/temporal perspective taking* abilities, which, in turn, rely upon having a concept of time that incorporates both "nonperspectival" (allocentric) and "perspectival" (egocentric) temporal frameworks. According to their theory, nonperspectival temporal frameworks are conceptual structures that represent the relationships between events located at different points in time, whereas perspectival temporal frameworks represent the temporal location of events in relation to one's own temporal location.

Infants of less than 12 months can imitate novel event sequences in the correct order (Bauer, 1997), thereby showing that they represent the temporal order of elements in event sequences – they have a rudimentary non-perspectival temporal framework. However, the scale on which events are represented is restricted to quite brief durations – they have a limited "temporal horizon" (Friedman, 1990, p.94) – at this point. The ability to represent event order over longer time-scales progressively increases with age. By 3 years of age, children are able to verbally describe everyday events, such as "going to McDonald's", in the correct temporal order (Nelson & Greundel, 1981; see Nelson, 1986, for a review), again showing that temporal order is represented within (semantic) memory.

The use of past and future tense at age 2.5 years (e.g., Weist, 1989) suggests that by this age children have at least a rudimentary perspectival temporal framework. It is not, however, until around 4 years of age that children can engage in the kind of temporal perspective taking that McCormack and Hoerl (1999) argue is fundamental to episodic memory. That is, the ability to imagine events and their relations to each other from a different temporal perspective whilst monitoring the relation between one's present temporal point of view and the one generated in imagination or recalled from memory. This is only possible once metarepresentational ability has developed because, crucially, it depends upon understanding that one's current perspective is just one of many possible perspectives. One must not only occupy (in imagination) different temporal perspectives but also explicitly conceive of them *as* temporal perspectives.

Early verbal descriptions of past or future events are said to involve temporal perspective *switching* as opposed to temporal perspective *taking*. In temporal perspective switching, alternative temporal perspectives are decoupled from one another in much the same way that, in pretence, the representation of the pretend scenario is quarantined from the (primary) representation of the actual state of affairs. Thus, temporal perspective switching may be said to rely upon secondary representation (Perner, 1991). Perspective switching does not, however, allow children to reason about the *relations between* different temporal perspectives. This requires "awareness of oneself as the occupier of these different perspectives" (McCormack & Hoerl, 1999, p.174). In other words, it requires temporally extended self-awareness. Indeed, McCormack & Hoerl (1999) see delayed self-recognition (Povinelli et al., 1996) as a measure of temporal decentering, requiring the child to reason about the relationships between past and present temporal perspectives.

Reasoning about the relationships between different temporal perspectives and, hence, episodic memory, in itself, seems to require an understanding of temporal-causal relationships. Povinelli, Landry, Theall, Clark, and Castille (1999) suggest that preschoolers have difficulty comprehending the "causal arrow of time" – with conceiving of time as a sequence of chronologically ordered, causally related episodes – and that this may be related to changes in self-concept and memory. Similarly, Campbell (1997, cited in Perner, 2000, p.304) argues that "it is the spatiotemporal continuity of a single self that forces a linear conception of time." Although fairly young children have a basic understanding of causality, realising that causes precede effects (e.g., Bullock & Gelman, 1979), it is not until around 4 to 5 years of age that children conceptualise the unfolding of time as "a successive series of causally interdependent states of the world" (Povinelli et al., 1999, p.1427). At this point, they begin to understand the causal significance of the temporal order of events sequences – that is, that more recently occurring events are likely to bear a more direct causal relation to present circumstances than events located in the more distant past, when event-outcome sequences are embedded within in a particular causal system.

This was first demonstrated in a study conducted by Povinelli and colleagues (1999). In this study, children played two distinctive games which were separated by a short delay. During the first game, out of the child's view, the experimenter placed a Mickey Mouse puppet in a box behind the child. During the second game, the experimenter moved the puppet to a new location in another box. Afterwards, the children were shown videos of the previous games, in which the experimenter's surreptitious actions were visible, and asked to locate the puppet. Two conditions were used: in the first, they were shown the two games in the correct temporal order and in the second, the games were shown in the reverse order. Thus, the children needed to remember the order in which the games had been played and then use this information to make an inference about the puppet's current whereabouts. They found that children below 5 years of age were unable to locate the puppet in the second of the two conditions, failing to understand that the most recently occurring events (in reality as opposed to on video) were the ones which would determine the current state of affairs.

Indeed, a number of studies have indicated that children's ability to make temporal-causal inferences dramatically improves between the ages of 3 and 5 years (McColgan & McCormack, 2007; McCormack & Hoerl, 2005; McCormack & Hoerl, 2007). For instance, McCormack and Hoerl (2005) designed another task which involved a totally different procedure from that used by Povinelli et al. (1999) but which also aimed to assess the ability to make such temporal-causal inferences. In their task, children were shown two dolls, Sally and Katy, and were told that, "Sally always goes first" and "Katy always goes next, after Sally". The children were then shown the experimental apparatus – a yellow box with a red button on one side and a blue button on the opposite side. They were shown that pushing one of the buttons caused a toy car to appear in a window at the front of the box and the other button caused a marble to appear in the same window. Only one object was visible at any one time (i.e., if Button A was pressed then Object A appeared. If Button B was subsequently pressed, Object A disappeared and Object B appeared). Children were given pre-test questions to ensure that they had learnt the association between the each of the buttons and each of the toys and that they remembered that "Sally always goes first". The test phase involved placing a screen in front of the box and letting Sally and Katy "have a go" at playing with the box. Both Sally and Katy each pressed one button. The screen was then removed. In the "infer object" condition, the dolls remained positioned next to the buttons they had respectively pressed but the window was occluded such that no toy was visible. In this condition, the child was asked what they thought was in the window. In the "infer agent" condition, the toy was visible and the children were asked to place each doll next to the button they thought she had pressed. As for Povinelli et al.'s (1999) study, the child needs to recognise that the most recently occurring event, in a particular causal sequence, bears a more direct causal relation to the current state of affairs than a less recently occurring event. And, in line with Povinelli et al.'s findings, McCormack and Hoerl found that whereas 4-year-olds had difficulty with this task, by the age of 5 years, children were able to engage in this type of reasoning. Povinelli and colleagues (1999) suggest that, without an appreciation of the causal arrow of time, as well as a capacity for metarepresentation, a child cannot understand the causal relation between present, past and future states of self, and thus cannot entertain a temporally-extended representation of self or experience autonoetic consciousness.

This brings the discussion of possible episodic memory precursors in typical development to an end. This focus of this review now turns to a developmental disorder which is known to be associated with a diminution of episodic memory: autism spectrum disorder (ASD).

1.5 MEMORY AND AUTISM SPECTRUM DISORDER

In the subsequent sections, research investigating long-term memory in ASD will be reviewed and explanations for the episodic memory diminution will be considered, but firstly a brief explanation of the nature of ASD is necessary.

1.5.1 What is Autism Spectrum Disorder?

Autism spectrum disorder is a term used to refer to a cluster of related pervasive developmental disorders that affect 116 per 10,000 people and affect disproportionately more males than females, with a ratio of 3.3:1 (Baird, Simonoff, Pickles et al., 2006). In psychiatric terms, the disorders subsumed by this label include *Autistic disorder*, *Asperger's disorder*, and *Pervasive developmental disorder not otherwise specified* (PDD-NOS) (DSM-IV, American Psychiatric Association, 1994). These conditions are characterised by a triad of impairments (Wing & Gould, 1979), including impairments in (1) social interaction and (2) communication, as well as (3) restricted, repetitive, and stereotyped patterns of behaviour. To receive a diagnosis of autistic disorder, onset must be prior to 3 years of age and the triad of impairments will typically be accompanied by a general cognitive delay (the term "autism" will be used to refer to Autistic disorder from herein). Asperger's disorder involves more subtle impairments in domains (1) and (3) and possibly, but not necessarily, (2) and does not involve a cognitive delay. PDD-NOS involves impairments in domain (1) and either domain (2) or (3). The term *high-functioning* is conventionally used to refer to individuals with ASD who have levels of intellectual ability in the average to above average range. The term *low-functioning* is used to refer to individuals with ASD who have intellectual impairments (learning disability).

In addition to these diagnostic features, ASD is also associated with a characteristic endophenotype[5] (Viding & Blakemore, 2007). For example, individuals with ASD show diminished executive functions (Hill, 2004) and "theory of mind" abilities (Yirmiya, Erel, Shaked, & Solomonica-Levi., 1998), and a tendency towards local, rather than global, information processing (Happé & Frith, 2006). ASD is also

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[5] "Endophenotypes" consist of heritable characteristics that are not direct symptoms of the condition under consideration but which are shown to be associated with the condition.

associated with a specific pattern of strengths and weaknesses in memory functions. The following section will outline evidence relating to long-term memory functioning in ASD, focussing particularly on episodic memory.

1.5.2 Profile of Long-Term Memory in ASD

Some researchers have suggested that autism may be conceived of as an amnesic disorder (Boucher & Warrington, 1976; DeLong, 1992). However, more recent evidence suggests a more complex picture: memory difficulties, particularly amongst high-functioning individuals, are subtler than implied by such a definition. In terms of the memory systems responsible for long-term retention, it seems that, for individuals with ASD of all levels of intellectual functioning, procedural memory is largely intact whereas episodic memory is diminished. Semantic memory is apparently normal (although, perhaps, qualitatively different) amongst high-functioning individuals but reduced amongst low-functioning individuals.

The characteristic repetitive behaviours associated with ASD are one indication that procedural memory is a relative strength (Boucher, 2001). Indeed, superb procedural memory is likely to account for many of the savant skills (e.g., exceptional musical or artistic abilities) exhibited by certain individuals with ASD who are profoundly intellectually impaired (Pring, in press). In terms of empirical evidence, good memory for paired associates (Minshew & Goldstein, 2001), intact priming (Bowler, Matthews, & Gardiner, 1997; Gardiner, Bowler & Grice, 2003 Renner, Klinger, & Klinger, 2000), and intact fear conditioning (Gaigg & Bowler, in press) are also indicative of spared procedural memory.

Performance on tests of recognition, cued recall, and free recall is likely to be mediated by both the semantic and episodic systems. However, recognition and cued recall are thought to depend predominantly on semantic memory and free recall is thought to depend predominantly on episodic memory (Wheeler et al., 1997). In general, it has been found that although recognition memory is impaired amongst *low-functioning* individuals with ASD (Ameli, Courchesne, Lincoln, Kaufman, & Grillon, 1988; Barth, Fein, & Waterhouse, 1995; Boucher & Warrington, 1976), in the absence of cognitive impairment, recognition memory is usually found to be intact (Minshew, Goldstein, Muenz, & Payton, 1992; Bennetto, Pennington, & Rogers, 1996; Bowler, Gardiner, & Grice, 2000a; Bowler, Gardiner, Grice, & Saavalainen, 2000b; Renner et al., 2000; but see Bowler, Gardiner, & Berthollier, 2004).

As performance on the remember-know paradigm suggests, both episodic and semantic processes contribute to recognition memory (e.g., Tulving, 2001; Yonelinas, 2001). However, it has been found that in the absence of episodic recollection, it is still possible to show normal levels of recognition memory (Düzel, Vargha-Khadem, Heinze, & Mishkin, 1999). Thus, although typical performance on recognition tests may involve some episodic recollection, it is possible to compensate in full using the semantic system to make familiarity judgments. Thus, evidence of intact recognition memory in ASD indicates, at minimum, intact semantic processing. Furthermore, cued recall is also found to be intact (Bennetto et al., 1996; Boucher & Warrington, 1976; Bowler et al., 1997; Gardiner et al., 2003; Mottron, Morasse & Belleville, 2001; Tager-Flusberg, 1991).

The relative contribution of the processes of recollection and familiarity in recognition memory performance appears to vary between typically developing individuals and individuals with ASD. Using the remember-know paradigm, Bowler and colleagues (Bowler et al., 2000a; Bowler, Gardiner, & Gaigg, 2007) found that, although the overall recognition scores of adults with Asperger's syndrome did not differ from IQ matched controls, they showed significantly less remembering and more knowing, thereby indicating that their memories were less likely to be accompanied by the type of autonoetic consciousness that defines episodic memory. These individuals were clearly able to compensate through utilising semantic memory. Bowler et al. (2007) did suggest, however, that the reduced remembering in the ASD group was, nonetheless, *qualitatively* similar to that of typical individuals. This conclusion was based on the finding that individuals with ASD were affected to the same extent as comparison individuals by various experimental manipulations known to alter the ratio of remembering to knowing responses.

The evidence regarding free recall in ASD is somewhat mixed: some studies have found it to be intact (Bennetto et al., 1996; Boucher, 1981a; Minshew Goldstein, & Siegel, 1997; Rumsey & Hamburger, 1988), whereas others have found it to be impaired (Boucher, 1981a; Boucher & Warrington, 1976; Bowler et al., 2000b; Hermelin & O'Connor, 1967; Ozonoff, Pennington, & Rogers, 1991; Summers & Craik, 1994; Tager-Flusberg, 1991). A number of studies have reported impaired recall when the studied material is semantically or associatively related but not when it is unrelated (Boucher & Warrington, 1976; Bowler et al., 1997; Tager-Flusberg, 1991). The emerging pattern of data seems to show that individuals with ASD show the least difficulty with recognition and cued recall tests, with comparatively more problems with free recall. This is consistent with the hypothesis that episodic memory is selectively impaired in ASD. A number of other sources of evidence also support this theory. For example, Boucher (1981b) found that children with autism were significantly poorer than comparison children, with learning disability or typical development, at recalling activities, such as playing with a camera, in which they had very recently participated.

1.5.2.1 Autobiographical Memory in ASD

There is a limited amount of evidence regarding autobiographical episodic memory in ASD. Klein, Chan, and Loftus (1999), for example, report a case study of R.J., a 21-year-old individual with high-functioning autism. They found that R.J. had detailed semantic knowledge of his personality traits but had great difficulty in generating episodic memories of occasions when he had demonstrated those traits. For instance, although he knew that he was friendly, when asked to recall a particular time when he had been friendly he encountered severe difficulties. In contrast to three verbal mental age matched comparison individuals, who generated episodic memories 100% of the time, R.J. could only generate such recollections 20% of the time.

Goddard, Howlin, Dritschel, and Patel (2006) assessed autobiographical memory in the context of both a "cueing" task and a social problem solving task in a sample of 37 adults with high-functioning ASD and an intellectual ability (but not age) matched comparison group. In the cueing task, the participants were given a series of 15 orally presented cue words (e.g., "leisure"), which varied according to emotional valence; some negative, some positive, and some neutral. Participants were asked to recount a specific autobiographical memory relating to that word as quickly as possible. The ASD group was found to recall significantly fewer specific autobiographical memories in response to all three types of cues and, unlike the control group, was not facilitated by the emotional as opposed to neutral cues. In terms of response latencies, the ASD group, on average, look almost twice as long as the control group to recall specific memories, indicating their difficulties with retrieval. The social problem solving task involved presenting participants with a series of vignettes and asking them to describe the steps required for the protagonist of the story to achieve a particular goal. They were also asked to report thoughts and images that came to mind during the task (these were found to be mainly autobiographical memories). Interestingly, although the solutions to the social problems presented were less effective for the ASD group, both groups were equally likely to recall their own past experiences during the task. Thus, autobiographical memory impairments were evident in the context of the first but not the second task.

However, Hobson et al. (2006) caution against interpreting the autobiographical memories of people with autism as episodic in nature. They cite evidence suggesting that people with autism may "report items of knowledge as if they were remembrances" (p.148). As part of a self-understanding interview, Lee and Hobson (1998) asked children, "Do you change from year to year?" In response to this question and subsequent probes, they found that 75% of participants with autism, but none of the comparison participants, recounted events from their own births. The quality of these "recollections" did not differ from any of their other reported memories. This suggests that the verbal accounts of autobiographical events of people with autism cannot be assumed to reflect autonoetic remembering. Thus the autobiographical memories generated by the participants in Goddard et al.'s (2006) and Klein et al.'s (1999) studies *may* have appeared to be episodic when they were, in fact, semantic.

1.5.2.2 Source Memory in ASD

If individuals with ASD show a reduced propensity to mentally re-experience past episodes then it would also be expected that they should be impaired on tasks requiring them to make source judgments. A number of studies have assessed source memory in ASD. However, the results of these studies have been somewhat inconsistent and require careful interpretation. As stated above, three basic types of source monitoring have been identified: internal; external; and internal-external (Johnson et al., 1993). In typical populations, internal-external (i.e., self-other) source judgments are easier to make than internal or external source judgments (e.g., Hashtroudi et al., 1989). The same pattern appears to apply to samples of individuals with ASD. A number of studies of source memory will be discussed next, the results of which are summarised in Table 1.1 below.

Russell and Jarrold (1999, Experiment 1) found all three types of source monitoring to be impaired in a sample of 22 children with autism/Asperger's syndrome. In their task, experimenter and child took turns to place a total of 24 picture cards onto a board, either on their own behalf or on the behalf of a designated doll "partner". Afterwards, the child had to remember with whom each card had originated and return the card to that person (themselves/experimenter) or doll (their doll/experimenter's doll). This task required elements of internal source monitoring (judging whether they had placed the card on their own behalf or on their doll's behalf), external source monitoring (judging whether the experimenter had placed the card on their own behalf or their doll's behalf), and internal-external source monitoring (judging whether they themselves or the experimenter had placed the card). Relative to verbal ability matched typically developing, and age and verbal ability matched learning disabled, comparison groups, the children with autism/Asperger's syndrome (who had mean VMAs of approximately 7 years) were impaired across all three types of source discrimination. Overall, they correctly identified the source in 72% of cases, compared to a significantly greater 86% of cases in children with learning disability and 90% in typically developing children.

In a second experiment, Russell and Jarrold (1999) gave children three separate card placement source memory tests. One of the tests involved the child, alone, taking picture cards from four different card holders and placing them onto the board, as in the first experiment. The second task involved the same procedure but, rather than making the card placements themselves, the child observed the experimenter making the placements. The final task was a computerised version in which card placements were simulated on a computer screen observed by the child. In each test, the child then had to remember which holder each card had originated from. The first task measured internal source monitoring, and the second and third measured external source monitoring. Overall, the results indicated equivalent performance by the children with autism and the comparison children with learning disability or typical development. However, the children with autism performed significantly less well than the typically developing comparison group on the second task.

It is clear that the results from the two experiments were somewhat inconsistent. External source monitoring was impaired in both experiments, when the relevant source was the experimenter. It was not impaired, however, when the external source was a computer simulation. Thus, this discrepancy may have been due to the social/non-social contrast between the different conditions. It is well established that children with ASD experience particular difficulty in processing social information. The discrepancy in results between Experiments 1 and 2, regarding internal source monitoring, may be attributable to differing task difficulty. Experiment 2 involved substantially fewer cards – 16 as opposed to 24 – and this may explain why children with ASD showed poorer performance in Experiment 1 but not in Experiment 2. Furthermore, Experiment 1 required the child to simultaneously monitor and subsequently recall both their own and the experimenter's actions, unlike Experiment 2. The internal task in Experiment 2 may simply have been too insensitive to detect group differences.

Farrant, Blades and Boucher (1998) used a self-other source monitoring task that involved the experimenter and participant listening to a tape which instructed either "the person holding the red block" or "the person holding the blue block" (referring to either the experimenter or participant) to repeat single words. After 28 instructions from the tape, the child was given a surprise recognition and source monitoring test. They were asked if particular words were "old" or "new". For the ones they said were old, they had to remember who had repeated the word aloud. They found that the children with autism (*n* = 15, mean VMA: 7 years 8 months) performed at a similar level to typically developing and learning disabled matched comparison children.

However, using the same paradigm, Hala, Rasmussen, and Henderson (2005) found a significant deficit in children with autism (*n* = 13, mean VMA: 6 years 7 months), relative to typically developing comparison children. The failure to replicate Farrant et al.'s (1999) results is likely to be due to discrepancies in the CAs and VMAs between the studies. The children in the Farrant et al. study had substantially higher VMAs (7 years 8 months vs. 6 years 7 months) and CAs (12 years 7 months vs. 8 years 5 months) than those in the Hala et al. study. This explanation seems particularly plausible given that Hala et al. found significant relationships between self-other source monitoring and both CA and VMA.

Hala et al. (2005) also adapted Farrant et al.'s (1999) paradigm to create internal and external source monitoring versions of the task. Children with autism also performed at significantly lower levels than typically developing comparison children on these tasks and, unlike controls, only performed at significantly above chance level (i.e., 50% correct) on the reality monitoring task. Interestingly, although the children with autism performed at a consistently lower level than controls, the pattern of performance across conditions was identical for both groups – that is, internal-external source monitoring being easiest and internal source monitoring being the most difficult. The main limitation of this study, however, is the fact that the typically developing control group was more than two years younger than the experimental group. Without an age and ability matched learning disabled control group, it is difficult to establish whether the group differences were simply a consequence of learning disability or a truly autism-specific impairment.

Hill and Russell (2002) designed another self-other source monitoring experiment in which the experimenter and participant took turns to perform designated actions on pairs of objects. For instance, "putting a coin in a book" or "wrapping a tissue around a pen". Then, in an unexpected memory test, the children were asked: (a) if particular object pairings had been put together earlier; (b) what action had been performed with the objects; and (c) who had performed the action. They found that children with autism, with a mean VMA of just under 6 years, did not perform significantly worse than comparison children with typical development or learning disability. However, a power analysis indicated that if a larger sample had been used significant differences may have been found (they included only 15 children with autism).

O'Shea, Fein, Cillessen, Klin, and Schultz (2005) designed an external source monitoring task in which children were shown three video recordings of different actors reading aloud three different stories. The surroundings of the actors varied on a number of dimensions, such as background colour and furnishings. Free recall and recognition of the story were assessed and then a forced-choice source monitoring task was administered. Contextual information about a number of elements was considered, including the actor's face and clothing, and the type of seating. Participants had to choose from three possibilities – one of the incorrect answers was entirely novel whereas the other originated from one of the other stories. Relative to an age and non-verbal ability matched comparison group, free recall of the story was diminished but recognition of the story was unimpaired (after controlling for VMA), consistent with the idea that episodic memory is impaired but semantic memory is spared in ASD. Regarding source memory, there were significant group differences even after VMA was controlled for. It was of note that particular types of contextual information seemed to be driving this result, namely social elements such as the person's face as opposed to nonsocial elements such as the background colour.

Bennetto et al. (1996) found that although word and picture recognition was normal amongst adolescents with ASD, memory for the temporal order of the items was significantly impaired relative to CA and VIQ matched comparison individuals with "learning disorders" (e.g., dyslexia; ADHD; borderline intellectual functioning). Memory for temporal order may be regarded as a form of external source monitoring and is thought to be mediated by the episodic system.

Bowler et al. (2004) gave, what they termed, "supported" and "unsupported" – recognition and recall – versions of an internal source memory test to adults and adolescents with Asperger's syndrome and age and IQ matched controls with typical development. During the study phase, participants were presented with a series of single words along with an instruction that they were told to follow. For example, "Think of a word that rhymes with *house*." The test phase consisted of a recognition test and either a forced-choice source test or an open-ended source test question. In the former condition, participants were presented with the target word and asked to choose which of four options applied to that word: (1) thought of another related word; (2) thought of an action; (3) thought of a rhyme; and (4) thought of a longer word. In the latter condition, they were presented with the word and simply asked, "What did you do with it?" In the supported condition both groups performed at very similar levels (Asperger's syndrome: 58%; comparison: 59%). However, in the unsupported condition source memory was significantly worse in the group with Asperger's syndrome (47% versus 63%). These results are entirely consistent with the hypothesis of a selective impairment of episodic memory. The supported test provided semantic cues which facilitate semantic retrieval whereas the unsupported test relied far more heavily on recall of episodic information. As the authors pointed out, these results also suggest that the problems are related to retrieval more than encoding since participants with Asperger's syndrome were able to identify source as effectively as controls in the supported condition – the difficulty seemed to be in *accessing* stored information.

The results of these studies of source monitoring are summarised in Table 1.1. The majority of the studies show both internal and external source monitoring to be impaired in ASD. The results pertaining to *internal-external* (self-other) source monitoring, on the other hand, remain somewhat more equivocal: 2 studies have found it to be significantly diminished amongst individuals with ASD (Hala et al., 2005; Russell & Jarrold, 1999, Experiment 1) and 2 studies found it to be intact

(Farrant et al., 1999; Hill & Russell, 2002). The findings of the Farrant et al. study may be the consequence of the relatively high chronological and verbal mental ages of the participants and the small sample size. Hill and Russell's findings may be the consequence of low statistical power – a possibility that they themselves suggested.

Table 1.1

Summary of Studies of Source Memory in ASD

Study	***n***	**Mean VMA**	**Type of source monitoring**		
			Internal-external	Internal	External
Bennetto et al. (1996)[6]	19	~ 13;2	-	-	×
Bowler et al. (2004)	16	> 16;0	-	×/✓	-
Farrant et al. (1999)	15	7;8	✓	-	-
Hala et al. (2005)	13	6;7	×	×	×
Hill & Russell (2002)	20	5;11	✓	-	-
O'Shea et al. (2005)	21	9;6	-	-	×
Russell & Jarrold (1999, Experiment 1)	22	7;1	×	×	×
Russell & Jarrold (1999, Experiment 2)	19	7;4	-	✓	×/✓

✓ No significant differences between groups

× ASD group significantly poorer than comparison group/s

1.5.2.3 Memory for Self and Other in ASD

It has been suggested that ASD might involve a particular problem with *personal* episodic memory (Powell & Jordan, 1993) or memory for experiences directly involving the self (Hare, Mellor, & Azmi, 2007). It is established that typical adults show better item memory for self-performed tasks than they do for experimenter-performed tasks (Engelkamp, 1998). This recall/recognition advantage, associated with being a participating agent rather than an observer, is known as the *enactment effect*. One explanation for this effect is that memory traces for self-performed

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[6] The mean VMA for this study was estimated from the mean VIQ and CA, which were provided in the paper, using the following formula: VMA = (VIQ/100) × CA.

actions are more salient because they are more detailed, involving an additional motoric component. An alternative explanation, however, is that the enactment effect is an extension of another well-known memory phenomenon: the *self-reference effect* (Rogers, Kuiper, & Kirker, 1977). This effect refers to the fact that typical individuals show enhanced memory for information that is self-relevant or encoded in relation to the self (Conway, 2001; Symons & Johnson, 1997). For example, individuals are better at remembering trait labels when those labels are claimed to apply to themselves. The self-reference effect is thought to be due to the fact that the self acts as a structure with elaborative and organisational properties that enhance the encoding of information into memory. It is possible that being the agent of an action "tags" that action as self-relevant in a similar manner.

The enactment effect has been demonstrated in children, as well as adults. For example, Foley and Johnson (1985, Experiment 2) found that 9-year-olds and adults, but not 6-year-olds, were significantly better at recalling self-performed than other-performed actions. Also, Foley et al. (1983, Experiment 2) found that 9- but not 6-year-olds were more accurate at recognising words they had themselves spoken than words they had heard spoken by another person. However, two further experiments found that 6-years-olds *did* show the enactment effect. Baker-Ward, Hess, and Flannagan (1989) found that both 6- and 9-year-olds showed superior recall for self-performed activities and Roberts and Blades (1998) found superior recognition for self-performed actions over other-performed actions in 6-year-olds. Four-year-olds, on the other hand, showed equivalent recognition for both self and other. Roberts and Blades (1998) also considered self-other differences in *source* memory. They found that 4-year-olds showed poorer source memory for actions performed by themselves than for actions performed by another. The pattern was reversed for 6- and 9-year-olds. This is an interesting finding because in adults, the enactment effect is found to be limited to item memory, not influencing memory for source (Hornstein & Mulligan, 2004).

Together these data suggest that the enactment effect applies to item memory amongst individuals over the age of 6 years, though not robustly until the age of 9 years. In relation to source memory, the role of this effect is less clear, with less available evidence. However, the study by Roberts and Blades (1998) is suggestive of an "observer effect" in source memory for 4-year-olds and an enactment effect for children over the age of 6. Thus, there are at least two possible accounts for this developmental pattern. In line with the first explanation of the enactment effect, perhaps young children are limited in their capacity for action monitoring and therefore fail to encode motor information into their memory traces, eliminating the self-advantage. Alternatively, in line with the second interpretation of the enactment effect, younger children may have insufficiently developed representations of self. Lack of an adequate self-schema might mean that memories could not be encoded with reference to this supporting structure, resulting in less organised and elaborate memory traces. Again, this conflicts with Howe and Courage's (1993) hypothesis: on their account, the self should be able to act as an organising structure in memory long before the age of 6 years.

Such interpretations suggest that there are grounds for predicting that individuals with ASD might be less subject to enactment and self-reference effects. Both explanations of the enactment effect, in fact, yield the same predictions. Russell (1997) has suggested that individuals with ASD are impaired in their ability to monitor their actions, citing evidence that children with autism have difficulties with error correction (Russell & Jarrold, 1998)[7]. Certainly an action monitoring impairment would result in reduced self-advantage, if the first explanation is correct and the additional motoric information is the key factor. Alternatively, if individuals with ASD have less elaborated self-concepts, as suggested by the evidence reviewed in the following section, then this might equally lead to a reduced self-advantage. Indeed, there are a number of studies that have reported such a pattern of performance.

For example, Millward, Powell, Messer, and Jordan (2000) found that children with autism recalled activities, such as picking up leaves in a street or playing with a skipping rope in a park, that they had themselves performed, significantly less well than activities they had observed a peer performing. The opposite was true for age and verbal ability matched children with learning disability and verbal ability matched typically developing children. However, there was not a significant difference between memory for the *peer's* action between children with autism and typically developing controls. (The comparison between the autism group and the learning disabled group was not reported.) Thus, the children were not simply showing a general memory deficit but, rather, a particular problem with remembering events

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[7] It should be noted that more recent evidence suggests that individuals with ASD are not impaired in monitoring their own actions (Russell & Hill, 2001; Williams & Happé, in preparation).

experienced by the self. This is consistent with Powell and Jordan's (1993) hypothesis that autism entails a specific problem with *personal* episodic memory rather than episodic memory per se.

Hare et al. (2007) found that adults with intellectual disability showed significantly better recall of "table-top" tasks that they themselves had performed than actions they had seen the experimenter perform. The ASD group did not show this advantage. However, under *cued recall*, both groups showed self-advantage. Farrant et al. (1998) found that children with autism showed similar levels of *recognition* for words that they themselves had spoken to words that the experimenter had spoken. Russell and Jarrold (1999) also found that whereas comparison children made significantly more correct source attributions for self-performed actions than other-performed actions, children with autism showed the reverse pattern of performance.

Thus, individuals with ASD seem to show the enactment effect in cued recall and recognition (which can be performed using semantic memory) but not source memory or free recall (which rely more heavily on episodic memory). These results, therefore, provide support for the hypothesis that individuals with autism have a particular problem with *personal episodic* memory (Powell & Jordan, 1993). In relation to the self-reference effect, however, Toichi, Kamio, Okada et al. (2002) found that for adults with high functioning autism, words processed self-referentially (e.g., like me/not like me) were recognised no better than words processed semantically. The individuals with autism clearly failed to demonstrate the effect.

1.5.3 Possible Explanations for Diminished Episodic Memory in ASD

We now turn to the question of *why* episodic memory is attenuated in people with ASD. Evidence relating to the development of self-awareness, representational ability and temporal cognition in autism is reviewed, building on material presented in the previous sections of the chapter. From the review of the evidence, it is concluded that impairments across all three prerequisites for episodic memory contribute to impaired autonoetic consciousness and hence impaired episodic memory in ASD.

1.5.3.1 Impaired Self-Awareness in People with ASD?

The ecological and interpersonal self.

Russell (1996) has suggested that autism involves impairments in self-awareness at the most primitive – ecological – level, hypothesising a fundamental impairment in self-monitoring and, hence, an impaired sense of agency. However, studies have shown that children with ASD *are* aware of their own agency in the physical/ecological domain. Russell and Hill (2001) and Williams and Happé (in preparation), for example, found that children with ASD were capable of identifying which of a number of moving dots displayed on a computer screen, one of which they were able to move with the computer's mouse, was under their control. More generally, individuals with ASD (who do not have co-morbid diagnoses of dyspraxia) have few difficulties in engaging with the physical world. For example, they do not show impairments in tool-use, object manipulation or sensorimotor coordination (Curcio, 1978; Sigman & Ungerer, 1981, cited in Pacherie, 1997). This suggests that they are aware of their bodies in relation to the physical environment and that ecological self-awareness is largely intact.

By contrast, individuals with ASD appear to be less aware of themselves in relation to other people. Many characteristics of autism suggest that interpersonal self-awareness is severely impaired (e.g., Hobson, 1990, 1993; Loveland, 1993; Neisser, 1988; Tomasello, 1995). In typical development, interpersonal self-awareness is obtained through early social interaction, imitation, turn-taking and so on. However, because social interaction among children with ASD is so impoverished, they cannot acquire the usual wealth of self-relevant information available through such experiences. Some children with autism show indifference to other people, treating them as objects rather than as beings with whom one can meaningfully and contingently interact. Even in less severe cases, interactions tend to be stereotyped and lacking in reciprocity (American Psychiatric Association, 1994). The difficulty may be with monitoring self in relation to other in order to coordinate action. Perhaps a specific problem of "interpersonal agency"?

The conceptual self.

There is clear evidence that children with autism do develop an explicit concept of self, albeit one that is somewhat developmentally delayed. What is striking, however, about the self-concepts of these children is their markedly atypical quality. Given that early implicit self-awareness is thought to serve as a foundation for later explicit forms of self-awareness, it is no surprise that interpersonally, but not ecologically, grounded components of explicit self-awareness are impaired in autism. So, for example, mirror self-recognition is relatively intact, whereas self-conscious emotion, pronoun use, and beliefs about the self are all atypical, as outlined below. Children with autism are capable of mirror self-recognition at the appropriate mental age (Dawson & McKissick, 1984; Ferrari & Matthews, 1983; Neuman & Hill, 1978; Spiker & Ricks, 1984). However, successful performance on the task is not evidence of *intact* conceptual self-awareness. It merely suggests that these individuals have conceptual self-knowledge of their typical facial appearance – they have mental representations of what they look like. It is worth noting here that the fact that mirror self-recognition is relatively unimpaired in children with autism, whereas episodic memory is impaired, weakens Howe and Courage's (1993) claim that mirror self-recognition marks the critical cognitive change underlying episodic memory.

The interpersonally grounded component of conceptual self-awareness has been explored in studies of children's conscious awareness of themselves in social situations. In particular, the experience of *self-conscious emotion* is clearly interpersonally grounded. Factors such as personal responsibility, normative standards, and the role of an audience, have been identified as important for the experience of these emotions (Capps, Yirmiya, & Sigman, 1992). None of the mirror self-recognition studies carried out with children with ASD reported the kind of self-conscious affective reactions that occur among typically developing children in this test. More generally, it seems that individuals with autism are less likely to spontaneously experience these emotions. They do not show the characteristic changes in facial expression, posture, or gestures that are associated with these emotional states (Kasari, Chamberlain, & Bauminger, 2001). For example, although they experience pleasure, they are less likely to experience pride, in response to a personal achievement (Kasari, Sigman, Baumgartner, & Stipek, 1993). It is possible, however, that the problem here lies not with conceptual self-awareness but, rather, with lack of awareness of the presence of others or lack of awareness of social standards. It has also been reported that children with ASD are less likely to empathise with others (Sigman, Kasari, Kwon, & Yirmiya, 1992). This is important because the capacity for empathy entails an understanding that self is like other, whilst also representing self and other as distinct individuals. Reduced empathising capacity may, therefore, reflect an impaired concept of self, at least at an emotional level.

There is also an autism-specific deficit in another of the established behavioural markers of conceptual self-awareness: *personal pronoun use*. Since Kanner's (1943) seminal paper, it has been widely acknowledged that individuals with autism tend to have difficulty using personal pronouns such as "I", "you", and "me". In young children with autism, pronoun reversal errors are relatively common (Lee, Hobson & Chiat, 1994; Tager-Flusberg, 1989). Indeed, the problem exists over and above any general language impairment, and is so prevalent that it is used as a diagnostic criterion for autism (Le Couteur, Lord, & Rutter, 2003). Typical patterns of difficulty include treating pronouns as if they were proper names attached to a fixed referent – saying, for example, "You want a drink?" in order to request a drink for themselves. Other characteristic difficulties include substituting third person pronouns such as "he" or "she" or proper names for first person pronouns (Jordan, 1989). Using third person labels in this way circumvents the problem of shifting referents, involved in pronoun use. Appropriate pronoun use is clearly an interpersonally grounded facet of conceptual self-awareness since it requires an understanding of self in relation to others.

Lee and Hobson (1998) assessed conceptual self-knowledge using Damon and Hart's (1988) self-understanding interview to compare the *beliefs about the self* of a group of children and adolescents with autism to those of a matched comparison group. Their results fit the emerging pattern, in that ecologically grounded conceptual self-knowledge was intact but interpersonally grounded conceptual self-knowledge was impaired. Specifically, participants with autism produced significantly more, but qualitatively similar, descriptions of their physical and active characteristics, relative to the comparison group. Self-descriptive statements of psychological and social characteristics, on the other hand, differed qualitatively from those of comparison children and, in the latter instance, quantitatively, in that they produced significantly fewer descriptions that fell into the social category.

The private self.

Autism clearly entails a serious impairment in private self-awareness. This may be regarded as a specific manifestation of the ToM impairment associated with autism. Individuals with ASD have difficulty not only with understanding others' mental states but also with understanding their own (this is discussed further in the following section which focuses on representational skills and ToM). For example, they find it difficult to distinguish their own intended from unintended actions. In particular, when their unintended actions have a desirable outcome they show a tendency to claim that their action was, in fact, deliberate (Philips, Baron-Cohen, & Rutter, 1998). This suggests an impairment of introspective awareness – difficulty with conceptualising their own mental processes. These problems appear to extend to the emotional domain also. Again, individuals with autism are not only impaired in identifying emotions in others but also in processing their own emotional states. In a recent study, Hill, Berthoz, and Frith (2004) asked adult participants to complete a questionnaire assessing own emotion processing. They found that, compared to a typically developing comparison group, participants with high-functioning autism reported greater difficulties in identifying and describing their feelings and showed a greater propensity for externally oriented thinking. Similarly, Ben Shalom, Mostofsky, Hazlett, et al. (2006) reported that children with ASD showed normal physiological emotional reactions, as measured by galvanic skin response, but impaired ability to report these emotions. Thus, impaired private self-awareness is evident in both adults and children with ASD.

Frith and Happé (1999) suggest that those high-functioning individuals who do develop some introspective awareness (many individuals produce elaborate autobiographical accounts) have done so through a "slow and painstaking learning process" (Frith & Happé, 1999, p.2), developing a qualitatively different kind of self-consciousness. In a study of three adults with Asperger's syndrome, Hurlburt, Happé, and Frith (1994) did, indeed, find that self-reported inner experiences differed markedly from those reported by typically developing individuals. Specifically, participants with Asperger's syndrome reported thoughts that were concrete and factually based comprising mainly visual images. Most intriguingly, they did not report any form of inner speech and tended not to report emotions or bodily sensations. This suggests that private self-awareness, like conceptual self-awareness, is qualitatively different in individuals with ASD.

The temporally extended self.

To date, just one study has sought to assess delayed self-recognition in ASD. Dissanayake and Suddendorf (unpublished, reported in Nielsen, Suddendorf, &

Dissanayake, in press) tested a group of 15 children with high-functioning ASD and 15 mental age matched typically developing comparison children. The ASD and comparison groups had mean CAs of 7 years 7 months and 7 years 0 months respectively. The authors report that 83% of participants with ASD and 100% of comparison participants passed the task and that this difference was not significant[8]. However, they do not report any statistics, as such, and it is therefore somewhat difficult to evaluate the study at this stage. Significant group differences may have been observed in a younger or less able sample.

There is some indirect evidence that children with ASD have impaired temporally extended self-awareness. Young typically developing children, who fail DSR, tend to label past self-images such as photographs and video recordings using their own name, rather than saying "me" (Povinelli et al., 1996). Taking a third person stance, by using a proper name, may well indicate an inability to identify with the depicted image (past self-representation), which would require a sense of personal continuity through time. Indeed, it is at least possible that those children who labelled the image using their proper name were not recognising the videos/photographs as themselves but, rather, showing a simple learned association between "that face" and "that name". Lee et al. (1994) found that, in contrast to comparison children, even fairly verbally able children with autism showed this same propensity to use proper names in a photograph naming task. This observation is suggestive of an impairment, or delay in the development of, a temporally extended self in children with autism.

Data obtained from Lee and Hobson's (1998) study, described above, is also relevant here. Among the responses of the children with autism to the self-understanding interview, there were only 3 references to the self in the future, in contrast to 8 references by the comparison participants. One child stated that his voice would change in the future, another claimed that he would not change in the future, and another claimed he would not change because his name would stay the same. These examples, in themselves, seem to demonstrate an inability to imagine the self in the future, implying an impaired sense of the temporally extended self.

To summarise, let us once again consider how Neisser's (1988) five kinds of self-awareness, as described in the section (1.4.1) on the development of self in typical children, manifest themselves in people with autism. The evidence reviewed

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[8] 83% constitutes 12.45 participants. This must therefore have been a typographical error.

earlier in the chapter suggests that although ecological self-awareness is probably intact, interpersonal self-awareness is not. Conceptual self-awareness is also atypical, as is evident from, amongst other things, abnormal pronoun use, self-conscious emotion and the formation of beliefs about the self that have social connotations. If autonoetic consciousness depends upon explicit self-awareness, it can be inferred that anything that disrupts this development may potentially impact upon episodic memory. Impairments in conceptual, private and temporally extended self-awareness are likely to contribute directly to the episodic memory impairment in autism. Impairments in interpersonal self-awareness may have indirect effects through altering the development of explicit self-awareness. Following Strawson (1962), Hobson et al. (2006) argue that "it is in the nature of concepts [and, hence, *self*-concepts] that they are generalizable and applicable to more than one instance of whatever they pick out" (p.132). Thus, reduced awareness of other "selves" or persons, that is characteristic of ASD, implies a lack of awareness of one's own self. A lack of awareness (or reduced awareness) of selves, in general, would prevent (or inhibit) the development of a generalisable concept of selves, of which one's own self is an example. In this way, difficulties with interpersonal engagement are likely to lead to impaired interpersonal self-awareness and, hence, impaired conceptual self-awareness.

The claim that an impaired sense of self contributes to episodic memory impairments in autism is consistent with the fact that individuals with ASD have particular difficulties when memory tasks demand a high degree of self-involvement (e.g., Millward et al., 2000; Russell & Jarrold, 1999). However, it is clear that episodic memory depends upon more than self-awareness. As explained above, it requires certain (related) representational and temporal-cognitive skills. This is further discussed below.

1.5.3.2 Impaired Representational Abilities?

The same underlying difficulty in ToM/metarepresentation that leads to impairments in private self-awareness is also likely to impact upon the capacity of people with ASD to experience autonoetic consciousness. Impaired performance on ToM tasks, particularly false belief tasks, is usually interpreted as the result of difficulty with metarepresentation – with conceptualising mental states. Metarepresentational problems would mean that individuals with autism would not be aware of their own propositional attitudes to the information in their own minds. Thus, memories could not be identified *as* memories and, therefore, could not be consciously reflected upon as memories. It certainly appears to be the case that children with autism have as much difficulty in attributing a (previous) false belief to themselves, as they do to ascribing one to another person (Fisher, Happé, & Dunn, 2005). This suggests that they lack, or have a diminished capacity to form, the kind of higher-order-thoughts that Perner (2000) argues are necessary for episodic remembering.

A study by Baron-Cohen and Goodhart (1994) suggests that children with autism have difficulty in understanding the relationship between seeing and knowing. Furthermore, children with autism have equal difficulty attributing knowledge or ignorance to self or other depending upon whether that person has had informational access to that knowledge (e.g., though seeing or being told about a piece of information) (Kazak, Collis, & Lewis, 1997; Perner, Frith., Leslie & Leekam, 1989). These studies suggest that children with autism may lack the requisite abilities for understanding causal self-referentiality, which Perner argues is essential for episodic memory.

1.5.3.3 Impaired Temporal Cognition?

As mentioned above, mental time travel requires past or future oriented thinking. Problems with these forms of cognition may well contribute to the observed difficulties with episodic memory. Both clinical and anecdotal accounts suggest that people with autism have a "poor intuitive sense of time" (Boucher, 2001, p.111). Wing (1996) suggests that the problem is that individuals with autism do not fully understand the passage of time and have problems linking it with ongoing activities. This may reflect a failure to conceive of the "causal arrow of time" (Povinelli et al., 1999). It is notable, also, that cognitive problems in autism include difficulty in both thinking backwards (episodic remembering) and thinking forwards (planning) through time (e.g., Bowler et al., 2000a; Ozonoff et al., 1991).

Very little work directly assessing temporal cognition in autism has been reported. Recently, however, Boucher, Pons, Lind & Williams (2007) found that children and adolescents with ASD were impaired relative to a matched comparison group on a number of tests designed to assess the ability to use temporal concepts in thinking and reasoning. Of particular note was the fact that the experimental group had significantly more difficulties with both past and future oriented thinking. So, for example, one of the tests involved presenting the children with a picture of a seaside scene and asking them to describe what was happening. Participants with autism were less likely to describe possible antecedents or consequents of the currently depicted state of affairs. Unlike comparison children, who produced descriptions such as, “That man's lying on the mat – he'll get sunburned if he's not careful,” children with autism tended to describe the scene primarily in terms of the present moment, producing descriptions such as, “There's a person surfing. And someone sunbathing.” These problems with past and future oriented thinking were not related to performance on a battery of tests of “theory of mind” suggesting that difficulties with temporal cognition – particularly the ability to make temporal-causal inferences – could contribute to episodic memory impairments independently of difficulties associated with impaired metarepresentation. What we do not yet know, however, is whether individuals with autism have a concept of the “causal arrow of time” and whether they can form and coordinate perspectival and non-perspectival temporal frameworks. If this ability were to be impaired then it may well contribute to episodic memory impairments.

1.6 SUMMARY

This literature review has considered research relating to episodic memory in both typical development and ASD. Experimental evidence shows that individuals with ASD have diminished episodic memory and the self-involved, time-related experiences of autonoetic awareness that accompany this kind of remembering. One of the main aims of this chapter was to develop a theory to explain the possible cause, or causes, of this impairment. There are a number of possible explanations, as is evident from a review of the prerequisites for the development of episodic memory in typically developing children. These include the normal development of self-awareness, particularly private and temporally extended self-awareness. Related to the development of self-awareness are changes in representational abilities, from primary to secondary representations, to metarepresentation. A third prerequisite for the development episodic memory is an ability to think and reason about time. In ASD, it is clear that self-awareness develops atypically and that metarepresentational ability is diminished. Moreover, there is also some evidence of impaired temporal cognition in people with ASD and this is consistent with the suggestion that people with ASD have an impoverished concept of the temporally extended self. It is argued that, together, these highly interdependent difficulties result in a selective impairment of episodic memory. This contention is yet to be empirically tested, however. In fact, there has not been any research to date which has sought to directly address the question of why episodic memory is impaired in ASD. Thus, the main aim of the empirical work subsequently reported in this thesis was to address this previously un-answered, indeed, un-investigated, question. The following chapter explains, in detail, precisely which questions were addressed and the methodological approach that was taken.

CHAPTER 2: Aims, Methods, and General Research Strategy

2.1 AIMS OF THE PRESENT RESEARCH

The literature reviewed in Chapter 1 demonstrates that episodic memory is diminished amongst individuals with ASD of all levels of ability. Semantic memory, by contrast, appears to be relatively intact, at least amongst high-functioning individuals. Although theoretical speculations have been made regarding the underlying causes of this diminution of episodic memory, there has not been any empirical work which has sought to address this question. The work undertaken in this thesis aimed to tackle this very issue, specifically, considering how episodic memory might relate to other areas of psychological functioning amongst individuals with ASD. Research on the typical development of episodic memory highlights a number of likely prerequisite cognitive abilities, including particular ToM skills and temporally extended self-awareness, which endow children with the capacity for autonoetic consciousness. The fact that adults with ASD show less remembering (indicative of episodic memory/recollection) and more knowing (indicative of semantic memory/familiarity) suggests that they have reduced autonoetic awareness (Bowler et al., 2000a, 2007). It was therefore hypothesised that impaired ToM and/or impaired temporally extended self-awareness might act as developmental precursors to the episodic memory impairment in ASD.

The fact that individuals with ASD have difficulties with understanding both the false beliefs of self and other (Fisher et al., 2005) and with understanding the relationship between perception and knowledge in self and other (Perner et al., 1989) suggests that they have difficulties with both higher-order-thought/metapresentation and with understanding causal self-referentiality. Perner (2000, 2001) argues that these ToM abilities are fundamental to episodic memory. It seems reasonable to suggest, therefore, that reduced introspective awareness, as a specific manifestation of impaired ToM, might contribute to difficulties with episodic recollection, particularly in light of evidence for a link between these abilities in typical development (Naito, 2003; Perner et al., in press; Perner & Ruffman, 1995).

Despite the fact that self-awareness in ASD has been fairly extensively investigated (see Hobson et al., 2006), at the outset of this PhD research, no study had previously sought to address *temporally extended* self-awareness. It was, therefore, of significant interest to assess this ability, not only because of its potential relationship with episodic memory but also in its own right. Temporally extended self-awareness is thought to rely on metarepresentation and an understanding of temporal-causal relationships (Povinelli, 2001). Thus, given that ASD typically entails problems with metarepresentation and that it also seems to involve difficulties with certain types of temporal cognition (Boucher et al., in press; also see Boucher, 2001; and Wing, 1996), it was hypothesised that temporally extended self-awareness would be impaired. McCormack and Hoerl (1999) have argued that temporally extended self-awareness is necessary for the type of temporal decentering that occurs during episodic remembering. So, if temporally extended self-awareness were to be impaired in ASD, it could certainly have an impact upon the capacity for autonoetic consciousness and episodic memory.

Thus, the present study sought to explore the relationship between episodic memory, temporally extended self-awareness, and ToM in ASD. One approach would have been to conduct a series of small scale studies, as is typical of ASD research. However, it was decided that a somewhat different strategy would be more fruitful in this instance. Given that the abilities of interest appear to be highly interrelated in typical development, it was desirable to attempt to disentangle their roles in order to establish the relative contributions of ToM skills and temporally-extended self-awareness to episodic memory in ASD.

In view of this, it was decided that a multiple regression would be the most suitable method of analysing the data. However, this type of analysis requires substantial sample sizes. It was decided, therefore, that the most effective method would be to test one large sample of participants on a battery of experimental tasks. Before explaining the details of the study itself, one other issue must be considered. The research to be undertaken rested on the assumption that so-called ToM tasks actually measure ToM. However, there are reasons to question whether this is the case, particularly amongst individuals with ASD (see Chapters 5 and 6 for further elaboration).

The ToM hypothesis of autism suggests that many of its diagnostic characteristics are due to an attenuation of the "ToM mechanism" (ToMM) (Leslie;

1987; Baron-Cohen, 1989; Frith, 1989; see Chapter 5 for more detail). If individuals with ASD have impaired ToMMs, they should not be able to pass ToM tasks. But, a proportion of individuals with ASD *do* pass them. This fact is clearly problematic for the theory. One suggestion, which preserves the hypothesis, is that individuals with ASD use compensatory verbal strategies to "hack out" solutions to the tasks (Bowler, 1992; Happé, 1995). If this were to be the case then the ToM task performance of individuals with ASD would not reflect the same underlying processes, whatever they might be, that operate in typically developing individuals. So, although we would expect ToM and episodic memory to be related in people *without* ASD we would not expect them to be related in people *with* ASD. A task-specific verbal strategy would not, after all, endow an individual with the capacity for autonoetic consciousness.

The most fully articulated account of the nature of such hypothesised verbal strategies is derived from the work of Jill de Villiers (e.g., 1995). De Villiers has argued that *complement syntax*, a specific aspect of grammar, is a prerequisite of false belief understanding in typical development (see Chapter 6 for more detail). Following de Villiers, Tager-Flusberg (2000) has suggested that complement syntax understanding may have a pivotal role in the false belief task performance of children with ASD. Although the evidence for a role for complement syntax in the typical development of ToM is not convincing (see Cheung, Hsuan-Chi, Creed et al., 2004; Perner, Sprung, Zauner, & Haider, 2003; and Tardif & Wellman, 2000), it may potentially explain successful ToM task performance in some individuals with ASD. It was decided, therefore, that complement syntax understanding should also be measured in the present study. Again, it was considered that (a) this would be an interesting study in its own right and (b) it might account for possible null results regarding the relationship between episodic memory and ToM in ASD.

To summarise, the main aims of the empirical work in this thesis were to: (1) replicate previous findings that episodic memory is impaired in ASD; (2) establish whether or not temporally extended self-awareness is impaired in ASD; (3) establish whether ToM impairments and/or temporally extended self-awareness impairments are related to episodic memory impairments in ASD; and (4) establish whether complement syntax understanding relates to ToM performance in ASD.

2.2 METHODS

The following sections explain the choice of experimental tasks, the procedures for each of the tasks, the scoring criteria for each of the tasks, the basis of the sample selection, and the participant recruitment strategy.

2.2.1 Choice of Experimental Tasks

This section offers justifications for the choice of measures used to assess each of the cognitive abilities of interest. Each of these methods were piloted, with both young typically developing children (*n* = 6) and children with ASD (*n* = 4), in order to ensure that the procedures were suitable and to practice the administration of the tasks. Pilot participant characteristics are displayed in Table 2.1. The data collected in the pilot work were not included in the main data set – these children were not included in the final sample.

Table 2.1

Pilot Participant Characteristics

	ASD	Comparison
N	4 (1 female)	6 (3 female)
VMA		
M	6.10	5.37
SD	1.35	0.91
Range	4.83 – 8.00	3.83 - 6.33
CA		
M	8.83	5.34
SD	3.33	0.33
Range	6.42 – 13.75	5.00 – 5.75
Verbal IQ		
M	80.50	100.83
SD	23.30	6.49
Range	47 – 101	90-107

2.2.1.1 Measure of Episodic Memory

When selecting a suitable measure of episodic memory, a number of factors had to be taken into consideration. Tulving (1991, 2002) argues that all memory tasks are "multiply determined", invoking more than one memory system. Nevertheless, certain tasks appear to depend more heavily on one system rather than another. The most direct way of determining whether conscious memories are episodic or semantic is to simply ask participants to report the types of conscious awareness that accompany their memories, as required for the remember-know paradigm (Tulving, 1985; see section 1.2). Unfortunately, this paradigm would not have been appropriate to use for the current study. It has been shown that in typical development, children below 6 to 7 years of age cannot reliably distinguish between the states of remembering and knowing (e.g., Johnson & Wellman, 1980). Children with *mental* ages below this threshold could not, therefore, be expected to verbally distinguish between these states of consciousness in a memory task. Since the current study was expected to involve at least some participants with mental ages below this threshold, the paradigm would not have been suitable. Indeed, Brainerd et al. (2004) have argued that remember-know judgements may not be reliable until early adolescence.

Thus, an indirect method of assessing episodic memory had to be employed. As previously stated, source memory is thought to invoke autonoetic consciousness, requiring retrieval of contextual information and is, therefore, accepted as a means of assessing episodic memory (Perfect et al., 1996; Wheeler et al., 1997). Indeed, fairly young children are able to perform tests of source monitoring and such tasks have been used successfully to test children with autism. On this basis, it was decided that a source memory task would be used for the current study. As explained in section 1.3.3, three distinct types of source monitoring have been identified: internal, external, and internal-external/self-other. A self-other task was selected for two reasons. Firstly, although previous studies have indicated clear impairments in both internal and external source monitoring in ASD, the findings regarding self-other source monitoring remain equivocal, due to small sample sizes. Using a self-other task for the present study aimed to clarify this ambiguity. Secondly, it was of interest to assess differences in memory for self- versus other-performed actions, given that it has been hypothesised that ASD involves a particular problem with *personal* episodic memory (Powell & Jordan, 1993) or memory for experiences directly involving the self (Hare et al., 2007).

Source monitoring tasks also tend to include an item memory component, involving either free recall, cued recall, or recognition. Of these types of item memory test, recognition tests arguably tax episodic memory to the least extent (Wheeler et al., 1997). Although recognition memory is typically mediated by both semantic and episodic memory (e.g., Yonelinas, 2001), a normal level of performance is possible in the absence of episodic recollective experience (Düzel et al., 1999). Since ASD is thought to involve a universal impairment of episodic memory but not semantic memory, it was of interest to contrast episodic and semantic memory performance and thus a recognition, rather than recall, based item memory component was selected. Including such a measure also allowed Boucher, Mayes, & Bigham's (in press) hypothesis that low functioning ASD involves a global explicit (episodic *and* semantic) memory impairment to be assessed.

Thus, the basic procedure of the final task involved experimenter and child picking up and naming picture cards and then, after a short delay, testing the child's item recognition and self-other source memory. The material was presented visually in the study phase and verbally in the recognition phase. Previous work has shown that such study/test modality incongruence does not usually affect performance (Gardiner, 2001). Given the fact that children with ASD often show pronoun reversal errors (Lee et al. 1994; Tager-Flusberg, 1989), it was decided to avoid use of the terms "you" and "me" in the source memory part of task. Instead, children were encouraged to use proper names.

2.2.1.2 Measure of Temporally Extended Self-Concept

Povinelli et al.'s (1996) delayed self-recognition test is the only established paradigm designed to measure the temporally extended self-concept. It has been argued that the task does not measure developments which are *specific* to self-awareness and, indeed, there is some evidence to support this view (see Chapter 4 for elaboration). However, I would argue, in line with Suddendorf (1999), that the task measures domain general abilities that have a bearing on (amongst other things) the child's self-concept. The task appears to measure the capacity to make temporal-causal inferences, which are necessary in order to conceive of the self as extended in time. McCormack & Hoerl (1999) have argued that delayed self-recognition is, in fact, a measure of temporal decentering, requiring the child to reason about the relationships between past and present temporal perspectives. This ability, in itself, is said to rely on having a temporally extended self-concept. So, although the task might not be a pure measure of temporally extended self-awareness, it does index a key cognitive ability that underlies, or arises as a consequence of, this form of self-awareness.

Pilot testing led to a decision to make a slight modification to Povinelli et al.'s (1996) original procedure. It was found that if children, particularly those with ASD, were shown the entire game replayed on film, as in the original study, they lost interest and stopped attending to the video. It was found that replaying the video from the second round of the game ensured that the children remained attentive.

2.2.1.3 "Theory of Mind" Measures

Two different ToM abilities have been hypothesised as essential to episodic memory: general metarepresentational ability and an understanding of causal self-referentiality – that is, recognising that knowledge is the consequence of perceptual experience (Perner, 2000, 2001). The most definitive method of assessing metarepresentational ability is to test children's ability to attribute of false beliefs (Dennett, 1978). As such, two of the classic false belief tests were chosen to use in the study: a location change task (Wimmer & Perner, 1983) and an unexpected contents task (Hogrefe, Wimmer, & Perner, 1986). Specifically, the "Sally-Anne" (Baron-Cohen, Leslie, & Frith, 1985) and "Smarties" (Perner et al., 1989) versions were used. The Smarties task was of particular interest because it provides a self-other contrast, asking the child about the contents of both another's belief and their own previous belief.

The second of the ToM abilities under consideration – the appreciation that knowledge is dependent upon informational access through perceptual experience – is typically assessed using "see-know" tasks, which assess children's understanding that having visual access to information is a way of gaining knowledge of that information (Hogrefe et al., 1986; Wimmer et al., 1988). For example, Wimmer et al. (1988) asked children to judge which of two helpers, one of whom had looked inside a box and one of whom had not, knew what the contents of the box were. They found that children below 4 years of age did not correctly infer that the helper who had looked inside the box would know what was inside. However, more recent research has suggested that children have this understanding slightly earlier in development. For instance, Pratt and Bryant (1990) found that when the language of the test question was simplified, from, "Does X know what's in the box or does X not know what's in the box?" to "Does X know what's in the box?" children as young as 3 years of age were able to make correct judgements about knowledge/ignorance.

In a study of children with ASD, Baron-Cohen and Goodhart (1994) adapted Pratt and Bryant's (1990) procedure by using dolls as protagonists rather than "helper" children. Participants were presented with two doll characters, called John and Fiona, and some small boxes, each containing an object. They were given six trials, each of which involved one of the dolls lifting a box and the other opening the box and having a look inside. They were then asked, "Who knows what's in the box? John or Fiona?" It was found that children with autism were significantly less likely than comparison children to answer these questions correctly. However, there were some problems with the task's pre-test control questions which raise issues regarding how to interpret this finding.

The control task involved the experimenter giving a red counter to John and a blue counter to Fiona, or vice versa, and then asking the child, "Who has the red/blue counter?" Participants were excluded if they did not pass 5 out of 6 trials – this was assumed to indicate an inability to follow the procedure. Generally, it is considered good practice, in ToM research, to include a control task that does not require reasoning about mental states but which is otherwise analogous to the experimental task. Acknowledging this expectation, Baron-Cohen and Goodhart (1994, p.399) describe the control questions as "comprising a very similar 'story' but no knowledge formation." They may, indeed, have involved a similar "story", but the cognitive demands of the control questions differed considerably from those involved in the experimental questions, raising the possibility that participants with ASD failed the experimental task for reasons other than failing to understand that seeing leads to knowing. The pre-test control questions required recognition memory whereas the experimental questions required free recall, which is often found to be impaired in ASD (Boucher, 1981a; Boucher & Warrington, 1976; Bowler et al., 2000b; Hermelin & O'Connor, 1967; Ozonoff et al. 1991; Summers & Craik, 1994; Tager-Flusberg, 1991). Furthermore, answering the experimental questions, unlike the control questions, involved recalling an action (e.g., Fiona opened the box and had a look) and making an inference based on that action (e.g., Fiona must, therefore, know what is inside the box). This confound means that children may have failed the experimental task because of a failure to recall the action and/or make an inference.

It was decided that, despite these problems, Baron-Cohen and Goodhart's (1994) experimental procedure would be used for the present study. The task was considered particularly suitable because it uses dolls rather than "helper" children, which would have been somewhat impractical. It was decided, however, that a new control task should be designed and implemented. Thus, for the current experiment a series of six new control questions were created. These questions each required the participant to recall an action and make an inference based on that action. In order to equate the control and experimental questions as closely as possible, the control questions were designed to require inferences about internal, unobservable (but not mental) states, such as feeling sick or cold. This was intended to ensure that difficulties were not arising as a consequence of problems with reasoning about, or representing, unobservable variables. The ideal control questions would match the experimental questions on all criteria, differing only in terms of mental/non-mental states. Although the match was closer than that in Baron-Cohen and Goodhart's study, the questions were not entirely analogous. For example, unlike the control questions, the experimental questions involved (a) each doll performing a different action but on the same object, and (b) each trial involved the same basic scenario: one character picking up the box and the other opening it.

2.2.1.4 Complement Syntax Measure

A "memory for complements" task was selected as the measure of complement syntax understanding for use in the current study. Details of the task, as well as the experimental materials, were kindly provided by Jill de Villiers. The task was similar to that used by de Villiers and Pyers (2002), which involved presenting children with a series of scenarios, described by a single sentence containing an embedded complement, which were followed by questions requiring the child to extract the complement from the sentence. For example, "She said *she found a monster under her chair*, but it was really the neighbour's dog. What did she say?" Each story consisted of a single sentence which contained a complement embedded under a tensed communication verb (either "say" or "tell"). The stories were followed by a simple question requiring the participant to extract the complement, which described what the protagonist was saying or telling. They described situations in which the protagonist could be construed as either lying or making a mistake. Communication verbs, rather than mental state verbs, were used to avoid confounding complement syntax understanding and ToM abilities.

This type of task was preferred because it was substantially simpler than many tests of complement syntax understanding (de Villiers, Roeper, & Vainikka, 1990; de Villiers, 1998), with fewer additional linguistic demands. Although this type of task does place some load on working memory, the particular working memory requirements involved are found to be unimpaired in ASD. Russell, Jarrold, and Henry (1996, Experiment 2), for example, found that sentence span, which involves similar cognitive demands to the memory for complements task, was not impaired in ASD. Thus, any possible group differences in memory for complements would be unlikely to be due to working memory issues.

2.2.2 General Procedure

The participants were seen individually for four sessions, each of which lasted for approximately 15 to 30 minutes. All testing was carried out within schools, usually in a separate room but, on a small number of occasions, within the classroom in a quiet corner. During Session 1, BPVS scores were established to ensure that participants were within the desired verbal age range. During Session 2, participants took part in the item/self-other source memory task. During Session 3, the battery of ToM tests was administered, followed by the memory for complements test. Finally, during Session 4, participants were given the delayed self-recognition test. Details of the specific procedures for each of the experimental tasks are outlined next.

2.2.2.1 Item/Self-Other Source Memory Task

Materials.

Forty-two pictures were taken from the Expressive One Word Vocabulary Scale (Brownell, 2000) and were used to compile a list of 42 words that corresponded to those pictures. Those 42 words were then randomly assigned to one of three lists: *a*, *b*, or *c* (see Appendix 1). The three lists were then paired together ($a + b$, $a + c$, and $b + c$) to produce three different stimulus order conditions, within which, words were randomly assorted (see Appendix 2). Participants were randomly allocated to one of these three conditions (Condition 1: $a + b$; Condition 2: $a + c$; Condition 3: $b + c$) such that, during the study phase, someone assigned to Condition 1 ($a + b$), for example, would not see any of the pictures from list *c* but would see all of the pictures from lists *a* and *b*. The words from list *c* would later act as lures during the test phase.

For each word, in each condition, self/other status (i.e., whether the participant or experimenter would be naming the picture) was designated at random, subject to the constraints that, in a given condition, no more that three turns of self or other would occur in a row and that, overall, there were equal numbers of self and other pictures. Each of the 42 words were used in two out of the three conditions. If, in one condition, a given word was assigned "self" status then, in the second condition in which it occurred, it was assigned "other" status. For example, if the item "fork" from list *b* was assigned "self" status in Condition 1 ($a + b$), then it was assigned "other" status in Condition 3 ($b + c$) (it simply would not appear in Condition 2). The lists *a*, *b*, and *c* were then recombined in a random order to produce one item recognition test list, received by participants in all three conditions (see Appendix 3).

Three sets (one for each condition) of laminated, grey-scale picture cards, measuring approximately 11 × 8 cm, were produced (see Appendix 4 for examples). Self/other (participant/experimenter) status was indicated by the absence/presence of a small, black "X" on the back of the cards. Participants responses were noted on a test record form (see Appendix 5).

Procedure.

Participants were randomly assigned to a condition. The experimenter sat opposite the participant and placed the pile of picture cards between them, whilst giving the participant the following instructions: *"Now we're going to play a picture naming game. I'd like you to try to remember the names, because I'm going to see how many you can remember later on. Sometimes, I'm going to pick up a picture and name it and sometimes, you're going to pick up a picture and name it. I'll tell you whose turn it is each time."* The experimenter and child then began picking up and naming the pictures. For each picture, the experimenter provided a verbal cue to indicate whose turn it was; either, *"Now it's [child's name]'s turn"* or *"Now it's [experimenter's name]'s turn."* If the participant did not pick up the picture after the initial cue, the experimenter gave the prompt, *"Can you pick up the picture and name it?"* If the participant did not respond with a label, the experimenter gave the prompt, *"What's that?"* If the child gave a name for the picture that did not correspond to the "expected" name (as listed in the recognition list), this was noted and used as a substitute for the "expected" name at the recognition stage.

After a delay of approximately two minutes, the participants were told, *"OK, now I'm going to read out some names of things and I want you to tell me whether or not we saw those things in the pictures we looked at earlier. We saw some of the things earlier but others we didn't see."* The experimenter then read the recognition list (see Appendix 3) aloud, each time saying, *"Did we see a picture of a [recognition item]?"* When the participant identified an item as old, responding with "yes," they were asked, *"Who picked up the picture of the [recognition item] and named it?* If they did not immediately respond, this was followed with: *[Name of child] or [Experimenter's name]/ [Experimenter's name] or [Name of child]."* The order in which the name of the experimenter and the name of the child were mentioned was randomised in advance.

2.2.2.2 "Theory of Mind" Tasks

Each participant completed three ToM tasks: a location change false belief task, an unexpected contents false belief task, and a see-know task. Three ToM conditions were used with the aim of avoiding order effects (see Appendix 6). Participants were randomly assigned to these conditions. All responses were recorded verbatim on specially designed forms at the time of testing (see Appendix 7).

Location change (Sally-Anne) false belief task.

Materials. Materials used included (1) two female "Playmobil" dolls, one with short dark hair and one with long blonde hair, which were approximately 7.5 cm tall, (2) one pink and one blue metallic box, with approximate dimensions of 3.0 × 5.5 × 5.5 cm (height × width × depth), and (3) one marble with a diameter of approximately 1.5 cm.

Procedure. First of all, the experimenter introduced the two dolls as Sally and Anne. The child was then asked to identify each of the dolls, in order to ensure that they knew their names. The child was also asked to name the colours of the boxes. The experimenter then acted-out the following sequence, whilst describing the ongoing events as follows: *"Sally's going to put her marble in the blue box. Now Sally's going out to play. While Sally's out, naughty Anne takes the marble out of the blue box and puts it in the pink box. When Sally comes back home..."* The following sequence of questions was then asked (the elements in parentheses were included if the child did not respond spontaneously):

(a) Test question: *"Where will she look for her marble first? (In the blue box or the pink box?)"*

(b) Reality control question: *"Where is the marble really? (In the blue box or the pink box?)"*

(c) Memory control question: *"Where was the marble in the beginning? (In the blue box or the pink box?)"*

Four conditions were created in order to counterbalance the colour of the box in which Sally put the marble and the order in which the colours were mentioned in the protocol questions (see Appendix 8). Participants were randomly assigned to these conditions.

Unexpected contents (Smarties) false belief task.

Materials. The materials used for the unexpected contents task included a "Pringles" (well-known type of potato crisp) box, a plastic carrier bag, and a tennis ball which was contained within the Pringles box.

Procedure. The experimenter removed the Pringles box from the carrier bag, showed it to the child, and asked, *"What's in here?"* They were then shown the true contents and told, *"No, it's a ball."* The ball was then replaced and the box was closed again. The child was then given the following sequence of questions:

(a) Reality control question: *"What's in here?"*

(b) False belief "self" question: *"When I first asked you, what did you say?"*

(c) False belief "other" question: *"Your teacher hasn't seen this box. When s/he comes in later, I'll show her/him this box just like this and ask him/her what's in here. What will your teacher say?"*

(d) Second reality control question: *"Is that what's really in the box?"*

(e) Memory control question: *"Do you remember when I took the box out of my bag and asked you what was in it, what did you say?"*

See-know task.

Materials. Materials for the see-know task included one male and one female "Playmobil" doll, as well as five small boxes, with approximate dimensions of 3.0 × 5.5 × 5.5 cm (height × width × depth), each with a distinct appearance. The boxes each contained a different toy object (flowers, dog, pineapple, basket, hairbrush).

Procedure. The experimenter introduced the two dolls as John and Fiona, and then asked the child to identify each doll by name. For the control procedure, the children were then told a series of one-sentence stories, which were each followed by a question:

(1) *"Fiona and John go out to play in the park. Fiona falls over and cuts her knees and John gets muddy knees. Who gets sore knees?"*

(2) *"John does some colouring while Fiona goes for a long run. Who gets tired out?"*

(3) *"It's snowing outside. Fiona goes outside to make a snowman while John stays indoors by the fire and reads a book. Who gets cold?"*

(4) *"John and Fiona are very hungry. Fiona has a small glass of water and John has a big roast dinner. Who gets full up?"*

(5) *"John and Fiona go to the beach. John lies down in the sun while Fiona goes swimming. Who gets hot?"*

(6) *"John and Fiona go to a birthday party. John has one plate of food and Fiona eats all the cakes and ice cream. Who starts feeling sick?"*

A Latin Square was used in order to counterbalance the order of the stories and the position of the information bearing part of the story (see Appendix 9). This created 12 conditions. For the test phase, having completed the control questions, the children were shown the boxes and told, *"Look I've got some boxes here. There's something inside each box. I'm going to show the boxes to John and Fiona."* They were then given the test questions, which were acted-out by the experimenter and which took the form: *"John lifts up the box and Fiona opens the box and has a look. Who knows what's in the box?"* The order of characters/looking and lifting was randomly assigned for each of the five questions (see Appendix 10). The set of questions remained fixed for all participants.

2.2.2.3 Complement Syntax Task

Materials.

An A4 ring binder containing colour photographs, which illustrated the stories, was used for the task.

Procedure.

Participants were read a series of eight stories in a fixed order:

(1) The girl said she was reading a book, but she was really playing cards. What did she say?

(2) She told the girl there was a bug in her hair, but it was only a leaf. What did she tell the girl?

(3) She told her husband she saw a ghost, but it was really a blanket. What did she tell her husband?

(4) She said she had a hole in her trousers, but it was really a piece of paper. What did she say?

(5) She told her dad he had a cut, but it was really ketchup. What did she tell her dad?

(6) She told the teacher she drew a face, but it was really a scribble. What did she tell her teacher?

(7) Her friend said she was eating an egg, but it was really a ball. What did she say?

(8) She said there was a spider in her cereal, but it was really a raisin. What did she say?

Each story was accompanied by two illustrative photographs. The experimenter pointed to the relevant parts of the pictures as she read the stories aloud. Participants' responses to the questions were recorded verbatim at the time of testing.

2.2.2.4 Delayed Self-Recognition Task

Materials.

The recording equipment used for the delayed self-recognition test included a Canon pal (MV550i) digital video camcorder which was connected to an AG Neovo (S-15V) 15 inch (38 cm) flat screen colour monitor. This equipment was used to record the "sticker game" and subsequently replay the recording of the game for the child to watch. An additional video camera – a Panasonic VHS-C (NV-RZ1) – was also used to record the entire session. The recordings from this camera were later used for the purposes of coding participant responses. The two video cameras were positioned opposite the table at which the child was to be seated, approximately 1.5 to 2.5 metres away, depending on the dimensions of the room, availability of power points, and so on, at any given school. The screen was also placed facing the table where the child was to be seated. During the sticker game the screen was covered with a piece of fabric (to eliminate reflections).

The materials used for the "sticker game" included two plastic cups with cartoon animal pictures glued onto them, one featuring Donald Duck and the other featuring Mickey Mouse, and a selection of children's stickers (e.g., shiny pictures of animals, Disney characters, etc.). Neon coloured sticky notes (3.8 × 5.1cm) were used to mark the children's heads.

Procedure.

The child was invited to play a game in which they could win some stickers. Experimenter and child sat side-by-side at a table. The experimenter told the child that she was going to record the game on video so that they could watch it back later. She turned the cameras on and returned to her seat. She then invited the child to choose a sticker that they would like to win and then asked them to cover their eyes so that they could not see what she was doing. She then hid the sticker under one of the cups. She told the child that they could uncover their eyes and then gave them a simple clue indicating which cup the sticker was under. For example, *"It's under the animal who's wearing shoes."* When the child had correctly guessed and retrieved the sticker from under the cup, the experimenter patted the child on the head in praise (sham marking). On the third round of the game, when the time came to pat the child on the head, the experimenter reached for a large brightly coloured sticky note from the back of the child's chair and surreptitiously placed it on top of their head, near the front of their hair. The child was then given a distractor task: they were asked to draw a picture of their choice. After a delay of approximately three minutes, the experimenter told the child that it was time to watch themselves "on TV". They watched the playback together on a monitor and this was filmed by the second video camera in order to record the child's reactions to the image. The video was replayed from the second round of the sticker game. The video was played back to the child and the child was encouraged to watch, and keep watching if their attention was flagging. Before the marking event, the child was asked, *"Who's that?"* (pointing to their image on the screen). If they did not give a response they were asked, *"Can you tell me who that is?"* (pointing to their image on the screen). If the child had not spontaneously removed the sticker within five seconds of seeing the marking event, they were given the prompt, *"What's that?"* (pointing to the image of the sticker on the screen). If they did not respond, the experimenter said, "*I think it's a sticker. Can you get that sticker for me?"* If the child was unable to locate the sticker after these prompts, the experimenter showed the child live video feedback of themselves on the same screen. The above prompts were once again used.

2.2.3 Scoring

2.2.3.1 Item/Self-Other Source Memory

Performance on yes-no recognition tests is typically summarised by two measures: hit rate and false alarm rate. The *hit rate* is the probability that the participant correctly identifies an old (studied) item as old. The *false alarm rate* is the probability that the participant incorrectly identifies a new (distractor) item as old. The simplest method of deriving a measure of *recognition* is to simply subtract the false alarm rate from the hit rate. However, this method only measures *discrimination* – the ability to distinguish between new and old items; it does not take into account *response bias*. Models of recognition memory based on *signal detection theory* offer estimates of both discrimination and bias, however. Signal detection theory assumes that item recognition is based on judgements of familiarity. Each studied item from a recognition test lies on a continuum of memory strength, ranging from low to high familiarity. Items are normally distributed through low to high familiarity. Distractor items are also thought to lie on this continuum but with a lower mean strength. Responses (i.e., yes/no) are based solely on the memory strength value and because the two distributions are thought to overlap, it is not possible to directly distinguish between old and new items. Thus, old items with low familiarity will be incorrectly identified as new, resulting in a miss, and new items with a high familiarity will incorrectly be identified as old, resulting in a false alarm.

The standard signal detection model uses d' as a measures of discrimination and C as a measure of bias (see Snodgrass & Corwin, 1988). However, these indices cannot tolerate hit rates or false alarm rates of 0 or 1. There are, however, alternative measures, which can be calculated under these circumstances: the nonparametric analogues A' and B''_D (see Donaldson, 1992). The higher the value of d' or A', the better the participant's ability to discriminate between old and new items. Values of C or B''_D which are greater than 0 indicate a conservative bias – that is, participants are less disposed to identifying an item is old – and values which are less than 0 indicate a liberal bias – that is, participants are more disposed to claiming that an item is old.

The current data[9] were analysed according to the nonparametric indices of discrimination and bias, A' and B''_D, which were calculated on the basis of participants' hit rates and false alarm rates. Following Grier (1971) and Donaldson (1992) respectively, A' and B''_D were calculated as follows (where H = hit rate and FA = false alarm rate):

$$A' = 1/2 + [(H - FA)(1 + H - FA)]/[4H(1 - FA)]$$

$$B''_D = [(1 - H)(1 - FA) - HFA]/[(1 - H)(1 - FA) + HFA]$$

These measures were used because the data did not meet the assumptions for d' and C. Four individuals had hit rates of 1.00 and 31 individuals had false alarm rates of 0.00 The non-parametric versions, therefore, provided more accurate estimates. *Source memory* scores were calculated using the method recommended by Bayen, Murnane, and Erdfelder (1996):

Source memory = number of correct source attributions/number of hits

Essentially, source memory was the proportion of correctly recognised items for which the source was correctly identified – a measure of a person's ability to discriminate the source of the items they correctly recognise as old. This method ensures that scores are largely independent of item recognition.

Self-other differences in item and source memory were also to be explored. Firstly, "self" and "other" hit rates were obtained by calculating separate hit rates for items that had been picked up by the child (self) or experimenter (other) at study. Two methods of calculating "self" and "other" recognition scores were used. The first method, "global corrected hit rate", involved simply subtracting a participant's overall false alarm rate from their "self" and "other" hit rates.

The second method, involved firstly calculating "self" and "other" false alarm rates. The "self"/"other" false alarm rate was the probability that a participant incorrectly identified a new item as old and claimed that they the child/the experimenter had picked up and named that item. These false alarm rates were not, therefore, independent of source judgments. To calculate self-other corrected hit rate, "self"/"other" false alarm rate was subtracted from the "self"/"other" hit rate.

Separate "self" and "other" source memory scores were also calculated in order to address the question of whether participants were better able to identify

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[9] The "current data" refers, here, to the subset of participants whose data were analysed in Chapter 3.

source information when they themselves had picked up the card or when they observed the experimenter picking up the card:

"Self" source memory = number of correct source attributions for self/number of hits for self

"Other" source memory = number of correct source attributions for other/number of hits for other

2.2.3.2 "Theory of Mind"

Sally-Anne.

Only the data from participants who passed the reality and memory control questions were considered valid. Participants who correctly predicted where Sally would search for the marble were classed as passers.

Smarties.

Participants were not required to give a correct response to the memory control question, since it appears to require the child to remember their own previous false belief, just as the false belief "self" question does. Participants were, however, required to give correct responses to the reality control questions in order for their data to be considered valid. Passing the task required the participant to predict that their teacher would say there were Pringles in the box.

See-know task.

In order for a participant's data to be considered valid, they were required to pass 5/6 control questions. Scores of ≤ 3/5 were coded as a fail and scores of ≥ 4/5 were coded as a pass.

2.2.3.3 Complement Syntax

Any mention of the final clause of the sentence (which always immediately followed the complement) resulted in a response being coded as incorrect. Thus, for the following example, any responses mentioning "playing cards" were coded as incorrect:

> "The girl said *she was reading a book*, but she was really playing cards. What did she say?"

Such responses included echoes – exact repetitions of the complement and the proceeding clause – (e.g., "She was reading a book, but she was really playing cards"), paraphrased repetitions of complement and final clause (e.g., "She read a book, but she didn't she played cards"), as well as other uses of the information contained within the final clause (e.g., "She was reading cards"). These responses were coded as incorrect because they were considered to reflect a failure to distinguish the complement from the complete sentence and selectively extract it. Bizarre or irrelevant responses were also coded as incorrect (e.g., "I was OK, I hope," "Yuk!" "I don't know").

The variable of interest was participants' ability to extract the *information* contained within the complement – that is, the semantics of the complement – from the embedding sentence. Thus, the criteria for a correct response were fairly lenient: a participant did not have to precisely repeat the complement as they heard it. The following types of response were all coded as correct:

(1) Complement + embedding verb. The complement was reproduced precisely along with the embedding verb (e.g., "She said she was reading a book")

(2) Complement in isolation (e.g., "She was reading a book")

(3) Partial complement (e.g., "Reading a book," "A book")

(4) Paraphrased complement. Responses with grammatical errors and/or word substitutions were accepted, provided the overall meaning of the complement was unaltered (e.g., "She was looking at a book," "She was reading story")

For further details of the coding scheme, including examples, see Appendix 11.

2.2.3.4 Delayed Self-Recognition

Two alternative methods of scoring mark-directed behaviour on the DSR task were used:

(1) *Dichotomous scoring* (simple passing/failing): Individuals who reached up to remove the sticker at any point during the delayed video playback were coded as "passing" the task and those who did not reach up at all were coded as "failing" the task.

(2) *Continuous scoring*: A continuous method of assessment which took into account the level of prompting was also used. Continuous DSR scores were assigned as follows:

Pass spontaneously = 3

Pass after one prompt = 2

Pass after two prompts = 1
Fail = 0

2.2.4 Selecting an Appropriate Sample

In order to effectively address the research questions under consideration, it was essential to select a sample of participants that would not show floor or ceiling effects in performance on the experimental tasks. In order to achieve this aim, it was necessary to select participants of a suitable level of ability. Amongst individuals with ASD, who may potentially have either very low or very high IQs, age is not necessarily a good indicator of ability level. Thus, it was necessary to initially screen participants with a measure of *mental* age.

At the time this work was planned, there had not been a particularly large amount of research on source memory in ASD and there had been no research whatsoever on delayed self-recognition in ASD. However, there had been a great deal of research into ToM in ASD. Since it was predicted that ToM would play a significant role in the development of episodic memory and since delayed self-recognition, like ToM, may depend on metarepresentation, it was decided to use previous research on ToM as a guide to try to select a sample which included both ToM passers and failers.

Happé (1995) conducted a meta-analysis which indicated that performance on false belief tasks was strongly related to verbal mental age (VMA), as measured with the British Picture Vocabulary Scale (BPVS; Dunn, Dunn, Whetton, & Burley, 1997), in both typically developing children and children with ASD. Specifically, she found that for typically developing children, the minimum VMA of those who passed the tests was 2 years 10 months and for children with ASD, the maximum VMA of those who failed the tests was 11 years 7 months. For the purposes of the present study, it was decided, therefore, to ascertain BPVS scores for potential participants and exclude all of those with VMAs over 11 years 7 months or under 2 years 10 months. It was considered that testing children outside of this range would be uninformative, since these children would be virtually guaranteed to perform either at ceiling or at floor across most of the tests.

In order to address the main aims of this thesis, a case-control design was selected. It was, therefore, necessary to recruit both a group of individuals with ASD and a comparison group of individuals who were of similar ages and of a similar level of intellectual ability. Since the experimental tasks were heavily language based, it was considered to be appropriate to match the experimental and comparison participants on a language measure – the BPVS served as such a measure. Although it may have proved useful to include a performance IQ measure, it was not considered essential and it was decided that in the interests of keeping the number of tests to a minimum (thereby avoiding overburdening participants and schools) such a measure, would not be included in the task battery. It was desirable to use a sample of individuals with ASD who were representative of the full range of ability levels and, consequently, it was necessary to recruit comparison participants spanning a wide range of IQs.

2.2.4.1 Participant Recruitment Strategy

For the purposes of recruitment, 145 schools were approached in writing and subsequently by telephone. Of these schools, 9 special and 3 mainstream schools agreed to help as well as 7 specialist ASD schools/units. These schools sent information sheets/consent forms (see Appendix 12) to the parents of children who had been provisionally identified as appropriate for the study. A total of 220 parents consented to their children taking part in the research. Each of the children for whom parental consent had been obtained had their Statements of Special Educational Needs reviewed before any testing was undertaken (if applicable).

2.2.4.2 Participant Selection Criteria

The ASD group consisted of individuals who had received a formal diagnosis from a qualified clinician of Autistic disorder, Asperger's disorder, or Pervasive developmental disorder not otherwise specified (PDD-NOS), according to the criteria set out in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV, American Psychiatric Association, 1994). Although DSM-IV distinguishes between these three conditions, there is little evidence that they differ qualitatively from one another, either in terms of symptomatology or cognitive profile (see Macintosh & Dissanayake, 2004, for a review). Rather, the differences lie in the severity of symptoms and cognitive deficits. On this basis, the current study did not distinguish between these disorders and an amalgamated ASD group was used. There were, however, a number of exclusion criteria for the ASD group. Potential participants were excluded if they had received diagnoses of Rett's disorder, Tuberous sclerosis, Prader-Willi syndrome, or Institutionalised autism. These are all conditions which manifest autism-like symptoms but have different and known aetiologies. Similarly, participants with ASD who had other co-morbid diagnoses, such as Attention deficit hyperactivity disorder (ADHD), were also excluded.

For the comparison group, children were selected on the basis that they were either considered to be typically developing or had global learning difficulties of unknown origin. Potential comparison participants were excluded if they had received specific psychiatric diagnoses, such as Down syndrome or ADHD, which in themselves might be associated with particular cognitive profiles. Any mention of social communication difficulties in the child's Statement of Special Educational Needs also resulted in exclusion from the comparison group, as this may have been indicative of autism-like symptoms or even undiagnosed autism. Furthermore, any teacher report of, or experimenter observed, autism-typical behaviour resulted in exclusion from the study. Given that ASD disproportionately affects males (Baird et al., 2006), it was desirable to obtain a comparison sample with a greater number of males than females. There was, therefore, positive selection in favour of males.

The second stage of participant selection involved assessing receptive language using the BPVS. Approximately 200 children were assessed using the BPVS. All those who obtained verbal age equivalents of under 2 years 10 months or over 11 years 7 months were excluded. It should be noted that this strategy resulted in a slight bias towards more able younger participants and less able older participants. Young participants with very low verbal ability were relatively likely to be excluded (if they had VMAs of less than 2 years 10 months) and older participants who had high verbal ability were also relatively likely to be excluded (if they had VMAs of more than 11 years 7 months). Thus, the correlation between CA and VMA is reported alongside sample characteristics throughout the thesis.

2.2.4.3 Characteristics of Final Sample

The total ASD sample consisted of 93 children/adolescents who had been diagnosed with Autistic disorder (63), Asperger's disorder (12), or PDD-NOS (18). The total comparison sample consisted of 69 children/adolescents, who ranged from typically developing to severely learning disabled. Participant characteristics for the total ASD and comparison groups are displayed in Table 2.2. The groups did not differ significantly in terms of VMA, $t(160) = 0.94$, $p = .35$, $r = .07$, but they did differ significantly in terms of CA, $t(111.97) = 3.00$, $p < .01$, $r = .66$, and VIQ, $t(123.17) = -3.72$, $p < .01$, $r = .32$. The percentage of males was 81.7% and 60.9% for the ASD and comparison groups respectively.

Table 2.2

Participant Characteristics for Total ASD and Comparison Samples

	ASD	Comparison
n	93 (17 female)	69 (27 female)
VMA		
M	6.21	5.90
SD	2.13	2.05
Range	2.83 – 11.33	2.83 – 10.83
CA		
M	9.99	8.19
SD	3.08	4.57
Range	5.00 – 17.08	3.17 – 16.17
Verbal IQ		
M	73.32	85.46
SD	18.06	23.50
Range	39 – 117	39 – 125

2.3 ISSUES WITH DATA COLLECTION

Despite the fact that a large number of participants were successfully recruited and tested, there were a number of problems with data collection which meant that the original plan to conduct a large multiple regression needed to be re-thought. The difficulties encountered in relation to each of the experimental tasks, which resulted in missing data, are summarised below. This is followed by a section outlining the implications of these problems and how these issues were resolved.

2.3.1 Summary of Missing Data

2.3.1.1 Item/Self-Other Source Memory Task

Nine children with ASD and 5 comparison children were unable to complete the item/source memory task, either due to lack of understanding or unwillingness to cooperate. Also, some of the data could not be used due to perseverative responses, which indicated an inability to perform the task. Responses were considered to be perseverative if a participant gave the same answer for more than 90% of the questions on either item or source memory. For example, answering, "yes," to every item on the recognition list. The numbers of participants who perseverated on each component of the item/source memory task are detailed in Table 2.3.

Table 2.3

Number of Participants Who Showed Perseveration in each of the Item/Self-Other Source Memory Task Components

	Number of participants who perseverated	
Task component	ASD	Comparison
Item memory ONLY	14	3
Source memory ONLY	4	3
Item AND source memory	5	0
Total	23	6

2.3.1.2 Location Change (Sally-Anne) False Belief Task

Seven children with ASD and 6 comparison children were unable to complete the Sally-Anne task, either due to lack of understanding or unwillingness to cooperate. Twenty-one participants with ASD and 7 comparison participants failed at least one control question. Details of how many participants from each group failed each of the control questions are displayed in Table 2.4.

Table 2.4

Number of Participants From Each Group Failing the Control Questions on the Sally-Anne Task

	Number of participants who failed	
Question	ASD	Comparison
Doll and colour naming control questions	0	0
Reality AND memory control questions	3	1
Reality control question ONLY	6	0
Memory control question ONLY	12	6
Total	21	7

2.3.1.3 Unexpected Contents (Smarties) False Belief Task

Eight children with ASD and 9 comparison children were unable to complete the Smarties task, either due to lack of understanding or unwillingness to cooperate. Forty-one children with ASD and 19 comparison children failed at least one control question. Details of how many participants from each group failed each of the Smarties control questions are displayed in Table 2.5. If participants had been required to pass all of these control questions in order to be included in subsequent analyses, as required for some previous studies (e.g., Hogrefe et al., 1986), then only 44/93 participants with ASD and 41/69 comparison children would have remained. It was decided that only those participants who failed the reality control questions would be eliminated, on the basis that the memory control question seemingly measures the same ability as the "self" false belief question. This probably explains the high rate of failure for this question.

Table 2.5

Number of Participants From Each Group Failing the Control Questions on the Smarties Task

	Number of participants who failed	
Question	ASD	Comparison
Reality control question	4	1
Second reality control question	3	1
Memory control question	34	17
Total	41	19

2.3.1.4 See-Know Task

Ten children with ASD and 7 comparison children were unable to complete the see-know task, either due to lack of understanding or unwillingness to cooperate. In order for a participant's test question scores to be considered valid, that participant was required to score at least 5/6 on the control questions. Twenty-three children with ASD and 10 comparison children failed more than one control question. The performance of the two groups on the control questions is summarised in Table 2.6.

Table 2.6

ASD and Comparison Group Performance on the See-Know Control Questions

Number of control questions failed	Number of participants	
	ASD	Comparison
0	44	35
1	16	17
2	12	5
3	5	5
4	3	0
5	2	0
6	1	0
Total number failing > 1	23	10

2.3.1.5 Complement Syntax Task

Seventeen children with ASD and 9 comparison children were unable to complete the complement syntax task, either due to lack of understanding, unwillingness to cooperate, or experimenter error.

2.3.1.6 Delayed Self-Recognition Task

Data collection for the delayed self-recognition task was subject to a range of different difficulties. For example: a number of children fortuitously discovered the sticker on their head before watching the video; a number of participants, particularly adolescents, did not wish to be filmed; and two schools could not provide an appropriate work space that had a power supply for the equipment. Details of the number of participants with missing data due to these, and some additional reasons, are displayed in Table 2.7.

Table 2.7

Details of Missing Data for the Delayed Self-Recognition Task

	Number of participants	
Reason for Missing Data	ASD	Comparison
Fortuitously noticed sticker	11	5
Unwilling to be filmed	7	10
Equipment failure	3	1
School lacked appropriate work space	7	13
Participant was absent from school	1	0
Experimenter error	1	0
Total	19	24

2.3.2 Implications and Matching Strategy

Given the fairly substantial amount of missing data, the strategy for data analysis needed to be modified. The approach taken was in fact much more in keeping with the majority of psychological ASD research, although sample sizes were substantially larger than is usually the case. For each experimental question/set of analyses, ASD and comparison participants were individually matched (unless otherwise stated) on the basis of verbal mental age, as measured with the BPVS, to within 12 months, and chronological age, to within 24 months. In most cases, however, matches were far closer than this. For each study, participants who did not have valid data for the particular measures under consideration were eliminated from the data set. Matched pairs of ASD and comparison participants were then selected from within that reduced data set. This strategy meant that the maximum possible number of matched pairs could be used within each different set of analyses. It should be highlighted that those individuals, for whom it was not possible to find an adequate match for a given experiment, were excluded from the analyses. Thus, the number of participants analysed within each experiment was not equivalent to the number of individuals with valid data for that experiment. Appendix 17 provides a summary of the tasks for which each individual participant had valid data as well as which experiments they were included in.

Each of the subsequent chapters reports group characteristics in terms of CA, VMA and verbal IQ. For each sub-sample of participants used, *t*-tests were performed and effect sizes (*r*) were calculated in order to evaluate matching. Groups were considered to be adequately matched if differences were not significant and effect sizes were negligible to small[10].

2.4 PREVIEW OF THE FOLLOWING CHAPTERS

As previously explained, all the data reported in this thesis were obtained from a single battery of tests, which was administered to all participants, constituting essentially one large experiment. However, the data are presented as a series of discrete "experiments", aimed at addressing specific research questions. Each "experiment" includes a set of analyses conducted on the data from a sub-sample of participants who were selected as described in the previous section. Thus, although these discrete sets of analyses were not technically separate experiments, for clarity, they will be referred to as such.

The empirical work is presented in Chapters 3 to 8. Chapter 3 considers the results from the item/source memory task. Group differences in item and source memory were explored with the main aim of confirming previous findings of a selective impairment in episodic memory. Differences in memory for self- and other-performed actions were also considered in order to address the question of whether memory for self was more impaired than memory for other. Chapter 4 presents the results from the delayed self-recognition task with the main aim of establishing whether or not temporally extended self-awareness in impaired in ASD. Chapter 5 presents the data from the three ToM tasks, again considering group performance differences. Chapter 6 considers the relationship between language and false belief task performance. The question of whether complement syntax understanding facilitates false belief task performance in ASD is addressed here. Chapter 7 explores

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[10] The effect size *r* will be used throughout this thesis (where appropriate), as recommended by Field (2005). For *t*-tests, *r* is calculated as follows: $r = \sqrt{[t^2 / (t^2 + df)]}$; and for ANOVAs, it is calculated as follows: $\sqrt{[F / (F + df \text{ residual})]}$. Effect sizes of $< .1$, .1, .3, and $\geq .5$ are considered to be negligible, small, medium, and large respectively.

the relationship between delayed self-recognition and source memory in order to establish whether impairments in temporally extended self-awareness contribute to diminished episodic memory in ASD. Chapter 8 goes on to explore the relationship between the performance on the three ToM tasks and source memory with the aim of testing the hypothesis that difficulties with metarepresentation and/or understanding of causal self-referentiality contribute to the episodic memory difficulties experienced by individuals with ASD. Finally, Chapter 9 offers a summary and discussion of this empirical work.

CHAPTER 3: Assessing Episodic and Semantic Memory in ASD

3.1 INTRODUCTION

The experiment reported in this chapter aimed to assess episodic and semantic memory functioning using an item/self-other source memory task. As explained in Chapter 1, source memory is considered to be a function of the episodic memory system (Johnson et al., 1993; Perfect et al., 1996; Wheeler et al., 1997), showing developmental improvements between the ages of 3 and 8 years (Roberts, 2002). Studies have shown that in typical development, children over the age of 6 years perform at adult levels on self-other (internal-external) source monitoring tasks (Foley et al., 1983; Foley & Johnson, 1985). The majority of the evidence suggests that individuals with ASD are impaired in their ability to distinguish between both internal sources and external sources (see Table 1.1). The evidence regarding their ability to make self-other source judgments is somewhat more equivocal, however. All of the studies of self-other source monitoring in ASD have involved relatively small samples (n = 13 to 22), which may have made group differences difficult to detect. The current study aimed to use a larger sample in order to obtain more definitive evidence. A *self-other* task was also selected in light of speculations that ASD might involve a particular problem with *personal* episodic memory (Powell & Jordan, 1993) or memory for experiences directly involving the *self* (Hare et al., 2007).

Hypotheses and Predictions

The experimental task assessed both item and self-other source memory. The study phase of the task involved the experimenter and child playing a picture card naming game and the test phase involved a yes-no recognition component and a self-other source attribution component. Although these two aspects of the task cannot be said to rely solely on particular memory systems, it was assumed that item memory invokes the semantic system to a greater extent than the episodic system and source memory invokes the episodic system to a greater extent than the semantic system. Given the hypothesis that episodic memory is impaired in ASD, it was predicted that the ASD group would perform significantly less well on source memory than participants in the comparison group.

Boucher et al. (in press) have suggested that low-functioning autism entails a global impairment in explicit memory, both episodic and semantic. Indeed, studies have indicated impairments in recognition memory in this population (Ameli et al., 1988; Barth et al., 1995; Boucher & Warrington, 1976). It was therefore predicted that, within high-functioning individuals, the ASD and comparison groups would show equivalent levels of performance on item memory, but, within low-functioning individuals, the ASD group would be significantly impaired.

In terms of memory for self versus other, there are theoretically based reasons for predicting a reduced self-reference/enactment effect in ASD. If individuals with ASD have insufficiently elaborated self-concepts (as indicated by the research reviewed in Chapter 1, section 1.5.3.1), the self may serve as a less effective organising structure for memory and these individuals may, therefore, be less able to encode memories in relation to the self, thereby eliminating or reducing the usual self-advantage. Alternatively, if they are impaired in their ability to monitor their own actions (Russell, 1995) and hence fail to encode motoric information, self-performed actions will be no more salient than other-performed actions. On this basis, it could be predicted that the ASD group would show a generally reduced self-advantage in their memory performance. However, previous *empirical* work suggests that this pattern should be observed in source but not item memory. It has been found that children with ASD do not show the enactment effect in source memory (Russell & Jarrold, 1999) or free recall but do show it in cued recall (Hare et al., 2007; Millward et al., 2000) and recognition (Farrant et al., 1998).

Previous studies have demonstrated the enactment effect in recognition memory among 6- but not 4-year-olds, with 4-year-olds showing equivalent recognition for self- and other-performed actions (Roberts & Blades, 1998; but see Foley et al., 1983). In terms of source memory, Roberts and Blades (1998) found that typically developing 4-year-olds showed significantly poorer source memory for actions performed by themselves than for actions performed by another, with 6- and 9-year-olds showing the opposite pattern. It was therefore predicted that the comparison group would show this developmental pattern, whilst the ASD group would not. That is, only comparison children with mental ages over the age of 6 years would show a significant self-advantage and this would apply to both item and source memory.

There is one final relevant issue concerning self-other source memory tasks. That is, in terms of item memory, participants – both adults (Johnson et al., 1993) and children aged 6 and 9 (Foley et al., 1983) – show a bias in source attribution for false alarms. Thus, it is found that when participants mistakenly identify a new item as old, they show a bias towards claiming the other rather than the self was the source. It was predicted that whereas comparison participants would show this pattern, participants with ASD would not.

3.2 METHOD

3.2.1 Participants

The ASD and comparison groups each consisted of 36 participants who were individually matched on VMA and CA. The groups did not differ significantly in terms of VMA, $t(70) = 0.16$, $p = .88$, $r = .02$; CA, $t(70) = 0.29$, $p = .78$, $r = .03$; or VIQ, $t(70) = -0.57$, $p = .57$, $r = .07$. Although participants were not explicitly matched on sex, the percentage of males was similar for both groups: 80.6% for the ASD group and 75.9% for the comparison group. See Table 3.1 for participant characteristics. CA and VMA were significantly positively correlated within both the ASD ($r = .61$, $p < .01$) and comparison ($r = .68$, $p < .01$) groups.

Table 3.1

Participant Characteristics

	ASD	Comparison
N	36 (7 female)	36 (9 female)
VMA		
M	6.76	6.68
SD	2.08	2.02
Range	2.92 – 11.25	3.25 – 10.83
CA		
M	10.25	10.00
SD	3.35	4.01
Range	5.00 – 16.75	4.33 – 15.67
Verbal IQ		
M	75.39	77.94
SD	17.07	20.65
Range	39 – 102	40 – 116

3.2.2 Procedure

Data from the item/source memory task are considered here. Full details of the procedure can be found in Chapter 2, section 2.2.2.1. In brief, the study phase involved experimenter and participant taking turns to pick up and name picture cards and the test phase, which occurred after a two minute delay, involved a yes-no recognition component and a self-other source judgment component.

3.2.3 Scoring

Complete details of the scoring methods are outlined in Chapter 2, section 2.2.3.1. The main measures which are considered here are:

(a) *Hit Rate*: The probability that the participant correctly identifies a studied item as old.

(b) *False Alarm Rate*: The probability that the participant incorrectly identifies a distractor item as old.

(c) *Recognition:* The hit rate corrected for false alarms.

(d) A': An estimate of participants' ability to discriminate between old and new items.

(e) B''_D: An estimate of response bias.

(f) *Source Memory*: The proportion of correctly recognised items for which the source was correctly identified.

(g) *"Self"/"Other" Hit Rate*: The hit rate for items that had been picked up by the child (self)/experimenter (other) at study.

(h) *Global Corrected Hit Rate*: The overall false alarm rate subtracted from "self" and "other" hit rates.

(i) *"Self"/"Other" False Alarm Rate*: The probability that a participant incorrectly identifies a new item as old and claimed that they the child/the experimenter had picked up and named that item.

(j) *Self-Other Corrected Hit Rate*: "Self"/"other" false alarm rate was subtracted from the "self"/"other" hit rate.

(h) *"Self"/"Other" Source Memory*: Proportion of correct source attributions for cards picked up by child/experimenter.

3.3 RESULTS

3.3.1 Differences in Item and Source Memory

First of all, overall differences in item and source memory between the ASD and comparison group were assessed. This was followed by an exploration of differences between high- and low-functioning individuals.

3.3.1.1 Overall Group Differences

The group means for each of the item and source memory measures are displayed in Table 3.2 and Figure 3.1. The comparison group achieved higher scores across all of the measures apart from false alarm rate, which was higher for the ASD group. Group differences in the item and source memory measures were analysed using independent *t*-tests. These indicated that there were no significant differences in hit rate, $t(70) = -0.24$, $p = .81$, $r = .03$; false alarm rate, $t(70) = 0.64$, $p = .52$, $r = .08$; recognition, $t(70) = -0.74$, $p = .46$, $r = .09$; A', $t(65.21) = -0.97$, $p = .34$, $r = .12$; or B''_D, $t(70) = -0.74$, $p = .46$, $r = .09$. Both groups showed a conservative response bias. However, the group difference in source memory was significant, $t(70) = -1.74$, p (one-tailed) $= .04$, $r = .20$, with the ASD group obtaining significantly lower scores than the comparison group.

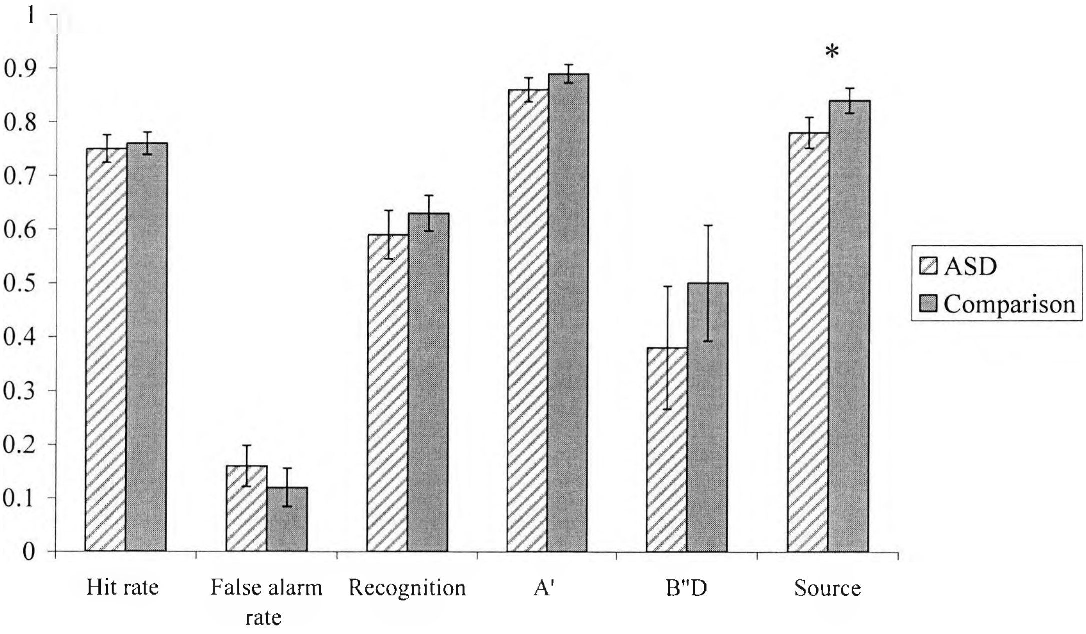
Table 3.2

Mean (SD) Hit Rate, False Alarm Rate, Recognition Memory, A', B''_D, and Source Memory for the ASD and Comparison Groups

	Group	
Memory measure	ASD	Comparison
Hit rate	.75 (.15)	.76 (.12)
False alarm rate	.16 (.23)	.12 (.22)
Recognition	.59 (.27)	.63 (.20)
A' (discrimination)	.86 (.13)	.89 (.10)
B''_D (bias)	.38 (.68)	.50 (.65)
Source	.78 (.17)	.84 (.14)

Figure 3.1

Mean Hit Rate, False Alarm Rate, Recognition Memory, A', B''D, and Source Memory for the ASD and Comparison Groups



* p (one-tailed) < .05

3.3.1.2 Differences Between High- and Low-Functioning Individuals

In order to assess possible differences in performance between high- and low-functioning individuals with ASD, those with VIQs < 70 were defined as *low-functioning* (scores under 70 are described in the BPVS manual as "extremely low scores") and those with VIQs ≥ 70 were defined as *high-functioning*. Each individual's matched comparison individual was assigned the same "level of functioning" as their ASD counterpart. Thus, each participant fell into one of four possible categories: low-functioning ASD (LFA), low-functioning comparison (LFC), high-functioning ASD (HFA), or high-functioning comparison (HFC)[11]. When the groups were divided up in this manner, it was found that the low-functioning sub-groups were substantially older (approximately 3 years older) than the high-functioning sub-groups. This pattern is likely to be due to the sample selection criteria, explained in section 2.2.4.1. In general, older participants needed to be

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[11] This meant that 3 of the comparison participants in the HFC group had VIQs < 70 (60, 67, 69) and 2 of the comparison participants in the LFC group had VIQs > 70 (72, 84).

somewhat less able in order to be included in the sample and younger participants needed to be somewhat more able.

T-tests revealed that the groups were adequately matched. The HFA and HFC groups did not differ significantly in terms of VMA, $t(48) = 0.30, p = .77, r = .04$; CA, $t(43.34) = .35, p = .73, r = .05$; or VIQ, $t(36.74) = -0.81, p = .42, r = .13$. The LFA and LFC groups did not differ significantly in terms of VMA, $t(20) = -0.17, p = .87, r = .04$; CA, $t(20) = 0.05, p = .96, r = .01$; or VIQ, $t(20) = -0.40, p = .70, r = .09$. Participant characteristics are displayed in Table 3.3.

Table 3.3

Participant Characteristics for Low and High Functioning Sub-Groups

	Group			
	LFA	LFC	HFA	HFC
N	11 (2 female)	11 (3 female)	25 (5 female)	25 (6 female)
VMA				
M	5.68	5.82	7.23	7.06
SD	1.87	1.91	2.02	1.99
Range	2.92 – 8.58	3.25 – 9.00	4.00 – 11.25	3.83 – 10.83
CA				
M	12.29	12.21	9.35	9.01
SD	3.64	3.64	2.73	3.84
Range	5.83 – 16.75	4.92 – 15.67	5.00 – 14.67	4.33 – 14.83
Verbal IQ				
M	53.82	55.91	84.88	87.64
SD	11.24	13.41	8.07	15.04
Range	39 – 68	40 – 84	70 – 102	60 – 116

A series of two-way (Group × Level of Functioning) ANOVAs were conducted in order to explore potential interaction effects between Group and Level of Functioning (LoF) on participants' performance on the item and source memory measures. Group means are displayed in Table 3.4 and Figures 3.2 and 3.3.

When hit rate was the dependant variable, the main effect of Group was not significant, $F(1,68) = 0.49, p = .49, r = .08$, the main effect of LoF was not significant, $F(1,68) = 2.57, p = .11, r = .19$, and the Group by LoF interaction was not significant, $F(1,68) = 1.51, p = .22, r = .15$.

When false alarm rate was the dependent variable, the main effect of Group was not significant, $F(1,68) = 1.08, p = .30, r = .13$, the main effect of LoF was not significant, $F(1,68) = 1.73, p = .19, r = .16$, and the Group by LoF interaction was not significant, $F(1,68) = 1.30, p = .26, r = .14$.

When recognition was the dependent variable, the main effect of Group was not significant, $F(1,68) = 2.04, p = .16, r = .17$, the main effect of LoF was significant, $F(1,68) = 5.00, p = .03, r = .26$, and the Group by LoF interaction approached significance, $F(1,68) = 3.39, p = .07, r = .22$.

When A' was the dependent variable, the main effect of Group was not significant, $F(1,68) = 2.88, p = .09, r = .20$, the main effect of LoF was significant, $F(1,68) = 4.31, p = .04, r = .24$, and the Group by LoF interaction was significant, $F(1,68) = 3.91, p = .05, r = .23$.

When B''_D was the dependent variable, the main effect of Group was not significant, $F(1,68) = 0.63, p = .43, r = .10$, the main effect of LoF was not significant, $F(1,68) = 0.16, p = .69, r = .05$, and the Group by LoF interaction was not significant, $F(1,68) = 0.09, p = .76, r = .04$.

When source memory was the dependent variable, the main effect of Group was not significant, $F(1,68) = 2.58, p = .11, r = .19$, the main effect of LoF was not significant, $F(1,68) = 1.22, p = .27, r = .13$, and the Group by LoF interaction was not significant, $F(1,68) < 0.01, p = .97, r < .01$.

Given that the ANOVA for A' revealed a significant Group by LoF interaction, independent *t*-tests were used to compare the LFA and LFC, and HFA and HFC groups. The LFA and LFC groups differed significantly on A', $t(14.67) = -1.75$, p (one-tailed) $= .05$, $r = .42$: the ASD group scored significantly lower than the comparison group. The HFA and HFC group did not differ significantly in terms of A', $t(48) = 0.29, p = .77, r = .04$. Inspection of the means (displayed in Table 3.4) indicates that the HFC, LFC and HFA groups were performing at very similar levels but the LFA group was performing substantially less well.

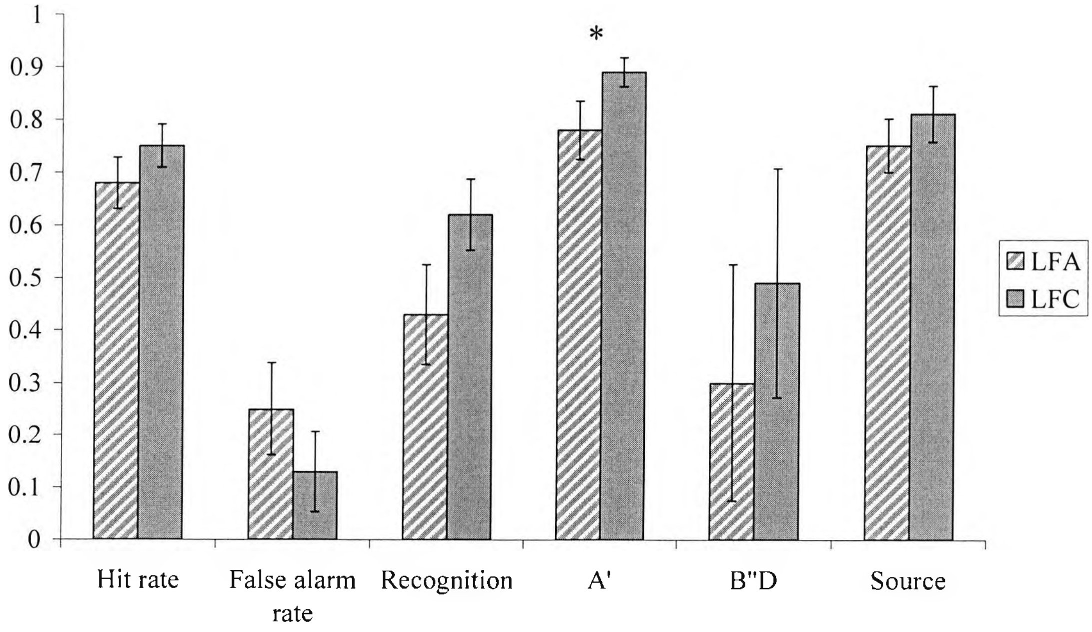
Table 3.4

Mean (SD) Hit Rate, False Alarm Rate, Recognition Memory, A', B''_D, and Source Memory for the LFA, LFC, HFA, and HFC Groups

	Group			
Memory measure	LFA	LFC	HFA	HFC
Hit rate	.68 (.16)	.75 (.14)	.78 (.14)	.76 (.12)
False alarm rate	.25 (.29)	.13 (.25)	.11 (.19)	.12 (.20)
Recognition	.43 (.31)	.62 (.22)	.66 (.22)	.64 (.19)
A' (discrimination)	.78 (.18)	.89 (.09)	.90 (.09)	.89 (.10)
B''_D (bias)	.30 (.75)	.49 (.72)	.42 (.66)	.51 (.63)
Source	.75 (.17)	.81 (.17)	.79 (.17)	.86 (.13)

Figure 3.2

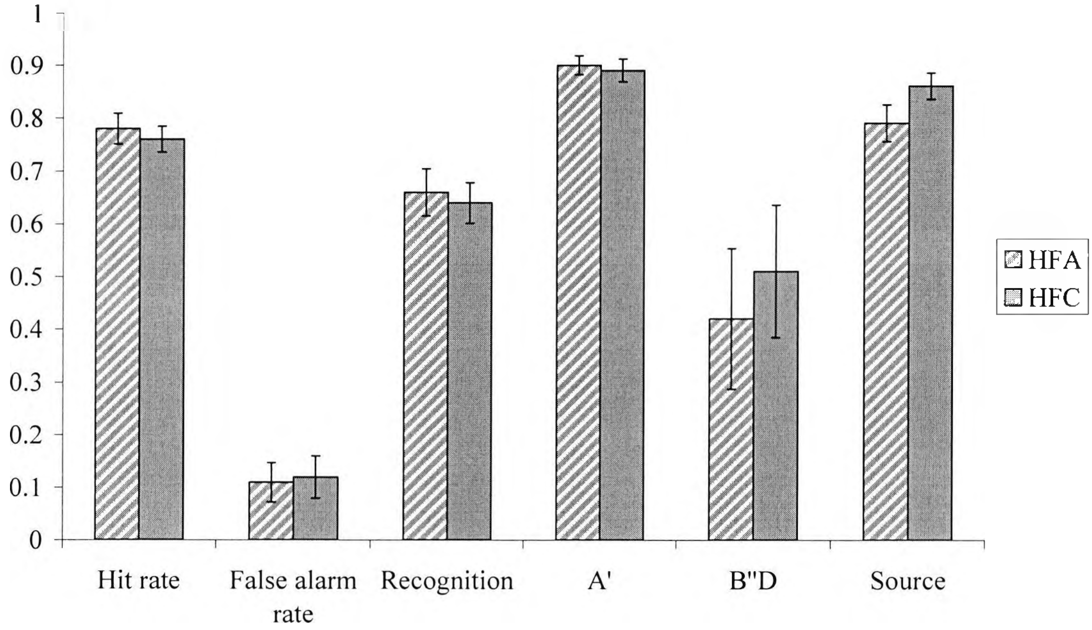
Mean Hit Rate, False Alarm Rate, Recognition Memory, A', B''_D, and Source Memory for the LFA and LFC Groups



*p (one-tailed) = .05

Figure 3.3

Mean Hit Rate, False Alarm Rate, Recognition Memory, A', B''$_D$ and Source Memory for the HFA and HFC Groups



3.3.2 Differences in "Self" and "Other" Item and Source Memory

Next, differences in "self" and "other" item and source memory were analysed. As before, overall group differences were considered first, followed by differences between low- and high-functioning individuals. Finally, the role of VMA was considered in relation to memory for self and other.

3.3.2.1 Overall Group Differences

Figure 3.4 displays group means for "self" and "other" hit rate, false alarm rate, global corrected hit rate, self-other corrected hit rate, and source memory (also see Appendix 13 for a table containing full details). A series of five two-way (Group × Self-Other) mixed ANOVAs, with Group as the between-participants variable and Self-Other as the within-participants variable, were conducted to assess differences in hit rate, false alarm rate, global corrected hit rate, self-other corrected hit rate, and source memory.

When *hit rate* was the dependent variable, the main effect of Group, $F(1,70) = 0.06$, $p = .81$, $r = .03$, was not significant; the main effect of Self-Other, $F(1,70) =$

77.29, *p* < .01, *r* = .72, was significant; and the Group by Self-Other interaction, *F*(1,70) = 0.11, *p* = .74, *r* = .04, was not significant. Thus, the overall "self" hit rate (*M* = .86, *SD* = .13) was significantly higher than the "other" hit rate (*M* = .65, *SD* = .20).

When *false alarm rate* was the dependent variable, neither the main effect of Group, *F*(1, 70) = 0.41, *p* = .52, *r* = .08; the main effect of Self-Other, *F*(1,70) = 0.59, *p* = .45, *r* = .09; nor the Group by Self-Other interaction, *F*(1,70) = 0.01, *p* = .95, *r* = .01, was significant.

When *global corrected hit rate* was the dependent variable, the main effect of Group, *F*(1,70) = 0.55, *p* = .46, *r* = .09, was not significant; the main effect of Self-Other, *F*(1,70) = 77.29, *p* < .01, *r* = .72, was significant; and the Group by Self-Other interaction, *F*(1,70) = 0.11, *p* = .74, *r* = .04, was not significant. Thus, the overall "self" global corrected hit rate (*M* = .72, *SD* = .26) was significantly higher than the "other" global corrected hit rate (*M* = .51, *SD* = .25).

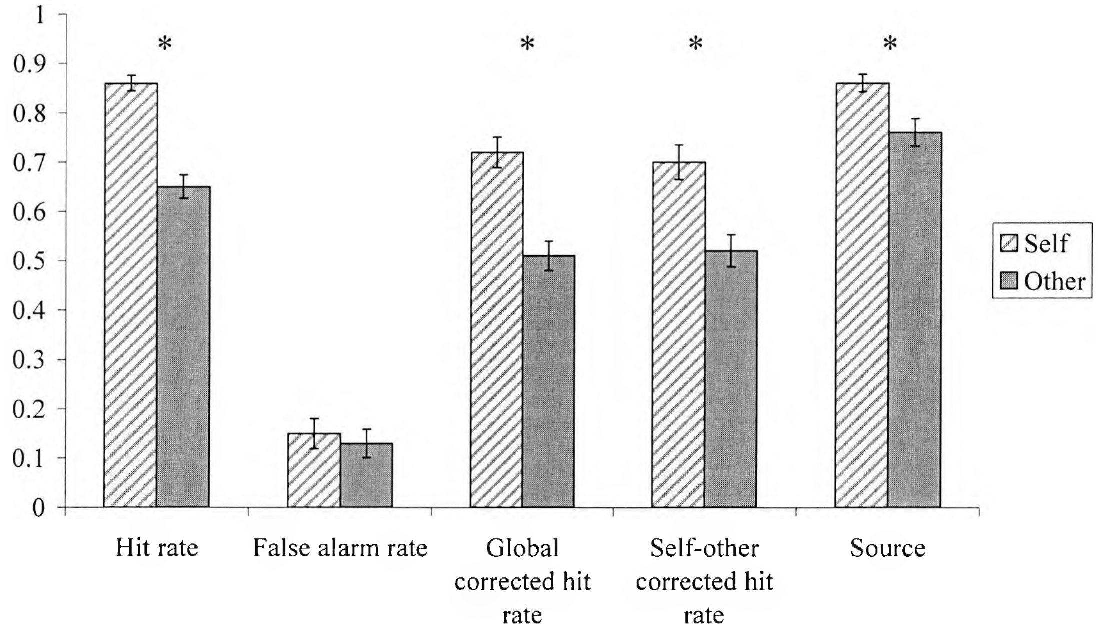
When *self-other corrected hit rate* was the dependent variable, the main effect of Group, *F*(1,70) = 0.55, *p* = .46, *r* = .09, was not significant; the main effect of Self-Other, *F*(1,70) = 23.49, *p* < .01, *r* = .50, was significant; and the Group by Self-Other interaction, *F*(1,70) = 0.07, *p* = .80, *r* = .03, was not significant. Thus, the overall "self" self-other corrected hit rate (*M* = .70, *SD* = .30) was significantly higher than the "other" self-other corrected hit rate (*M* = .52, *SD* = .28).

When *source memory* was the dependent variable, the main effect of Group, *F*(1,70) = 3.01, *p* = .09, *r* = .20, was not significant; the main effect of Self-Other, *F*(1,70) = 11.60, *p* < .01, *r* = .38, was significant; and the Group by Self-Other interaction, *F*(1,70) = 0.01, *p* = .92, *r* = .01, was not significant. Thus, the overall "self" source memory score (*M* = .86, *SD* = .15) was significantly higher than the "other" source memory score (*M* = .76, *SD* = .24).

Thus, regardless of group, there was a significant self-advantage in hit rate, global corrected hit rate, self-other corrected hit rate, and source memory.

Figure 3.4

Means Scores for "Self" and "Other" Hit Rate, False Alarm Rate, Global Corrected Hit Rate, Self-Other Corrected Hit Rate and Source Memory for the Combined Groups



*$p < .01$

Figures 3.5 and 3.6 also illustrate the self-advantage in global corrected hit rate and source memory. Figure 3.5 indicates the clear positive relationship between "self" and "other" global corrected hit rate, r (72) = .71, $p < .01$. The correlation between "self" and "other" source memory was not as strong, r (72) = .33, p = .33. This provides some validation for the assumption that item and source memory each rely upon different memory systems: If both tasks relied on semantic memory, for instance, then one would expect to observe correlations between self and other of similar degrees of magnitude. Figure 3.6 also indicates a tendency towards ceiling effects, with a fairly large number of participants obtaining scores of 1.00 on either "self" or "other" source memory.

Figure 3.5

Scatterplot of "Self" Global Corrected Hit Rate Against "Other" Global Corrected Hit Rate According to Group

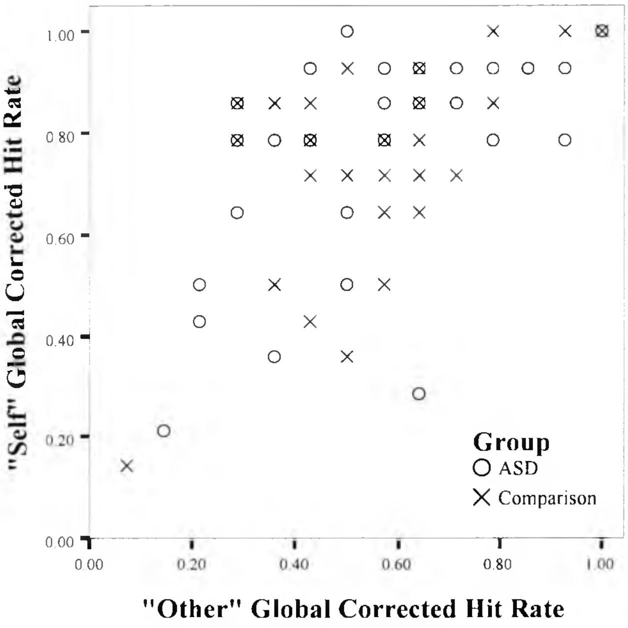
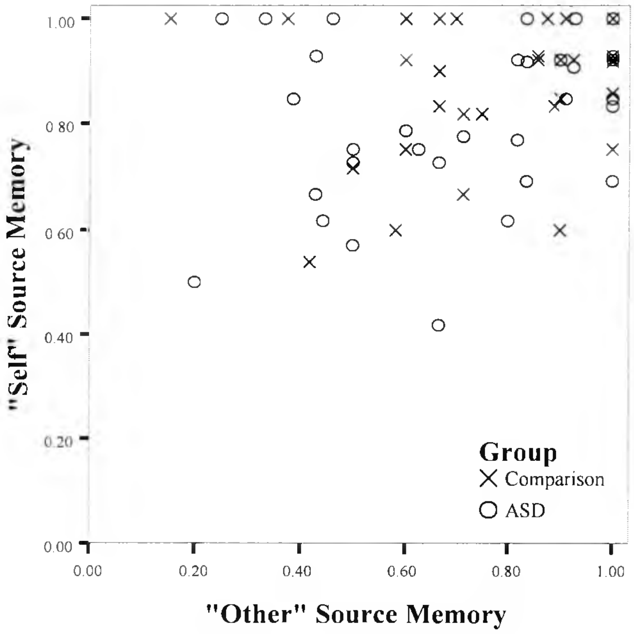


Figure 3.6

Scatterplot of "Self" Source Memory Against "Other" Source Memory According to Group



The possibility that the observed self-advantage in source memory was a consequence of a self-bias or "I did it" bias (the tendency to attribute others' actions to oneself; Sommerville & Hammond, 2007) was considered next. The mean total numbers of "self" and "other" responses (regardless of whether they were correct or incorrect) for each group are displayed in Table 3.5. A two-way (Group × Self-Other) mixed ANOVA was conducted, with group as the between-participants variable and Self-Other as the within-participants variable, in order to consider whether participants were showing such a self-bias. The main effect of Group was not significant, $F(1,70) = 0.30$, $p = .56$, $r = .07$, the main effect of Self-Other was significant, $F(1,70) = 54.58$, $p < .01$, $r = .66$, and the Group by Self-Other interaction was not significant, $F(1,70) = 0.01$, $p = .93$, $r = .01$. Thus, regardless of group, participants, indeed, showed a bias towards claiming it was they themselves, as opposed to the experimenter, who had picked up and named the cards.

Table 3.5

Mean (SD) Number of Self and Other Responses for the ASD, Comparison and Total Groups

Total number of responses	**ASD**	**Comparison**	**Total**
"Self"	11.17(2.85)	11.56 (2.77)	11.36 (2.80)
"Other" responses	7.81 (3.99)	8.11 (3.59)	7.96 (3.77)

Alternative "self" and "other" source memory scores ("Response bias corrected source scores") were created by (a) dividing the number of correct "self" source judgments by the total number of "self" responses and (b) dividing the number of correct "other" source judgments by the total number of "other" responses. The aim of this was to assess whether or not the established "self" advantage in source memory was in fact due to this apparent response bias. Table 3.6 displays the mean "Self" and "Other" response bias corrected source scores for the ASD, comparison and total groups.

A two-way mixed ANOVA was conducted with Group as the between-participants variable, Self-Other as the within-participants variable and Response bias corrected source score as the dependent variable. The main effect of Group was not significant, F(1,70) = 2.15, p = .15, r = .17, the main effect of Self-Other was not significant, F(1,70) = 1.04, p = .31, r = .12, and the Group by Self-Other interaction was not significant, F(1,70) = 0.60, p = .44, r = .09.

Table 3.6

Mean (SD) "Self" and "Other" Response Bias Corrected Source Scores for the ASD, Comparison and Total Groups

	ASD	**Comparison**	**Total**
"Self"	.90 (.15)	.94 (.12)	.92 (.14)
"Other"	.87 (.17)	.93 (.14)	.90 (.16)

3.3.2.2 Differences Between High- and Low-Functioning Individuals

Low- and high-functioning individuals were defined as above in section 3.3.1.2. Appendix 13 displays the LFA, LFC, HFA, and HFC group means and standard deviations for "self" and "other" hit rate, false alarm rate, global corrected hit rate, self-other corrected hit rate, and source memory scores. In order to assess group, level of functioning and self-other differences in hit rate, false alarm rate, global corrected hit rate, self-other corrected hit rate, and source memory, a series of three-way mixed ANOVAs (Group × LoF × Self-Other) were conduced, with Group and LoF as the between-participants variables and Self-Other as the within-participants variable. The statistics are reported in Table 3.5. These analyses revealed that the majority of the effects were non-significant. However, the main effect of Self-Other was significant when hit rate, global corrected hit rate, self-other corrected hit rate and source memory were the dependent variables. In each case, this reflected a "self" advantage. Also, the main effect of level of functioning was significant when global corrected hit rate and self-other corrected hit rate were the dependent variables. None of the other main effects or interaction effects was significant in any of the analyses.

Table 3.7

ANOVA Statistics for Hit Rate, False Alarm Rate, Global Corrected Hit Rate, Self-Other Corrected Hit Rate, and Source Memory Scores

Dependent variable	**Factor**	***F***	***df***	***p***	***r***
Hit rate	Group	0.43	1,68	.49	.08
	LoF	2.57	1,68	.11	.19
	Self-Other	73.92	1,68	<.01	.72
	Group × LoF	1.51	1,68	.22	.15
	Group × Self-Other	0.83	1,68	.37	.11
	LoF × Self-Other	1.13	1,68	.29	.13
	Group × LoF × Self-Other	2.37	1,68	.13	.18
Global corrected hit rate	Group	2.04	1,68	.16	.17
	LoF	5.00	1,68	.03	.26
	Self-Other	73.92	1,68	<.01	.72
	Group × LoF	3.39	1,68	.07	.22
	Group × Self-Other	0.83	1,68	.37	.11
	LoF × Self-Other	1.23	1,68	.29	.13
	Group × LoF × Self-Other	2.36	1,68	.13	.18
False alarm rate	Group	1.08	1,68	.30	.13
	LoF	1.73	1,68	.19	.16
	Self-Other	0.19	1,68	.66	.05
	Group × LoF	1.30	1,68	.26	.14
	Group × Self-Other	<0.01	1,68	.92	.01
	LoF × Self-Other	0.43	1,68	.52	.08
	Group × LoF × Self-Other	<0.01	1,68	.92	.01

Continued over page…

Table 3.7 (continued)

ANOVA Statistics for Hit Rate, False Alarm Rate, Global Corrected Hit Rate, Self-Other Corrected Hit Rate, and Source Memory Scores

Dependent variable	**Factor**	***F***	***df***	***p***	***r***
Self-other corrected hit rate	Group	2.04	1,68	.16	.17
	LoF	5.00	1,68	.03	.26
	Self-Other	24.21	1,68	<.01	.51
	Group × LoF	3.39	1,68	.07	.22
	Group × Self-Other	0.41	1,68	.53	.08
	LoF × Self-Other	1.31	1,68	.23	.14
	Group × LoF × Self-Other	1.04	1,68	.31	.12
Source memory	Group	2.49	1,68	.12	.19
	LoF	1.16	1,68	.28	.13
	Self-Other	9.45	1,68	<.01	.35
	Group × LoF	<0.01	1,68	.95	.01
	Group × Self-Other	0.04	1,68	.84	.02
	LoF × Self-Other	<0.01	1,68	.99	.01
	Group × LoF × Self-Other	0.03	1,68	.87	.02

3.3.2.3 Differences in Memory for Self and Other According to Verbal Mental Age

In order to assess differences between memory for self and other (hit rate, global corrected hit rate, false alarm rate, self-other corrected hit rate, and source memory) according to verbal mental age, a series of three-way (Group × VMA Category [< 6 years vs. ≥6 years] × Self-Other) mixed ANOVAs were conducted with Self-Other as the within-participants factor. Appendix 14 displays means and standard deviations for "self" and "other" hit rates, false alarm rates, global and self-other corrected hit rate, and source memory scores according the group and VMA category.

When the dependent variable was hit rate, the main effects of Group and VMA Category were not significant but the main effect of Self-Other was, with participants obtaining significantly higher "self" (M = .86, SD = .13) than "other" (M = .65, SD = .20) hit rates. None of the between- or within-participants interactions were significant. The ANOVA statistics are reported in Table 3.8.

Table 3.8

Mixed ANOVA for Self-Other Differences in Hit Rate

Source	***F***	***df***	***p***	***r***
Between-participants				
Group	0.18	1	.37	.05
VMA Category (VMAcat)	0.04	1	.84	.02
Group × VMAcat	0.62	1	.43	.10
Within-participants				
Self-Other	69.36	1	<.01*	.71
Self-Other × Group	0.35	1	.55	.07
Self-Other × VMAcat	0.47	1	.50	.08
Self-Other × Group × VMAcat	0.57	1	.22	.09
Error		68		

When the dependent variable was global corrected hit rate, the main effect of Group was not significant. The main effects of VMA Category (under 6: $M = .52$, $SD = .28$; over 6: $M = .66$, $SD = .24$) and Self-Other (self: $M = .72$, $SD = .26$; other: $M = .51$, $SD = .25$) were significant, however. None of the interactions were significant. The ANOVA statistics are reported in Table 3.9.

Table 3.9

Mixed ANOVA for Self-Other Differences in Global Corrected Hit Rate

Source	*F*	*df*	*p*	*r*
Between-participants				
Group	0.81	1	.37	.11
VMA Category (VMAcat)	6.13	1	.02*	.29
Group × VMAcat	0.12	1	.73	.04
Within-participants				
Self-Other	69.36	1	<.01*	.71
Self-Other × Group	0.35	1	.55	.07
Self-Other × VMAcat	0.47	1	.50	.08
Self-Other × Group × VMAcat	1.57	1	.22	.15
Error		68		

When the dependent variable was false alarm rate, the main effects of Group and Self-Other were not significant. The main effect of VMA Category was significant, however (under 6: *M* = .23, *SD* = .32; over 6: *M* = .08, *SD* = .19). None of the interactions were significant. The ANOVA statistics are reported in Table 3.10.

Table 3.10

Mixed ANOVA for Self-Other Differences in False Alarm Rate

Source	*F*	*df*	*p*	*r*
Between-participants				
Group	0.50	1	.48	.09
VMA Category (VMAcat)	8.10	1	<.01*	.33
Group × VMAcat	0.83	1	.37	.11
Within-participants				
Self-Other	0.46	1	.50	.08
Self-Other × Group	0.01	1	.93	.01
Self-Other × VMAcat	0.02	1	.88	.02
Self-Other × Group × VMAcat	< .01	1	.99	< .01
Error		68		

When the dependent variable was self-other corrected hit rate, the main effect of Group was not significant. However, the main effect of VMA Category was significant: those with VMAs under 6 and over 6 obtained mean scores of .52 (*SD* = .33) and .67 (*SD* = .25) respectively. The Group by VMA Category interaction was not significant. The main effect of Self-Other was significant with participants obtaining significantly higher "self" (*M* = .70, *SD* = .30) than "other" (*M* = .52, *SD* = .28) source memory scores. None of the within-participants interactions were significant. The statistics are reported in Table 3.11.

Table 3.11

Mixed ANOVA for Self-Other Differences in Self-Other Corrected Hit Rate

Source	***F***	***df***	***p***	***r***
Between-participants				
Group	0.81	1	.37	.11
VMA Category (VMAcat)	6.13	1	.02*	.29
Group × VMAcat	0.12	1	.73	.04
Within-participants				
Self-Other	20.91	1	<.01*	.48
Self-Other × Group	0.18	1	.67	.05
Self-Other × VMAcat	0.09	1	.76	.04
Self-Other × Group × VMAcat	0.60	1	.44	.09
Error		68		

When source memory was the dependent variable, the main effect of Group was significant, with the comparison group obtaining higher scores than the ASD group. The main effect of VMA Category was not significant but the main effect of Self-Other was significant. None of the interactions were significant but the three-way interaction approached significance. The ANOVA statistics are reported in Table 3.12.

Table 3.12

Mixed ANOVA for Self-Other Differences in Source Memory

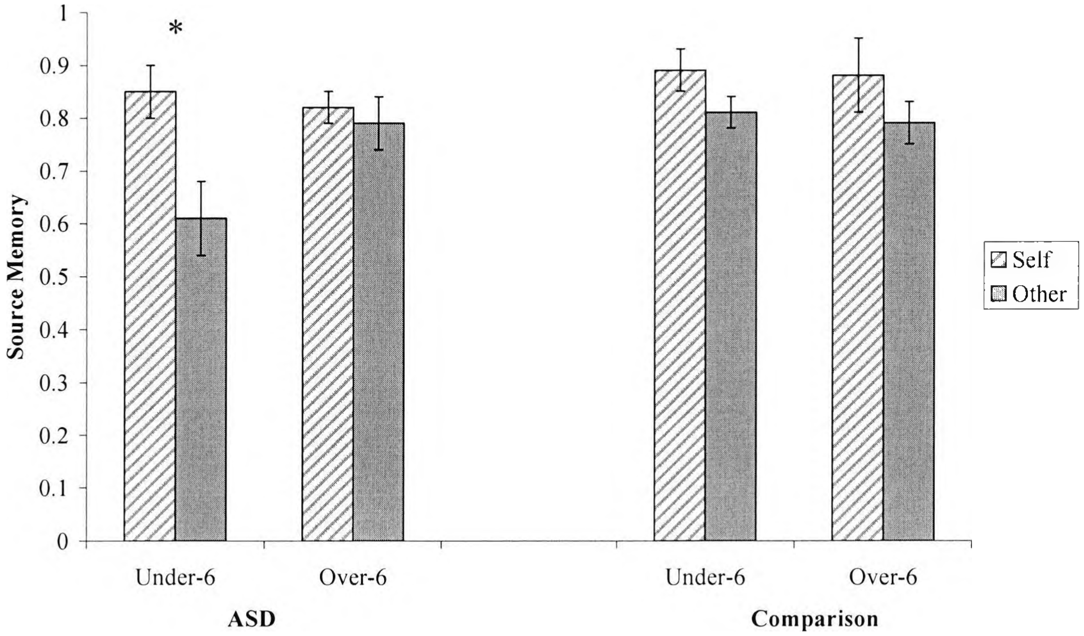
Source	*F*	*df*	*p*	*r*
Between-participants				
Group	4.12	1	.05*	.24
VMA Category (VMAcat)	0.60	1	.43	.09
Group × VMAcat)	1.40	1	.24	.14
Within-participants				
Self-Other	16.13	1	<.01*	.44
Self-Other × Group	0.77	1	.38	.11
Self-Other × VMAcat	3.03	1	.09	.21
Self-Other × Group × VMAcat	3.61	1	.06	.22
Error		68		

Given that the three-way interaction in the previous analysis so closely approached significance, the data were subsequently broken down according to Group, and two separate two-way (Self-Other × VMA Category) mixed ANOVAs were conducted – one for the ASD group and one for the comparison group. Mean "self" and "other" source memory scores according to group and VMA category are displayed in Figure 3.7. The analysis of the ASD group revealed a significant main effect of Self-Other, *F*(1,34) = 10.93, $p < .01$, $r = .49$, a non-significant main effect of VMA Category, *F*(1,34) = 1.57, $p = .22$, $r = .21$, and a significant Self-Other by VMA Category interaction, *F*(1,34) = 6.05, $p = .02$, $r = .39$. The analysis of the comparison group revealed a significant main effect of Self-Other, *F*(1,34) = 5.42, $p = .03$, $r = .37$, a non-significant main effect of VMA Category, *F*(1,34) = 0.01, $p = .91$, $r = .05$, and a non-significant Self-Other by VMA Category interaction, *F*(1,34) = 0.10, $p = .76$, $r = .02$.

The interaction found between Self-Other and VMA Category within the ASD group was further broken down according to VMA Category. Dependent *t*-tests revealed that the difference between "self" and "other" source memory was not significant for the under-6s, *t*(10) = 2.52, $p = .06$, $r = .62$, or the over-6s, *t*(24) = 0.97, $p = .68$, $r = .19$ (after Bonferroni adjustment).

Figure 3.7

Mean "Self" and "Other" Source Memory Scores According to Group and VMA Category



*$p < .05$

3.4 SUMMARY AND DISCUSSION

In terms of the item memory measures, relative to the total comparison group, the total ASD group obtained lower scores on hit rate, recognition, A', and B''_D, and a higher score on false alarm rate. However, none of these performance differences were significant and all of the effect sizes were negligible to small. The ASD and comparison group, alike, showed a conservative response bias, suggesting that participants were not highly inclined to claim that items were old. The groups did, however, differ significantly in terms of source memory, with the comparison group showing an advantage. However, the effect size was small (r = .20), suggesting a subtle impairment of source memory in the ASD group. The ASD and comparison groups correctly identified the source 78% and 84% of the time respectively.

The possible mediating role of level of functioning was also explored. No interaction effects between group and level of functioning were observed for any of the item or source memory measures except for A' scores. This interaction effect was shown to be due to the particularly poor performance of low-functioning individuals with ASD. The HFA and HFC groups did not differ significantly, whereas the LFA and LFC groups did. The LFA group scored substantially less than the LFC group, as indicated by the medium effect size (*r* = .42). So whereas item discrimination in recognition memory was unimpaired amongst high-functioning individuals with ASD, it was markedly impaired among low-functioning individuals with ASD. However, these results should be interpreted with caution, given that they are based on data from only a small number of children (only 11 children with ASD and 11 comparison children were classed as low-functioning).

The item and source memory data were also analysed in order to assess differences in memory for self-performed versus other-performed actions. When the overall ASD and comparison groups were considered, it was found that there was no "self" or "other" advantage for false alarms, showing that participants were equally as likely to attribute false alarms to themselves as they were to the experimenter. However, there was a consistent significant "self" advantage, independent of group, for hit rate, global corrected hit rate, self-other corrected hit rate, and source memory. The effect sizes were large for the item memory measures and moderate for the source memory measure.

Previous research with young typically developing children has indicated that they show an "I did it" bias in memory for collaborative situations – that is, they tend to attribute others' past actions to themselves (Sommerville & Hammond, 2007). Given that the current task involved turn-taking, it was possible that the current results were the consequence of a similar mechanism. Indeed, it was found that, irrespective of accuracy, participants from both groups gave significantly more "self" than "other" responses overall. It was also found that the apparent self-advantage in source memory was, in fact, attributable to the "I did it" bias – it did not reflect a genuine advantage in "self" source memory.

When the data were re-analysed according to level of functioning, it was found that the "self" advantage for hit rate, global corrected hit rate, and self-other corrected hit rate applied to both high- and low-functioning individuals. Again, there was no "self" or "other" advantage for false alarm rate. It was also found that high-functioning individuals (both ASD and comparison) obtained significantly higher global corrected hit rates and self-other corrected hit rates.

The data were also analysed in order to assess whether participants with VMAs over or under 6 years would show a self- or other-advantage to the same extent. A series of Group by VMA Category by Self-Other ANOVAs were conducted to assess differences in the various item and source memory measures. The item memory ANOVAs revealed no significant interactions between Group, Self-Other and VMA Category for any of the dependent measures, indicating that both over and under-6s (with and without ASD) showed the same self-advantage or lack thereof. However, the source memory ANOVA revealed a three-way interaction that approached significance. This analysis was, therefore, broken down according to group. These subsequent analyses did not reveal any significant differences between "self" and "other" source memory for the under-6s or the over-6s.

Thus, the results provide some support for the prediction that source memory would be impaired in the ASD group, though not robustly so. The initial *t*-test, comparing the overall ASD and comparison groups, indicated a significant difference. However, when the groups were broken down into high- and low-functioning subgroups, no significant differences were found. The results were in the expected direction, however, and the effect size remained very similar to that obtained in the original analysis, suggesting that the significant difference was lost due to lower power (given the addition of an extra independent variable). Also, the fact that, when the data were analysed for self-other differences in source memory, no significant main effect of Group was obtained, highlights the lack of a robust difference. Overall, the results suggest a subtle impairment of episodic memory amongst children with ASD.

Regarding the second prediction, that item memory would be impaired in low-functioning but not high-functioning individuals, the results again appear to provide some support. The fact that a significant decrement in A' scores was obtained for the low-functioning group only, shows that these individuals experienced difficulty in distinguishing between old and new items. This suggests, in line with Boucher et al.'s (in press) hypothesis, that these individuals had impaired semantic memory. Although recognition memory is thought to involve both the processes of recollection (episodic memory) and familiarity (semantic memory), which, incidentally, A' does not take account of (Yonelinas, 2001), it is clear that these children had difficulty using familiarity to make old/new judgements. As mentioned above, it should be highlighted that these results are based on a sample of just 11 children with ASD and 11 comparison children and may not be generalisable.

It was also predicted that children with ASD would show a reduced enactment/self-reference effect. The results did not support this prediction. There was a consistent enactment effect in both item and source memory (though in the case of source memory this was shown to be due to the "I did it" bias), irrespective of group. Thus, the underlying mechanisms responsible for this effect appear to be intact in ASD. The results do not suggest that individuals with ASD have an impairment in action monitoring or insufficiently elaborate self-concepts and are consistent with previous research showing the enactment effect in recognition memory (Farrant et al., 1998) and cued recall (Hare et al., 2007; Millward et al., 2000).

On the basis of findings from typical development it was predicted that, within the comparison group, children with verbal mental ages over 6 years would show the enactment effect, but those with verbal mental ages under 6 would not. This prediction was not confirmed by the data. The final prediction was that comparison participants, but not participants with ASD, would show a bias towards attributing false alarms to the experimenter. In fact, the results showed that regardless of group, participants were just as likely to attribute false alarms to self as other.

Overall, these results are consistent with idea that ASD entails a diminution of episodic memory. Experiencing more difficulty attributing source information is likely to reflect the fact that these individuals show a reduced propensity to mentally re-experience past episodes. What remains to be addressed is *why* individuals with ASD are less disposed to remembering episodically. This question is addressed directly in Chapters 7 and 8.

CHAPTER 4: Assessing Temporally Extended Self-Awareness in ASD

4.1 INTRODUCTION

Explicit, conceptual self-awareness is traditionally assessed using the *mark test* of mirror self-recognition (MSR) (Amsterdam, 1972; Gallup; 1970). In this test, the child is presented with a mirror, having had their face covertly marked with a spot of rouge. To pass the task, which children can do at a mean age of 18 months (Anderson, 1983; Courage et al., 2004; Lewis & Ramsey, 2004), the child must try to remove the mark. However, success on this task is not informative about whether the self is represented as extended through time. Povinelli et al. (1996) developed a task with the specific aim of assessing such temporally extended self-awareness. They modified the traditional mirror mark test, by introducing a temporal component, to create the delayed self-recognition (DSR) paradigm. In their test, the experimenter and child played a game, which was captured on film, during which the child was praised by patting them on the head. Whilst praising the child for the third time, the experimenter covertly placed a large sticker on top of their head. After a delay of three minutes, the pair watched the recording and the child's reaction was assessed. Successful performance involved mark-directed behaviour – that is, reaching up to touch or remove the sticker – either spontaneously or with prompting. The test is meant to establish whether the child understands the temporal-causal relation between this "past self" represented on the screen and their "present self". That is, do they have the temporally extended self-concept resulting in the expectation that the sticker will be on their head *here-and-now* not just *there-and-then*? They found that no 2-year-olds showed mark directed behaviour in this task, whereas 25% of 3-year-olds and 75% of 4-year-olds did. The same pattern of results was found when the delayed feedback medium was a Polaroid photograph rather than a video recording. These results have been replicated in a number of studies (Lemmon & Moore, 2001; Povinelli & Simon, 1998; Povinelli et al., 1996; Suddendorf, 1999; Zelazo et al., 1999).

Povinelli (2001) presents a theory which aims to account for this developmental lag between successful MSR and DSR. He suggests that MSR is possible because infants are able to detect *equivalence relations* between their perceived mirror self-image and their represented bodily self-image, not because they realise that the mirror image is a representation of themselves. He argues that two types of equivalence relation are important: *kinaesthetic* and *featural*. In other words, self-recognition can involve detecting, "that moves like me" and/or "that looks like me". For young children, kinaesthetic equivalence relations are most salient. As they grow older, featural equivalence relations increase in salience. He argues that, for young children who do not have knowledge of what they look like (through prior mirror experience), mark directed behaviour occurs because they have an intrinsic interest in the mark. Older children, who already have a schema for what they typically look like, may detect that the image violates their expectations (i.e., that they don't normally have a mark on their face) and this is what motivates mark directed behaviour. This model accounts for the fact that infants can pass the mark test without prior experience with mirrors (Priel & Schonen, 1986).

It is argued that the introduction of a temporal delay to visual feedback means that the self-image presents conflicting information: "the kinaesthetic information says 'no', but the featural information says 'yes'" (Povinelli, 2001, p.86). If children attend to the kinaesthetic information alone they *will not* remove the sticker. If they attend to the featural information they *will* remove the sticker. In general, the kinaesthetic information will dominate but, in some instances, the featural information may become temporarily salient, leading them to remove the sticker. It is argued that the small proportion of under-4s who remove the sticker do so for different reasons to the over-4s. Under-4s pass on the basis of featural equivalence relations. Over-4s pass on the basis of inferences derived from their temporally extended representations of self.

In order to test this hypothesis, Povinelli and Simon (1998) compared DSR performance over brief (5 minute) and extreme (7 day) delays. If under-4s remove the sticker because of featural equivalence, rather than understanding of temporal-causal relations between states of self, then they should reach to remove the sticker when presented with a recording after both short and long delays, since their physical features will be largely invariant across both durations of delay. The over-4s should only do so after short delays because they are thought to understand the temporal-causal relations between present and various past states of self. They should realise that the image recorded shortly before bears a fairly direct causal relation to their current self, whereas the image recorded a week before bears a far less direct causal relation to the current state of self and is, therefore, unlikely to be informative about the appearance of the current self (a sticker is unlikely to remain undiscovered on one's head for a whole week!). This was exactly the pattern the researchers found. Three-year-olds were almost as likely to reach for the sticker in the extreme delay condition as in the brief delay condition. Few 4- or 5-year-olds reached up in the extreme delay condition but most of them did in the brief delay condition.

There have, however, been a number of criticisms of the DSR task. For example, Suddendorf (1999) has argued that performance on the task does not reflect a cognitive change that is specific to self-awareness: it simply measures the ability to use a delayed video (or photographic) representation in order to locate an otherwise invisible object. Performance, on his view, reflects the development of domain-general skills, which, among other things, also affect the developing self-concept (Suddendorf, 1999, p.160). Similarly, Zelazo et al. (1999) have argued that difficulties using the video medium might mask performance in under-4s.

Indeed, both Suddendorf (1999) and Zelazo et al. (1999) found that children had equal difficultly using delayed videos to locate objects situated in locations other than their body (a teddy in a box/a sticker on a stuffed animal's head), visible to the camera but not to the child, as they did to locate stickers on their heads. In a more recent experiment, Skouteris, Spataro and Lazaridis (2006) trained 2.5- and 3-year-olds to use delayed videos to locate hidden toys, in an attempt to improve rates of DSR. They found that whereas 3-year-olds benefited from this training, showing improvements in DSR performance, 2.5-year-olds did not. Specifically, after the training, 83% of the 3-year-olds passed DSR, whereas only 17% of 2.5-year-olds passed. Thus, the 3-year-olds were able to transfer their newly acquired skills in order to locate the sticker on themselves. This suggests that DSR performance is, indeed, masked in 3-year-olds because they do not understand that delayed videos can provide information about the location of unseen objects. Interestingly, although the 2.5-year-olds were poor at locating a sticker on their body (DSR), they were in fact able to use the video to locate objects situated elsewhere.

Another important question is whether self-recognition difficulties in young children are limited to *delayed* video self-recognition or whether they apply to video self-recognition per se. Povinelli's (2001) basic argument rests on the assumption that a live video is equivalent to a mirror. He argues that the developmental asynchrony in MSR and DSR is due to the contrast between live versus delayed visual feedback. In fact, recent data suggest that there is a developmental lag between (live) mirror and live video self-recognition. Problems with video self-recognition persist even with live videos, suggesting that the developmental asynchrony may be at least partially attributable to media type. For example, although the vast majority of 2-year-olds pass MSR, Miyazaki and Hiraki (2006) found that just 20% of 2-year-olds passed live video self-recognition. There are a number of possible explanations for this.

For example, the qualities of the visual feedback obtained from mirrors and live videos are somewhat different. Notably, a video image is left-right reversed: when viewing one's own mirror image, a movement results in an ipsilateral corresponding movement in the image, whereas in video feedback the corresponding change appears contralaterally. Also, the self image in video feedback typically appears to be much smaller than one's reflection in a mirror. Finally, in contrast to a mirror image of oneself, there is a lack of direct eye contact in video feedback. Each of these differences may potentially make the self-image less salient and hence make mark directed behaviour more difficult with videos than with mirrors.

In a series of carefully controlled experiments, Suddendorf, Simcock, and Nielsen (in press) attempted to assess each of these possible explanations. In their first experiment, they gave children both live video and mirror self-recognition tests. Crucially, the size of the self-image was equated in both the video and mirror conditions, and the video image was manipulated such that it was not left-right reversed. They found that whereas 90% of the 24-month-olds passed the mirror version, only 35% passed the video version, and it was not until 36 months that 90% of children passed the video version. In another experiment (Experiment 3), they assessed the possibility that direct eye contact, not attainable with video feedback, facilitates MSR. Children were seated in a high chair with an occluder which ensured that their legs were not directly visible. The mark was surreptitiously placed on the child's leg and the live video feedback showed their legs only; their faces were not visible. The video feedback was otherwise equivalent to that used in Experiment 1. They found that only 17% of 24-month-olds passed. In a mirror version of the task, used in a previous study, it was found that 88% of 24 month-olds passed the task (Nielsen, Suddendorf, & Slaughter, 2006).

These data certainly seem to rule out the possible explanations, outlined above, for the mirror/video performance decrement. Suddendorf et al. (in press) propose, therefore, that children may only gradually refine mental representations of their appearance to the level of abstraction required for self-recognition in feedback such as live videos, which have less fidelity than mirrors. In terms of Povinelli's (2001) model, in live videos the kinaesthetic information says "yes" but, perhaps, the featural information says "no", at least to a certain extent. Certainly, if children of this age are relying on featural information for self-recognition and they are presented with somewhat degraded visual feedback, detecting equivalence relations on the basis of featural information could prove problematic. In other words, detecting the fact that the perceived image of self does not match one's represented self-schema may be more taxing.

Returning to the issue of the temporally extended self-concept, it is argued that such a self-concept relies on the capacity for metarepresentation (Povinelli, 2001). That is, an understanding of mental representations *as* representations (Perner, 1991; see Chapter 5, section 5.1). The capacity for metarepresentation develops at around the age of 4, enabling children to entertain multiple, and contradictory, representations of the same object or event and understand them as (alternative) representations of that object or event. In relation to the self-concept, along with an understanding of the "causal arrow of time" (Povinelli et al., 1999; see Chapter 1, section 1.5.3.3), it allows children to "organise previous, current and future representations under a temporally extended metaconcept of 'me'" (Povinelli, 2001, p.87). However, there is no empirical support for this suggestion. Zelazo et al., (1999) found there to be no correlation between DSR and a ToM score, which was derived from responses to questions on an unexpected contents false belief task, including self and other false belief questions and an appearance-reality question. Similarly, Suddendorf (1999) found no relationship between DSR and performance on the Sally-Anne location change false belief task.

Aims and Hypotheses of the Current Study

Although children with ASD show MSR at the appropriate mental age (e.g., Ferrari & Matthews, 1983), the fact that they are seemingly impaired in their capacity for metarepresentation (e.g., Happé, 1995; Yirmiya et al., 1998) and it may be speculated that their difficulties with temporal cognition (Boucher et al., 2007) extend to understanding of the causal arrow of time, suggests that individuals with ASD may have impaired temporally extended self-concepts. A recent study by Dissanayake and Suddendorf (unpublished, reported in Nielsen et al., in press) has investigated DSR in a sample of 15 children with high functioning ASD. They found no impairment in the ASD group relative to a slightly younger comparison group[12]. The children they tested had a mean age of 7 years 7 months, leaving open the possibility that younger or less able children with ASD may experience more difficulties with DSR than comparison children.

Another element of the DSR task, not discussed thus far, is that fact that children are typically asked to name their video image (i.e., by asking them, "Who's that?"). Povinelli et al. (1996) found that whereas younger children were more likely to name their image using their proper name, older children were more likely to use the pronoun "me". They also found that use of proper names or other "dissociative phrases", such as describing the sticker as being on "his/her/the head", was associated with failing DSR. On the basis of previous research, which has found children with autism to show a tendency to label photographs of themselves using their proper names (Lee et al., 1994), it was also predicted that children with ASD would be more likely than comparison children, to label their self-images using their proper names.

Thus, the current experiment aimed to test the hypothesis that children with ASD have impaired temporally extended self-concepts, through the use of the DSR paradigm. Performance on the DSR paradigm was considered, as well as its relation to false belief understanding, as measured by the Sally-Anne location change and Smarties unexpected contents false belief tasks. It was predicted that children with ASD would show diminished performance on the DSR task and an increased propensity to use their proper names as opposed to the pronoun "me" to label their video self-image. It was also predicted that performance on DSR would be related to ToM performance since both are thought to reply on the capacity for metarepresentation (Povinelli, 2001).

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[12] They report that 100% of typically developing children and 83% of children with ASD passed. It can only be assumed that this is a typographical error, since this would mean that 12.45 children with ASD passed.

4.2 METHOD

4.2.1 Participants

The ASD and comparison groups each consisted of 30 participants who were individually matched on VMA and CA (see Table 4.1 for participant characteristics). The groups did not differ significantly in terms of VMA, $t(58) = -0.13$, $p = .90$, $r = .02$; CA, $t(53.29) = 0.25$, $p = .81$, $r = .03$; or VIQ, $t(55.00) = -0.99$, $p = .33$, $r = .13$. Although participants were not explicitly matched on sex, the percentage of males was similar for both groups: 73.3% and 66.7% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .69$, $p < .01$) and comparison ($r = .79$, $p < .01$) groups.

Table 4.1

Participant Characteristics

	ASD	**Comparison**
N	30 (8 female)	30 (10 female)
VMA		
M	6.18	6.26
SD	2.32	2.11
Range	2.83 – 11.33	3.17 – 10.83
CA		
M	8.99	8.74
SD	3.31	4.50
Range	5.00 – 16.17	3.58 – 15.67
Verbal IQ		
M	79.10	83.90
SD	16.39	20.79
Range	46 – 117	39 – 117

4.2.2 Procedure

For full details of the procedure see Chapter 2, section 2.2.2.4. Briefly, experimenter and child were filmed playing a game, during which a sticker was surreptitiously placed on the child's head. After a delay of three minutes, the child was shown the recording of the previously occurring events. The child was asked, *"Who's that?"* If they did not spontaneously remove the sticker within five seconds of seeing the marking event, they were given the prompt, *"What's that?"* If they did not respond, the experimenter said, *"I think it's a sticker. Can you get that sticker for me?"* If the child was unable to locate the sticker after these prompts, the experimenter showed the child live video feedback of themselves on the same screen. The above prompts were once again used.

4.2.3 Scoring

For full details of scoring methods see section 2.2.3.4. Two alternative methods of scoring mark-directed behaviour on the DSR task were used:

(1) Dichotomous scoring: simple passing/failing
(2) Continuous scoring: pass spontaneously = 3; pass after one prompt = 2; pass after two prompts = 1; fail = 0

4.2.4 Reliability

An independent rater was trained to code performance on the delayed self-recognition task, according to the level of prompting required to elicit mark-directed behaviour, as well as verbal responses. The second rater re-scored 17 of the videos. Scores were found to be highly consistent with the original coding, $\kappa = .91$. This is considered to be a high kappa value (Cohen, 1960).

4.3 RESULTS

4.3.1 Dichotomous Scoring: Simple Passing/Failing

Firstly, group differences in mark-directed behaviour were analysed according to the dichotomous scoring method. The numbers of participants in each group who passed and failed the task, on the dichotomous scoring criteria, are displayed in Table 4.2. The association between group and passing/failing the task was significant, Fisher's exact $p = .05$, $\phi = .30$, reflecting the fact that 5/30 children in the ASD group, but 0/30 children in the comparison group, completely failed the task. However, only 2 of the 5 children who failed were able to locate the sticker when given live feedback and this only occurred after being given 2 prompts (in both cases).

Table 4.2

Number of Participants in Each Group Passing and Failing DSR

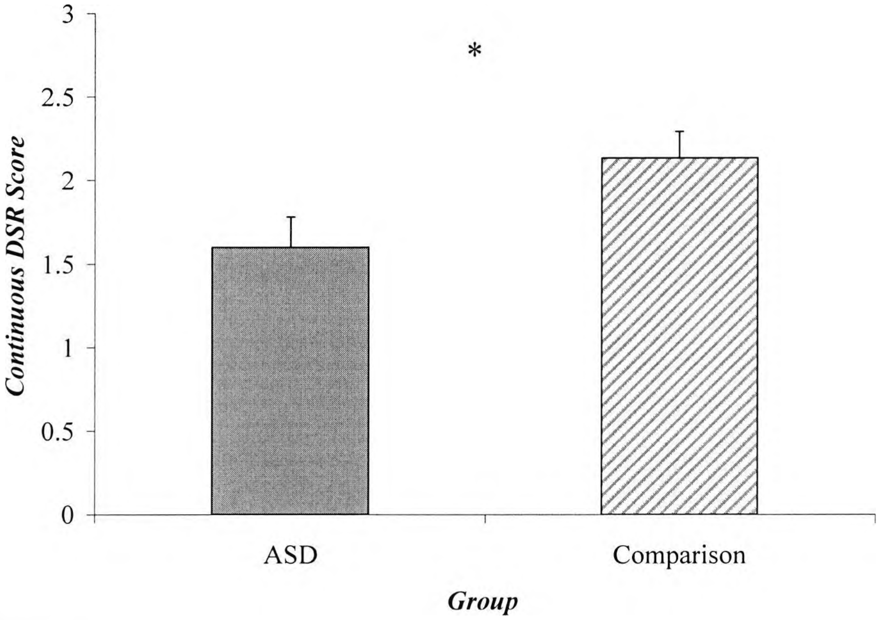
	Group	
Dichotomous DSR score	ASD (% of group)	Comparison (% of group)
Fail	5 (16.67%)	0 (0%)
Pass	25 (83.3%)	30 (100%)

4.3.2 Continuous Scoring

Group differences in continuous DSR scores were assessed using a Mann-Whitney test, which indicated significantly better performance in the comparison group (M = 2.13, SD = 0.86) than in the ASD group (M = 1.60, SD = 1.00), U = 320.00, z = -2.01, p = .04, r = -.26. Group means are displayed in Figure 4.1. Table 4.3 provides a breakdown of performance according to the level of prompting required to elicit mark directed behaviour.

Figure 4.1

Mean Continuous DSR Scores for the ASD and Comparison Groups



* $p = < .05$

Table 4.3

Breakdown of DSR Performance According to Level of Prompting Required to Elicit Mark Directed Behaviour

	Group	
Level of prompting	ASD (% of group)	Comparison (% of group)
Fail	5 (16.7%)	0 (0%)
Pass after 2 prompts	8 (26.7%)	9 (30%)
Pass after 1 prompt	11 (36.7%)	8 (26.7%)
Pass spontaneously	6 (20%)	13 (43.3%)

4.3.3 Verbal Responses

Participants' verbal responses to the self-image naming question, "Who's that?" were considered next. Fifty-nine children responded with either "me" or their proper name and one child (with ASD) did not respond. See Table 4.4 for the number of participants in each group who gave each type of response. A chi-square test indicated a significant association between group and response to the naming question, $\chi^2(1, N = 59) = 4.58, p = .04$, $\phi = .28$, reflecting the fact that children in the ASD group were more likely to label their video image using their proper name than children in the comparison group.

Table 4.4

Number of Participants in Each Group who Gave Their Proper Name/"Me" as a Response

	Group	
Verbal response	ASD (% of group)	Comparison (% of group)
Me	21 (72.4%)	28 (93.3%)
Proper name	8 (27.6%)	2 (6.7%)

4.3.4 Association Between Verbal Responses and DSR

The association between DSR performance and response to the naming question was considered next.

4.3.4.1 Dichotomous DSR Scores

Given the lack of variation in dichotomous DSR scores, no statistical analyses are reported regarding their relationship with responses to the naming question. Instead, a simple tabular summary is provided. Table 4.5 displays the contingency between dichotomous DSR scores and verbal responses for the ASD and comparison groups.

Inspection of Table 4.5 indicates that, within the ASD group, DSR failers were as likely to use their proper name as they were to use the pronoun "me", whereas DSR passers were much more likely to use the pronoun "me" than their proper name. Given the very small number of failers, this apparent trend should be interpreted with caution.

Table 4.5

Contingency Between Dichotomous DSR Scores and Response to the Naming Question

Group	**Dichotomous DSR score**	**Verbal response** Proper name	 Me
ASD	Fail	2	2
	Pass	6	19
Comparison	Fail	0	0
	Pass	2	28

4.3.4.2 Continuous DSR Scores

In order to maximise the statistical power of the following analysis, the ASD and comparison samples were combined[13]. The difference in continuous DSR scores between children using "me" (M = 1.98, SD = 0.88) versus their proper name (M = 1.50, SD = 1.18) was investigated using a Mann-Whitney test. Continuous DSR scores were not significantly different between those who labelled their image with "me" and those who used their proper name, $U = 183.00$, $z = -1.31$, $p = .20$, $r = .17$.

4.3.5 Relationship Between DSR and "Theory of Mind"

The association between DSR and ToM task performance, including Sally-Anne, Smarties "other", and Smarties "self", was considered next. The tasks were considered separately because a substantial number of children (10 with ASD, 2 comparison) did not have complete data for both of the false belief tasks.

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[13] The results did not differ when the groups were analysed separately.

Furthermore, given the lack of variation in performance, the data were not subjected to statistical analysis. Instead, tabular summaries of the results are provided.

4.3.5.1 Sally-Anne

A total of 50/60 children passed the Sally-Anne control questions. Only the data from these participants are considered here.

Dichotomous scoring method.

Of the 5 children who completely failed DSR, only 2 passed the Sally-Anne control questions. Table 4.6 displays the contingency between dichotomous DSR scores and Sally-Anne performance. Given that only 2 participants from this subset failed the DSR task, very little can be gathered from this data.

Table 4.6

Contingency Between Dichotomous DSR Scores and Sally-Anne Performance

Group	**Dichotomous DSR score**	**Sally Anne** Fail	**Sally Anne** Pass
ASD	Fail	2	0
	Pass	4	16
Comparison	Fail	0	0
	Pass	4	24

Continuous DSR scores.

Table 4.7 displays mean continuous DSR scores according to group and Sally-Anne performance.

Table 4.7

Mean (SD) Continuous DSR Scores According to Group and Sally-Anne Performance

Group	Sally Anne	
	Fail	Pass
ASD	1.33 (1.21)	2.13 (0.72)
Comparison	2.50 (1.00)	2.00 (0.83)

4.3.5.2 Smarties "Other"

Dichotomous DSR scores.

The contingency between dichotomous DSR score and Smarties "other" score is displayed in Table 4.8. Within the ASD group, there appeared to be a trend towards an association between dichotomous DSR score and Smarties "other" performance, in that the majority of DSR failers also failed Smarties "other" and the majority of DSR passers also passed Smarties "other".

Table 4.8

Contingency Between Dichotomous DSR Scores and Smarties "Other" Performance

Group	Dichotomous DSR score	Smarties "other"	
		Fail	Pass
ASD	Fail	4	1
	Pass	10	13
Comparison	Fail	0	0
	Pass	6	24

Continuous DSR scores.

Table 4.9 displays mean continuous DSR scores according to group and Smarties "other" performance

Table 4.9

Mean (SD) Continuous DSR Scores According to Group and Smarties "Other" Performance

Group	Sally Anne	
	Fail	Pass
ASD	1.43 (1.22)	1.86 (0.77)
Comparison	2.83 (0.41)	1.95 (0.86)

4.3.5.3 Smarties "Self"

Dichotomous DSR scores.

The contingency between dichotomous DSR score and Smarties "self" score is displayed in Table 4.10. There was no clear trend in the data.

Table 4.10

Contingency Between Dichotomous DSR Scores and Smarties "Self" Performance

Group	Dichotomous DSR score	Smarties "self"	
		Fail	Pass
ASD	Fail	3	2
	Pass	6	17
Comparison	Fail	0	0
	Pass	4	26

Continuous DSR scores.

Table 4.11 displays mean continuous DSR scores according to group and Smarties "self" performance

Table 4.11

Mean (SD) Continuous DSR Scores According to Group and Smarties "Self" Performance

	Sally Anne	
Group	Fail	Pass
ASD	1.22 (1.20)	1.84 (0.90)
Comparison	2.57 (0.50)	2.04 (0.87)

4.3.6 Relationship Between DSR and CA, VMA, and VIQ

The relationship between measures of DSR and VMA, CA, and VIQ were also investigated. Correlations between dichotomous and continuous DSR measures and VMA, CA, and VIQ are displayed in Table 4.14. For the ASD group there was a significant correlation between dichotomous DSR score and VMA, and dichotomous DSR score and CA, but not dichotomous DSR score and VIQ (correlations could not be computed for the comparison group because no participants failed). In terms of continuous DSR score the same pattern was observed in the ASD group. In the comparison group, neither VMA, nor CA, nor VIQ correlated with continuous DSR score.

Table 4.12

Correlations Between Dichotomous (r_{pb}) and Continuous (r_s) DSR Measures and VMA, CA, and VIQ

	VMA	CA	VIQ
ASD Group			
Dichotomous DSR score	.48***	.34*	.11
Continuous DSR score	.44**	.46**	.04
Comparison Group			
Dichotomous DSR score	-	-	-
Continuous DSR score	-.07	-.07	-.09

*p (one-tailed) < .05, **p < .05, *** p < .01

The characteristics of the children who completely failed the task were also of specific interest. These are displayed in Table 4.13.

Table 4.13

Characteristics of Individuals who Failed DSR (Dichotomous Scoring)

Participant	**Live self-recognition**	**Naming question**	**VMA**	**CA**	**VIQ**
1	fail	Name	2.83	5.25	68.00
2 (Emily)	fail	Me	3.83	6.33	81.00
3	fail	Name	3.42	7.33	68.00
4	pass with prompt	-	3.58	6.42	77.00
5 (Sam)	pass with prompt	Me	4.92	7.33	81.00

4.3.7 Examples of Transcripts

The above analyses do not fully capture how interesting some of the children's reactions were. The DSR transcripts for three children, Sam, Emily, and Matthew, are reported below in Figures 4.2, 4.3, and 4.4 respectively (all names have been changed in order to protect participant anonymity). Sam is an example of a child who failed to remove the sticker when provided with delayed video feedback but succeeded to locate it when provided with live feedback and prompts. Emily, by contrast, failed to locate the sticker even when given live feedback. She appeared to have a partial or somewhat fragmented understanding of the task. Matthew, despite eventually locating the sticker, also showed some interesting behaviours suggesting a fragile grasp of the situation.

Figure 4.2

DSR Transcript for Sam

Delayed feedback	
Experimenter:	"Who's that?" (pointing to sticker on screen)
Child:	"That's me!....Huh?...What's that on my head?"
Experimenter:	"I don't know. I think it's a sticker. Can you get that sticker for me?"
Child:	"No. I can't."
Live feedback	
Child:	"Hey?...Umm?"
Experimenter:	"Look. What's that?" (pointing to sticker on screen)
Child:	"Umm."
Experimenter:	"It's a sticker, isn't it? Can you get that sticker for me?"
Child:	(Reaches up and removes sticker) "Huh!" (Gives experimenter a 'cross' look and puts hand on hip!)

Figure 4.3

DSR Transcript for Emily

Delayed feedback

Child:	"Ahh!" (laughs) "That's me! That's you!....Sticky bit off." (Child points to her own head but does not try to remove sticker)
Experimenter:	"Oh! What's that Emily?" (pointing to sticker on screen)
Child:	"Yeah." (Child makes strange noise and points to her own head) "(indistinguishable word) on head."
Experimenter:	"I think it's a sticker. Can you get that sticker for me?"
Child:	(Child gets up, goes towards screen and touches it)
Experimenter:	"Can you get it for me?"
Child:	"I can't."
Experimenter:	"You can't? Ok, would you like to sit down again please Emily? There we go."
Child:	"I've got a sticker on my head."
Experimenter:	"Yeah."

Live feedback

Child:	"Ah - let's watch the proper one. And I've got a sticker off my head. I've got a sticker off my head."
Experimenter:	"What's that?" (pointing to sticker on screen)
Child:	"Another sticker on my head."
Experimenter:	"Look there. Can you get it for me?"
Child:	(Child gets up and goes towards screen. This means she is out of view of the camera and her image is no longer visible on the screen.) "She's gone."
Experimenter:	"Can you sit down on the chair for me please Emily. There's a good girl. Look there – can you get the sticker?" (pointing to sticker in the screen)
Child:	(Child gets up again and goes to screen so she is out of view of the camera again) "And she's gone again."

Figure 4.4

DSR Transcript for Matthew

	Delayed feedback
Experimenter:	"Who's that?" (pointing to image of child)
Child:	"Matthew."
Experimenter:	"What's that?"
Child:	"His on head."
Experimenter:	"I think it's a sticker."
Child:	"Yeah. He's on his head."
Experimenter:	"Can you get that sticker for me?"
Child:	"OK." (child gets up and goes to touch the screen)
Experimenter:	"Do you want to sit down again for me please?"
Child:	(Returns to seat and then reaches up to get sticker)
Experimenter:	"Now we can have a look at it live."
Child:	"Got it."
Experimenter:	"You got it? So you did."
Child:	"It's on my head."

4.4 SUMMARY AND DISCUSSION

In line with predictions, children in the ASD group were significantly more likely than children in the comparison group to fail the DSR task. Whereas 5 children with ASD failed, no comparison children failed. From this, it could be concluded that children with ASD are more likely to have difficulty in representing themselves as persisting through time or, more conservatively, that they had greater difficulty in making the necessary temporal-causal inference to locate the sticker. However, these explanations may be too simplistic. In fact, only 2 children showed a self-recognition problem that was *specific* to delayed video feedback. For these children, it does indeed seem that the temporal delay was the key factor. The transcript for Sam, reported in Figure 4.2, provides a clear illustration of a specific difficulty with DSR but not live self-recognition. The other 3 children appeared to display a more profound difficulty, being unable to locate the sticker even when provided with live video feedback (see Figure 4.3 for an example). There are at least two possible explanations for this failure.

The three children who failed live video self-recognition had VMAs/CAs of 2.83/5.25, 3.83/6.33, and 3.42/7.33 years. As explained in the introduction, in typical development 90% of 3-year-olds pass live self-recognition (Suddendorf et al., in press). Thus, on the basis of their mental ages, we would probably have predicted that these three children would have passed live self-recognition. The reason that they did not may have been due to the fact that they had impoverished conceptual self-awareness of their physical appearance. That is, they may not have had sufficiently abstracted representations of self to enable the detection of featural equivalence relations with live videos. This would be in keeping with previous research which has indicated atypical conceptual self-awareness in ASD (see section 1.5.3.1).

Alternatively, these children may have lacked the motivation to remove the sticker. Kagan (1981) suggested that prior to the age of 18 months, children are not aware of social standards and norms. On this view, children who do not show mark directed behaviour simply do not care that they have a mark on their face. Given that ASD is defined by social impairments, this could plausibly explain why these children did not reach for the sticker. Perhaps they did not see any need to remove the sticker. From a qualitative point of view, this second explanation seems less likely given that they were explicitly asked, “Can you get that sticker for me?” and still they did not retrieve the sticker. These children had participated fully in the other experimental tasks in the main battery of tests and were generally happy to cooperate. It is conceivable, however, that they did not grasp the pragmatics of the question. Individuals with autism are known to have difficulties with the pragmatics of language. For example, a child with autism may well respond to a question such as “Can you pass the salt?” with “Yes” (Frith, 2003, p.119). Perhaps then, had the experimenter said, “Give me the sticker,” they may have done so.[14] In any case, all three children seemed to be very engaged in the task, enjoying testing the contingency between their own movements and the video image. I would argue that their difficulties lay in detecting the equivalence relations between their perceived self-

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[14] It is interesting to note that after delayed feedback, Sam and Emily (see Figures 4.2 and 4.3) responded to that question with “I can’t.” These children did appear to understand what was being asked of them but did not believe that they were able to comply.

images and their representations of their own physical characteristics, due to their somewhat insubstantial self-concepts and the degraded perceptual information provided by the representational medium.

There also still remains the possibility that some of the children with ASD, despite lacking a temporally extended self-concept, were able to pass the task on the basis of detecting featural equivalence relations, as Povinelli (2001) hypothesised that under-4s do. This could explain cases like Matthew (see Figure 4.4) who did not seem to grasp the nature of the task as "automatically" as many of the other children. His initial attempt to retrieve the sticker involved trying to obtain the sticker from the screen. Only after this unsuccessful attempt did he reach for the sticker on his own head. This remains a speculation, however, and is an interesting empirical question which I hope to address in future research.

The results of the current experiment do not replicate the findings of Dissanayake and Suddendorf (unpublished), who did not find a significant group difference. This is likely to be due to the fact that the sample used here was much larger than, in fact double the size of, that used by Dissanayake and Suddendorf and the mean developmental level and IQ was substantially lower. Indeed, all the children who failed had low verbal mental ages, ranging from 2.83 to 4.92. This study was therefore more likely to detect possible group differences.

The dichotomous method of measuring DSR did not capture the more fine grained differences between the ASD and comparison groups, however. It was found that children in the ASD group obtained significantly lower continuous DSR scores, reflecting the fact that they required a greater degree of prompting in order to pass the task. Once again, these findings may be interpreted in a number of different ways. The children with ASD may, on the one hand, have had less firmly established capacities for representing the self through time but were able to benefit from the scaffolding provided by the prompting. On the other hand, the prompting may have ensured that they were attending to the relevant information and given them external motivation (by making a direct request) to search for the sticker. In this case, group differences would not reflect any underlying conceptual differences.

It was also found that children with ASD were less likely than comparison children to use the personal pronoun "me" to label their delayed video image. Two children with ASD also made other third person self-references at points during the procedure. Emily (see Figure 4.3), for example, said, "She's gone," referring to her live self-image (despite having previously used the term "me") and Matthew said, "He's on his head," describing what he saw on the screen. The finding that children with ASD used third person labels such as proper names, "she", and "his" is consistent with previous research and may be interpreted as a reflection of impaired self-awareness. The fact that verbal responses were not found to be related to any measure of DSR performance suggests that use of proper names is unlikely to reflect diminished *temporally extended* self-awareness. It is more likely to be the result of impaired (interpersonally grounded) conceptual self-awareness.

In terms of the relationship between DSR and ToM, the data were suggestive of a relationship between false belief understanding, as measured by Smarties "other performance and DSR. However, the ceiling effects in the data meant that this could not be fully investigated.

In summary, the results appear to demonstrate that some individuals with ASD have less concrete temporally extended self-concepts than comparison individuals. This is indicated by the fact that a greater number of children with ASD failed to recognise their delayed self-image and more generally required a greater amount of support, in the form of prompting, to complete the task. Although other explanations have been considered, on balance it can be argued that the results reflect genuine differences in self-awareness, particularly in light of the fact that some children with ASD also showed difficulty with live self-recognition and labelled their video images using their proper names. If one makes a more conservative interpretation, however, the results appear to suggest that children with ASD have more difficulty in making temporal-causal inferences, requiring more external support in order to make them. Thus, even if the task is not measuring domain specific changes in self-awareness, I would suggest that it does, at least, measure a domain general cognitive skill that plays an important role in the development of self-awareness.

CHAPTER 5: Assessing "Theory of Mind" in ASD

5.1 GENERAL INTRODUCTION

5.1.1 Theory of Mind and False Belief Tasks

"Theory of mind" (ToM) – that is, the ability to attribute mental states, such as beliefs and desires, to self and other to explain and predict behaviour (Premack & Woodruff, 1978) – has been one of the most thoroughly investigated cognitive abilities in ASD. It has been consistently found, using a wide variety of paradigms, that individuals with ASD are impaired, relative to their mental ages, in their ability to perform tasks designed to measure ToM, most notably *false belief tasks* (Happé, 1995; Yirmiya et al., 1998). False belief tasks are widely regarded as the litmus tests of mental state understanding (Dennett, 1978). There are two main types: *location change* (Wimmer & Perner, 1983) and *unexpected contents* (Perner et al., 1987) tasks. These tasks typically require the participant to impute a false belief to a mistaken protagonist in order to correctly predict their behaviour. So, for example, in the "Sally-Anne" location change task (Baron-Cohen et al., 1985), the child is presented with the following scenario: "Sally puts her marble in the basket. Then she goes out for a walk. While she is gone, Anne takes the marble out of the basket and puts it in the box. When Sally comes back, where will she look for her marble first?" In order to correctly predict that Sally will look in the basket, the child must understand that people's actions are determined not by the real state of the world, but by their mental representations of the world, which may or may not be accurate. In the "Smarties" unexpected contents task (Perner et al., 1987) the child is shown that a tube of Smarties contains pencils rather than the expected sweets and is then asked what someone else, who has not seen inside the tube, will think is in there before it is opened. Once again, the child must invoke the notion of a hypothetical unseen entity – a mental state – in order to answer the question correctly. Without the notion of a false belief, the idea of Sally looking for her marble in an empty basket, or someone thinking there will be sweets in the Smarties tube when really there are pencils, simply does not make sense. Although ToM abilities become increasingly sophisticated during the preschool years, it is not until around 4 years of age that typically developing children are able to pass such false belief tasks (Wellman, Cross, & Watson, 2001).

Such false belief understanding is a fairly sophisticated cognitive achievement. The ability to attribute knowledge/ignorance of a given piece of information, depending upon whether an individual has had access to that piece of information, appears to be an important preceding step in ToM development (Hogrefe et al., 1986). Indeed, an appreciation of the relationship between informational access and knowledge is thought to be essential to a mature concept of belief (Wimmer & Gschaider, 2000). This particular ToM achievement is typically assessed using "see-know" tasks which test children's understanding that visual access to information is a way of gaining knowledge of that information (Wimmer et al., 1988). For example, Pratt and Bryant (1990) presented children with scenarios such as, "John picks up the box and Fiona opens the box and has a look. Who knows what's in the box?" They found that children were able to respond correctly to this type of question by 3 years of age. Using an adaptation of this paradigm, Baron Cohen and Goodhart (1994) found that children with autism were impaired in their ability to attribute knowledge/ignorance. Problems with the control task for this experiment cast some doubt on the legitimacy of this conclusion, however (see Chapter 2, section 2.2.1.3).

The notion of ToM has particular relevance to our understanding of autism because impaired ToM provides a potential explanation for the social and communication difficulties associated with ASD. In the literature on typical development, hypotheses regarding the cognitive processes which underlie ToM are varied (e.g., Gopnik & Meltzoff, 1998; Harris, 1992; Leslie, 1987; Perner, 1991), with particular controversy surrounding the question of whether ToM is innate or learnt, domain specific or domain general. However, many *autism* researchers (e.g., Baron-Cohen, 1989; Frith, 1989) have espoused an innate modularist view of ToM, following Leslie (1987).

5.1.2 Leslie's ToM Mechanism

Leslie (e.g., 1987; Leslie & Roth, 1993) has argued that ToM abilities emerge at around 18 months, as a consequence of the maturation of an innate, modular, cognitive system – the "theory of mind mechanism" (ToMM) – which allows the child to interpret agents' behaviours in terms of mental states. The ToMM is domainspecialised for the processing of mental states, using "M-representations"/ "metarepresentations"[15](Leslie & Roth, 1993) to describe the attitudes of agents towards propositions. M-representations are created by the "decoupling mechanism", which consists of three parts: the "expression raiser", the "manipulator", and the "interpreter". The expression raiser copies a "primary representation" (which veridically describes some aspect of the world) and places it in "decoupling marks," which quarantine and distinguish it from the original primary representation. This decoupled representation can then be manipulated such that it represents some imaginary or counterfactual situation. The most well used example of an M-representation is:

Mother PRETENDS [of] the banana [that] "it is a telephone"

Thus, the M-representation data structure specifies four pieces of information:

(1) an informational relation, specifying an attitude (e.g., PRETENDS)
(2) an agent (e.g., Mother)
(3) an aspect of reality, or anchor, described by a primary representation (e.g., it is a banana)
(4) an imaginary/counterfactual situation, described by a decoupled representation (e.g., it is a telephone)

In the case of the Sally-Anne task, the ToMM would need to create the following M-representation:

Sally BELIEVES [of] the marble [that] "it is in the box"

The claim that beliefs and pretences are represented in the same way raises the question of why we observe an asynchrony in the development of pretence and belief

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[15] Leslie (1987) adopted the term *metarepresentation* from Pylyshyn (1978) to refer to decoupled representations because they are essentially *representations of representations*. However, as Perner (1993) has highlighted, Leslie's intended meaning of the term departs from the original definition in which it meant, "representing the representational relation itself" – or *representing representations as representations*. The term metarepresentation will be used here in Pylyshyn's sense. The term *M-representation* will be used herein to refer to Leslie's (1987) concept of "metarepresentation".

understanding: 18-month-olds understand and engage in pretence but will not pass false belief tasks until age 4. Leslie's (e.g., Surian & Leslie, 1999) argument is that although children under the age of 4 years have the necessary conceptual *competence* to pass false belief tasks – they are capable of forming M-representations – they are limited by *performance* factors. Specifically, they lack the necessary processing resources. It is argued that the operation of the ToMM also depends upon receiving appropriate input from an additional system known as the "selection processor" (SP; Leslie & Roth, 1993; Leslie, German, & Polizzi, 2005). The SP must select the correct representation from a number of possibilities. There are at least two possible sets of contents for Sally's belief about the location of the marble: (a) "it is in the box" and (b) "it is in the basket." The true belief (b) is always more salient for the SP and will be selected by default. In order to correctly select (a), the content of (b) must be actively inhibited. It is argued that children younger than 4 do not have a sufficiently developed SP to enable this particular inhibitory process. Manipulations to false belief tasks, such as asking where Sally will look for her marble *first*, which are thought to make the *false* contents more salient, thereby reducing the inhibitory demands, have been shown to improve performance in typically developing children (Surian & Leslie, 1999).

There are, however, alternative explanations for 3-year-olds' difficulties with false beliefs. Contrary to Leslie's claims, these children may in fact lack the necessary conceptual *competence*. Perner (1991) has argued that false belief task failure is the result of an inability to represent a belief *as* a mental representation. Three-year-olds lack the explicit understanding that beliefs can bear either a true or false relation to reality. This is considered to be part of a domain-general difficulty with metarepresentation. As Zaitchik (1990, p.61) put it, "mental representations may not be hard because they're *mental* but because they're *representations.*" This hypothesis is given credibility by findings which show young children to have difficulty in reporting the contents of non-mental representations, such as photographs, when their content conflicts with reality.

5.1.3 The Case of False Photographs

The "false photograph task", originally designed by Zaitchik (1990), was modelled on the location change false belief task. The crucial manipulation was to ask the child about the representational contents of an out-of-date photo rather than an out-of-date belief. The task structure was roughly as follows: “Bert decides to take a photo of Rubber Duckie. He takes Rubber Duckie out of the bath and puts her on the bed. He takes a photo of her. Ernie then wants to go to bed so he puts Rubber Duckie back in the bath where she belongs. In the picture, where is Rubber Duckie?” Surprisingly, many typically developing 4- and even 5-year-olds could not answer this question correctly. These findings have been replicated in a number of studies (Leekam & Perner, 1991; Leslie & Thaiss, 1992; Sabbagh, Moses, & Shiverick, 2006). The fact that young children cannot assign counterfactuality to either beliefs or photographs suggests that they have problems understanding representations per se, not just mental representations.

It is clear that the domain-general account can explain both false belief and false photograph task performance. However, Leslie cannot appeal to the ToMM to explain false photograph performance: clearly reporting the propositional content of a photo could not be mediated by the mental state specific ToMM. Instead, he suggests that once again the SP is responsible for performance (Leslie & Thaiss, 1992). The critical evidence that should convince us of the domain-specific explanation, argue Leslie and Thaiss (1992), is derived from data obtained from samples of children with autism.

5.1.4 Autism and the ToMM

Both typically developing 3-year-olds and the majority of children with ASD fail false belief tasks. Leslie and Thaiss (1992) argue that these groups present a double-dissociation in the (dis)functioning of the selection processor and the ToMM: Typically developing 3-year-olds have intact ToMMs but underdeveloped SPs and fail ToM tasks because of performance limitations. By contrast, although children with autism have intact SPs, they fail because they lack the underlying *competence* required – they are “decoupling impaired” (Leslie, 1987, p.424) due to damage to the ToMM. Certainly, this could explain why both pretence (Jarrold, 2003) and understanding of belief is impaired in ASD. Consistent with this claim, children with autism are perfectly able to pass false photograph tasks (Leekam & Perner, 1991; Leslie & Thaiss, 1992). It is also found that children with autism do not benefit from being asked where Sally will look *first*, which arguably reduces the demands placed on the SP (Surian & Leslie, 1999). If children with autism had problems in selecting the correct representation, then we would expect such manipulations to improve performance. Despite these findings, there are a number of reasons to question whether false photograph tasks are sufficiently similar to false belief tasks to allow one to conclude that mental and non-mental representations are processed by unique mechanisms.

5.1.5 Why False Photos are not Equivalent to False Beliefs

There are a number of reasons to conclude that false belief and false photo tasks are not equivalent. Firstly, the tasks differ in structural terms: the false belief task involves more episodes and elements than the photo task (Bowler, Briskman, Gurvidi, & Fornells-Ambrojo, 2005). Secondly, and perhaps more fundamentally, beliefs and photographs have very different functions (Sabbagh et al., 2006). Whereas, a photo is "intended" to accurately *represent a specific time in the past*, a belief is intended to accurately *represent the present state of affairs* so far as is possible. In contrast to photos, which are (relatively) permanent, beliefs are continually updated in light of new information. Thus, a photograph is not a good analogue of a belief because their respective functions differ substantially[16]. Put another way, the "representational targets" of photos and beliefs differ (Perner, 2007). In false photo tasks there is no mismatch between representational target (Rubber Duckie on the bed) and representational content (Rubber Duckie on the bed) whereas in the false belief task there is an obvious mismatch between target (marble in the box) and content (marble in the basket).

5.1.6 False Signs/Signals: Better Analogues of False Beliefs

Parkin and Perner (1996, cited in Sabbagh et al., 2006; and by Perner, 2007) designed a task which did not suffer from same the limitations as the false photo task. Their task used false signs rather than false photos as non-mental representations. False signs are more similar to false beliefs because both are intended to accurately

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[16] This is not to say that a photograph could not be a good analogue of *any* mental state – certainly there would seem to be greater similarities between photos and *memories* than photos and beliefs, since both are intended to accurately represent a specific time in the past.

represent the present state of affairs. Sabbagh et al. (2006) used a version of the task devised by Parkin and Perner to test young typically developing children. The task involved a story with two dolls, two cardboard houses, and a sign. The story was roughly as follows: "Chester and Marianne were deciding whether to play in the red or blue house. Then Marianne got hungry. Chester told her to go ahead and get a snack and that he would leave the sign (an arrow) pointing to his location. Chester initially decided to go to the red house and he pointed the sign towards it. After a while, he decided to move to the blue house, but forgot to change the sign. Then Marianne returned wanting to find Chester." The test question was, "Where does the sign say Chester is?" Although, the sign was in their full view, children below the age of about 4 years found this task very difficult. Consistent with the analysis of the tasks, performance on false belief tests was highly correlated with false sign tests and only moderately correlated with false photograph tests (Sabbagh et al., 2006), thus suggesting that the false sign test was a better analogue.

The arguments outlined so far present the serious possibility that the dissociation between photo and belief performance in ASD is not due to the mental/non-mental distinction but, rather, to other aspects of the task. However, these findings from typical development still fail to distinguish between the domain-specific and domain-general accounts – it could be argued, as with the false photo task, that separate systems are responsible for dealing with signs and mental representations; they just happen to develop at the same time. More convincing evidence, however, was provided by a study of false signs in ASD. Bowler et al. (2005) used a non-social false sign task: the train task. It was based around a model airport which had a yellow and a blue landing pad, and a driverless delivery train that collected items from the planes upon landing. It was explained that if a plane landed on the yellow pad, the yellow signal light was activated, and if it landed on the blue pad, the blue signal light was activated, and that the train automatically went to the yellow pad if the yellow light was shown and the blue pad if the blue light was shown. Next, the children were told, "Now the plane comes in to land on the yellow pad. Oh! Look! The blue light has come on. The plane's on the yellow pad but the blue light is on," and asked, "Where will the train go now?" The correct answer being the blue pad. Even though the signal was "false", the train would still head for the pad of the colour corresponding to the light. Children were also given the Sally-Anne task. The results were striking: performance on the Sally-Anne and train tasks was strongly associated in children with autism, matched controls and a typically developing group. The tasks were also found to be equally difficult. The same results were found when the task was modified such that a bird rather than a plane triggered the activation of a signal light, thereby incorrectly signalling the train to travel to the corresponding pad. These findings have a direct bearing on the claim that the hypothesised decoupling impairment "will not fundamentally affect the autistic child's apprehension of physical artefacts, including representational artefacts such as photographs or maps" (Leslie & Roth, 1993, p.92). After all, a sign is a purely physical artefact.

What underlies ToM, as it was originally defined by Premack and Woodruff (1978), is clearly still yet to be fully understood. One particularly interesting issue concerns whether ToM for self operates according to the same principles as ToM for other as was implied by this original definition. In typical development, understanding own and others' mental states appears to develop in tandem (Gopnik & Meltzoff, 1992). Less is known about own mental state understanding in ASD. Frith and Happé (1999) have argued ToM impairments mean that individuals with autism are not able to introspect upon their internal mental states and "may know as little about their own minds as about the minds of other people" (Frith & Happé, 1999, p.7).

It has been shown, for example, that children with autism have equal difficulty attributing knowledge or ignorance to self or other depending upon whether that person has had informational access to that knowledge (e.g., though seeing or being told about a piece of information) (Kazak et al., 1997; Perner et al., 1989). Furthermore, they find it difficult to distinguish their own intended from unintended actions. In particular, when their unintended actions have a desirable outcome they show a tendency to claim that their action was, in fact, intended (Philips et al., 1998). In relation to false belief understanding, the Smarties "self" question ("Before you saw inside the tube, what did *you* think was in it?") is as difficult as the "other" question for children with ASD (Fisher et al., 2005). These difficulties with understanding one's own mental states clearly have implications in terms of effecting autonoetic awareness. This issue will be discussed further in Chapter 8.

5.1.7 Aims of the Current Chapter

The purpose of the current chapter was to present the results from the ToM tasks which were used as part of the larger battery of tests. The results from the see-know, Sally-Anne, and Smarties tasks are presented in sections 5.2, 5.3, and 5.4 respectively. Results from each of the three experiments are then summarised at the end of the chapter in the general discussion (section 5.5). In light of previous research, it was predicted that participants with ASD would be impaired across all three tasks.

5.2 SEE-KNOW

5.2.1 Method

5.2.1.1 Participants

Only those participants who passed 5/6 control questions were included (see Chapter 2, section 2.2.3.2). The final ASD and comparison groups each consisted of 33 participants who were individually matched on VMA and CA (see Table 5.1 for participant details). The groups did not differ significantly in terms of VMA, $t(64) = 0.10$, $p = .92$, $r = .01$, CA, $t(61.62) = 0.56$, $p = .58$, $r = .07$, or VIQ, $t(59.88) = -1.07$, $p = .29$, $r = .14$. Although participants were not explicitly matched on sex, the percentage of males was fairly similar for both groups: 81.8% and 72.7% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .73$, $p < .01$) and comparison ($r = .78$, $p < .01$) groups.

Table 5.1

Participant Characteristics

	ASD	**Comparison**
n	33 (6 female)	33 (9 female)
VMA		
M	6.79	6.74
SD	2.28	2.08
Range	2.92 – 11.33	3.17 – 10.83
CA		
M	10.39	9.85
SD	3.49	4.26
Range	5.08 – 16.75	3.58 – 15.42
Verbal IQ		
M	74.88	79.48
SD	15.08	19.72
Range	39 – 102	42 – 117

5.2.1.2 Procedure

For full details of the see-know task procedure see Chapter 2, section 2.2.2.2.

5.2.2 Results

Group differences in performance on the see-know task were analysed using a 2 × 2 (Group × See-Know) chi-square test, which indicated that there was a significant association between the variables, χ^2 (1, N = 66) = 3.67, p = .05, ϕ = .24 (see Table 5.2 for frequencies of passes and fails by group). This appeared to be due to the fact that individuals in the comparison group were 3.75 times more likely to pass the task than individuals in the ASD group.

Table 5.2

Number of See-Know Passes and Fails for the ASD and Comparison Groups

	Group	
See-know	ASD (% of group)	Comparison (% of group)
Fail	9 (27.3%)	3 (9.1%)
Pass	24 (72.7%)	30 (90.9%)

5.3 SALLY-ANNE

5.3.1 Method

5.3.1.1 Participants

Only those participants who passed both the memory and reality control questions on the Sally-Anne task were included in the sample (see Chapter 2, section 2.2.3.2). The final ASD and comparison groups each consisted of 33 participants who were individually matched on VMA and CA. Participant characteristics are displayed in Table 5.3. The groups did not differ significantly in terms of VMA, $t(64) = -0.11$, $p = .91$, $r = .01$; CA, $t(64) = 0.41$, $p = .68$, $r = .05$; or VIQ, $t(64) = -0.79$, $p = .43$, $r = .10$, and, although participants were not specifically matched on sex, the percentage of males was similar for both groups: 78.8% and 72.7% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .56$, $p < .01$) and comparison ($r = .64$, $p < .01$) groups.

Table 5.3

Participant Characteristics

	ASD	Comparison
n	33 (7 female)	33 (9 female)
VMA		
M	6.45	6.51
SD	2.24	2.06
Range	2.92 – 11.25	3.17 – 10.83
CA		
M	10.51	10.12
SD	3.44	4.09
Range	5.08 – 16.75	3.33 – 15.67
Verbal IQ		
M	71.82	75.64
SD	17.95	21.20
Range	39 – 102	39 – 106

5.3.1.2 Procedure

For full details of the Sally-Anne task procedure see Chapter 2, section 2.2.2.2.

5.3.2 Results

Table 5.4 displays the number of Sally-Anne passers and failers in each group. A chi-square test revealed a significant association between group and Sally-Anne task performance, $\chi^2(1, N = 66) = 6.99, p = .02, \phi = .33$. The phi coefficient indicated that this association was moderate[17]. Finally, the odds ratio showed that individuals in the

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[17] Following Rea & Parker (1997), effect sizes of phi were interpreted as negligible (.00 to .09), weak, (.10 to .19), moderate (.20 to .39), relatively strong (.40 to .59), strong, (.60 to .79), and very strong (.80 to 1.00).

ASD group were 5.71 times more likely fail the task than individuals in the comparison group.

Table 5.4

Number of Sally-Anne Passers and Failers in the ASD and Comparison Groups

	Group	
Sally-Anne	ASD (% of group)	Comparison (% of group)
Fail	12 (33.4%)	3 (9.1%)
Pass	21 (66.6%)	30 (90.9%)

5.4 SMARTIES

5.4.1 Method

5.4.1.1 Participants

Only those participants who passed the reality control question from the Smarties task were included in the sample (see Chapter 2, section 2.2.3.2). The final ASD and comparison groups each consisted of 41 participants who were individually matched on VMA and CA. Participant characteristics are displayed in Table 5.5. The groups did not differ significantly in terms of VMA, $t(80) = -0.24$, $p = .81$, $r = .03$; CA, $t(80) = 0.41$, $p = .68$, $r = .05$; or VIQ, $t(80) = -1.03$, $p = .31$, $r = .11$, and, although participants were not individually matched on sex, the percentage of males was fairly similar for both groups: 70.7% and 73.2% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .65$, $p < .01$) and comparison ($r = .70$, $p < .01$) groups.

Table 5.5

Participant Characteristics

	ASD	**Comparison**
n	41 (12 female)	41 (11 female)
VMA		
M	6.41	6.53
SD	2.22	2.10
Range	2.92 – 11.33	3.08 – 10.83
CA		
M	10.22	9.86
SD	3.62	4.20
Range	5.00 – 16.75	3.58 – 15.67
Verbal IQ		
M	73.44	77.78
SD	17.03	20.98
Range	39 – 102	39 – 107

5.4.1.2 Procedure

For full details of the Smarties task procedure see Chapter 2, section 2.2.2.2.

5.4.2 Results

The number of Smarties "self" and "other" passers and failers in each group are displayed in Table 5.6. Group differences in performance on the "other" question were analysed using a chi-square test, which revealed a significant association between group and task performance, $\chi^2(1, N = 82) = 7.57$, $p = .05$, $\phi = .30$. The phi coefficient indicated that this association was of moderate strength. When the odds ratio was calculated, it was found that individuals in the ASD group were 3.73 times more likely fail the "other" question than individuals in the comparison group.

A second chi-square analysis was used to examine group differences on the "self" question. The association between group and task performance was again found to be significant, $\chi^2(1, N = 82) = 4.00$, p (one-tailed) = .04, $\phi = .22$. The phi coefficient indicated an association of moderate strength. This appeared to be due to the fact that individuals in the comparison group were 3.39 times more likely to pass the question than those in ASD group.

Table 5.6

Number of Smarties "Self" and "Other" Passers and Failers in the ASD and Comparison Groups

	Group	
	ASD (% of group)	Comparison (% of group)
Smarties "Other"		
Fail	21 (51.2%)	9 (22.0%)
Pass	20 (48.8%)	32 (78.0%)
Smarties "Self"		
Fail	11 (26.8%)	4 (9.8%)
Pass	30 (73.2%)	37 (90.2%)

The next analyses aimed to assess whether the Smarties "self" and "other" questions varied in difficulty. Table 5.7 displays the number of participants passing/failing Smarties "other" and passing/failing Smarties "self". McNemar's tests were used to assess the relative difficulty of the "self" and "other" questions within each group. These indicated that for the ASD group, the "self" question was significantly easier than the "other" question, $\chi^2(1, N = 41) = 9.48$, McNemar's $p < .01$, but for the comparison group, "self" and "other" were not shown to vary systematically in difficulty, $\chi^2(1, N = 41) = 7.28$, McNemar's $p = .13$. Ceiling effects may, however, have masked the true pattern in this group.

Table 5.7

Number of Participants Passing/Failing Smarties Other and Passing/Failing Smarties Self

	Smarties "Other"	
Smarties "Self"	Fail	Pass
ASD		
Fail	10	1
Pass	11	19
Comparison		
Fail	3	1
Pass	6	31

5.5 SUMMARY AND DISCUSSION

Consistent with predictions, participants with ASD were found to perform significantly less well than comparison participants on the Sally-Anne, Smarties "self" and "other", and see-know test questions. The results represent a replication of the many published studies which have found ToM impairments in ASD.

One finding that was particularly interesting, however, concerned the apparent discrepancy in performance on the Smarties "self" and "other" questions. Previous research has indicated that children with ASD find these questions equally difficult, whereas children with MLD find the "self" question significantly easier than the "other" question (Fisher et al., 2005). The opposite pattern was observed in the current study: for participants with ASD, but not for comparison participants, the "self" question was found to be significantly easier than the "other" question.

One explanation for this could simply be that awareness of one's own mental states is not as markedly diminished as awareness of others' mental states in individuals with ASD. This contradicts the position held by Frith and Happé (1999), who have argued that impaired ToM should equally affect the ability to attribute mental states to self and other – that impaired ToM should result in an impaired awareness of one's own mental life. Indeed, it is true to say that the individuals with ASD in the current sample were impaired on the "self" question, relative to comparison individuals: they were significantly worse at both attributing a false belief to another person and recalling their own previous false belief. However, they were significantly less likely to fail the "self" question than they were the "other" question.

However, it is possible that these self-other differences do not genuinely reflect differences in ToM for self and other. The task demands for each of these test questions differ substantially. Responding to the "self" question may not require one to recall one's previous belief (or impute a belief to one's past self) but, rather, it may require one to recall one's previous *verbalisation* of one's previous belief. That is, children may simply have recalled what they said without explicit reference to their mental state. In recalling what they said, they are reporting the *content* of their belief "without any guarantee that they also understand that they were holding this content as a belief" (Perner, Baker, & Hutton, 1994, p.278).

This argument is consistent with the fact that Fisher et al. (2005) found that children with ASD showed equivalent performance on the self and other questions when the verb "think", rather than "say" (as in the present experiment), was used in the test questions. Moreover, there is some evidence to suggest that when their original false belief is not verbally stated, children with autism have significantly more difficulty in reporting their own previous false belief than in predicting another's false belief (Williams & Happé, 2007).

The finding that children with ASD showed diminished performance on the see-know task provides more convincing evidence, than that previously published by Baron-Cohen and Goodhart (1994), that understanding of the perception-knowledge relationship is impaired in ASD. All of the children included in the sample were able to recall a piece of information and make an inference on the basis of that information, as indicated through their successful performance on the control tasks.

The children with ASD had a specific problem when they were required to recall who had and who had not seen inside the box and make an inference about the knowledge/ignorance of those protagonists on this basis.

CHAPTER 6: Assessing the Relationship Between Language and "Theory of Mind" in ASD

6.1 GENERAL INTRODUCTION

Despite the fact that, as a population, individuals with ASD show impaired performance on "theory of mind" (ToM) tasks (see Chapter 5), there are nonetheless many individuals who pass these tasks. For example, even in the original Baron-Cohen et al. (1985) study of false belief understanding, 20 per cent of the children with autism passed the task. If the core features of ASD are the result of an attenuated ToM mechanism (ToMM), as many researchers have maintained (e.g., Baron-Cohen, 1995; Frith, 1989; Leslie, 1987), then such findings must be accounted for. One argument, which preserves the integrity of the ToM hypothesis of autism, is that those individuals who pass the tasks do so by using compensatory strategies. For example, Bowler (1992) suggested that intellectually able people with ASD may be able to apply their *cognitive* resources in order to compute solutions to these problems which would typically be solved using *emotional* processes. It was argued that such cognitive routes, although sufficient for solving ToM tests, would be too slow and cumbersome for flexible application in real-life social situations, explaining why people with ASD who pass ToM tasks still display social oddities. Happé (1995) adopted a similar explanation, suggesting that some individuals with autism may use verbally mediated strategies in order to "hack out" solutions to ToM tasks.

6.1.1 Language and "Theory of Mind"

The proposal that verbal strategies facilitate ToM test performance in people with ASD is consistent with the substantial amount of data which shows there to be a particularly strong relationship between language and ToM within this population (see Tager-Flusberg, 2000; and Tager-Flusberg & Joseph, 2005, for summaries). Lexical knowledge is one aspect of language found to be related to ToM performance. For example, Happé (1995) conducted a meta-analysis of all the studies to date which had used the "Sally-Anne" location change (Baron-Cohen et al., 1985) and "Smarties" unexpected contents (Perner et al., 1989) false belief tasks and the British Picture Vocabulary Scale (Dunn et al., 1997) as a measure of receptive vocabulary. She included data from a group of 70 children with autism and a group of 34 children with learning difficulties, of similar age and ability level. A dichotomous system was used to score false belief understanding, such that, to "pass", the child had to correctly answer the test questions from both the Sally-Anne and Smarties tasks. Failing either one or both tasks resulted in a "fail". In the ASD group, false belief score was significantly correlated with vocabulary (strongly) and verbal IQ (moderately). The correlation with chronological age was not significant, however. In the learning difficulties group, the opposite pattern was evident: false belief score was significantly (negatively) correlated with age but not vocabulary or verbal IQ. Happé also found that for the ASD group, unlike for the learning difficulties group, false belief passers had significantly higher verbal mental ages than failers (passers: M = 9.58, SD = 3.87; failers: M = 5.42, SD = 1.75). Calculating the effect size indicates that the difference was large (r = .57). Furthermore, logistic regression analyses indicated that for the ASD group, the only significant predictor of false belief task performance was VMA. No predictor was significant for the comparison group; possibly because of the relatively small sample size. These findings clearly indicate a relationship between false belief understanding and language, as measured by receptive vocabulary, for children with autism.

More recently, Fisher et al. (2005) conducted another large scale (prospective) study to examine the role of age and language, including both vocabulary and grammar, on false belief task performance in a sample of 63 children with ASD and 118 children with moderate learning difficulties (MLD). The inclusion of a larger group of comparison participants in this study allows one to draw firmer conclusions about patterns of performance in this group. They found significant correlations between false belief understanding and age, receptive vocabulary scores, and receptive grammar scores for both groups. Notably, the correlation with grammar was *significantly* stronger in the ASD group than in the MLD group. Logistic regression analyses indicated that for the ASD group, both vocabulary and grammar, but not age, were significant predictors of false belief performance. For the comparison group vocabulary and age, but not grammar, were significant predictors.

Together, these studies indicate that language and false belief task performance are intimately linked. Both studies found a relationship with receptive vocabulary among individuals with ASD and the Fisher et al. (2005) study suggests that this relationship is somewhat stronger for individuals with ASD than for those with MLD. As Fisher et al. point out, the direction of causality with respect to this relationship does remain somewhat uncertain, however. Although good lexical knowledge may indeed facilitate performance in false belief tasks, it is also possible that good early “ToM skills”, such as joint attention, enhance vocabulary acquisition (Baldwin, 1995; Morales, Mundy, Delgado et al., 2000). Fisher et al. argue that the observed relationship with grammar is less ambiguous, since early ToM skills are unlikely to directly affect the acquisition of grammar. They conclude that grammatical competence may be a precursor of ToM, playing a particularly important role for individuals with ASD. Indeed, in typical development, at least, it has been found that longitudinally, grammar predicts later-ToM, but ToM does not predict later-grammar (Astington & Jenkins, 1999).

6.1.2 Complement Syntax and False Belief Understanding

Tager-Flusberg (2000) has also argued that grammatical competence may be important for grasping the nature of false beliefs. However, she has emphasised the possible role of a specific type of grammatical competence: the syntax of complementation. This argument is derived from de Villiers’ theoretical account of false belief task performance in typical development (e.g., de Villiers, 1995; de Villiers & de Villiers, 2000). De Villiers has argued that a specific type of linguistic competence is required for the mastery of false belief tasks. Her theory of “linguistic determinism” suggests that once a child has developed the syntax and understood the semantics of complementation, they have available a new capacity for representing propositional attitudes – the linguistic structure provides the necessary representational format. Complementation is a syntactic process which allows one propositional argument to be embedded under another proposition. Both communication (e.g., “say”, “tell”) and mental state verbs (e.g., “think”, “believe”, “know”) can take embedded sentential complements. For example:

(a) “She said *she was drawing a face*, but it was really a scribble.”
(b) “Sally thought *the marble was in the box*, but it was really in the basket.”

The semantics of complement structures mean that the embedded proposition – the complement (depicted in italics in (a) and (b) above) – can itself be either true or false without affecting the truth value of the sentence as a whole. It is this feature of sentential complements – that is, their "open truth value" – that is said to make them ideal for representing false beliefs. It is argued that complementation is initially appropriated in relation to communication verbs which, like mental state verbs, can take objectively true or false complements. The child must then "bootstrap his way to a full mastery of mental verbs and their complements" (de Villiers & Pyers, 2002, p.1056).

De Villiers and Pyers (2002) conducted a longitudinal study to examine this relationship. They used a "memory for complements" task to assess complement syntax understanding, and typical location change and unexpected contents tasks to assess false belief understanding. The memory for complements paradigm involves presenting children with short stories containing an embedded complement which are followed by questions which require the child to disembed that complement from the sentence. For example, "She said *she found a monster under her chair*, but it was really the neighbour's dog. What did she say?" They found that memory for complements embedded under communication verbs was significantly correlated with performance on the location change false belief task. The correlation with the unexpected contents task approached significance. Longitudinally, memory for communication complements predicted false belief understanding three months later, even after controlling for mean length of utterance and grammatical complexity. False belief understanding did not predict later memory for complements. Two training studies also support the hypothesised link between complement syntax and false belief task performance (Hale & Tager-Flusberg, 2003; Lohmann & Tomasello, 2003).

There are some potentially serious concerns with de Villiers' theory, however. For example, Cheung et al. (2004) found that after controlling for receptive vocabulary and grammar, memory for complements did not account for a significant proportion of variance in ToM scores. Other studies of typical development also cast doubt on some of the specifics of the account. De Villiers' theory aims to explain the developmental lag between desire and belief understanding, again in terms of the language used to represent each of these states. English-speaking children seem to understand *infinitive* "to" complements, as required for representing desires, earlier than the more sophisticated *tensed* "that" complements, used to represent beliefs (Roeper & de Villiers, 1994) as shown below in (c) and (d) respectively.

(c) "Big Bird forgot *to invite Bert to the party*"
(d) "Big Bird forgot *that he invited Grover to the party*"

However, this aspect of the theory is challenged by evidence obtained from Mandarin-, Cantonese-, and German-speaking children. In Mandarin and Cantonese, both beliefs and desires are encoded with the same fairly simple grammatical construction and yet children still talk about desires substantially earlier than beliefs (Tardif & Wellman, 2000), just as English-speaking children do (Bartsch & Wellman, 1995). Furthermore, in German both terms require the more sophisticated "that" complements and yet young German-speaking children still use and comprehend expressions of desires at an early age (Perner et al., 2003). These studies strongly suggest that the developmental lag between desire and belief understanding cannot be the consequence of differences in the language used to represent them, casting serious doubts on the idea of linguistic determinism.

However, even if false belief understanding is not linguistically determined in typical development, there remains the possibility that some children *with ASD* do "bootstrap their way" to a mastery of false belief understanding through learning about complement structures. A similar proposal was put forward by Leslie and Roth (1993) who suggested that, "verbally able autistic children are eventually able to exploit the fact that verbal expressions lay out the structure of propositional attitudes…using a unique verb-argument structure where the object of the verb is another sentence" (Leslie & Roth, 1993, pp.103-104). There has in fact been some work aimed at assessing whether children with autism need to have mastered the syntax of complementation in order to pass false belief tasks.

6.1.3 Complement Syntax and "Theory of Mind" in Autism

Tager-Flusberg (2000) reports data from two tasks which aimed to assess the relationship between complement syntax and false belief understanding in autism. Her sample included 20 children with autism and 20 matched comparison children. The participants were told stories which were followed by "wh-questions", such as, "When did the girl think/say that she broke the radio?" Half of the questions included communication verbs and half included mental state verbs. Answers to these questions were used as an index of knowledge of complement constructions. A location change task was used to measure false belief understanding. Tager-Flusberg reports that false belief passers gave significantly more correct responses to the wh-questions than failers. However, since general language ability was not controlled for, it is not possible to say whether these differences were merely a reflection of superior overall language amongst false belief passers. In an attempt to control for general language ability, she performed regression analyses for each of the groups, including receptive vocabulary, syntactic knowledge, communication verb performance, and mental state verb performance as predictors, with false belief understanding as the outcome variable. For the ASD group, the only significant predictor was performance on communication verbs. For the comparison group, the only significant predictor was performance on mental state verbs. Unfortunately, it is not possible to draw valid conclusions from these results. The use of multiple regression in this context was inappropriate, given the sample sizes involved. Four predictor variables were used with sample sizes of 20. The bare minimum sample size required for a regression analysis is 10 to 15 participants per predictor (Field, 2005). Tager-Flusberg's samples clearly fell well short of this.

In a second study, Tager Flusberg (2000) used a memory for complements task, similar to that used by de Villiers and Pyers (2002; described above), using the verb, "say". Both true and false complements were included. For both groups, participants who passed the false belief task gave significantly more correct responses to the false complement stories and for the autism group only, this relationship held even when the complements represented the true state of affairs. It was concluded that because participants with autism who failed the false belief task had difficulty with both true and false complements, they must have difficulties with both the syntax (true complements) and semantics (false complements) of complementation. Again, the fact that general language level was not controlled for means a specific relationship between complementation and false belief understanding was not isolated.

Building on the previous study, Tager-Flusberg and Joseph (2005) aimed to explore the relationship between complement syntax and ToM, both cross-sectionally and longitudinally, in a group of participants with autism. Again, they used a memory for complements task. They gave participants two questions each of four types of complement: (1) true communication; (2) false communication; (3) true mental; and (4) false mental verbs. Separate scores were derived for each of these four types of complement. They also measured receptive and expressive vocabulary as well as expressive syntax. ToM scores were derived from responses to a series of test questions across three ToM tasks, including location change and unexpected contents false belief tasks, and a perception-knowledge test. They conducted a regression analysis ($N = 35$), entering age and expressive syntax on the first step and the four types of complement score on the second step. Of these variables, the only significant predictor was the false communication complement score, which explained 25.3% of the variance in concurrent ToM scores. A follow-up analysis was then conducted excluding the true and false mental complement predictors. This analysis showed true and false communication complements to respectively account for 18% and 9% of the variance. As in the previous study, it was argued that the fact that this second analysis showed there to be a relationship between both true and false complements and ToM, indicated the importance of knowledge of both syntactic (true) and semantic (false) properties of complements. However, given that true complements were not shown to be significant in the first analysis, there was no justification for including this predictor in the follow-up regression.

Tager-Flusberg and Joseph (2005) also report analyses of longitudinal data. Here, ToM at Time 1 and expressive syntax were included on the first step and the four types of complement score were entered on the second step. Of these, the only significant predictor, once again, was the false communication complement score, which explained 5.8% of the variance in ToM scores measured one year later. They also analysed whether ToM at Time 1 predicted later complement scores, finding null results. From these findings, the authors concluded that knowledge of sentential communication complements fostered a mastery of tasks requiring a representational understanding of mind. As for the studies reported by Tager-Flusberg (2000), there are reasons to question these interpretations. First of all, the inclusion of a perception-knowledge test as part of a ToM composite is rather strange, given that complement syntax is thought to be related specifically to the representation of false beliefs. Secondly, no control group was included. And, thirdly, the use of multiple regression was clearly inappropriate, once again. In the initial concurrent regression, 6 predictor variables were included with a sample size of 35. In the longitudinal regression, again, 6 predictors were used, this time with just 25 participants. Overall, the evidence for the role of complement syntax understanding in false belief task performance in autism is not convincing. It is unfortunate that these potentially fascinating studies are let down by inappropriate statistical analyses. Consequently, it is still unknown whether complement syntax understanding genuinely plays a role in false belief task performance of children with ASD.

6.1.4 Aims of the Current Chapter

The aim of the current chapter was to consider the relationship between false belief task performance and other variables such as age, receptive vocabulary, verbal IQ and complement syntax understanding. Section 6.2 considers the roles of age, verbal IQ and receptive vocabulary, in order to compare the results obtained in the present study to those obtained by Happé (1995) and Fisher et al. (2005). Section 6.3 considers the relationship between Sally-Anne and complement syntax test performance and section 6.4 examines the relationship between Smarties and complement syntax test performance. If some children with ASD use their linguistic knowledge of complement structures to pass false belief tasks, then one would expect false belief passers to have significantly higher complement syntax scores than false belief failers. This pattern should be less evident in the comparison group.

6.2 THE ROLE OF AGE, RECEPTIVE VOCABULARY, AND VERBAL IQ IN FALSE BELIEF TASK PERFORMANCE

6.2.1 Introduction

Both Happé (1995) and Fisher et al. (2005) found that amongst participants with ASD, false belief passers had significantly higher VMAs than failers. They did not, however, have significantly higher CAs than failers. Although Fisher et al. did not consider VIQ, Happé found that amongst children with ASD, false belief passers had significantly higher VIQs than failers. In terms of the variables which correlated with false belief performance, Happé found that within the ASD group, false belief was significantly correlated with VMA and VIQ but not CA. Fisher et al. found that false belief performance was significantly correlated with VMA and CA. Both Happé and Fisher et al. also attempted to establish which variables predicted passing/failing false belief tasks using logistic regression. Happé found that within the ASD group, VMA, but not CA or VIQ, was a significant predictor of false belief task performance. Fisher et al. also found that VMA but not CA was a significant predictor of false belief task performance in the ASD group.

Happé (1995) and Fisher et al. (2005) found somewhat disparate results within their comparison groups. Happé did not find significant differences in VMA, CA, or VIQ between false belief passers and failers. However, using a far larger sample, Fisher et al. (2005) found that false belief passers had significantly higher VMAs and CAs than failers (VIQ was not considered). However, the effect sizes were smaller than those obtained with the ASD group. Happé (1995) found that within the comparison group, false belief performance was not significantly correlated with VMA or CA. It was, however, significantly but negatively correlated with VIQ. By contrast, Fisher et al. (2005) found that VMA and CA *were* significantly correlated with false belief for the comparison group. These correlations were weaker, although not significantly so, than for the ASD group. Happé found that neither VMA, nor CA, nor VIQ were significant predictors of false belief performance in the comparison group. Fisher et al. found that both vocabulary and age were significant predictors of false belief task performance.

Thus, the main questions to be addressed here were: (1) did false belief passers have significantly higher VMAs, CAs, or VIQs than false belief failers in either the ASD or comparison group and (2) was false belief performance correlated with VMA, CA, or VIQ in either group. Composite false belief scores were used in this section.

6.2.2 Method

6.2.2.1 Participants

Only those participants who passed both the Sally-Anne and Smarties false belief control tasks were included (see Chapter 2, section 2.2.3.2). The final ASD and comparison groups each consisted of 32 participants who were individually matched on VMA and CA (see Table 6.1 for participant characteristics). The groups did not differ significantly in terms of VMA, $t(62) = -0.09$, $p = .93$, $r = .01$; CA, $t(62) = 0.37$, p

= .71, $r = .05$; or VIQ, $t(62) = -0.68$, $p = .50$, $r = .09$, and, although participants were not explicitly matched on sex, the percentage of males was very similar for each group: 78.1% and 75.0% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .52$, $p < .01$) and comparison ($r = .61$, $p < .01$) groups.

Table 6.1

Participant Characteristics

	ASD	**Comparison**
n	32 (7 female)	32 (8 female)
VMA		
M	6.57	6.61
SD	2.19	2.00
Range	2.92 – 11.25	3.25 – 10.83
CA		
M	10.67	10.34
SD	3.35	3.97
Range	5.83 – 16.75	4.58 – 15.67
Verbal IQ		
M	71.69	75.03
SD	17.99	21.25
Range	39 – 102	39 – 106

6.2.2.2 Procedure

Data from the Sally-Anne and Smarties tasks are considered here. See Chapter 2, section 2.2.2.2 for details of the procedures.

6.2.2.3 Coding

A dichotomous composite false belief scoring system was created in order to compare the results to those obtained by Happé (1995) and Fisher et al. (2005). Following Fisher et al., to be coded as a “passer”, all three false belief questions – Sally-Anne, Smarties “self” and Smarties “other” – had to be answered correctly: any incorrect response at all resulted in being coded as a “failer”.

6.2.3 Results

Table 6.2 displays the numbers and percentages of false belief passers and failers in the ASD and comparison groups. The majority of the ASD group failed (at least one question) and the majority of the comparison group passed (all three questions). The association between Group and False belief task performance proved to be significant and moderately strong, $\chi^2(1, N = 64) = 5.11, p = .04, \phi = .28$, and appeared to be due to the fact that individuals in the comparison group were 3.22 times more likely pass than individuals in the ASD group.

Table 6.2

Number of False Belief Passers and Failers in the ASD and Comparison Groups

False belief	**Group**	
	ASD (% of group)	Comparison (% of group)
Fail	19 (59.4%)	10 (31.3%)
Pass	13 (40.6%)	22 (68.8%)

Next, the VMA, CA, and VIQ characteristics of false belief passers and failers in each group were considered. A series of 2 × 2 (Group × False belief) ANOVAs were conducted in order to address the question of whether there were significant differences in VMA, CA, or VIQ between false belief passers and failers within the ASD or comparison groups. Mean VMAs, CAs, and VIQs are displayed according to group and false belief score in Table 6.3.

When VMA was the dependent variable, the main effect of Group was not significant, $F(1,60) = 0.62, p = .43, r = .10$; the main effect of False belief was significant, $F(1,60) = 11.12, p < .01, r = .40$; and the Group by False belief interaction was not significant, $F(1,60) = 0.38, p = .54, r = .08$. Although the interaction was not found to be significant, it was of particular interest to compare the magnitude of the effect for each of the groups. It was found that the effect size[18] for the difference in VMA between false belief passers and failers was greater for the ASD group (r = .45) than for the comparison group (r = .36).

When CA was the dependent variable, neither the main effect of Group, $F(1,60) = 0.55$, $p = .46$, $r = .10$; nor the main effect of False belief, $F(1,60) = 2.37$, $p = .13$, $r = .19$; nor the Group by False belief interaction, $F(1,60) = 0.20$, $p = .69$, $r = .06$, were significant.

Again, when VIQ was the dependent variable, neither the main effect of Group, $F(1,60) = 0.21$, $p = .65$, $r = .06$; nor the main effect of False belief, $F(1,60) = 0.40$, $p = .53$, $r = .08$; nor the Group by False belief interaction, $F(1,60) < 0.00$, $p = .99$, $r < .01$, were significant.

Table 6.3

Mean (SD) VMAs, CAs and VIQs According to Group and False Belief Score

Group	False belief	*N*	VMA	CA	VIQ
ASD					
	Pass	13	7.76 (1.88)	11.80 (3.72)	73.37 (17.23)
	Fail	19	5.74 (2.11)	9.90 (2.90)	70.37 (17.23)
	Total	32	6.57 (2.18)	10.67 (3.34)	71.69 (17.99)
Comparison					
	Pass	22	7.05 (2.10)	10.66 (4.01)	76.09 (18.72)
	Fail	10	5.66 (1.39)	9.62 (3.99)	72.70 (26.98)
	Total	32	6.61 (2.00)	10.34 (3.96)	75.03 (21.25)
Total					
	Pass	35	7.31 (2.10)	11.09 (3.89)	75.17 (18.80)
	Fail	29	5.72 (1.70)	9.80 (3.25)	71.17 (20.64)
	Total	64	6.59 (2.08)	10.50 (3.64)	73.35 (19.60)

Next, the relationship between false belief performance and CA, VMA, and VIQ was explored for each of the groups by calculating point biserial correlations. The coefficients are displayed in Table 6.4 and show that the only variable to be

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[18] Here, the effect size r was derived from the means and standard deviations. Firstly Cohen's d was calculated and r was then derived from this: $d = [M_1 - M_2] / [\sqrt{(SD_1^2 + SD_2^2 / 2)}]$; $r = d / [\sqrt{(d^2 + 4)}]$

significantly correlated with false belief performance for either group was VMA. Both of these correlations were positive and moderately strong. Fisher's *z* transformations indicated that the correlations for the ASD and comparison groups did not significantly differ ($z_{r1-r2} = 0.57$). In Figures 6.1 and 6.2 false belief passers and failers are plotted according to VMA and CA. These figures indicate that the distributions were fairly similar for both groups.

Table 6.4

Point Biserial Correlations Between False Belief (FB) and VMA, CA, and VIQ for the ASD and Comparison Groups

	Group	
	ASD	Comparison
FB × VMA	.46**	.33*
FB × CA	.28	.12
FB × VIQ	.09	.09

* *p* (one-tailed) < .05, ** *p* < .01

Figure 6.1

Scatterplot of ASD Group False Belief Passers and Failers Plotted According to Chronological and Verbal Mental Age

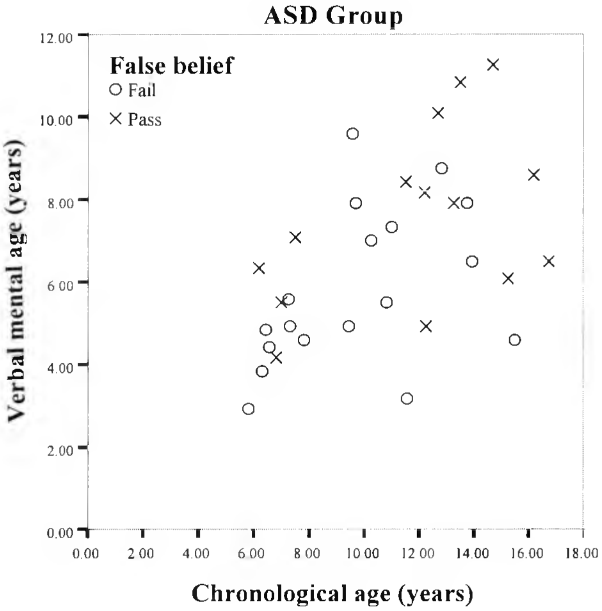
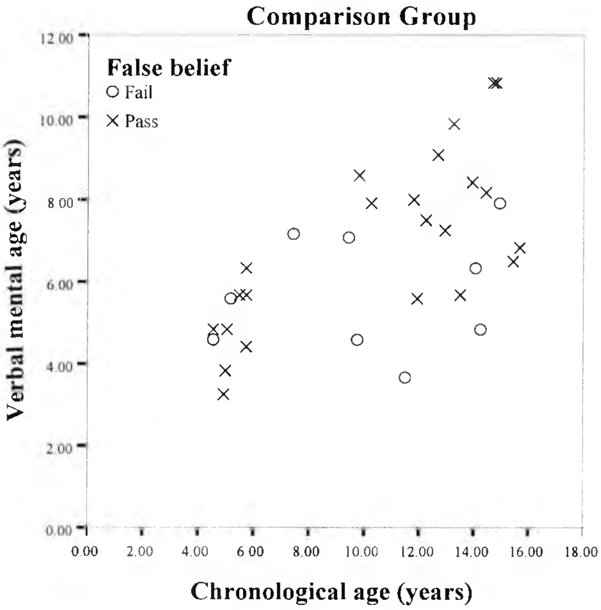


Figure 6.2

Scatterplot of Comparison Group False Belief Passers and Failers Plotted According to Chronological and Verbal Mental Age



6.2.4 Summary

As expected, participants with ASD were significantly more likely, in fact over three times more likely, than comparison participants to fail one or more of the false belief tasks. Nevertheless, a substantial proportion (40.6%) passed all three tasks, allowing the question of *how* individuals with ASD pass false belief tasks to be considered.

The first question of interest was whether false belief passers had significantly higher VMAs, CAs, or VIQs than false belief failers in either the ASD or comparison groups. This question was addressed by using a series of 3 two-way ANOVAs, including Group and False belief task performance as independent variables. These analyses indicated that neither CA nor VIQ differed significantly between (a) the ASD and comparison groups (confirming that they were matched) or (b) false belief passers and failers. The absence of significant interaction effects confirmed that, regardless of group, false belief passers and failers did not differ significantly in CA or VIQ. However, the third ANOVA indicated that although VMA did not significantly differ between the ASD and comparison groups (again, confirming that they were matched), it did differ significantly between false belief passers and failers. False belief passers had a mean VMA that was 1.59 years higher than false belief failers. The effect size for the difference between false belief passers and failers was somewhat larger for the ASD group than for the comparison group but the interaction effect between Group and False belief performance was not significant. Overall, it was found that irrespective of group, false belief passers were not significantly older and did not have significantly higher VIQs than false belief failers but they did have significantly higher VMAs.

With respect to CA, these results are consistent with those obtained by Happé (1995) but not Fisher et al. (2005). Fisher et al. found a significant age difference within the comparison group (passers were significantly older), but not within the ASD group. It is possible that significant results for the comparison group were not evident here because the present sample (like Happé's) was substantially smaller than that used in Fisher et al.'s study (n = 32 vs. n = 118). The sample may thus have lacked the necessary power to detect a significant difference, given that the effect size was relatively small (r = .19). Consistent with this suggestion, the age difference between false belief passers and failers in the present study (1.04 years) was similar to that found in Fisher et al.'s study.

With respect to VIQ, the current results contrast with Happé's (1995) finding that false belief passers in the ASD group (but not the comparison group) had significantly higher VIQs (Fisher et al. did not consider VIQ). Finally, in relation to VMA, the current results are consistent with those obtained by Fisher et al., who found that within both the ASD and comparison groups, false belief passers had significantly higher VMAs than false belief failers, with the effect size being larger for the ASD group. Happé did not find significant differences in VMA within her comparison group, possibly due to small sample size.

The second question to be addressed was whether false belief performance was correlated with VMA, CA, or VIQ in either group. The analyses revealed that neither CA nor VIQ were significantly correlated with false belief performance in either the ASD or comparison groups. However, VMA was significantly correlated with false belief performance and this was the case within both groups. Both of these relationships were moderately strong but the correlation was somewhat stronger, although not significantly so, within the ASD group than within the comparison group. With respect to CA, these results replicate Happé's as opposed to Fisher et al.'s findings (they found significant relationships within both groups). With respect to VIQ, the results from the ASD group but not the comparison group are consistent with Happé's (1995) findings: within her comparison group, VIQ was (inexplicably) found to be negatively correlated with false belief task performance. With respect to VMA, the results largely replicate those obtained by Fisher et al., except for the fact that they found a significantly stronger correlation within the ASD group. They differ from Happé's findings, in that she failed to find a significant correlation within the comparison group.

Overall, these results seem to indicate that neither age nor VIQ played an important role in participants' false belief task performance. VMA, by contrast, was consistently found to be related to performance. The fact that the ANOVA did not yield a significant Group by False belief interaction effect on VMA and the fact that correlations between false belief performance and VMA for the ASD and comparison groups were not significantly different in strength undermines the suggestion that receptive vocabulary plays a *special* role for children with ASD in their false belief task performance. These findings did not, therefore, support the hypothesis that children with ASD use verbally mediated strategies to pass false belief tasks to a greater extent than children without ASD.

6.3 THE ROLE OF COMPLEMENT SYNTAX IN SALLY-ANNE TASK PERFORMANCE

6.3.1 Introduction

This section considers the relationship between Sally-Anne and complement syntax task performance. If some children with ASD use their linguistic knowledge of complement structures to pass false belief tasks, then one would expect Sally-Anne passers to have significantly higher complement syntax scores than Sally-Anne failers. This pattern should be less evident in the comparison group. As explained above, previous studies of complement syntax and false belief task performance have been inconclusive. These questions are addressed below.

6.3.2 Method

6.3.2.1 Participants

Only those participants who passed the control questions on the Sally-Anne task were included in the sample (see Chapter 2, section 2.2.3.2). The ASD and comparison groups each consisted of 39 participants who were individually matched on VMA and CA (see Table 6.5 for participant details) and did not differ significantly in terms of VMA, $t(76) = 0.28$, $p = .78$, $r = .03$; CA, $t(70.78) = .50$, $p = .62$, $r = .06$; or VIQ, $t(76) = -0.62$, $p = .54$, $r = .07$. Although participants were not explicitly matched on sex, the percentage of males was fairly similar for both groups: 82.1% and 74.4% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .50$, $p < .01$) and comparison ($r = .70$, $p < .01$) groups.

Table 6.5

Participant Characteristics

	ASD	Comparison
n	39 (7 female)	39 (10 female)
VMA		
M	6.54	6.40
SD	2.17	2.13
Range	2.92 – 11.25	2.92 – 10.83
CA		
M	10.33	9.90
SD	3.29	4.35
Range	5.08 – 16.75	3.42 – 15.67
Verbal IQ		
M	73.56	76.41
SD	18.46	21.78
Range	39 – 117	39 – 122

6.3.2.2 Procedure

Data from the Sally-Anne and memory for complements tasks were considered here. See Chapter 2, sections 2.2.2.2 and 2.2.2.3, for full details of the procedures and Chapter 2, sections 2.2.3.2 and 2.2.3.3, for full details of the coding. In brief, the memory for complements task involved reading a series of 8 one-line stories (e.g., "She told her husband she saw a ghost but it was really a blanket.") to children and then asking them a question which required them to extract the complement (e.g., "What did she tell her husband?"). Children could score a maximum of 8 points.

6.3.3 Results

The numbers of individuals in the ASD and comparison groups who passed and failed the Sally-Anne task are displayed in Table 6.6. A chi-square test indicated that the association between group and performance was not significant, $\chi^2(1, N = 78) = 1.47$, $p = .17$, $\phi = .14$. The value of phi indicated that the association was weak.

Table 6.6

Number of Sally-Anne Passers and Failers in the ASD and Comparison Groups

Sally-Anne	**Group**	
	ASD (% of group)	Comparison (% of group)
Fail	15 (38.5%)	10 (25.6%)
Pass	24 (61.5%)	29 (74.5%)

In order to assess the relationship between complement syntax scores and Sally-Anne performance, it was decided to analyse differences in complement syntax scores between Sally-Anne passers and failers in the ASD and comparison groups. However, before conducting this analysis, Spearman's correlations[19] between complement syntax and VMA, CA, and VIQ were computed for each of the groups. The coefficients are displayed in Table 6.7. Within both groups, complement syntax was found to be significantly correlated with VMA and CA but not VIQ. Given these findings, both VMA and CA were controlled for in the subsequent analysis.

Table 6.7

Spearman's Correlations Between Complement Syntax and VMA, CA, and VIQ for the ASD and Comparison Groups

	Group	
	ASD	Comparison
Complement syntax × VMA	.62**	.52**
Complement syntax × CA	.54*	.51**
Complement syntax × VIQ	.37	-.34

* p (one-tailed) < .05, ** p < .01

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[19] Spearman's, rather than Pearson's, correlations were used because the data were not normally distributed.

In order to assess the differences in complement syntax scores between Sally-Anne passers and failers in the ASD and comparison groups, a 2 × 2 (Group × Sally-Anne) ANCOVA was conducted with VMA and CA as covariates and complement syntax as the dependent variable. Mean complement syntax scores for Sally-Anne passers and failers in the ASD and comparison groups are displayed in Table 6.8. The effect of the CA covariate was not significant, $F(1,72) = 2.34$, $p = .13$, $r = .18$, but the effect of the VMA covariate was, $F(1,72) = 10.29$, $p < .01$, $r = .35$. Neither the main effect of Group, $F(1,72) = 1.08$, $p = .30$, $r = .12$; nor the main effect of Sally-Anne, $F(1,72) = 0.77$, $p = .38$, $r = .10$; nor the Group by Sally-Anne interaction, $F(1,72) = 3.08$, $p = .08$, $r = .20$, were significant.

Table 6.8

Mean (SD) Complement Syntax Scores for Sally-Anne Passers and Failers in the ASD and Comparison Groups

Group	**Sally-Anne**	***N***	**Complement syntax**
ASD			
	Pass	24	5.83 (2.97)
	Fail	15	3.20 (2.73)
	Total	39	4.82 (3.13)
Comparison			
	Pass	29	5.28 (3.17)
	Fail	10	4.30 (3.02)
	Total	39	5.02 (3.12)
Total			
	Pass	53	5.53 (3.10)
	Fail	25	3.64 (3.07)
	Total	78	4.92 (3.10)

6.3.4 Summary

A chi-square test indicated that the children with ASD in this particular sample did not show any significant impairment in false belief understanding, as measured by the

Sally-Anne task. It was found that complement syntax scores were significantly correlated with both VMA and CA but not VIQ in both groups. Consequently, when assessing differences in complement syntax scores between groups and between false belief passers and failers, both VMA and CA were controlled for by entering them as covariates in the two-way analysis of covariance. In terms of performance on the complement syntax task, the analysis of covariance showed that, after controlling for CA and VMA, individuals with ASD were unimpaired in their complement syntax understanding, relative to the comparison group. It also showed that, contrary to predictions, the complement syntax scores of false belief passers and failers were not significantly different. The absence of a Group by Sally-Anne interaction indicated that this pattern applied equally to both groups. Thus, complement syntax scores were related solely to VMA. CA, group, and Sally-Anne performance were shown to be unrelated to complement scores.

Overall, these results are not consistent with the hypothesis that individuals with ASD use knowledge of complement syntax as a compensatory strategy when completing false belief tasks. No support was found for Tager-Flusberg and Joseph's (2005) suggestion that communication complements provide a concrete way of representing different perspectives and can be used as a means of representing beliefs in compensation for the lack of a concept of a belief as a mental representation.

6.4 THE ROLE OF COMPLEMENT SYNTAX IN SMARTIES TASK PERFORMANCE

6.4.1 Introduction

This section aims to assess the same questions as the previous section, using alternative false belief measures: the Smarties "self" and "other" questions. Again, based on the hypothesis that complement syntax facilitates false belief task performance in ASD, it was predicted that Smarties "self"/"other" passers would have significantly higher complement syntax scores than failers and that this pattern would apply particularly to the ASD group.

6.4.2 Method

6.4.2.1 Participants

Only those participants who passed the reality control question on the Smarties task were included in the sample (see Chapter 2, section 2.2.3.2). The ASD and comparison groups each consisted of 40 participants who were individually matched on VMA and CA (see Table 6.9 for participant details) and did not differ significantly in terms of VMA, $t(78) = 0.03$, $p = .98$, $r < .01$; CA, $t(78) = .26$, $p = .80$, $r = .03$; or VIQ, $t(78) = -0.53$, $p = .60$, $r = .06$. Although participants were not explicitly matched on sex, the percentage of males was fairly similar for both groups: 72.5% and 70.0% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .59$, $p < .01$) and comparison ($r = .70$, $p < .01$) groups.

Table 6.9

Participant Characteristics

	ASD	**Comparison**
n	40 (11 female)	40 (12 female)
VMA		
M	6.58	6.57
SD	2.22	2.16
Range	2.92 – 11.33	2.92 – 10.83
CA		
M	10.39	10.17
SD	3.35	4.42
Range	5.58 – 16.75	3.42 – 15.67
Verbal IQ		
M	73.53	75.80
SD	17.92	20.65
Range	39 – 117	39 – 107

6.4.2.2 Procedure

Data from the Smarties and memory for complements tasks are considered here. See Chapter 2, sections 2.2.2.2 and 2.2.2.3 for full details of procedures and sections 2.2.3.2 and 2.2.3.3 for full details of the scoring.

6.4.3 Results

6.4.3.1 Background Statistics

The numbers of individuals in each group who passed and failed the Smarties "self" and "other" questions are displayed in Table 6.10. Chi-square tests indicated that the association between Group and Smarties "self" performance was not significant, $\chi^2(1, N = 80) = 2.81, p = .16, \phi = .18$, and that the association between Group and Smarties "other" performance was significant, $\chi^2(1, N = 80) = 4.27$, p (one-tailed) $= .03, \phi = .23$.

Table 6.10

Number of Smarties "Self" and "Other" Passers and Failers in the ASD and Comparison Groups

		Group	
		ASD (% of group)	Comparison (% of group)
Smarties "Self"	Fail	11 (27.5%)	5 (12.5%)
	Pass	29 (72.5%)	35 (87.5%)
Smarties "Other"	Fail	20 (50%)	11 (27.5%)
	Pass	20 (50%)	29 (72.5%)

Before assessing possible differences in complement syntax scores between groups and Smarties "self" and "other" passers and failers, some background analyses were conducted. Spearman's correlations[20] were computed in order to assess the relationship between complement syntax and VMA, CA, and VIQ. The coefficients are displayed in Table 6.11. For each group, the correlations between complement syntax and both VMA and CA, but not VIQ, were found to be significant. Thus, VMA and CA were controlled for in subsequent analyses.

Table 6.11

Spearman's Correlations Between Complement Syntax and VMA, CA, and VIQ for the ASD and Comparison Groups

	Group	
	ASD	Comparison
Complement syntax × VMA	.64**	.52**
Complement syntax × CA	.42*	.52**
Complement syntax × VIQ	.07	-.29

* $p < .05$, ** $p < .01$

6.4.3.2 Smarties "Other"

In order to explore the relationship between complement syntax score and Smarties "other" performance in each of the groups, a 2 × 2 (Group × Smarties "other") ANCOVA was conducted with VMA and CA as covariates and complement syntax as the dependent variable. Mean complement syntax scores for Smarties "other" passers and failers in the ASD and comparison groups are displayed in Table 6.12. The effect of the CA covariate was not significant, $F(1,74) = 2.25, p = .14, r = .17$, but the effect of the VMA covariate was significant, $F(1,74) = 7.14, p < .01, r = .30$. Neither the main effect of Group, $F(1,74) = 0.22, p = .64, r = .05$; nor the main effect of Smarties "other", $F(1,74) = 0.69, p = .41, r = .10$; nor the Group by Smarties "other" interaction, $F(1,74) = 0.57, p = .45, r = .09$, were significant.

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[20] Spearman's, rather than Pearson's, correlations were used because the data were not normally distributed.

Table 6.12

Mean (SD) Complement Syntax Scores for Smarties "Other" Passers and Failers in the ASD and Comparison Groups

Group	Smarties "other"	*N*	Complement syntax
ASD			
	Pass	20	6.10 (3.04)
	Fail	20	4.30 (3.26)
	Total	40	5.20 (3.24)
Comparison			
	Pass	29	5.79 (3.09)
	Fail	11	3.27 (2.80)
	Total	40	5.10 (3.18)
Total			
	Pass	49	5.92 (3.04)
	Fail	31	3.94 (3.10)
	Total	80	5.15 (3.19)

6.4.3.3 Smarties "Self"

In order to explore the relationship between complement syntax score and Smarties "self" performance in each of the groups, a 2 × 2 (Group × Smarties "self") ANCOVA was conducted with VMA and CA as covariates and complement syntax as the dependent variable. Mean complement syntax scores for Smarties "self" passers and failers in the each group are displayed in Table 6.13. The effect of the CA covariate was not significant, $F(1,74) = 1.41$, $p = .24$, $r = .14$, but the effect of the VMA covariate was significant, $F(1,74) = 6.50$, $p = .01$, $r = .28$. The main effect of Group, $F(1,74) < 0.01$, $p = .92$, $r = .01$, was not significant. However, the main effect of Smarties "self", $F(1,74) = 3.94$, $p = .05$, $r = .22$, was significant. The group by Smarties "self" interaction, $F(1,74) = 0.56$, $p = .46$, $r = .09$, was not significant.

Table 6.13

Mean (SD) Complements Scores for Smarties "Self" Passers and Failers in the ASD and Comparison Groups

Group	Smarties "other"	*N*	Complement syntax
ASD			
	Pass	29	6.34 (2.82)
	Fail	11	2.18 (2.23)
	Total	40	5.20 (3.24)
Comparison			
	Pass	35	5.42 (3.24)
	Fail	5	2.80 (1.48)
	Total	40	5.10 (3.18)
Total			
	Pass	64	5.84 (3.07)
	Fail	16	2.38 (2.00)
	Total	80	5.15 (3.19)

6.4.4 Summary

Chi-square analyses indicated that participants with ASD were significantly more likely than comparison participants to fail the Smarties "other" question but not significantly more likely to fail the "self" question. It was predicted that Smarties "self"/"other" passers would have significantly higher complement syntax scores than failers. Within both groups, complement syntax scores were found to be significantly correlated with VMA and CA (but not VIQ). Thus, the subsequent analyses of variance, which were aimed at assessing the differences in complement syntax scores between the ASD and comparison groups and between Smarties "self"/"other" passers and failers, included both VMA and CA as covariates. The first analysis of covariance included Group and Smarties "other" as the independent variables. This analysis revealed that complement syntax scores did not significantly differ between (a) the ASD and comparison groups or (b) Smarties "other" passers and failers and that the interaction between Group and Smarties "other" was not significant. The second analysis of covariance included Group and Smarties “self” as the independent variables. This analysis revealed that although the two groups did not significantly differ in terms of complement syntax scores, Smarties “self” passers had significantly higher complement scores than failers. There was no interaction effect, confirming that this pattern applied to both groups. Smarties “self” passers and failers had mean scores of 5.84 (*SD* = 3.07) and 2.38 (*SD* = 2.00) respectively.

6.5 OVERALL SUMMARY AND DISCUSSION

This chapter aimed to address the question of whether children with ASD use linguistic strategies in order to pass ToM tasks. The results from the first experiment indicated that, although there was a moderately strong relationship between receptive vocabulary and false belief task performance, this pattern of results applied equally to both groups. This suggests that verbal ability plays a role in false belief task performance (or vice versa) regardless of whether an individual has ASD or not. These results speak against the hypothesis that children with ASD use alternative strategies to pass false belief tasks.

The second and third experiments investigated the relationship between complement syntax and false belief understanding. The results from these experiments indicated that, irrespective of group, there was no relationship between complement syntax performance and either Sally-Anne or Smarties “other” performance, after controlling for age and receptive vocabulary. There was, however, a significant difference in complement syntax scores between Smaries “self” passers and failers. That is, passers obtained significantly higher scores than failers. There was no significant interaction with group, however.

The discrepancy in results across the different ToM measures may be due to a number of factors. A significant relationship between complement syntax and Smarties “self” may have been observed because asking a child the Smarties “self” question, “When I first asked you, what did you say?” is linguistically very similar to asking them, “What did she say?” in the context of the complement syntax task. The test question in the Sally-Anne task (“Where will she look for her marble first?”) is far less similar, possibly explaining the nonsignificant relationship. Moreover, in Chapter 5 it was suggested that the task demands for the Smarties “self” and “other” questions differ. Responding to the "self" question may not require one to recall one's previous *belief* but, rather, one's previous *verbalisation* of one's previous belief: children may simply need to recall *what they said* without considering their mental state. If this is the case, then it should be no surprise that performance on this question ("What did you say?") but not the "other" question (which requires one to impute a mental state) is related to performance on the complement syntax task – each question on this task involves asking the child to recall what someone said or what someone told.

Overall, the results reported in this chapter suggest that children with ASD are no more reliant than comparison children on their linguistic knowledge when performing false belief tasks. There was no convincing evidence that children in either group were using their knowledge of complement syntax to aid them in their false belief task performance. However, there was clear evidence of a group-independent relationship between vocabulary and ToM task performance.

CHAPTER 7: Assessing the Relationship Between Episodic Memory and Temporally Extended Self-Awareness in ASD

7.1 INTRODUCTION

So far, it has been established that the participants with ASD showed a subtle impairment in self-other source memory, reflecting a diminution in the capacity for episodic autonoetic remembering. It was also demonstrated that these children had impaired ToM abilities and experienced greater difficulty than comparison children with the delayed self-recognition task. Now we take up the discussion, first broached in Chapter 1, section 1.4.1.3, where it was argued that self-awareness is critical to the development of episodic memory. According to Wheeler et al. (1997), episodic memory entails conscious awareness that "the self doing the [re] experiencing now is the same self that did it originally" (Wheeler et al., 1997, p.349). It therefore involves an explicit understanding of the self's temporal continuity. The delayed self-recognition task is purported to measure conceptual awareness of the self's continuity through time (Povinelli et al., 1996) and, indeed, performance on this task has been shown to be related to performance on episodic memory measures in typical development (Lemmon & Moore, 2001; Welch-Ross, 2001). However, as explained in Chapter 4, there has been some dispute over precisely what the task measures. Suddendorf (1999), for example, has argued that it measures developmental changes, not specific to self-awareness. This may be correct, in part. The task seems to require that one understands temporal-causal relationships and that one has a concept of the "causal arrow of time" (Povinelli et al., 1999), and *this* is thought to be essential for remembering personally experienced events. Campbell (1997, cited in Perner, 2000) argues that such a concept of time, in itself, arises out of temporally extended self-awareness. He claims that the self in memory must be "spatiotemporally connected with one's present self". This spatiotemporal continuity of the self endows an individual with a "linear conception of time" or, what Povinelli et al. (1999) refer to as the "causal arrow of time". Similarly, McCormack and Hoerl (2001) argue that having a temporally extended self-concept is necessary for the temporal perspective taking that they see as central to episodic memory (and delayed self-recognition).

Thus, having a temporally extended representation of self is thought to allow one to contemplate the connection between the current state of self or of the world (online representation) with non-current (past or future) states of self or the world. If DSR is indexing this capacity then it should be predicted that it is related to source memory.

7.2 METHOD

7.2.1 Participants

The ASD and comparison groups each consisted of 27 participants who were equated[21] for VMA and CA (17 pairs were individually matched). Participant characteristics are displayed in Table 7.1. The groups did not differ significantly in terms of VMA, $t(52) = 0.39$, $p = .70$, $r = .05$; CA, $t(45.60) = 0.44$, $p = .66$, $r = .05$; or VIQ, $t(49.49) = -0.74$, $p = .47$, $r = .10$. Although participants were not explicitly matched on sex, the percentage of males was fairly similar for both groups: 81.5% and 66.7% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .62$, $p < .01$) and comparison ($r = .79$, $p < .01$) groups.

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[21] The groups here were equated rather than individually matched in order to boost the number of participants in the sub-sample and increase power. Within the sample, only 17 matched pairs of individuals were available amongst the pool of participants who had valid data for the DSR and item/source memory task. Another 10 unmatched pairs were included in order to bring the sample size to within a similar range to those used elsewhere in this thesis.

Table 7.1

Participant Characteristics

	ASD	**Comparison**
n	27 (5 female)	27 (9 female)
VMA		
M	6.57	6.34
SD	2.15	2.05
Range	2.92 – 11.33	3.17 – 10.83
CA		
M	9.39	8.93
SD	3.03	4.49
Range	5.00 – 16.17	3.58 – 15.67
Verbal IQ		
M	79.44	83.22
SD	16.58	20.86
Range	46 – 117	44 – 122

7.2.2 Procedure

Data from the source memory and DSR tasks are considered here. See Chapter 2, section 2.2.2.4 for complete details of the procedure and section 2.2.3.4 for details of the coding.

7.3 RESULTS

7.3.1 Background Statistics

Correlations between source memory, "self" source memory, "other" source memory and (a) VMA, (b) CA, and (c) VIQ were computed for both the ASD and comparison groups. The coefficients are displayed in Table 7.2. Only two of these correlations were significant: within the ASD group, the relationships between (a) "other" source memory and VMA, and (b) "other" source memory and CA were significant. None of the other correlations was significant (all other *r*s < .29, all other *p*s > .16).

Table 7.2

Correlations Between Source Memory, "Self" Source Memory, "Other" Source Memory, and VMA, CA, and VIQ for the ASD and Comparison Groups

	Group	**VMA**	**CA**	**VIQ**
Source memory	ASD	.28	.28	-.08
	Comparison	.31	.03	.16
"Self" source memory	ASD	.07	-.06	.13
	Comparison	.23	.07	.12
"Other" source memory	ASD	.33*	.41**	.18
	Comparison	.23	.07	.12

**p* (one-tailed) < .05, ** *p* < .05

The mean continuous DSR scores for the ASD and comparison groups were 1.85 (*SD* = 0.91) and 2.30 (*SD* = 0.87) respectively. A Mann-Whitney test indicated that this difference was significant, *U* = 261.00, *p* (one-tailed) = .03, *r* = .26. Table 7.3 provides a breakdown of performance according to the level of prompting required to elicit mark directed behaviour. The association between Group and Dichotomous DSR score (simple passing/failing) was also not found to be significant, Fisher's exact *p* = 1.00, ϕ = .27, with the vast majority of individuals in each group passing the task.

Table 7.3

Summary of DSR Performance According to Level Of Prompting Required to Elicit Mark Directed Behaviour

DSR prompting category	**Group** ASD (% of group)	 Comparison (% of group)
Fail	2 (7.4%)	1 (3.7%)
Pass after 2 prompts	7 (25.9%)	4 (14.8%)
Pass after 1 prompt	11 (40.7%)	8 (29.6%)
Pass spontaneously	7 (25.9%)	14 (51.9%)

7.3.2 Main Analyses

7.3.2.1 Dichotomous DSR Analyses

It was of interest to assess the difference in source memory scores between dichotomous DSR passers and failers. However, in the current sample, only three participants completely failed. Despite this limitation and in order to be thorough, the results (collapsed across groups) were nevertheless analysed to assess this difference. Differences in source memory, "self" source memory, and "other" source memory between dichotomous DSR passers (n = 51) and failers (n = 3) were explored using Mann-Whitney tests. These tests revealed no differences in source memory, U = 34.00, p = .12, r = .23, "self" source memory, U = 73.00, p = .92, r = .02, or "other" source memory, U = 35.00, p = .13, r = .22. The mean scores are displayed in Table 7.4.

Table 7.4

Mean (SD) Source, "Self" Source and "Other" Source Memory According to Dichotomous DSR Score

	DSR	
	Pass	Fail
Source memory	.81 (.18)	.67 (.15)
"Self" source memory	.85 (.17)	.78 (.32)
"Other" source memory	.76 (.25)	.56 (.27)

7.3.2.3 Continuous DSR Score Analyses

Next, the data were analysed by assessing the relationship between the source memory measures and continuous DSR scores. For this purpose, Spearman's correlations were computed[22]. These revealed no significant relationships within either the ASD or comparison group. The coefficients are displayed in Table 7.5 and the relationships between source memory and continuous DSR scores for the ASD and comparison groups are illustrated in Figures 7.1 and 7.2.

Table 7.5

Spearman's Correlations Between DSR Continuous Scores and Source Memory, "Self" Source Memory, and "Other" Source Memory

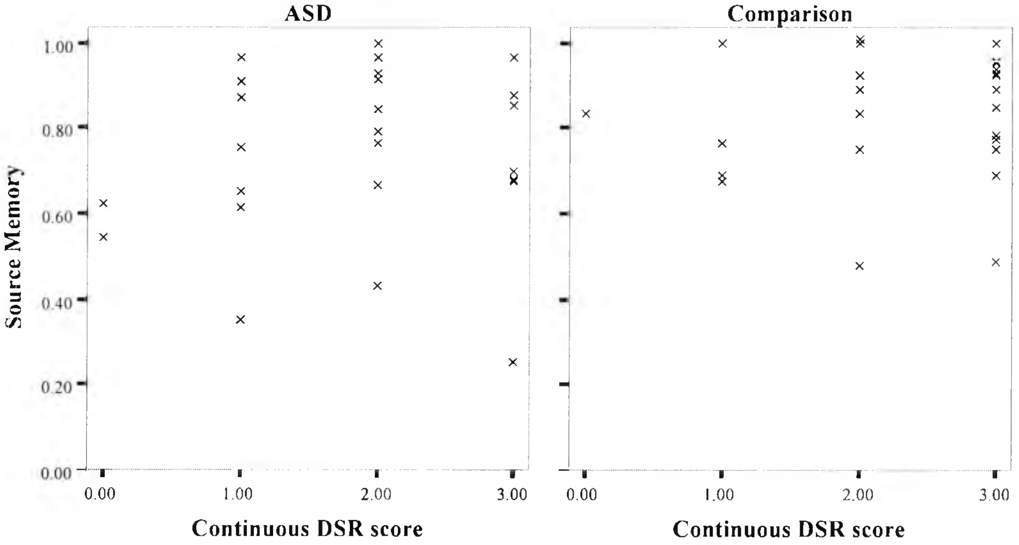
	ASD	**Comparison**
DSR × Source memory	.17	.10
DSR × "Self" source memory	-.02	.13
DSR × "Other" source memory	.12	.12

---

[22] The data did not meet the assumptions for Pearson's correlations. Ideally, VMA and CA would have been controlled for when the correlation between "other" source memory and continuous DSR score within the ASD group was computed. However, this was not possible given that Spearman's correlations were used.

Figures 7.1 and 7.2

Scatterplots Showing the Relationship Between Continuous DSR Scores and Source Memory Within the ASD and Comparison Groups



7.3.3 Exploratory Analyses Within (Unmatched) Groups

Given that both groups showed ceiling effects in dichotomous DSR scores (only 3 completely failed), it was decided that some exploratory analyses should be conducted, within-groups, including every participant who had complete data for both the DSR task and the source memory task. Although, this meant that the groups were no longer equated, it also had the desired effect of reducing the mean VMA and hence increasing the chance of finding DSR failers.

The unmatched participant characteristics are displayed in Table 7.6. Independent *t*-tests revealed that the groups did not differ significantly in terms of VMA, *t*(74) = 0.64, *p* = .52, *r* = .07, the difference in CA approached significance, *t*(52.40) = 1.77, *p* = .08, *r* = .24, and the difference in VIQ was significant, *t*(56.64) = -2.68, *p* = .01, *r* = .34. These differences were not of particular concern, however, since groups were to be analysed independently of each other.

Table 7.6

Unmatched Participant Characteristics

	ASD	Comparison
n	41 (8 female)	35 (12 female)
VMA		
M	6.42	6.14
SD	1.84	1.97
Range	2.92 – 11.33	3.17 – 10.83
CA		
M	9.36	7.88
SD	2.53	4.39
Range	5.00 – 16.17	3.58 – 15.67
Verbal IQ		
M	77.93	89.66
SD	14.40	22.17
Range	46 – 117	44 – 122

7.3.3.1 Background Statistics

Correlations between source memory, "self" source memory, "other" source memory, and (a) VMA, (b) CA, and (c) VIQ were computed for both of the unmatched groups. The coefficients are displayed in Table 7.7. Three of these correlations were found to be significant (all remaining *ps* > .11): within the ASD group, the correlations between source memory and CA, "other" source memory and VMA, and "other" source memory and CA were significant.

Table 7.7

Correlations Between Source Memory, "Self" Source Memory, "Other" Source Memory, and VMA, CA, and VIQ for the Unmatched ASD and Comparison Groups

	Group	**VMA**	**CA**	**VIQ**
Source memory	ASD	.25	.27*	-.09
	Comparison	.17	-.02	.18
"Self" source memory	ASD	.04	-.03	.05
	Comparison	.18	.02	.13
"Other" source memory	ASD	.32**	.37**	-.15
	Comparison	.12	-.05	.18

**p* (one-tailed) < .05, ** *p* < .05

The mean continuous DSR scores for the unmatched ASD and comparison groups were 1.93 (*SD* = 0.84) and 2.31 (*SD* = 0.87) respectively. Table 7.8 provides a breakdown of performance according to the level of prompting required to elicit mark directed behaviour.

Table 7.8

Summary of DSR Performance According to Level of Prompting Required to Elicit Mark Directed Behaviour within the Unmatched Groups

	Group	
DSR prompting category	ASD (% of group)	Comparison (% of group)
Fail	2	1
	(4.9%)	(2.9%)
Pass after 2 prompts	10	6
	(24.4%)	(17.1%)
Pass after 1 prompt	18	9
	(43.9%)	(25.7%)
Pass spontaneously	11	19
	(26.8%)	(54.3%)

7.3.3.2 Dichotomous DSR Analyses

Unfortunately, including more participants did not increase the number of dichotomous DSR failers. Thus, again the results were collapsed across groups and differences in source memory, “self” source memory, and “other” source memory between DSR passers (n = 73) and failers (n = 3) were explored using Mann-Whitney tests. These tests revealed significant differences in source memory, U = 43.00, p (one-tailed) = .04, r = .20, and “other” source memory, U = 46.00, p (one-tailed) = .05, r = .20, but not “self” source memory, U = 99.50, p = .40, r = .03. The mean scores are displayed in Table 7.9. However, these differences may have been attributable to the VMA or CA differences between passers (VMA: M = 6.36, SD = 1.88; CA: M = 8.73, SD = 3.60) and failers (VMA: M = 4.47, SD = 0.92; CA: M = 6.53, SD = 1.39). Indeed, VMA was significantly higher amongst the passers than the failers, U = 37.50, p (one-tailed) = .40, r = .22. However, CA did not differ significantly between passers and failers, U = 71.50, p = .33, r = .12.

Table 7.9

Mean (SD) Source, "Self" Source and "Other" Source Memory According to Dichotomous DSR Score for Collapsed Unmatched Groups

	DSR	
	Pass	Fail
Source memory	.83 (.17)	.67 (.15)
"Self" source memory	.86 (.16)	.86 (.16)
"Other" source memory	.79 (.24)	.56 (.27)

7.3.3.3 Continuous DSR Score Analyses

Next, Spearman's correlations were computed between the source memory measures and continuous DSR scores within the unmatched ASD and comparison groups. None of these correlations was significant (all *p*s > .20). The coefficients are displayed in Table 7.10. The relationships between source memory and continuous DSR scores within each of the unmatched groups are illustrated in Figures 7.3 and 7.4.

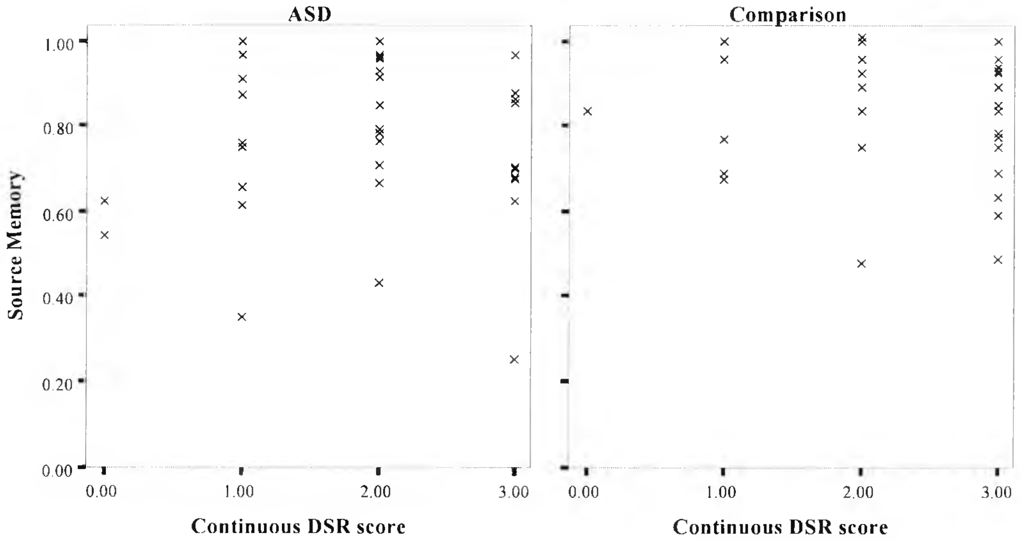
Table 7.10

Spearman's Correlations Between Continuous DSR Scores and Source Memory, "Self" Source Memory, and "Other" Source Memory in the Unmatched Groups

	ASD	Comparison
DSR × Source memory	<.01	.08
DSR × "Self" source memory	-.21	<.01
DSR × "Other" source memory	.04	-.04

Figures 7.3 and 7.4

Scatterplots Showing the Relationship Between Continuous DSR Scores and Source Memory Within the Unmatched ASD and Comparison Groups



7.4 SUMMARY AND DISCUSSION

The ASD group had significantly lower continuous DSR scores than the comparison group. However, the groups did not differ in terms of dichotomous DSR score. The difference in source memory scores between the groups also failed to reach significance.

The main question to be addressed in this chapter was whether delayed self-recognition and source memory performance were related. In the main analyses, it was found that the source memory scores of DSR (dichotomous scoring) passers and failers did not differ significantly. The same finding was evident when “self” and “other” source memory were considered. However, if there was any systematic difference it would have been difficulty to detect, given the very small number of individuals in the sample who failed the task. Furthermore, the correlations between continuous DSR score and source memory, “self” source memory, and “other” source memory were not found to be significant within either group.

Essentially, the data from the matched groups provided no support for the initial prediction that delayed self-recognition performance would be related to source memory performance. This may have been due to the fact that the sample was inappropriate: they showed clear ceiling effects in their DSR scores. Had a sample with a lower mean verbal mental age been tested, the results may have differed. However, even when additional participants who had lower VMAs were included (in the unmatched groups), the findings remained largely unchanged and the number of DSR failers remained at three. The only results which differed between the matched and unmatched group analyses were the differences in source memory and "other" source memory between dichotomous DSR passers and failers: the results of the Mann-Whitney tests reached significance in the latter but not the former analyses (due to greater power). It should be noted, however, that this difference may have been attributable to the difference in VMA or CA between DSR passers and failers – the passers had significantly higher VMAs and non-significantly higher CAs, and these variables were found to be correlated with the source memory measures.

More importantly, however, it seems that the particular combination of tasks used was inappropriate: the tasks were essentially incompatible – the source memory task was too challenging for children who might have failed DSR. In typical development, 75% of 4-year-olds pass the delayed self-recognition task (Povinelli et al., 1996). Thus, in order to obtain a sample which included a significant number of DSR failers, it would be necessary to test participants with mental ages of less than 4 years. However, the source memory task was too difficult for children of this ability level. Looking at the complete data set, it can be seen that, amongst individuals with ASD who had VMAs of less than 4 years (n = 15), 40% (n = 6) were unable to complete the task due to a failure to understand the instructions and 46.7% (n = 7) perseverated. Thus, only 13% (n = 2) were capable of completing the task.

In order to effectively assess the present research question of whether temporally extended self-awareness is necessary for episodic memory, it would be necessary to overcome this methodological problem and select a less demanding test of episodic memory. This will be discussed at greater length in Chapter 9.

CHAPTER 8: Assessing the Relationship Between Episodic Memory and "Theory of Mind" in ASD

8.1 GENERAL INTRODUCTION

Perner (2000, 2001) has argued that episodic memory is highly dependent on developments in "theory of mind" (also see Nelson & Fivush, 2004; Perner & Ruffman, 1995; Welch-Ross, 1995; Welch-Ross, 2001). Specifically, metarepresentation is thought to play two key roles: one must represent (a) one's present mental state ("I *remember* X") and (b) the past mental state ("I *experienced* X") to which one's present mental state refers. Thus, episodic remembering involves the explicit understanding that what is being brought to mind is a *mental representation* of a past experience – that is, the memory is represented *as* a memory (a mental *re*-experience) and recognised as such. It is also thought to be essential that one understands the causal relationship (causal self-referentiality) between these past and present mental states – that is, that one's memory was *caused* by having had direct experience of an event.

As explained in Chapters 5 and 6, children with ASD have difficulty with tasks which assess false belief understanding (Happé, 1995; Yirmiya et al., 1998). They also have difficulty in representing the causal origin of their own and others' knowledge (Baron-Cohen & Goodhart, 1994; Perner et al., 1989, and Chapter 5). These findings suggest that children with ASD lack, or have diminished forms of, the conceptual apparatus necessary for metarepresentation and for representing causal self-referentiality. This may contribute to their difficulties with, or even prohibit them from, remembering episodically. The experiments reported in this chapter aimed to assess this possibility. The first and second experiments consider the relationship between episodic memory, indexed by source memory, and general metarepresentational ability, as assessed by performance on false belief tasks (Sally-Anne and Smarties). The third experiment considers the importance of understanding causal self-referentiality – that is, representing the origin of knowledge, as measured with the see-know task.

8.2 SALLY-ANNE AND SOURCE MEMORY

8.2.1 Method

8.2.1.1 Participants

The ASD and comparison groups were equated[23] for VMA and CA (28 pairs were individually matched). The groups each consisted of 32 participants. See Table 8.1 for participant characteristics. The groups did not differ significantly in terms of VMA, $t(62) = -0.06$, $p = .96$, $r = .01$; CA, $t(58.70) = -0.18$, $p = .86$, $r = .02$; or VIQ, $t(62) = -0.19$, $p = .85$, $r = .02$. Although participants were not individually matched on sex, the percentage of males was similar for both groups: 84.4% and 75.0% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .53$, $p < .01$) and comparison ($r = .66$, $p < .01$) groups.

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[23] The groups here were equated rather than individually matched in order to increase the variation in Sally-Anne scores within the sub-sample (specifically to increase the number of failers).

Table 8.1

Participant Characteristics

	ASD	Comparison
n	32 (5 female)	32 (8 female)
VMA		
M	6.97	6.99
SD	2.17	2.05
Range	2.92 – 11.33	3.25 – 10.83
CA		
M	10.41	10.57
SD	3.19	4.06
Range	5.83 – 16.75	4.42 – 15.67
Verbal IQ		
M	75.66	76.63
SD	18.33	21.53
Range	39 – 117	40 – 122

8.2.1.2 Procedure

Performance on the Sally-Anne and source memory tasks was considered here. The task procedures are detailed in Chapter 2, sections 2.2.2.2 and 2.2.2.1, and the scoring methods are detailed in Chapter 2, sections 2.2.3.2 and 2.2.3.1.

8.2.2 Results

8.2.2.1 Background Statistics

The numbers of Sally-Anne passers and failers within each group are reported in Table 8.2. The association between Group and Sally-Anne score was found to be significant, $\chi^2(1, N = 64) = 7.73, p = .01, \phi = .35$. Correlations between "Self" Source

Memory and "Other" Source memory, and VMA, CA, and VIQ were computed for both groups. The relevant statistics are reported in Table 8.3. Within the ASD group, "other" source memory was found to be significantly correlated with VMA and CA. Thus, VMA and CA were controlled for in subsequent analyses.

Table 8.2

Number of Sally-Anne Passes and Fails for Each Group

Sally-Anne	**Group**		
	ASD	Comparison	Total
Pass	18	28	46
Fail	14	4	18

Table 8.3

Correlations Between "Self" and "Other" Source Memory and VMA, CA and VIQ

Group		VMA	CA	VIQ
ASD	"Self" source memory	$r = .03$, $p = .88$	$r = .04$, $p = .83$	$r = -.11$, $p = .56$
	"Other" source memory	$r = .37$, $p = .04$	$r = .44$, $p = .01$	$r = -.21$, $p = .24$
Comparison	"Self" source memory	$r = -.11$, $p = .55$	$r = -.15$, $p = .42$	$r = .09$ $p = .61$
	"Other" source memory	$r = .04$, $p = .81$	$r = .06$, $p = .76$	$r < .01$, $p = .99$

8.2.2.2 Main Analysis

In order to assess the relationship between Sally-Anne and "self" and "other" source memory performance across groups, a three-way (Group × Sally-Anne × Self-Other) mixed ANCOVA was conducted, with Group and Sally-Anne as between-participants variables, Self-Other as the within-participants variable, VMA and CA as covariates and Source Memory as the dependent variable. The statistics are reported in Table

8.4 and mean "self" and "other" source memory scores, according to Group and Sally-Anne performance, are reported in Table 8.5. Neither of the effects of the covariates were found to be significant. The main effect of Group was significant, with the comparison group performing significantly better than the ASD group. The main effect of Sally-Anne was not significant. The main effect of Self-Other was significant, with participants showing significantly better "self" than "other" source memory. None of the between- or within-participants interactions were found to be significant but the Group by Sally-Anne interaction approached significance.

Table 8.4

Mixed ANOVA for Self-Other Differences in Source Memory

Source	***F***	***df***	***p***	***r***
Covariates				
CA	0.03	1	.88	.02
VMA	0.40	1	.53	.08
Between-participants				
Group	4.80	1	.03*	.28
Sally-Anne (SA)	0.29	1	.59	.07
Group × SA	3.17	1	.08	.23
Within-participants				
Self-Other	7.11	1	.01*	.33
Self-Other × Group	0.21	1	.65	.06
Self-Other × SA	1.30	1	.26	.15
Self-Other × Group × SA	1.36	1	.25	.15
Error		58		

Table 8.5

Mean (SD) "Self" and "Other" Source Memory Scores According to Group and Sally-Anne Performance

Source	Sally-Anne	Group		
		ASD	Comparison	Total
Self	Fail	.73 (.26)	.93 (.13)	.77 (.25)
	Pass	.75 (.20)	.83 (.18)	.80 (.18)
	Total	.74 (.22)	.84 (.17)	.79 (.20)
Other	Fail	.49 (.36)	.82 (.24)	.57 (.36)
	Pass	.79 (.29)	.75 (.27)	.77 (.28)
	Total	.66 (.35)	.76 (.27)	.71 (.31)

8.3 SMARTIES AND SOURCE MEMORY

8.3.1 Method

8.3.1.1 Participants

The ASD and comparison groups were equated[24] for VMA and CA (32 pairs were individually matched). The groups each consisted of 35 participants. Table 8.6 displays participant characteristics. The groups did not differ significantly in terms of VMA, $t(68) = 0.33$, $p = .74$, $r = .04$; CA, $t(68) = .27$, $p = .79$, $r = .03$; or VIQ, $t(68) = -0.43$, $p = .67$, $r = .05$. Although participants were not explicitly matched on sex, the percentage of males was similar for both groups: 77.1% and 68.6% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .62$, $p < .01$) and comparison ($r = .69$, $p < .01$) groups.

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[24] The groups here were equated rather than individually matched in order to increase the variation in Smarties scores within the sub-sample (specifically to increase the number of failers).

Table 8.6

Participant Characteristics

	ASD	Comparison
n	35 (8 female)	35 (11 female)
VMA		
M	6.84	6.66
SD	2.26	2.09
Range	2.92 – 11.33	3.25 – 10.83
CA		
M	10.17	9.92
SD	3.52	4.22
Range	5.00 – 16.75	3.17 – 15.67
Verbal IQ		
M	76.68	78.77
SD	17.83	22.33
Range	39 – 117	40 – 125

8.3.1.2 Procedure

Performance on the Smarties and source memory tasks was considered here. The task procedures are detailed in Chapter 2, sections 2.2.2.2 and 2.2.2.1, and the scoring methods are detailed in Chapter 2, sections 2.2.3.2 and 2.2.3.1.

8.3.2 Results

8.3.2.1 Background Statistics

The number of Smarties "self" and "other" passers and failers within each group are reported in Table 8.7. Neither, the association between Group and Smarties "Self", $\chi^2(1, N = 70) = 1.61, p = .34, \phi = .15$, nor the association between Group and Smarties "Other" was significant, $\chi^2(1, N = 70) = 1.12, p = .43, \phi = .13$. Correlations between "Self" Source Memory and "Other" Source memory, and VMA, CA, and VIQ were computed for both groups. These correlations are reported in Table 8.8. The only correlations found to be significant were that between “other” source memory and CA, and “other” source memory and VMA, within the ASD group alone. Thus, CA and VMA were controlled for in subsequent analyses.

Table 8.7

Number of Smarties “Self” and “Other” Passers and Failers

	Group		
Smarties	ASD	Comparison	Total
“Self”			
Fail	8	4	12
Pass	27	31	58
“Other”			
Fail	12	8	20
Pass	23	27	50

Table 8.8

Correlations Between “Self” and “Other” Source Memory and VMA, CA and VIQ

Group		VMA	CA	VIQ
ASD	“Self” source memory	$r = .01, p = .94$	$r = .02, p = .89$	$r = -.05$ $p = .76$
	“Other” source memory	$r = .38, p = .03$	$r = .45, p < .01$	$r = -.26, p = .13$
Comparison	“Self” source memory	$r = .16, p = .36$	$r = .02, p = .89$	$r = .10, p = .57$
	“Other” source memory	$r = .15, p = .40$	$r = .15, p = .38$	$r = -.07, p = .67$

Subsequent analyses are broken down into two sections: the first considers the relationship between “self” and “other” source memory performance and performance on the *Smarties “other”* question and the second considers the relationship between "self" and "other" source memory performance and performance on the *Smarties "self"* question.

8.3.2.2 Smarties "Other"

In order to assess the relationship between Smarties "other" performance and "self" and "other" source memory performance across groups, a three-way (Smarties "Other" × Group × Self-Other) mixed ANCOVA was conducted with CA and VMA as covariates, Smarties "other" and Group as the between-participants variables, Self-Other as the within-participants variable, and Source Memory as the dependent variable. The statistics are reported in Table 8.9 and mean "self" and "other" source memory scores, according to Group and Smarties "Other" performance, are reported in Table 8.10. The effects of the CA and VMA covariates were not significant and the main effect of Group was not significant. However, the main effect of Smarties "Other" was significant, with passers performing significantly better than failers, overall. The main effect of Self-Other was also significant, with participants performing significantly better on "self" source memory than "other" source memory. None of the interactions was significant except for the Smarties "Other" by Self-Other interaction.

This significant interaction was explored using 2 one-way ANCOVAs, one with "Self" Source Memory, and one with "Other" Source Memory, as the dependent variable, both with Smarties "Other" as the independent variable and CA and VMA as the covariates. The effect of the CA covariate was not significant for either "Self" Source Memory, $F(1,66) = 0.13$, $p = .72$, $r = .04$, or "Other" Source Memory, $F(1,66) = 1.79$, $p = .19$, $r = .16$. Furthermore, the effect of the VMA covariate was not significant for either "Self" Source Memory, $F(1,66) = 0.21$, $p = .65$, $r = .06$, or "Other" Source Memory, $F(1,66) < .01$, $p = .98$, $r < .01$. It was found that Smarties "Other" passers and failers did not perform significantly differently on "Self" Source Memory, $F(1,66) = 0.57$, $p = .45$, $r = .09$, whereas they did perform significantly differently on "Other" Source Memory, $F(1,66) = 9.44$, $p < .01$, $r = .35$, with passers performing better than failers. These results are illustrated in Figure 8.2.

Table 8.9

Mixed ANCOVA for Self-Other Differences in Source Memory

Source	***F***	***df***	***p***	***r***
Covariate				
CA	0.56	1	.45	.09
VMA	0.15	1	.70	.05
Between-participants				
Group	0.64	1	.43	.10
Smarties ‘other’ (SO)	6.28	1	.02*	.30
Group × SO	0.18	1	.67	.05
Within-participants				
Self-Other	5.34	1	.02*	.28
Self-Other × Group	< 0.01	1	.94	<.01
Self-Other × SO	4.99	1	.03*	.27
Self-Other × Group × SO	0.26	1	.61	.06
Error		64		

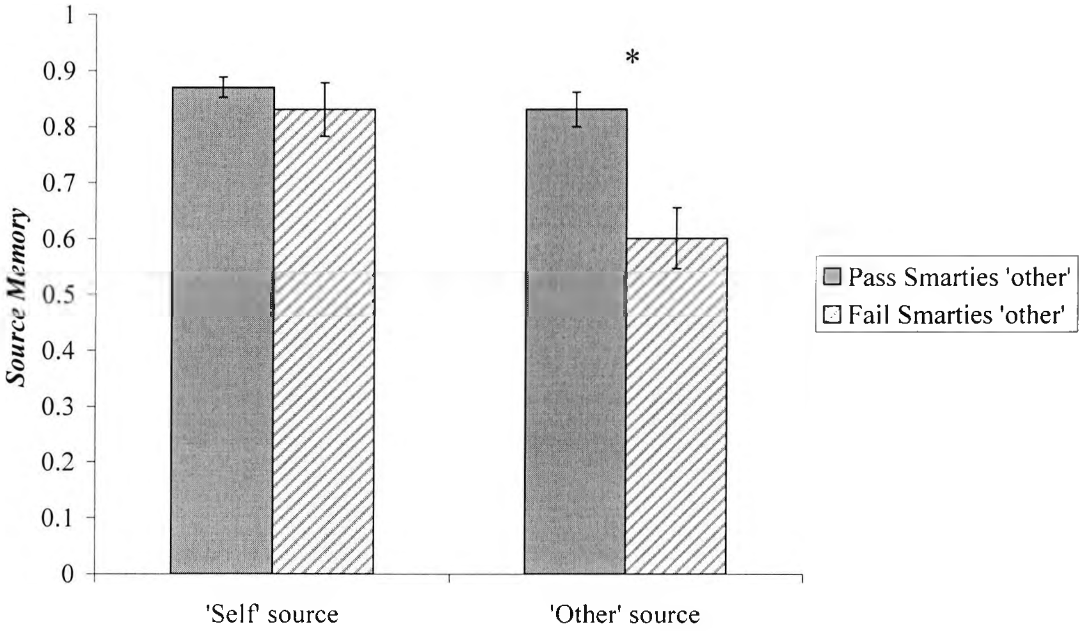
Table 8.10

Mean (SD) "Self" and "Other" Source Memory Scores According to Group and Smarties "Other" Performance

Source	**Smarties "Other"**	**Group**		
		ASD	Comparison	Total
Self	Fail	.83 (.20)	.83 (.24)	.83 (.21)
	Pass	.84 (.13)	.90 (.12)	.87 (.13)
	Total	.83 (.15)	.88 (.16)	.85 (.16)
Other	Fail	.59 (.24)	.60 (.26)	.79 (.23)
	Pass	.81 (.26)	.84 (.19)	.83 (.22)
	Total	.73 (.27)	.79 (.23)	.76 (.25)

Figure 8.2

Mean "Self" and "Other" Source Memory Scores According to Smarties "Other" Performance



*p < .01

8.3.2.3 Smarties "Self"

Next, the relationship between Smarties "self" performance and "self" and "other" source memory performance across groups was assessed using a three-way (Smarties "self" × Group × Self-Other) ANCOVA with VMA and CA as covariates, Smarties "self" and Group as the between-participants variables, Self-Other as the within-participants variable, and Source memory as the dependent variable. The statistics are reported in Table 8.11 and mean "self" and "other" source memory scores, according to Group and Smarties "self" performance, are reported in Table 8.12.

Neither of the effects of the covariates nor any of the between-participants effects were significant. Regarding the within-participants effects, the main effect of Self-Other was significant but neither of the two-way interactions were significant. The three-way interaction between Group, Smarties "Self", and Self-Other was significant, however. Inspection of the data suggested that the analysis should be followed up with separate two-way (Smarties "Self" × Self-Other) ANCOVAs for the ASD and comparison groups. None of the results was significant for the comparison group (see Table 8.14). For the ASD group, the effects of the VMA and CA covariates were not significant. The main effect of Smarties "Self" was not significant but the main effect of Self-Other was. The Smarties "Self" by Self-Other interaction was also significant (see Table 8.13). This interaction was further explored but it was found that, within the ASD group, after controlling for CA and VMA, Smarties "Self" passers and failers did not perform significantly differently on "self" source memory, $F(1,31) = 0.72$, $p = .40$, $r = .15$, or on "other" source memory, $F(1,31) = 3.25$, $p = .08$, $r = .31$. These results are illustrated in Figure 8.3.

Table 8.11

ANCOVA for Self-Other Differences in Source Memory

Source	***F***	***df***	***p***	***r***
Covariate				
VMA	0.52	1	0.48	.09
CA	0.49	1	0.49	.09
Between-participants				
Group	1.00	1	.32	.12
Smarties “Self” (SS)	1.56	1	.22	.15
Group × SS	0.04	1	.84	.02
Within-participants				
Self-Other	5.42	1	.02*	.28
Self-Other × Group	2.10	1	.15	.18
Self-Other × SS	1.50	1	.23	.15
Self-Other × Group × SS	5.00	1	.03*	.27
Error		64		

Table 8.12

Mean (SD) “Self” and “Other” Source Memory Scores According to Group and Smarties “Self” Performance

Source	**Smarties “Self”**	**Group**		
		ASD	Comparison	Total
Self	Pass	.82 (.15)	.89 (.14)	.86 (.15)
	Fail	.87 (.17)	.80 (.30)	.84 (.21)
	Total	.83 (.15)	.88 (.16)	.86 (.16)
Other	Pass	.80 (.25)	.80 (.23)	.80 (.24)
	Fail	.52 (.22)	.72 (.19)	.59 (.22)
	Total	.73 (.27)	.79 (.23)	.76 (.25)

Table 8.13

ANCOVA for Self-Other Differences in Source Memory for the ASD Group

Source	*F*	*df*	*p*	*r*
Covariate				
VMA	0.04	1	.84	.04
CA	1.81	1	.18	.23
Between-participants				
Smarties "Self" (SS)	0.83	1	.37	.16
Within-participants				
Self-Other	6.78	1	.02*	.42
Self-Other × SS	5.34	1	.03*	.38
Error		31		

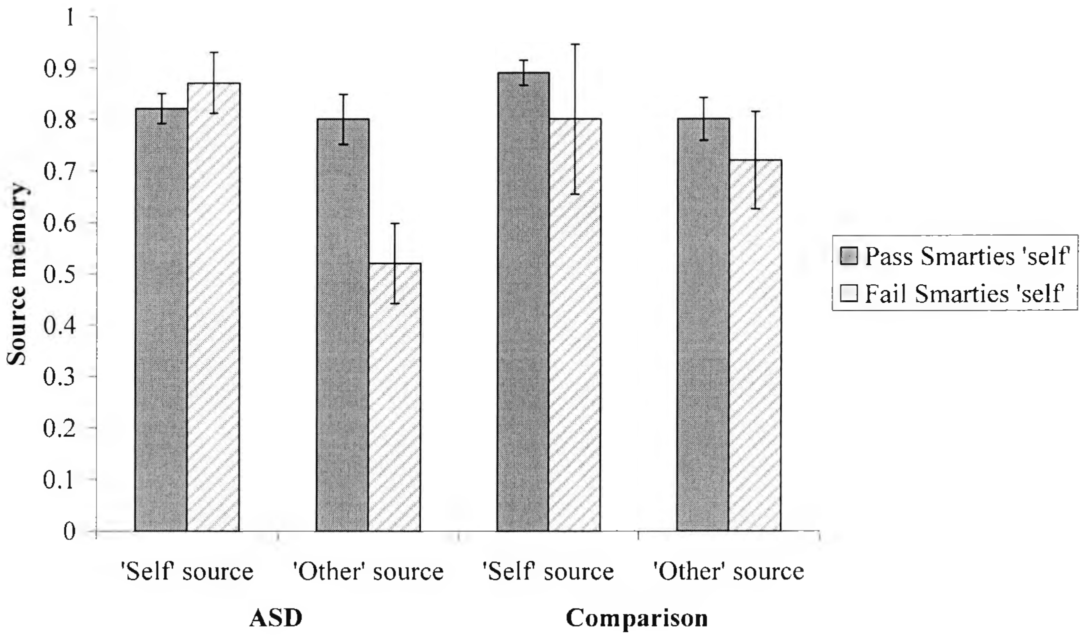
Table 8.14

ANCOVA for Self-Other Differences in Source Memory for the Comparison Group

Source	*F*	*df*	*p*	*r*
Covariate				
VMA	0.77	1	.39	.16
CA	0.08	1	.78	.05
Between-participants				
Smarties "Self" (SS)	0.86	1	.37	.16
Within-participants				
Self-Other	0.63	1	.43	.14
Self-Other × SS	0.17	1	.68	.07
Error		31		

Figure 8.3

Mean "Self" and "Other" Source Memory Scores According to Group and Smarties "Self" Performance



8.4 SEE-KNOW AND SOURCE MEMORY

8.4.1 Method

8.4.1.1 Participants

The final ASD and comparison groups each consisted of 28 participants who were individually matched on VMA and CA (see Table 8.15 for participant details). The groups did not differ significantly in terms of VMA, $t(54) = 0.23$, $p = .82$, $r = .03$; CA, $t(54) = 0.23$, $p = .82$, $r = .03$; or VIQ, $t(54) = -0.44$, $p = .66$, $r = .44$. Although participants were not matched on sex, the number of males and females was not significantly discrepant, $\chi^2(1, N = 56) = 1.95$, $p = .30$. The percentage of males was 89.3% and 75.0% for the ASD and comparison groups respectively. CA and VMA were significantly positively correlated within both the ASD ($r = .68$, $p < .01$) and comparison ($r = .72$, $p < .01$) groups.

Table 8.15

Participant Characteristics

	ASD	Comparison
n	28 (3 female)	28 (7 female)
VMA		
M	7.30	7.17
SD	2.23	1.99
Range	2.92 – 11.33	3.25 – 10.83
CA		
M	10.68	10.45
SD	3.40	4.02
Range	5.83 – 16.75	4.33 – 15.42
Verbal IQ		
M	76.68	78.79
SD	15.40	20.12
Range	39 – 102	42 – 116

8.4.1.2 Procedure

Performance on the see-know and source memory tasks was considered here. The task procedures are detailed in Chapter 2, sections 2.2.2.2 and 2.2.2.1 and the scoring methods are detailed in Chapter 2, sections 2.2.3.2 and 2.2.3.1.

8.4.2 Results

8.4.2.1 Background Statistics

The numbers of see-know passers and failers within each group are reported in Table 8.16. The association between Group and See-Know performance was not significant, $\chi^2(1, N = 56) = 1.02, p = .50, \phi = .14$. Correlations between "Self" Source Memory and "Other" Source memory, and VMA, CA, and VIQ were computed for both groups. These are reported in Table 8.17. The only correlations found to be significant were between "other" source memory and VMA, and "other" source memory and CA, within the ASD group only. None of the other correlations was significant. Thus, VMA and CA were controlled for in subsequent analyses.

Table 8.16

Number of See-Know Passes and Fails for Each Group

	Group		
See-know	ASD	Comparison	Total
Pass	21	24	45
Fail	7	4	11

Table 8.17

Correlations Between "Self" and "Other" Source Memory and VMA, CA and VIQ

Group		VMA	CA	VIQ
ASD	"Self" source memory	$r = .08$ $p = .68$	$r = -.05, p = .81$	$r = .09, p = .64$
	"Other" source memory	$r = .54, p < .01$	$r = .41, p = .03$	$r = -.02, p = .92$
Comparison	"Self" source memory	$r = -.04, p = .85$	$r = .04, p = .85$	$r = -.10, p = .65$
	"Other" source memory	$r = .14, p = .48$	$r = .10, p = .62$	$r = .01, p = .95$

8.4.2.2 Main Analyses

In order to explore the relationship between performance on the see-know task and "self" and "other" source memory, a three-way (Group × See-Know × Self-Other) mixed ANCOVA was conducted, with VMA and CA as covariates, Self-Other as the within-participants variable, and Source Memory as the dependent variable. The statistics are reported in Table 8.18 and mean "self" and "other" source memory scores, according to Group and See-Know performance, are reported in Table 8.19. Neither the effects of the covariates, nor any of the between-participants effects were significant. The within-participants main effect of Self-Other was significant, however. Finally, none of the within-participants interactions was significant.

Table 8.18

ANCOVA for Self-Other Differences in Source Memory

Source	***F***	***df***	***p***	***r***
Covariate				
VMA	2.11	1	.15	.20
CA	0.03	1	.87	.02
Between-participants				
Group	1.88	1	.18	.19
See-Know (SK)	0.22	1	.64	.07
Group × SK	0.37	1	.54	.09
Within-participants				
Self-Other	11.92	1	<.01	.44
Self-Other × Group	0.63	1	.43	.11
Self-Other × SK	0.19	1	.66	.06
Self-Other × Group × SK	2.73	1	.11	.23
Error		50		

Table 8.19

Mean (SD) "Self" and "Other" Source Memory Scores by Group and See-Know Performance

Source	See-know	Group		
		ASD	Comparison	Total
Self	Pass	.83 (.18)	.91 (.10)	.87 (.14)
	Fail	.81 (.15)	.84 (.20)	.82 (.16)
	Total	.83 (.17)	.90 (.12)	.86 (.15)
Other	Pass	.80 (.29)	.79 (.23)	.79 (.26)
	Fail	.58 (.23)	.79 (.23)	.66 (.25)
	Total	.74 (.29)	.79 (.23)	.77 (.26)

8.5 OVERALL SUMMARY AND DISCUSSION

The first experiment, reported in section 8.2, assessed the relationship between Sally-Anne and source memory performance. A Group by Sally-Anne by Self-Other ANCOVA indicated that (a) the ASD group showed significantly poorer source memory than the comparison group, (b) overall, Sally-Anne passers and failers did not significantly differ in terms of source memory and (c) irrespective of group or Sally-Anne performance, participants showed significantly better "self" than "other" source memory. Thus, the results from this experiment were not consistent with the hypothesis that metarepresentation is necessary for episodic memory.

The second experiment, reported in section 8.3, considered the relationship between source memory and performance on both the Smarties "self" and "other" questions. The analyses concerning Smarties "other" are considered first. A Group by Smarties "other" by Self-Other ANCOVA revealed that (a) the ASD and comparison groups did not significantly differ in terms of their source memory performance, (b) regardless of group, Smarties "other" passers achieved significantly higher source memory scores than Smarties "other" failers, and (c) regardless of group or Smarties "other" performance, participants showed significantly better "self" than "other" source memory. Unlike the results from the previous experiment, these findings are consistent with the hypothesis that metarepresentation is related to episodic memory. It was also found that there was a significant interaction between Smarties "other" and Self-Other. This was subsequently shown to be due to the fact that Smarties "other" passers performed significantly better than failers on "other" but not "self" source memory. This may suggest that ToM development facilitates memory for others' actions to a greater extent than memory for one's own actions. It may be speculated that children who pass the Smarties "other" question are more able to shift to another's perspective, thereby increasing the salience of the other's actions and experiences of the world. Indeed, although not found to be significant, a similar *pattern* of results was observed in relation to Sally-Anne performance.

Further analyses were conducted to assess the relationship between source memory and Smarties "self" performance. A Group by Smarties "self" by Self-Other ANCOVA confirmed that source memory did not differ significantly between the ASD and comparison groups and showed that participants showed significantly better "self" than "other" source memory. However, it also revealed that source memory did not differ between Smarties "self" passers and failers.

The third experiment, reported in section 8.4, considered the relationship between source memory and performance on the see-know task. A three-way ANCOVA indicated no significant differences in source memory between either the ASD and comparison groups or see-know passers and failers. However, it once again indicated a significant advantage in "self" source memory over "other" source memory. Thus, these results do not offer any support for Perner's (2000) contention that representing causal self-referentiality is essential for episodic memory. He argues that episodic memory relies on the capacity to represent the fact that one's memory was caused by direct experience of an event. However, those children who passed the see-know task and who, therefore, apparently had the requisite conceptual apparatus to understand their memories as having derived from past experiences, did not show significantly better source memory. The pattern of results was in the expected direction, however, with passers obtaining somewhat better source memory scores than failers. Indeed, there was a tendency towards a ceiling effect in see-know scores and this may have influenced the result.

Overall, based on the assumption that self-other source monitoring indexes episodic memory and that the Sally-Anne and Smarties tasks assess the ability to metarepresent, the results reported in this chapter provide partial support for the theory that metarepresentation is related to the capacity for autonoetic remembering. Thus, those children who failed the Smarties false belief task would not be able to identify their memories *as* memories and, therefore, could not consciously reflect upon their memories, resulting in poorer source memory performance than those who passed.

A somewhat surprising finding also emerged – that is, that false belief performance was specifically related to source memory for the experimenter's cards. This seems to suggest that the mechanisms for remembering one's own actions and the mechanisms for remembering other people's actions are at least partly distinct. Perhaps "self" source memory performance was being mediated by a more primitive mechanism such as action monitoring, which of course would not facilitate "other" source memory. If this were to be the case, then "other" source memory might be purer measure of episodic memory than either "self" or overall source memory.

CHAPTER 9: Discussion

9.1 OVERVIEW

The main purpose of this thesis was to explore possible explanations for the diminution of episodic memory that is associated with ASD. The core hypothesis was that impairments in certain ToM abilities and/or temporally extended self-awareness are precursors to this episodic memory impairment. Thus, the main aims of the empirical work were to: (a) assess episodic memory in ASD and explore possible differences in memory for self and other; (b) establish whether temporally extended self-awareness is impaired in ASD; and (c) establish whether ToM impairments and/or impaired temporally extended self-awareness contribute to episodic memory impairments in ASD. In addition, the question of whether individuals with ASD use compensatory verbal strategies – specifically, knowledge of complement syntax – to pass ToM tasks was considered. The methodological approach taken, involved testing a large sample of individuals with ASD as well as comparison individuals without ASD on a series of tasks aimed at assessing the cognitive functions under consideration. Episodic memory was assessed using a self-other source memory task and ToM was assessed using location change and unexpected contents false belief tasks as well as a see-know task. Temporally extended self-awareness was assessed using the delayed self-recognition paradigm and, finally, complement syntax was assessed using a memory for complements task. What follows is a summary and discussion of the empirical work reported in Chapters 3 to 8. Important findings and conclusions are then discussed. Finally, consideration is given to the various methodological issues that were encountered during the course of this work and suggestions for future research are offered.

9.2 SUMMARY OF EMPIRICAL CHAPTERS

9.2.1 Chapter 3

The experiment reported in Chapter 3 considered a number of questions concerning episodic and semantic memory in ASD. An item/self-other source memory task was selected as the experimental measure, given that item and source memory are considered to index semantic and episodic memory respectively (Wheeler et al., 1997). The basic procedure involved experimenter and child picking up and naming picture cards and then, after a short delay, testing the child's item recognition and source memory. In the task, children could "know" (through use of semantic memory) they had looked at a particular card without actually "remembering" (using episodic memory) the contextual details of the event. However, to make an accurate self-other source judgement, it is likely that the children needed to utilise episodic memory in order to mentally re-experience the event and consider who performed the action of picking up and naming the card. It would appear to require retrieval of at least some episodic trace information. A group of 36 children with ASD and 36 comparison children with verbal mental ages of just over 6.5 years, chronological ages of approximately 10 years, and verbal IQs in the mid-70s was tested. It was predicted that source memory would be impaired in the total ASD group and item memory would be impaired amongst low-functioning individuals with ASD but intact among high-functioning individuals with ASD. Both of these predictions were confirmed in the initial analyses. The ASD group showed significantly poorer source memory than the comparison group, being less able to remember whether it was they or the experimenter who had picked up and named the cards they had correctly recognised as old. However, the effect size was small, indicating that the groups were performing at consistently, but not substantially different levels. This finding is likely to reflect a subtle attenuation of the episodic memory system and is consistent with the hypothesis that individuals with ASD have reduced autonoetic awareness.

The sample ($n = 36$) used in the present study was substantially larger than those used in any previous investigation (maximum $n = 22$; Russell & Jarrold, 1999) of self-other source monitoring in ASD. These results are therefore likely to be somewhat more representative of the performance of the general population of individuals with ASD. It is interesting to note that, of all the previous studies, the one with the largest sample (Russell & Jarrold, 1999) found self-other source memory impairments. This is likely to be because the impairment is relatively subtle and, therefore, difficult to detect with small sample sizes and low power. The present results differ from those obtained by Farrant et al., (1998) who found no group differences. This is likely to be due to a combination of factors: their sample was (a) smaller and (b) more verbally able (mean VMA: 7 years 8 months vs. 6 years 9 months). Perhaps, if the present sample had had somewhat higher verbal mental ages, no differences would have been found. It may be that children with ASD are delayed in their source monitoring capacities but are able to "catch up" after a certain point in development – somewhere between verbal mental ages of about 6.5 and 7.5 years. In typical development, it is found that children over the age of 6 years perform at adult levels on self-other source monitoring tasks (Foley et al., 1983; Foley & Johnson, 1985). Although it is not known how well typically developing adults would perform on the current task, it seems fairly likely that they would perform at close to ceiling. Thus, neither group in the present study performed at the expected "adult level" (which typically developing children may have).

The findings regarding group differences in source memory were not entirely clear-cut, however. A number of other analyses (both within Chapter 3 and in Chapters 7 and 8) did not find significant group differences in source memory. For example, the analyses of variance reported in sections 8.3.2.2 (Smarties/source memory) and 8.4.2.2 (see-know/source memory) indicated non-significant main effects of group when source memory was the dependent variable. Overall, the finding of a self-other source memory impairment in ASD was not robust. There are two possible conclusions that could be drawn on this basis. Either episodic memory is not impaired in ASD or individuals with ASD are able to use semantic processes in order to compensate for their difficulties with episodic remembering in the context of the task used here. Certainly, it has been shown that this is the case in recognition memory, with individuals with ASD showing typical levels of performance but less "remembering" and more "knowing" (Bowler et al., 2000a; Bowler et al., 2007). Perhaps this can be extended to include relatively simple judgments about source. Bowler et al. (2004) suggest that "task support" at test facilitates the performance of individuals with ASD in memory tasks. That is, the provision of cues during the test phase of an experiment aids the retrieval of information. The source memory task used here involved a forced-choice procedure and this represents considerable task support. Thus, the task may not necessarily *demand* the engagement of the episodic memory system. In which case, the performance of individuals with and without ASD may be mediated by different underlying cognitive mechanisms. To establish robust group differences, it may be necessary to use tasks that are not conducive to such compensatory mechanisms and necessitate self-generated, un-cued recall of episodic trace information. Such alternative tasks are discussed below in the context of suggested future research.

The initial prediction that item memory would be impaired among individuals with low-functioning ASD was largely upheld. It was found that the high-functioning ASD and high-functioning comparison groups did not differ on any of the item memory measures, suggesting that semantic memory was intact within this ASD sub-group. However, the low-functioning ASD group obtained significantly lower A' scores than the low-functioning comparison group. Thus, item discrimination was intact among high-functioning individuals with ASD but was markedly reduced among low-functioning individuals. These results support Boucher et al.'s (in press) hypothesis that semantic as well as episodic memory is impaired in low-functioning individuals with ASD. Importantly, this finding was observed even though the low-functioning ASD and low-functioning comparison groups were of a very similar developmental level and had similar verbal IQs. However, this finding should be regarded as suggestive rather than conclusive given that it was based on a very small sample of individuals.

It was also predicted that, due to reduced self-awareness/capacity for action monitoring, individuals with ASD would show a reduced enactment effect. In order to assess this prediction, differences in memory for self-performed and other-performed actions were considered. It was found that, regardless of diagnostic status, there was a significant advantage in memory for self-performed actions in terms of hit rate, global corrected hit rate, self-other corrected hit rate, and source memory (however, it was also shown that the self-advantage in source memory was in fact due to a response bias, whereby participants tended to claim the other's actions as their own). The effect sizes were large for the item memory measures and moderate for the source memory measure, reflecting a substantial enactment effect within both groups. Thus, the prediction was not supported. It was also predicted that participants with ASD would be more likely than comparison participants to attribute false alarms to themselves. In fact, no self- or other-advantage was found for either group:

participants were as likely to attribute false alarms to themselves as they were to the experimenter and this pattern applied to both groups equally.

Russell (e.g., 1997) has suggested that individuals with ASD are impaired in their ability to monitor their actions, citing evidence that children with autism have difficulties with error correction (Russell & Jarrold, 1998). Action monitoring involves copying an internally generated motor command and comparing this, "efference copy", to a perceived end-state. As Pacherie (1997) puts it, children with autism may have difficulty with converting unconscious motor commands into conscious motor images (efference copies). In terms of the self-other source task used here, an action monitoring impairment could result in a reduced enactment effect. If children with ASD had problems with producing conscious motor images then this information could not be encoded within explicit memory. However, this theory is now increasingly untenable in light of more recent empirical findings which point away from action monitoring difficulties in ASD (e.g., Russell & Hill, 2001; Williams & Happé, in preparation). The present results also speak against this proposal. If, on the other hand, the enactment effect is an extension of the self-reference effect (Rogers et al., 1997) then these results suggest that children with autism have sufficiently sophisticated concepts of self to enable information to be organised in memory with respect to this structure. Overall, the results seem to point to a mild diminution of episodic memory per se rather than a problem of *personal* episodic memory (Powell & Jordan, 1993) or memory for experiences directly involving the self (Hare et al., 2007).

It was also predicted that the comparison group but not the ASD group would show the same developmental pattern of performance as typically developing children with respect to memory for self and other. Roberts and Blades (1998) found that typically developing children aged under 6 showed equivalent recognition memory for self and other and an advantage for other in source memory. Children aged over 6 were found to show a self-advantage (i.e., the enactment effect) in both recognition and source memory. With respect to the current study, this pattern was not observed and hence the prediction was not confirmed. In both the ASD and comparison groups, both over- and under-6s showed a self-advantage in item and source memory.

9.2.2 Chapter 4

The experiment reported in Chapter 4 aimed to assess temporally extended self-awareness in ASD using the delayed self-recognition (DSR) paradigm. Children were filmed playing a game, during which they were covertly marked with a large sticker. After a three-minute delay, the child watched the recording and their response was assessed. Successful DSR involved reaching up to touch/remove the sticker from their head. The sample included 30 children with ASD and 30 matched comparison children without ASD, who had mean verbal mental ages of just over 6 years, mean chronological ages of just under 9 years, and mean verbal IQs of around 80.

It was found that, although the majority of the children with ASD passed the DSR task, either spontaneously or with additional prompting, children with ASD were significantly more likely to fail the task than comparison children. Indeed, not a single comparison child failed the task. This result is consistent with the predictions. However, 3/5 of the children who failed DSR also failed live video self-recognition. Thus, only 2 children could be said to have a *specific* impairment of temporally extended self-awareness – or, difficulty with understanding the causal connection between the "past self" represented on video and the "present self" currently watching the video. The other 3 children seemed to have a more severe lack of self-awareness. Despite the availability of both featural and contingency cues, they were not able to detect the equivalence between themselves and the image. Although these children were relatively young and had relatively low verbal mental ages, based on research from the literature on typical development (Suddendorf et al., in press), these children would be expected to pass live video self-recognition. It was argued that these particular children lacked adequately abstracted representations of self to enable the detection of featural equivalence relations with live videos. In other words, they had impoverished conceptual self-awareness of their physical appearance. This needs to be studied further using a more appropriate sample of younger/less able children with ASD, as discussed below.

Future research must also compare brief (e.g., 3 minute) to extreme (e.g., 7 days) feedback delays. Povinelli (1999) argues that those typically developing children, aged under 4, who pass the task, do so without having temporally extended self-concepts. These children detect the salient featural equivalence relations between their mental representations of their physical features and the image represented on the video screen. Some of the children in the present study, particularly those with ASD, may have been using this type of alternative strategy. Lee and Hobson's (1998) study of self-understanding indicated that children and adolescents with autism produced significantly more descriptions of their physical and active characteristics than the comparison group. This suggests that the physical and active characteristics of children with ASD are the most dominant dimensions of their self-concepts. This may increase the salience of physical features thereby promoting successful performance in the DSR task. They may pass the task despite having less firmly established capacities for representing the self through time. This probably also accounts for the generally successful performance of children with autism in mirror self-recognition. If some of the children with autism were using such a mechanism, this may explain why they required significantly more prompting to pass the task than comparison children. Those children with temporally extended self-concepts would be more likely to immediately spot the causal connection between the external representation and their internal representations. A purely featural, less automatic, heuristic strategy may require the additional scaffolding provided by the prompts. However, this argument is somewhat speculative and it is possible that the prompts simply ensured that the children with ASD were paying due attention.

The prediction that children with ASD would be more likely to use their proper names, as opposed to a personal pronoun, to label their self-image was confirmed. This is consistent with the results of Lee et al. (1994) who found that children with autism showed an increased tendency to label photographs of themselves using proper names. In Chapter 1, it was argued that labelling past self-images using proper names may reflect a failure to identify with a "past self", which would require a temporally extended self-concept. Labelling an image with a proper name could potentially be achieved through a learned association between "that face" and "that name" or through detecting featural equivalence relations between a mental representation of one's physical appearance and the perceived image. However, an alternative explanation seems more plausible. It seems more likely that this proper name use resulted from impaired (interpersonally grounded) conceptual self-awareness. However, in order to empirically assess this suggestion it would be necessary to compare use of personal pronouns in interpersonal settings and image-labelling settings. The fact that, in the present study, verbal responses were not found to be related to any measure of DSR performance further suggests that use of proper names is unlikely to specifically reflect diminished *temporally extended* self-awareness. Another possibility, worth considering, is that encouraging children to use proper names in the source memory task, in Session 1, elevated the rate of proper name use in the DSR task, in Session 4. The participants may have thought that the experimenter wanted them to continue using their proper names in this second context. However, this does not explain why so few children in the comparison group used their proper name. If this explanation is correct then one would expect the comparison group to be *more* influenced by such a perceived expectation on the part of the experimenter.

It was also of specific interest to consider whether DSR performance was related to false belief task performance, given that both are thought to rely on the capacity for metarepresentation. However, ceiling effects in the data prevented this issue from being addressed. There was simply not enough variation in performance to justify statistical analyses. Thus, the question of whether DSR requires metarepresentation remains unanswered by the current experiment.

Overall, the results reported in Chapter 4 indicated that the majority of children with ASD could successfully locate the sticker on their head in the delayed self-recognition task. Nevertheless, the fact remains that significantly more children in the ASD group failed the task and, in general, the ASD group were shown to have more problems with the DSR task than the comparison group. This, in itself, is consistent with the hypothesis that some individuals with ASD have less well established temporally extended self-concepts than non-autistic comparison individuals, although it suggests that the problem may not be as prevalent or as striking as expected. However, the fact that *delayed self-recognition* did not present a problem for most individuals may not necessarily mean that they have intact *temporally extended self-concepts*. One important question to consider is whether the task is an unambiguous measure of temporally extended self-awareness. Do children who pass the task necessarily have temporally extended self-concepts? It remains a distinct possibility that they may be passing on some other basis, as discussed above.

9.2.3 Chapter 5

Chapter 5 presented details of the results from the three ToM tasks in three separate sets of analyses. A large amount of data, from many different studies (e.g., Happé, 1995; Yirmiya et al., 1998), indicate that children with ASD have difficulties with both the Sally-Anne and Smarties false belief tasks. Such problems are considered to be a manifestation of an underlying difficulty with metarepresentation. Understanding of the relationship between perception and knowledge has been a less well studied aspect of ToM, but previous results are also indicative of a diminution (Baron-Cohen & Goodhart, 1994; Perner et al., 1989).

The first experiment investigated understanding of the perception-knowledge relationship using a see-know task in a group of 33 children with ASD and a group of 33 comparison children, who had mean verbal mental and chronological ages of just under 7 years and approximately 10 years, respectively, and a mean VIQ of around 75. The children with ASD showed diminished performance relative to the matched comparison group. Thus, children with ASD had greater difficulty in drawing an inference about a character's knowledge/ignorance of a piece of information based on whether or not they had had visual access to that information. This provides more conclusive evidence than that obtained in the study by Baron-Cohen and Goodhart (1994), given that the control tasks used were more closely equated with the demands of the experimental task.

The second experiment considered Sally-Anne performance in a sample of 33 children with ASD and 33 matched comparison children, who had mean verbal mental and chronological ages of approximately 6.5 and 10.5 years, respectively, and a mean VIQ of around 70. As expected, the ASD group showed a significant performance decrement, relative to the comparison group, being less likely to attribute a false belief to the protagonist, Sally, regarding the location of her marble.

The third experiment considered performance on the Smarties task in a group of 41 children with ASD and 41 comparison children, who had very similar verbal mental ages, chronological ages, and verbal IQs to those children included in the previous Sally-Anne experiment. Again, in line with predictions, children with ASD were shown to perform significantly less well than comparison children, whether they were asked to attribute a false belief to another person or to recall their own previous false belief. It was, however, found that the latter type of attribution was significantly easier than the former, raising concerns about the validity of the own-false-belief test question. It was suggested that it might involve recalling one's prior verbalisation rather than recalling one's prior belief, particularly given that the wording of the test question involved the verb "say" rather than "think". In which case, it would not, in fact, index the ability to consciously consider one's own mental states (private self-awareness), as previously thought.

Thus, these results confirm that children with ASD (who had similar ages and ability levels to those included in previous studies) are impaired in their false belief and see-know task performance. From this, it is concluded that they are impaired in their capacity for metarepresentation and in their understanding of causal self-referentiality. The question that remains to be addressed is whether or not these difficulties have knock-on effects in terms of episodic memory capacity.

9.2.4 Chapter 6

If autistic social and communication impairments are the consequence of impaired ToM then individuals who meet the diagnostic criteria for ASD should not be able to pass tasks, such as false belief tasks, which reputedly measure ToM. But, as we have seen both from the literature reviewed and the data reported in this thesis, a proportion of individuals do. There are a number of possible explanations for this. The most obvious explanation is that ASD symptomatology cannot be adequately explained by the ToM account. A second possibility is that any hypothesised ToM impairment in ASD may be more or less severe between individuals, allowing successful performance, on tasks designed to assess ToM, by those less markedly affected. Another possibility is that these tasks are poor measures of ToM, indexing performance but not underlying competence. Or, perhaps individuals with ASD sometimes adopt compensatory cognitive strategies which enable them to painstakingly work out solutions, as Bowler (1992) and Happé (1995) have proposed. Chapter 6 considered this final possibility, with the aim of further elucidating the mechanisms by which those children with ASD, who pass false belief tasks, do so. Specifically, the possible role of linguistic strategies was explored.

The first of the experiments reported in Chapter 6 considered the role of language, indexed by receptive vocabulary, in false belief task performance. The

ASD and comparison groups had mean verbal mental ages of approximately 6.5 years, mean chronological ages of approximately 10.5 years, and mean verbal IQs in the mid-70s. The results indicated that the relationship between vocabulary and false belief task performance was equally strong within both the ASD and comparison groups. Thus, the present study failed to replicate previous findings which have shown a significantly stronger relationship between these variables amongst individuals with ASD (Happé, 1995; Fisher et al. 2005). These results speak against the theory that children with ASD use verbally-mediated strategies to hack out solutions to the ToM tasks.

The second and third experiments tested the hypothesis that complement syntax – a specific element of syntactic knowledge – facilitates performance on false belief tasks. The complement syntax task, which was common to both experiments, involved reading one-line, complement-containing descriptions of pairs of pictures to the children. The children were then required to recall the sentence and extract the complement. Both of these experiments included samples which had mean verbal mental ages of approximately 6.5 years, mean chronological ages of approximately 10 years, and mean verbal IQs of approximately 75.

The second experiment indicated that, regardless of group, and after controlling for VMA and CA, complement syntax and Sally-Anne performance were not related. These results were clearly inconsistent with the hypothesis that children with ASD use knowledge of complement structures as a means of solving false belief problems. However, it remains a distinct possibility that *general* grammatical competence is an important underlying contributor to performance on the Sally-Anne task. This seems particularly plausible given the finding of Fisher et al. (2005) that receptive grammar was the best predictor of performance on false belief tasks, particularly amongst individuals with ASD, and the fact that in typical development grammar predicts ToM longitudinally but ToM does not predict grammar (Astington & Jenkins, 1999). Thus, it remains a possibility that ToM task performance is “linguistically determined” for individuals with ASD. Future research must include comprehensive measures of grammatical knowledge, such as the Test for Reception of Grammar (TROG; Bishop, 1989) or the Clinical Evaluation of Language Fundamentals (CELF; Semel, Wiig, & Secord, 1995) to provide definitive evidence. A longitudinal study of the relationship between linguistic competence and false belief task performance would be particularly informative if it included a comprehensive language battery and both verbal and non-verbal false belief tasks.

The third experiment revealed a (group-independent) relationship between complement syntax score and the Smarties own- but not other's-false-belief test question. However, it is quite possible that this result was an artefact of the (arguably) flawed experimental procedure. It is tentatively suggested that no such relationship would have been found if the children had not been asked to explicitly verbalise their belief prior to being asked the test question, thereby equating the "self" and "other" questions. The other possibility is that children with ASD are able to recruit their knowledge of complement syntax in order to solve false belief problems in the context of some tasks but not others.

Beyond the theoretical implications of these results in terms of potential linguistic compensatory strategies, these results indicate that children with ASD show grammatical skills, in the domain of complement syntax, that are equivalent to those of vocabulary matched comparison children. Their generally good performance on the task indicates a sound knowledge of both the syntax and semantics of complement structures.

So, what are the implications of these findings in terms of the overall aims of the thesis? The possibility that false belief tasks index different underlying cognitive processes amongst individuals with and without ASD was not upheld by the results from the Sally-Anne and Smarties own-false-belief analyses. On the basis of the current data, it is, therefore, assumed that both the Smarties "other" and Sally-Anne tasks measure metarepresentational skill to the same extent amongst individuals both with and without ASD. The Smarties "self" task appears to be a more ambiguous measure.

9.2.5 Chapter 7

The aim of Chapter 7 was to assess the relationship between delayed self-recognition and source memory, in order to test the hypothesis that temporally extended self-awareness is necessary for episodic memory. The sample included 27 participants with ASD and 27 comparison participants, who had mean verbal mental ages of approximately 6.5 years, mean chronological ages of around 9 years and mean verbal

IQs of around 80. Regardless of which delayed self-recognition scoring method was considered, there was no significant relationship with source memory. Essentially, the data from both the matched and unmatched groups provided no support for the initial prediction that delayed self-recognition performance would be related to source memory performance. The most plausible explanation for these null results is that there were ceiling effects in delayed self-recognition performance. This was particularly problematic for the analyses involving dichotomous delayed self-recognition scoring. These ceiling effects were probably due to the relatively high verbal age of the participants but may have also been due, in part, to the fact that there may be more than one way to pass the task. As discussed above, passing the task may not necessarily indicate the presence of a temporally extended self-concept. Instead, at least some of the children may have passed on the basis of detecting featural equivalence relations (Povinelli, 2001).

However, the main issue was that this experiment was hampered by a major methodological problem. The particular measures used to assess episodic memory and temporally extended self-awareness were incompatible. Put simply, the DSR task was too easy and the source memory task was too difficult (potential DSR failers tended to perseverate on the source memory task). This difficulty was unanticipated from the pilot work. Even if a sample with a greater number of DSR failers had been obtained, it is more than likely that these children would have been unable to complete the source memory task. Thus, in order to effectively assess the question of whether temporally extended self-awareness is necessary for episodic memory – of whether episodic retrieval involves the understanding that "the self doing the [re] experiencing now is the same self that did it originally" (Wheeler et al., 1997, p.349) – it would be necessary to select a less demanding test of episodic memory, as discussed below.

9.2.6 Chapter 8

Chapter 8 aimed to test the hypothesis that diminished ToM in ASD results in episodic memory difficulties. Drawing on the theoretical account explicated in depth by Perner (2000, 2001), two key ToM skills were identified as possible developmental precursors of the observed memory problems: (1) a general capacity for metarepresentation and (2) an ability to represent causal self-referentiality.

The first experiment explored the relationship between Sally-Anne and source memory performance in a sample of 32 children with ASD and 32 comparison children, who had a mean verbal mental age of approximately 7 years, a mean chronological age of approximately 10.5 years, and a mean verbal IQ of approximately 75. The analyses showed that after controlling for age and verbal ability Sally-Anne passers did not obtain significantly higher source memory scores than failers.

The second experiment investigated the relationship between performance on the Smarties own-/other's-false-belief questions and source memory. The sample characteristics were similar to those from the previous Sally-Anne experiment. The results indicated that, regardless of group, Smarties "other" passers achieved significantly higher source memory scores than Smarties "other" failers. In contrast to the findings from the previous (Sally-Anne) experiment, these results support the hypothesis that metarepresentational ability is a precursor of episodic memory and that impairments in this ability may contribute to impairments of episodic memory in ASD.

The possible differential influence of ToM on episodic memory for self- versus other-performed actions was also considered. It was found that Smarties "other" passers and failers did not perform significantly differently on "self" source memory but Smarties "other" passers obtained significantly higher mean "other" source memory scores than failers. That is, individuals, irrespective of diagnostic group, who were able to attribute a false belief to another person, in the context of the Smarties task, showed significantly better memory for source when the protagonist was another person. When the protagonist in question was the self, Smarties "other" performance did not relate to source attribution. Essentially, developments in Smarties "other" performance were related specifically to source memory for other's actions.

Smarties "self" performance was not found to be related to source memory, however. This failure to find a significant result may have been due to ceiling effects in Smarties "self" performance or it may, indeed, be that this test question is not a good measure of metarepresentational ability, as previously argued above.

These two experiments thus provide partial support for the suggestion that metarepresentational ability is important for source memory. Given that source memory is considered to require autonoetic awareness, these results are consistent with the theory that metarepresentation is necessary for autonoetic episodic remembering.

It was found that false belief understanding was related, in particular, to "other" source memory – that is, identification of the source of cards that had been picked up and named by the experimenter. These results seem to suggest that developments in metarepresentational capacity are involved in the development of memory for others' actions to a greater extent than memory for one's own actions. One possible explanation for this is that source memory for the experimenter's cards relies on episodic recollection to a greater extent than source memory for one's own cards. It is suggested that "self" source memory can be accomplished through action monitoring. Encoding a conscious motor image may facilitate memory for one's own actions, but remembering the actions of others may be more heavily dependent on the ability to become autonoetically aware of one's own memories. Furthermore, children with a ToM might be more likely to attend to, and therefore encode, information about what others are doing and hence have more elaborate memories for others' actions.

The third experiment reported in Chapter 8 considered the second of the hypothesised episodic memory precursors, assessing the relationship between source memory and performance on the see-know task. The aim was to explore the possibility that a failure to grasp the fact that perception is necessary for knowledge acquisition means that children with ASD do not understand that their memories originate from their past (perceptual) experiences. Data from 28 participants with ASD and 28 comparison participants, again with similar characteristics to those in the first of the experiments reported in Chapter 8, were considered. The results were in the predicted direction, with see-know failers attaining lower source memory scores. However, no significant results were obtained. Again, this may have been due to the fact that relatively few individuals in either group actually failed the task ($n = 11$). In which case, the null results may have been the consequence of ceiling effects. However, if we assume that this was not the case, it can be inferred that the episodic memory difficulties experienced by individuals with ASD are not due to difficulty with representing causal self-referentiality but, rather, with understanding that the information being brought to mind is a mental representation of a past experience – a memory. It seems likely that understanding of causal self-referentiality is necessary, but not sufficient, for episodic memory.

9.3 IMPORTANT FINDINGS AND CONCLUSIONS

In sum, the empirical work outlined in this thesis has demonstrated that:

(a) episodic memory, as indexed by self-other source monitoring, was subtly impaired in children/adolescents with ASD

(b) semantic memory, as indexed by A' (item discrimination), was attenuated in children/adolescents with low-functioning ASD

(c) individuals with ASD demonstrated the enactment effect in memory to the same extent as those without ASD

(d) individuals with ASD were more likely than comparison individuals to fail delayed self-recognition and required more prompting, possibly implying impaired temporally extended self-awareness amongst some individuals

(e) lexical knowledge but not complement syntax was related to false belief task performance, within both groups, inconsistent with the hypothesis that individuals with ASD use linguistic strategies to "hack-out" solutions to false belief tasks

(f) metarepresentational ability, assessed with the Smarties false belief task, was related to episodic (source) memory, particularly source memory for other-performed actions

The finding that source memory was subtly impaired in ASD confirms the results of previous research which have suggested that episodic memory is impaired in this population (see section 1.5.2). However, the fact that item discrimination was also found to be impaired amongst certain individuals suggests that the picture is somewhat more complex and that memory difficulties are not isolated to the episodic system in low-functioning individuals, extending to the semantic system in this subgroup. Overall, the results support the idea that individuals with ASD are less able, or less disposed to, become autonoetically aware of their memories. This is consistent with research which suggests that, in general, individuals with ASD show atypical introspective abilities (e.g., Ben Shalom et al., 2006; Hill et al., 2004; Hurlburt et al., 1994). This seeming reduction in private self-awareness clearly impacts on episodic memory capacity and is likely to be tied up with difficulties in ToM, given that this form of self-awareness involves reflecting upon the self's *mental states*. Certainly, memories are a type of mental state and, indeed, the results from the current research suggest that ToM and the capacity for autonoetic remembering are related in ASD. Specifically, the ability to *represent a representation as a representation* is key to autonoetic awareness. After all, if a memory cannot be identified as a memory then it cannot be consciously reflected upon as such.

The fact that individuals with ASD, including ToM task failers, were shown to demonstrate the enactment effect in memory suggests that this effect is the result of processes that do not rely on introspective abilities. Specifically, memory for one's own actions may not depend on the capacity for autonoetic remembering, perhaps, depending upon a more basic mechanism such as action monitoring. Furthermore, it seems likely that those individuals who passed the ToM tasks were more likely to attend to other's actions, thereby improving their "other" source memory. When one understands that others have minds, other people take on a greater significance and become objects "worth" attending to. This would greatly increase the amount of information about others' actions to be encoded within episodic and, indeed, semantic memory.

There was also limited evidence that temporally extended self-awareness is impaired in ASD. Whilst the majority of individuals from both diagnostic groups passed the DSR task, it was still the case that participants with ASD were significantly more likely to fail the task than comparison participants. One interesting issue to consider is that temporally extended self-awareness may be multidimensional and delayed self-recognition may be limited in its scope for assessing the various dimensions, perhaps, being limited to assessing temporally extended awareness (or, even, basic conceptual awareness in some cases) of the *physical* self. Autonoetic awareness may require somewhat more sophisticated awareness of self – awareness of one's *mental* continuity – which is not captured by the task. It could be argued that, without the additional awareness of mental states, reasoning about the causal connection between a past state and a present state cannot be applied to memory, since memories are internal, mental phenomena. It may be that individuals with ASD have an impaired ability to conceive of the temporal continuity of their private selves and this is what underlies their impaired episodic memory. It is the conjunction of metarepresentation, self-awareness, and temporal cognition that seems to be critical.

9.4 ORIGINAL CONTRIBUTIONS OF THIS THESIS TO THE FIELD OF AUTISM RESEARCH

This thesis has contributed to the field of autism research both theoretically and empirically. The literature review, as well as the subsequent chapters, brought together previously disparate empirical findings and set them within a theoretical framework which had previously only been considered in relation to typical development. Most notably, the novel hypothesis, that impairments in ToM, self-awareness, and temporal cognition are precursors to the episodic memory impairments observed amongst individuals with ASD, was suggested. There were also a number of original empirical contributions.

No currently published studies have investigated temporally extended self-awareness in individuals with ASD, although Nielsen et al. (in press) report that Dissanayake and Suddendorf (unpublished) failed to find differences between participants with ASD and typically developing comparison participants on the DSR task. Thus, the current finding that, children with ASD were significantly more likely to fail the DSR task than comparison children, furthers our understanding of ASD. Similarly, there have been no peer-reviewed, published studies of complement syntax and false belief understanding in ASD. The current findings do not suffer from problematic statistical analyses, unlike these previous studies, and therefore provide more convincing evidence, in fact, suggesting that complement syntax is *not* used by individuals with ASD as compensatory mechanism in false belief task performance. Moreover, no research has previously sought to address the question of *why* episodic memory is impaired in ASD. The finding that metarepresentational competence and episodic memory are related in ASD thus represents an entirely unique contribution to the field.

In summary, our understanding of ASD has been advanced by this thesis in the following areas: it has now been established that: (a) children with and without ASD are equally susceptible to the enactment effect; (b) some individuals with ASD appear to show impaired temporally extended self-awareness; (c) metarepresentational ability and episodic memory are related in ASD; and (d) complement syntax understanding does not predict false belief performance in ASD after controlling for age and receptive vocabulary.

9.5 METHODOLOGICAL ISSUES AND DIRECTIONS FOR FUTURE RESEARCH

A number of the original research questions could not be adequately addressed due to methodological constraints. The main difficulties concerned the self-other source memory task. Firstly, the task used here did not appear to be a very sensitive measure of episodic memory and hence robust group differences in performance were not observed. It allowed for the possibility that performance could be supported by semantic memory. Secondly, the task was too challenging for the particular sample which was required to assess the question of whether temporally extended self-awareness or understanding of causal self-referentiality were related to episodic memory. That is, those children who fell within the necessary age range to address this question tended to show perseverative responses, being unable to perform the task. The children who were able to complete the source memory task tended to perform at ceiling on the DSR and the see-know tasks and, consequently, valid conclusions could not be drawn.

Thus, in terms of future research, aimed at addressing the causes of the episodic memory impairment in ASD, a more developmentally appropriate test of episodic memory should be implemented. It would be particularly interesting to use the task designed by Perner et al. (in press, see Chapter 1, section 1.3.3) which involved manipulating whether information was learned though direct experience or through indirect information. If children with ASD have selectively impaired episodic memory then they should be expected to perform as well as comparison children in the indirect-information condition but significantly worse than comparison children in the direct-experience condition. Using such a task, it is likely that more robust group difference would be observed. The task is also more developmentally appropriate and perserveration would not be a problem. Thus, the relationship between episodic memory, ToM, and temporally extended self-awareness could be more effectively explored.

Alternatively, if one were interested in assessing episodic memory, in and of itself, a more suitable source memory task could be adopted. An (unsupported) internal source monitoring task is likely to prove most difficult for individuals with ASD, given that such tasks require the highest degree of introspection. Using an unsupported task would probably also reduce the likelihood of perseverative responses. The only difficulty might be that such a task could potentially have limited scope for use with children with a low developmental level. Internal source monitoring is obviously of great practical significance. In our everyday lives, it is essential that we can distinguish between imagined and performed actions. For example, it is important that one remembers whether one turned the iron off or whether one just thought about doing so. It would also be useful to validate the use of source monitoring as a test of episodic memory in ASD. Perfect et al. (1996) demonstrated that, in typical adults, individuals who show more "remembering" and less "knowing" in recognition memory also show better source memory. However, there is no guarantee that the same mechanisms underlie source monitoring in ASD and typical development.

In terms of ToM measures, the tasks used here mainly assessed attribution of mental states to others when, in fact, it is theory-of-own-mind that is required for episodic memory. It would be interesting, therefore, to include both "self" and "other" see-know conditions and to equate the task demands of the self and other questions in the Smarties task in future research.

In terms of the complement syntax task, it may have been useful to include a control task. Each of the questions involved stating two things (e.g., [1] she told her husband she saw a ghost, [2] but it was really a blanket) and then asking the child to recall and verbalise the first of those things. Thus, it is at least possible that participants were simply biased towards responding with the first of the two clauses. To rule out this possibility, children could have been given control questions such as, "He had ketchup on his arm and he wiped it off with a tissue. What did he wipe it off with?" This possibility does seem quite unlikely, however. The tendency for echolalia, often associated with ASD, would have been more likely to result in the final part of the sentence being repeated. Indeed, the observed successful performance necessitated inhibition of such echolalic responses.

Future research should also further investigate delayed self-recognition in ASD and include a sample with lower verbal mental ages. It would be particularly interesting to use an extreme (seven day) delay, following Povinelli and Simon (1998). This would allow the hypothesis, that the some children with ASD were able to pass the task by detecting featural equivalence relations rather than by reasoning about the relationship between past and present states of self, to be tested. If this were the case then children with ASD may be as likely to reach for the sticker in the extreme delay condition as in the brief delay condition. Another consideration is that the DSR task involves reasoning about the causal connection between a past self represented by an *external* medium and an *internal* mental representation of one's present self. This is not the same as reasoning about the relation between present and past mental representations of self, as required for temporally extended self-awareness. This could explain why the task is, arguably, conducive to alternative performance strategies, not necessarily indexing temporally extended self-awareness.

Thus, it would be useful to assess the ability to make temporal-causal inferences in ASD, using the type of task devised by McCormack and Hoerl (2005; see Chapter 1, section 1.4.3). This would provide a better indication of whether individuals with autism have a concept of the "causal arrow of time" and whether they can form and coordinate perspectival and non-perspectival temporal frameworks. If it is temporally extended self-awareness that provides us with a linear conception of time and the ability to reason about the relationship between different temporal perspectives (Campbell, 1997, cited in Perner, 2000, p.304; McCormack & Hoerl, 1999) then performance on such tasks could be seen as a proxy for temporally extended self-awareness. Such tasks may, in fact, provide a better indication of whether a child is aware of their temporal continuity than DSR, which may be achieved without a temporally extended self-concept. It would therefore be predicted that performance on tests of temporal-causal reasoning would be impaired in ASD and would be related to episodic memory capacity.

Finally, as we have seen in this thesis, it is now reasonably well established that *past-oriented* mental time travel is attenuated in ASD. It is essential, however, that we determine whether or not *future-oriented* mental time travel (episodic future thinking) is diminished in ASD. This cognitive capacity has never before been assessed within this population. However, given that it is thought to invoke the same neurocognitive system as episodic remembering, in typically developing populations (Addis, Wong, & Schacter, 2007; Buckner & Carroll, 2006; Schacter & Addis, in press), it is likely to be similarly impoverished.

In the wider field of psychology, there has recently been a surge of interest in episodic future thinking and related concepts, in both typically developing humans and non-human animals. For example, it has recently been argued, from an evolutionary standpoint, that the episodic memory system has conferred a selective advantage for humans because it has enabled them to recall specific past events and to use this information in order to anticipate and plan for specific future experiences (Addis et al., 2007; Suddendorf & Corballis, in press). The real utility of memory for the past is that is helps us to consider what may happen in the future; it is not useful in and of itself. Thus, episodic future thinking is thought to underpin the high degree of behavioural flexibility that is typical of humans and has ensured their survival. Clearly, the ability to flexibly plan and act effectively for one's future needs and desires is essential for everyday functioning and independence.

Given that episodic future thinking is thought to be essential for behavioural flexibility, it could be hypothesised that a diminution of this capacity contributes, in particular, to the restricted, repetitive, and stereotyped patterns of behaviour that are characteristic of ASD. Such an impairment could explain why some individuals with ASD find unfamiliar events or disruptions to the expected sequence of events stressful. Difficulty with imagining oneself in an unexpected or novel future situation would result in a great deal of uncertainty and, consequently, anxiety. It may be hypothesised that impairments in the episodic memory system have profound consequences for the ability of individuals with ASD to plan and act in the world. Thus, diminished episodic future thinking may contribute to some of the key diagnostic features of ASD. Clearly, given the potential explanatory power of this hypothesised impairment, it is essential that carefully controlled, hypothesis-driven experiments are conducted in order to assess the capacity for future-oriented mental time travel in ASD.

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Appendices

APPENDIX 1: Item/Self-Other Source Memory Word Lists

	List a	List b	List c
1	snail	penguin	tree
2	chicken	bird	boat
3	trumpet	book	rabbit
4	dog	tiger	leaf
5	computer	foot	cat
6	cup	shoe	phone
7	plane	duck	rectangle
8	smoke	bike	apple
9	chair	train	bed
10	bus	trousers	butterfly
11	scissors	cheese	socks
12	basket	fork	lorry
13	knife	eyes	shirt
14	cow	watch	swing

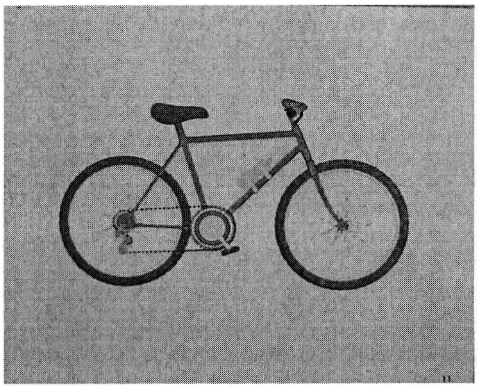
APPENDIX 2: Item/Self-Other Source Memory Stimulus Presentation Conditions

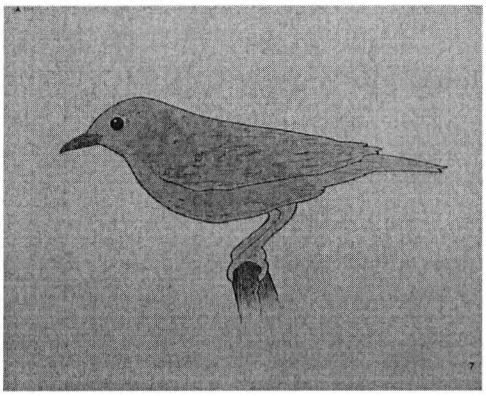
	Condition 1 **a + b**		**Condition 2** **a + c**		**Condition 3** **b + c**	
1	chair	a	snail	a	train	b
2	trousers	b	cow	a	apple	c
3	watch	b	boat	c	penguin	b
4	dog	a	scissors	a	swing	c
5	foot	b	socks	c	leaf	c
6	computer	a	lorry	c	foot	b
7	eyes	b	cat	c	tree	c
8	knife	a	plane	a	duck	b
9	penguin	b	chair	a	bike	b
10	book	b	smoke	a	phone	c
11	bike	b	rabbit	c	bed	c
12	duck	b	butterfly	c	bird	b
13	train	b	computer	a	watch	b
14	bird	b	rectangle	c	tiger	b
15	shoe	b	shirt	c	eyes	b
16	trumpet	a	cup	a	socks	c
17	cow	a	tree	c	boat	c
18	plane	a	leaf	c	trousers	b
19	smoke	a	swing	c	shirt	c
20	tiger	b	apple	c	shoe	b
21	basket	a	dog	a	butterfly	c
22	chicken	a	chicken	a	fork	b
23	bus	a	bus	a	rectangle	c
24	fork	b	basket	a	book	b
25	cup	a	phone	c	rabbit	c
26	cheese	b	knife	a	lorry	c
27	snail	a	bed	c	cheese	b
28	scissors	a	trumpet	a	cat	c

APPENDIX 3: Item/Self-Other Source Memory Recognition List and Test/Lure and Self/Other (Participant/Experimenter) Status for Each Stimulus Condition

		Condition 1 (a+b)			**Condition 2 (a+c)**			**Condition 3 (b+c)**	
Recognition list	**word list**	**Test/ lure**	**Self/ other**		**Test/ lure**	**Self/ other**		**Test/ lure**	**Self/ other**
book	b	test	other		lure			test	self
dog	a	test	other		test	self		lure	
chair	a	test	self		test	other		lure	
socks	c	lure			test	self		test	other
smoke	a	test	self		test	other		lure	
scissors	a	test	self		test	other		lure	
cheese	b	test	other		lure			test	self
cat	c	lure			test	other		test	self
trumpet	a	test	other		test	self		lure	
rabbit	c	lure			test	other		test	self
chicken	a	test	other		test	self		lure	
knife	a	test	self		test	other		lure	
tree	c	lure			test	self		test	other
bird	b	test	other		lure			test	self
swing	c	lure			test	other		test	self
computer	a	test	self		test	other		lure	
cow	a	test	self		test	other		lure	
cup	a	test	other		test	self		lure	
shirt	c	lure			test	self		test	other
phone	c	lure			test	other		test	self
plane	a	test	other		test	self		lure	
bus	a	test	self		test	other		lure	
watch	b	test	self		lure			test	other
apple	c	lure			test	self		test	other
foot	b	test	other		lure			test	self
bed	c	lure			test	self		test	other
bike	b	test	self		lure			test	other
boat	c	lure			test	other		test	self
trousers	b	test	self		lure			test	other
lorry	c	lure			test	self		test	other
fork	b	test	self		lure			test	other
duck	b	test	other		lure			test	self
basket	a	test	self		test	other		lure	
shoe	b	test	other		lure			test	self
penguin	b	test	other		lure			test	self
rectangle	c	lure			test	self		test	other

APPENDIX 4: Examples of Stimulus Cards Used for Item/Self-Other Source Memory Test





APPENDIX 5: Test Record Form for Item/Self-Other Source Memory Task

Name:	
Date:	
Condition:	

	Word	**Alternative word**	**Did we see it earlier?**			**Who named it?**		
1	book		Yes			**Sophie**		
			No			Child		
2	dog		Yes			**Sophie**		
			No			Child		
3	chair		Yes			**Sophie**		
			No			Child		
4	socks		Yes			Sophie		
			No			**Child**		
5	smoke		Yes			Sophie		
			No			**Child**		
6	scissors		Yes			**Sophie**		
			No			Child		
7	cheese		Yes			Sophie		
			No			**Child**		
8	cat		Yes			**Sophie**		
			No			Child		
9	trumpet		Yes			Sophie		
			No			**Child**		
10	rabbit		Yes			Sophie		
			No			**Child**		
11	chicken		Yes			**Sophie**		
			No			Child		
12	knife		Yes			**Sophie**		
			No			Child		
13	tree		Yes			Sophie		
			No			**Child**		
14	bird		Yes			**Sophie**		
			No			Child		
15	swing		Yes			Sophie		
			No			**Child**		
16	computer		Yes			Sophie		
			No			**Child**		
17	cow		Yes			**Sophie**		
			No			Child		
18	cup		Yes			Sophie		
			No			**Child**		
19	shirt		Yes			**Sophie**		

			No			Child		
20	phone		Yes			Sophie		
			No			**Child**		
21	plane		Yes			Sophie		
			No			**Child**		
22	bus		Yes			**Sophie**		
			No			Child		
23	watch		Yes			Sophie		
			No			**Child**		
24	apple		Yes			Sophie		
			No			**Child**		
25	foot		Yes			**Sophie**		
			No			Child		
26	bed		Yes			**Sophie**		
			No			Child		
27	bike		Yes			Sophie		
			No			**Child**		
28	boat		Yes			**Sophie**		
			No			Child		
29	trousers		Yes			**Sophie**		
			No			Child		
30	lorry		Yes			**Sophie**		
			No			Child		
31	fork		Yes			Sophie		
			No			**Child**		
32	duck		Yes			**Sophie**		
			No			Child		
33	basket		Yes			**Sophie**		
			No			Child		
34	shoe		Yes			Sophie		
			No			**Child**		
35	penguin		Yes			**Sophie**		
			No			Child		
36	rectangle		Yes			Sophie		
			No			**Child**		
37	train		Yes			Sophie		
			No			**Child**		
38	butterfly		Yes			**Sophie**		
			No			Child		
39	leaf		Yes			Sophie		
			No			**Child**		
40	eyes		Yes			**Sophie**		
			No			Child		
41	tiger		Yes			Sophie		
			No			**Child**		
42	snail		Yes			Sophie		
			No			**Child**		

APPENDIX 6: Task Order for Each "Theory of Mind" Condition

Condition 1
Sally-Anne
Smarties
See-know

Condition 2
See-know
Sally-Anne
Smarties

Condition 3
Smarties
See-know
Sally-Anne

APPENDIX 7: Examples of ToM Response Sheets

SALLY-ANNE MARK SHEET (condition 1)

Name:	
Date:	

This is Sally and this is Anne **"Who's this? Who's this?"**	
Sally's going to put her marble in the **BLUE** box. Now Sally's going out to play. While Sally's out, naughty Anne takes the marble out of the blue box and puts it in the pink box. When Sally comes back home… **"Where will Sally look for her marble first?"** "In the **PINK** box or the blue box?"	
"Where is the marble really?" "In the **PINK** box or the blue box?"	
"Where was the marble in the beginning?" "In the **PINK** box or the blue box?"	

‘SMARTIES’ ANSWER SHEET

Name:	
Date:	

Question	**Response**	
“What’s in here?” (show contents and say “no it’s a…” – put back in box and close)		
“What’s in here?” (control)		
“When I first asked you, what did you say?”		
“Your teacher hasn’t seen this box. When s/he comes in later, I’ll show her/him this box just like this and ask him/her: what’s in here” **“What will your teacher say?”**		
“Is that what’s really in the box?”		
“Do you remember, when I took the box out of my bag (re-enact episode) **and asked you what was in it, what did you say?”**		

SEE-KNOW RESPONSE SHEET (condition 1)

Name	
Date:	

“This is John and this is Fiona”.

“Who’s this?” “Who’s this”

I’m going to tell you some stories about John and Fiona and ask you some questions.

1	1a) Fiona and John go out to play in the park. Fiona falls over and cuts her knees and John gets muddy knees.	
	Who gets sore knees?	
2	2b) John does some colouring while Fiona goes for a long run.	
	Who gets tired out?	
3	3a) It's snowing outside. Fiona goes outside to make a snowman while John stays indoors by the fire and reads a book.	
	Who gets cold?	
4	4b) John and Fiona are very hungry. Fiona has a small glass of water and John has a big roast dinner.	
	Who gets full up?	
5	5a) John and Fiona go to the beach. John lies down in the sun while Fiona goes swimming.	
	Who gets hot?	
6	6b) John and Fiona go to a birthday party. John has one plate of food and Fiona eats all the cakes and ice cream.	
	Who starts feeling sick?	

"Look I've got some boxes here. There's something inside each box. I'm going to show the boxes to John and Fiona"

1	**John LIFTS** the box up	Fiona opens the box and has a LOOK
	"Who knows what is in the box?	**Fiona** or John
2	**Fiona LIFTS** up the box	John opens the box and has a LOOK
	"Who knows what is in the box?	**John** or Fiona
3	**John opens** the box and has a **LOOK**	Fiona LIFTS up the box
	"Who knows what is in the box?	**Fiona** or John
4	**Fiona opens** the box and has a **LOOK**	John LIFTS up the box
	"Who knows what is in the box?	**Fiona** or John
5	**Fiona LIFTS** up the box	John opens the box and has a LOOK
	"Who knows what is in the box?	**John** or Fiona
6	**John opens** the box and has a **LOOK**	Fiona LIFTS up the box
	"Who knows what is in the box?	**Fiona** or John

APPENDIX 8: Sally-Anne Conditions

	Condition			
	1	2	3	4
Sally's going to put her marble in the ...... box	Blue	Blue	Pink	Pink
Where will Sally look for her marble first? In the ...... box or the blue/pink box?	Pink	Blue	Pink	Blue
Where is the marble really? In the ...... box or the blue/pink box?	Pink	Blue	Pink	Blue
Where was the marble in the beginning? In the ...... box or the blue/pink box?	Pink	Blue	Pink	Blue

APPENDIX 9: Counterbalancing for See-Know Control Questions

Each of the six questions could take four different forms if the order of characters was varied and the order of the action upon which the inference is based was also varied:

(1) FIONA performs INFO bearing action then JOHN performs NON INFO bearing action
(2) JOHN performs INFO bearing action then FIONA performs NON INFO bearing action
(3) FIONA performs NON INFO bearing action then JOHN performs INFO bearing action
(4) JOHN performs NON INFO bearing action then FIONA performs INFO bearing action

Given that there were six control questions, to fully counterbalance the questions it would have been necessary to use 24 versions of the control task. Given that the characters themselves were not of any theoretical interest, it was decided that to reduce the number of possible control conditions, order of characters would not be counterbalanced.

Thus, the order of the stories and the position of the information bearing part of the story were counterbalanced using a Latin Square. This produced 12 conditions. John and Fiona were then pseudo-randomly assigned to the information bearing parts of the stories, subject to the constraint that neither character occurred more than twice in a row.

	Information first	Information second
(1) “Fiona and John go out to play in the park. Fiona falls over and cuts her knees and John gets muddy knees. Who gets sore knees?”	A	1
(2) “John does some colouring while Fiona goes for a long run. Who gets tired out?”	B	2
(3) “It's snowing outside. Fiona goes outside to make a snowman while John stays indoors by the fire and reads a book. Who gets cold?”	C	3
(4) “John and Fiona are very hungry. Fiona has a small glass of water and John has a big roast dinner. Who gets full up?”	D	4
(5) “John and Fiona go to the beach. John lies down in the sun while Fiona goes swimming. Who gets hot?”	E	5
(6) “John and Fiona go to a birthday party. John has one plate of food and Fiona eats all the cakes and ice cream. Who starts feeling sick?”	F	6

Condition	
1	A 2 C 4 E 6
2	2 C 4 E 6 A
3	C 4 E 6 A 2
4	4 E 6 A 2 C
5	E 6 A 2 C 4
6	6 A 2 C 4 E
7	1 B 3 D 5 F
8	B 3 D 5 F 1
9	3 D 5 F 1 B
10	D 5 F 1 B 3
11	5 F 1 B 3 D
12	F 1 B 3 D 5

APPENDIX 10: See-Know Test Questions

The order of "looking and lifting and which doll "looked" and which doll "lifted" was randomly assigned as shown below.

Question	Who lifts	Who looks inside	Order of looking/lifting
1	John	Fiona	Lift then look
2	Fiona	John	Lift then look
3	John	Fiona	Look then lift
4	Fiona	John	Look then lift
5	Fiona	John	Lift then look

APPENDIX 11: Complement Syntax Scoring

Correct responses were coded according to four categories as follows:

(1) *Complement + embedding verb.*

To obtain this coding, the complement had to be reproduced precisely along with the embedding verb (said/told). Responses had to include:
- She/the girl said she was reading a book
- She told the girl there was a bug in her hair
- She told her husband/him she saw a ghost
- She said she had a hole in her trousers
- She told her dad/him he had a cut
- She told her teacher/her she drew a face
- Her friend/she said she was eating an egg
- She said there was a spider in her cereal

(2) *Complement in isolation.*

To obtain this coding, the complement had to be reproduced precisely as it was heard. The complement could be preceded by "that" but responses had to include:
- she was reading a book
- there was a bug in her hair
- she saw a ghost
- she had a hole in her trousers
- he had a cut
- she drew a face
- she was eating an egg
- there was a spider in her cereal

(3) *Partial complement.*

This coding required the child to report the key element contained within the complement

Responses must include:
- reading a book/ book/ reading
- bug in her hair/bug
- a ghost
- hole in her trousers/ hole
- cut
- face
- eating an egg/ egg
- spider in her cereal/ spider

Examples marked as correct:

It's a ghost

(4) *Paraphrased complement.*

This coding allowed for mistakes with grammar. Word substitutions which did not significantly alter the meaning of the complement were also accepted here.

Examples coded here included:

Q1: "She is reading a book"
Q2: "Bug in the head"
Q3: "She said there's a ghost over there"
Q3: "I thought there was a zombie"
Q5: "You're bleeding
Q8: "She had a bug in her cereal"

Regarding codes 1 – 4, any mention of the final clause in the sentence precluded the response from being coded as correct. Thus, any mention of the following, resulted in the response being coded as incorrect =

- playing cards
- leaf
- blanket
- piece of paper
- ketchup
- scribble
- ball
- raisin

Incorrect responses were coded under 5 categories.

(1) *Exact echo.*

These responses were exact repetitions of the complement and the following clause. For example:

"The girl said she was reading a book, but she was really playing cards"

"There was a bug in her hair, but it was only a leaf."

(6) *Paraphrased repetition of complement and final clause.*

For example:

"She drawed a face but she didn't, she drawed a scribble."

(7) *Mention of final clause in any other context*

For example:

"It was looking like an ice cream but it was only a golf ball"

"Ketchup on the hands"

"She had a leaf in her hair"

(8) *Other response.*

"I was OK, I hope."
"Yuk!"

(9) *I don't know.*

APPENDIX 12: Sample of Information Sheet and Consent Form

CITY City University
London

Memory development research project

Dear Parent,

I am a researcher from the department of Psychology at City University in London. I would like to invite your child to take part in a study of memory development. This project will help us to better understand how children learn and help us to design better teaching programmes for them. For this work, we will be using some fun and rewarding tasks involving games and play-type interactions. These tasks involve looking at pictures and acting-out scenes with dolls and puppets. The children will also be offered stickers as a 'thank you' for helping. Some of the work will be recorded on video.

With your permission, I would like to see your child at school for four sessions at times agreed with their teachers. Your child would only be taken out of a lesson if they were completely happy to take part. If you do agree to your child taking part, you can withdraw them at any time, without giving any reason, and with no consequences for you or your child. **All of the information that I collect will be treated as completely anonymous and confidential**.

Please do not hesitate to contact me with any questions, or queries that you may have. My email address is s.e.lind@city.ac.uk and my telephone number is 020 8291 0521.

Thank you very much for taking the time to consider this request. **Please complete the consent slip overleaf and return it to your child's school.**

Yours sincerely,

Sophie Lind

Consent form

Please tick the appropriate boxes below:

- ☐ I would **like** my child to take part in this study
- ☐ I would **not like** my child to take part in this study
- ☐ I have read and understood the information above and have been invited to contact the researcher to ask any questions
- ☐ I understand that I can withdraw my child from this study at any time with no consequences to me or my child

Signed..Date...............................

Your name (in block letters)..

Child's name (in block letters)...

Relationship to child...

Child's date of birth...

APPENDIX 13: Group Means and Standard Deviations for “Self” and “Other” Hit Rate, Global Corrected Hit Rate, False Alarm Rate, Self-Other Corrected Hit Rate, and Source Memory According to Group and Level of Functioning

Memory measure	Self-Other	Level of functioning	Group	Mean	SD	N
Hit rate	Self	Low	ASD	.83	.14	11
			Comparison	.84	.14	11
			Total	.83	.14	22
		High	ASD	.87	.15	25
			Comparison	.86	.11	25
			Total	.86	.13	50
		Total	ASD	.86	.15	36
			Comparison	.86	.12	36
			Total	.86	.13	72
	Other	Low	ASD	.53	.22	11
			Comparison	.66	.21	11
			Total	.59	.22	22
		High	ASD	.69	.20	25
			Comparison	.66	.18	25
			Total	.67	.19	50
		Total	ASD	.64	.22	36
			Comparison	.66	.19	36
			Total	.65	.20	72
Global corrected hit rate	Self	Low	ASD	.58	.36	11
			Comparison	.71	.27	11
			Total	.64	.32	22
		High	ASD	.75	.24	25
			Comparison	.74	.23	25
			Total	.75	.23	50
		Total	ASD	.70	.29	36
			Comparison	.73	.24	36
			Total	.72	.26	72
	Other	Low	ASD	.27	.29	11
			Comparison	.53	.23	11
			Total	.40	.29	22
		High	ASD	.58	.25	25
			Comparison	.54	.19	25
			Total	.56	.22	50
		Total	ASD	.48	.30	36
			Comparison	.53	.20	36
			Total	.51	.25	72

Continued…

….Continued

Memory measure	**Self-Other**	**Level of functioning**	**Group**	**Mean**	**SD**	**N**
False alarm rate	Self	Low	ASD	.25	.29	11
			Comparison	.13	.27	11
			Total	.19	.28	22
		High	ASD	.13	.26	25
			Comparison	.14	.25	25
			Total	.13	.25	50
		Total	ASD	.17	.27	36
			Comparison	.13	.25	36
			Total	.15	.26	72
	Other	Low	ASD	.26	.34	11
			Comparison	.13	.34	11
			Total	.19	.34	22
		High	ASD	.10	.16	25
			Comparison	.10	.22	25
			Total	.10	.19	50
		Total	ASD	.15	.24	36
			Comparison	.11	.26	36
			Total	.13	.24	72
Self-other corrected hit rate	Self	Low	ASD	.58	.36	11
			Comparison	.71	.31	11
			Total	.65	.33	22
		High	ASD	.73	.30	25
			Comparison	.73	.27	25
			Total	.73	.28	50
		Total	ASD	.69	.32	36
			Comparison	.72	.27	36
			Total	.70	.30	72
	Other	Low	ASD	.27	.35	11
			Comparison	.53	.34	11
			Total	.40	.36	22
		High	ASD	.59	.22	25
			Comparison	.55	.21	25
			Total	.57	.21	50
		Total	ASD	.49	.30	36
			Comparison	.54	.25	36
			Total	.52	.28	72
Source	Self	Low	ASD	.80	.17	11
			Comparison	.85	.17	11
			Total	.83	.17	22
		High	ASD	.84	.15	25
			Comparison	.90	.12	25
			Total	.87	.14	50
		Total	ASD	.83	.16	36
			Comparison	.89	.14	36
			Total	.86	.15	72
	Other	Low	ASD	.70	.26	11
			Comparison	.77	.28	11
			Total	.73	.27	22
		High	ASD	.75	.26	25
			Comparison	.81	.19	25
			Total	.78	.22	50
		Total	ASD	.73	.25	36
			Comparison	.80	.22	36
			Total	.76	.24	72

APPENDIX 14: Group Means and Standard Deviations for "Self" and "Other" Hit Rates, False Alarm Rates, Global Corrected Hit Rate, Self-Other Corrected Hit Rate, and Source Memory According to Group and Verbal Mental Age Category

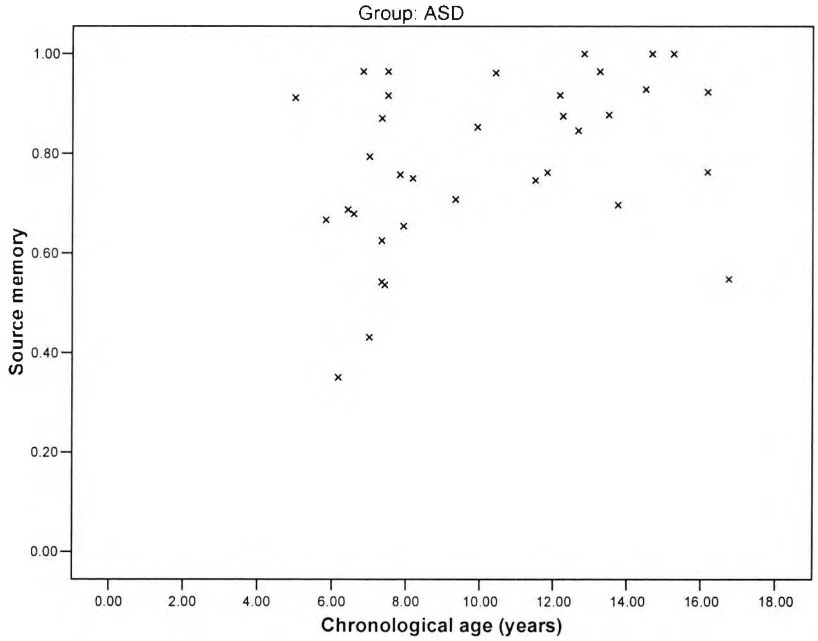
Memory measure	Self-Other	Group	VMA Category	Mean	SD	N
Hit Rate	Self	ASD	Under 6	.85	.16	11
			Over 6	.86	.14	25
			Total	.86	.15	36
		Comparison	Under 6	.85	.11	15
			Over 6	.86	.13	21
			Total	.86	.12	36
		Total	Under 6	.85	.13	26
			Over 6	.86	.14	46
			Total	.86	.13	72
	Other	ASD	Under 6	.62	.23	11
			Over 6	.65	.22	25
			Total	.64	.22	36
		Comparison	Under 6	.70	.19	15
			Over 6	.62	.18	21
			Total	.66	.19	36
		Total	Under 6	.67	.21	26
			Over 6	.64	.20	46
			Total	.65	.20	72
Global corrected hit rate	Self	ASD	Under 6	.62	.32	11
			Over 6	.73	.28	25
			Total	.70	.29	36
		Comparison	Under 6	.61	.29	15
			Over 6	.82	.14	21
			Total	.73	.24	36
		Total	Under 6	.62	.30	26
			Over 6	.77	.23	46
			Total	.72	.26	72
	Other	ASD	Under 6	.39	.33	11
			Over 6	.53	.28	25
			Total	.48	.30	36
		Comparison	Under 6	.47	.21	15
			Over 6	.58	.19	21
			Total	.53	.21	36
		Total	Under 6	.43	.26	26
			Over 6	.55	.24	46
			Total	.51	.25	72

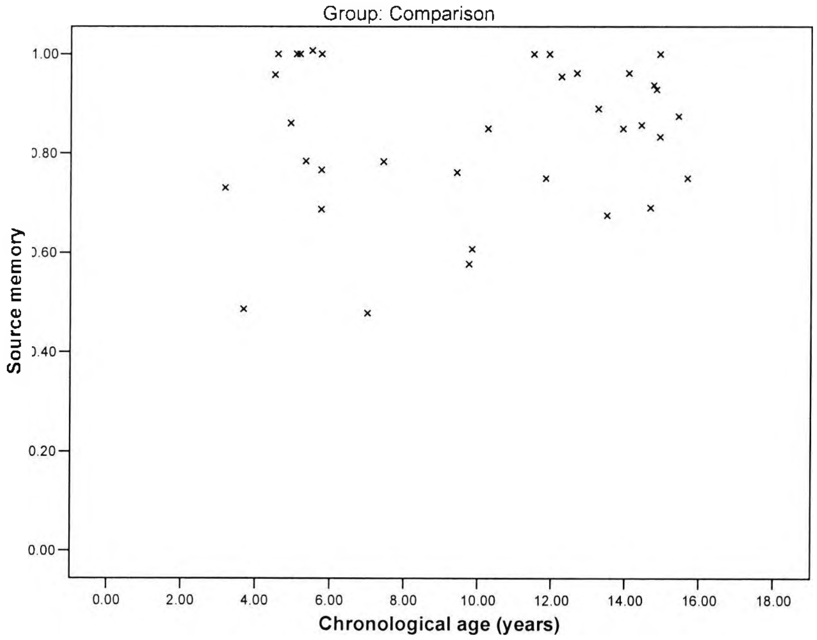
Continued….

…Continued

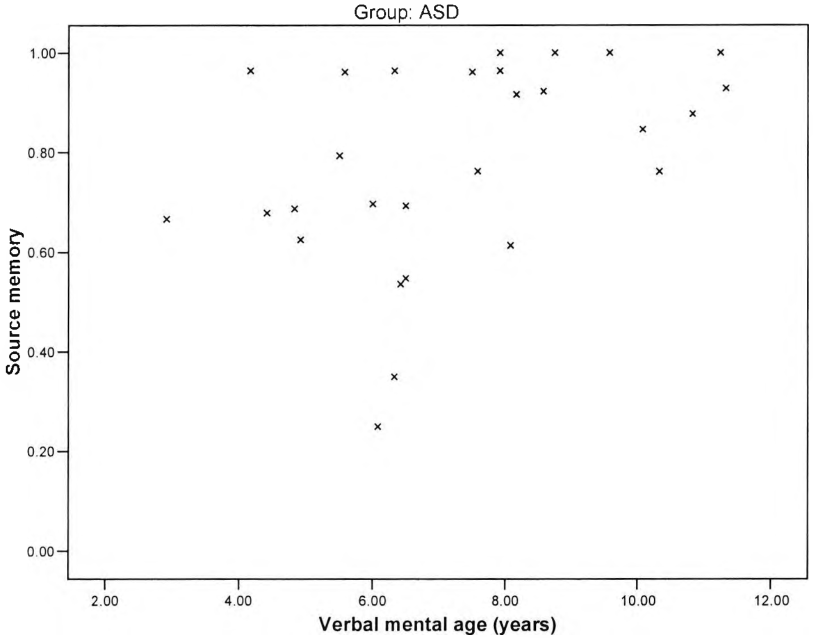
Memory measure	Self-Other	Group	VMA Category	Mean	SD	N
False alarm rate	Self	ASD	Under 6	.22	.29	11
			Over 6	.11	.21	25
			Total	.15	.24	36
		Comparison	Under 6	.23	.37	15
			Over 6	.03	.06	21
			Total	.11	.26	36
		Total	Under 6	.23	.33	26
			Over 6	.07	.16	46
			Total	.13	.24	72
	Other	ASD	Under 6	.23	.29	11
			Over 6	.14	.26	25
			Total	.17	.27	36
		Comparison	Under 6	.25	.34	15
			Over 6	.05	.11	21
			Total	.13	.25	36
		Total	Under 6	.24	.31	26
			Over 6	.10	.21	46
			Total	.15	.26	72
Self-other corrected hit rate	Self	ASD	Under 6	.62	.34	11
			Over 6	.72	.32	25
			Total	.69	.32	36
		Comparison	Under 6	.60	.34	15
			Over 6	.81	.18	21
			Total	.72	.27	36
		Total	Under 6	.61	.33	26
			Over 6	.76	.26	46
			Total	.70	.30	72
	Other	ASD	Under 6	.40	.34	11
			Over 6	.54	.28	25
			Total	.49	.30	36
		Comparison	Under 6	.48	.32	15
			Over 6	.60	.18	21
			Total	.55	.25	36
		Total	Under 6	.44	.33	26
			Over 6	.56	.24	46
			Total	.52	.28	72
Source	Self	ASD	Under 6	.85	.17	11
			Over 6	.82	.15	25
			Total	.83	.16	36
		Comparison	Under 6	.89	.15	15
			Over 6	.88	.12	21
			Total	.89	.13	36
		Total	Under 6	.87	.16	26
			Over 6	.85	.14	46
			Total	.86	.15	72
	Other	ASD	Under 6	.61	.24	11
			Over 6	.79	.24	25
			Total	.73	.25	36
		Comparison	Under 6	.81	.26	15
			Over 6	.79	.18	21
			Total	.80	.22	36
		Total	Under 6	.72	.27	26
			Over 6	.79	.22	46
			Total	.76	.24	72

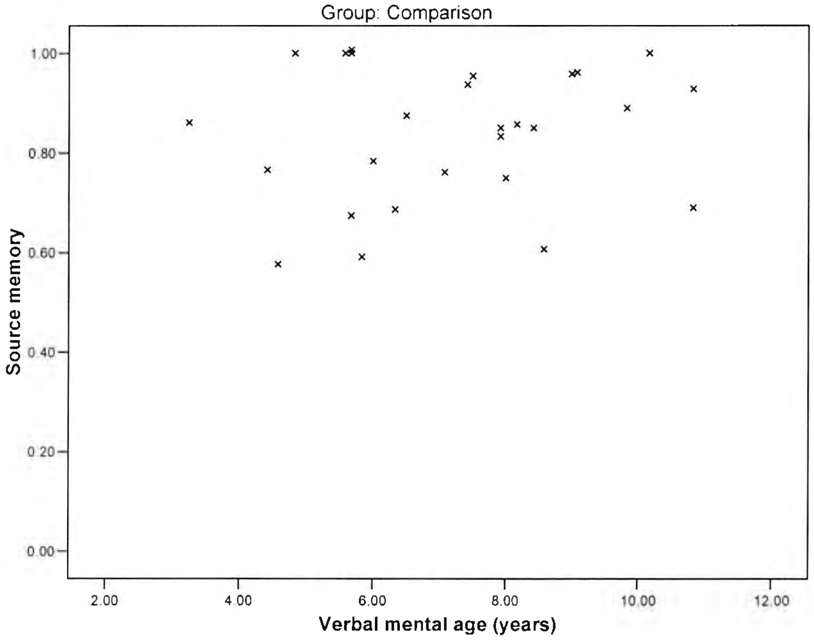
APPENDIX 15: Scatterplots Displaying the Relationship Between Chronological Age and Source Memory for the ASD (Top Graph) and Comparison (Bottom Graph) Groups





APPENDIX 16: Scatterplots Displaying the Relationship Between Verbal Mental Age and Source Memory for the ASD (Top Graph) and Comparison (Bottom Graph) Groups





APPENDIX 17: Summary of the Tasks for Which Each Individual Participant had Valid Data as the Well as Which Experiments They Were Included in

In the table displayed on the following 6 pages, in the set of columns labelled under "Tasks with valid data", the grey boxes indicate that a participant had valid data for a particular task. In the columns labelled under "Experiments", the grey boxes indicate that the participant was included in that experiment. Below is a key specifying the numbers assigned to each experiment as well as the sections in the thesis describing the particular samples.

	Experiment
1	Item/source memory (3.2.1)
2	Delayed self-recognition (4.2.1)
3	See-know (5.2.1.1)
4	Sally-Anne (5.3.1.1)
5	Smarties (5.4.1.1)
6	CA/VMA/VIQ and false belief performance (6.2.2.1)
7	Complement syntax and Sally-Anne (6.3.2.1)
8	Complement syntax and Smarties (6.4.2.1)
9	DSR and source memory (7.2.1)
10	Sally-Anne and source memory (8.2.1.1)
11	Smarties and source memory (8.3.1.1)
12	See-know and source memory (8.4.1.1)

Participant ID	Tasks with valid data							Experiments											
	Item/source memory	DSR	Smarties	Sally-Anne	See-know	Complement syntax		1	2	3	4	5	6	7	8	9	10	11	12
ASD1	▨	▨	▨	▨	▨	▨		▨	▨	▨		▨		▨	▨	▨	▨	▨	▨
ASD2		▨	▨	▨		▨			▨										
ASD3		▨			▨	▨													
ASD4			▨	▨		▨					▨	▨	▨	▨	▨				
ASD5		▨	▨	▨	▨	▨			▨	▨	▨	▨	▨	▨	▨				
ASD6		▨	▨	▨					▨										
ASD7	▨	▨	▨	▨	▨	▨		▨	▨	▨				▨	▨	▨	▨	▨	▨
ASD8	▨							▨											
ASD9		▨	▨	▨		▨			▨		▨	▨	▨	▨	▨				
ASD10	▨	▨	▨	▨	▨	▨			▨	▨		▨			▨	▨	▨	▨	▨
ASD11	▨		▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨
ASD12	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
ASD13	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
ASD14	▨		▨	▨	▨	▨													
ASD15	▨		▨	▨		▨		▨			▨	▨	▨	▨	▨		▨	▨	
ASD16				▨															
ASD17	▨	▨	▨	▨	▨	▨			▨	▨		▨			▨	▨			▨
ASD18	▨	▨	▨	▨	▨	▨								▨					
ASD19	▨	▨	▨			▨		▨	▨			▨			▨	▨		▨	
ASD20	▨	▨		▨	▨	▨		▨	▨	▨				▨		▨	▨		▨
ASD21	▨	▨	▨		▨	▨		▨	▨	▨		▨			▨	▨		▨	
ASD22	▨	▨	▨			▨												▨	
ASD23			▨	▨		▨					▨	▨	▨		▨				
ASD24	▨																		
ASD25	▨		▨	▨	▨	▨		▨				▨		▨	▨		▨		
ASD26	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
ASD27	▨		▨	▨	▨	▨		▨										▨	▨
ASD28	▨	▨	▨	▨	▨	▨													
ASD29	▨	▨	▨	▨		▨			▨					▨	▨	▨	▨	▨	
ASD30		▨	▨	▨		▨						▨		▨	▨				
ASD31	▨	▨	▨	▨		▨										▨		▨	
ASD32	▨		▨	▨	▨	▨		▨											▨

Participant ID	Tasks with valid data							Experiments											
	Item/source memory	DSR	Smarties	Sally-Anne	See-know	Complement syntax		1	2	3	4	5	6	7	8	9	10	11	12
ASD33	■	■	■		■	■													
ASD34		■	■		■	■													
ASD35	■	■	■	■	■	■													
ASD36	■		■	■	■	■		■		■		■			■			■	■
ASD37		■	■	■	■	■			■	■	■	■	■	■	■				
ASD38	■		■	■	■	■					■	■	■	■	■				
ASD39	■		■	■	■	■		■		■	■	■	■	■	■		■	■	■
ASD40	■	■	■		■	■		■	■	■		■			■	■		■	■
ASD41	■		■	■	■	■		■		■	■	■	■	■	■		■	■	■
ASD42			■	■	■	■													
ASD43			■	■	■	■													
ASD44	■	■	■	■	■	■		■		■	■	■	■	■		■	■	■	■
ASD45	■		■	■		■							■				■		
ASD46	■	■	■	■		■					■	■	■		■		■		
ASD47	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■
ASD48	■	■	■	■	■	■		■						■			■	■	
ASD49	■		■	■	■	■		■		■	■	■	■	■	■		■	■	■
ASD50	■		■	■	■	■								■					■
ASD51	■	■	■	■	■	■			■							■			
ASD52		■	■	■	■	■				■				■					
ASD53				■		■													■
ASD54	■	■	■	■	■	■								■					
ASD55		■	■			■			■			■			■				
ASD56		■	■	■	■	■			■	■	■	■	■	■	■				
ASD57	■	■	■	■	■	■											■		
ASD58	■		■	■		■		■											
ASD59		■	■	■	■	■				■	■		■	■					
ASD60			■	■		■						■			■				
ASD61																			
ASD62	■	■		■		■		■			■			■			■		
ASD63		■	■	■		■						■			■				
ASD64		■	■	■		■													

Participant ID	Tasks with valid data							Experiments											
	Item/source memory	DSR	Smarties	Sally-Anne	See-know	Complement syntax		1	2	3	4	5	6	7	8	9	10	11	12
ASD65	▨	▨	▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
ASD66		▨		▨		▨			▨		▨			▨					
ASD67	▨	▨	▨	▨	▨			▨	▨	▨	▨	▨	▨			▨	▨	▨	▨
ASD68	▨	▨	▨	▨	▨			▨	▨	▨	▨	▨	▨			▨	▨	▨	▨
ASD69	▨	▨	▨	▨	▨	▨								▨					
ASD70	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨		▨	▨		▨	▨	▨	▨
ASD71	▨	▨	▨	▨		▨					▨	▨	▨	▨	▨	▨	▨	▨	
ASD72	▨	▨	▨	▨	▨												▨		
ASD73	▨	▨	▨	▨	▨											▨			
ASD74	▨	▨	▨	▨															
ASD75		▨	▨	▨	▨														
ASD76	▨	▨	▨	▨				▨	▨			▨				▨		▨	
ASD77	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨		▨	▨		▨	▨	▨	
ASD78			▨	▨		▨					▨		▨	▨					
ASD79																			
ASD80																			
ASD81	▨							▨											
ASD82		▨	▨	▨	▨				▨	▨		▨			▨				
ASD83	▨	▨	▨	▨	▨	▨				▨						▨		▨	
ASD84	▨		▨	▨	▨	▨					▨		▨				▨		▨
ASD85	▨	▨	▨	▨	▨	▨		▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	
ASD86	▨	▨	▨	▨	▨	▨										▨	▨		▨
ASD87		▨	▨	▨	▨	▨			▨	▨	▨	▨	▨		▨				
ASD88	▨	▨	▨	▨	▨	▨		▨			▨								
ASD89	▨		▨	▨	▨	▨		▨		▨		▨	▨	▨	▨			▨	
ASD90			▨	▨	▨														
ASD91	▨		▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨
ASD92	▨		▨		▨	▨		▨		▨		▨			▨			▨	▨
ASD93						▨													

Participant ID	Tasks with valid data							Experiment											
	Item/source memory	DSR	Smarties	Sally-Anne	See-know	Complement syntax		1	2	3	4	5	6	7	8	9	10	11	12
Comp1	▨																		
Comp2	▨																		
Comp3	▨	▨	▨	▨	▨	▨			▨										
Comp4	▨	▨	▨	▨	▨	▨				▨		▨			▨	▨			
Comp5	▨	▨	▨	▨	▨	▨						▨			▨				
Comp6	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨		▨			▨	
Comp7	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨			
Comp8	▨	▨	▨	▨	▨	▨			▨	▨								▨	
Comp9	▨		▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨
Comp10	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp11	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨
Comp12	▨	▨	▨	▨	▨	▨		▨	▨	▨		▨			▨	▨	▨	▨	▨
Comp13	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨		▨	▨		
Comp14	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	
Comp15	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp16	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp17	▨	▨	▨	▨	▨	▨		▨	▨		▨	▨	▨	▨	▨	▨		▨	▨
Comp18	▨	▨	▨	▨	▨	▨			▨			▨				▨			
Comp19			▨	▨		▨													
Comp20			▨	▨	▨	▨													
Comp21	▨		▨	▨	▨	▨													
Comp22	▨		▨	▨		▨						▨		▨	▨				
Comp23			▨	▨	▨														
Comp24				▨		▨													
Comp25	▨		▨	▨		▨												▨	
Comp26	▨			▨		▨					▨								
Comp27	▨																		
Comp28			▨	▨		▨								▨	▨				
Comp29	▨		▨	▨	▨	▨													
Comp30				▨															
Comp31	▨	▨	▨	▨	▨	▨													
Comp32	▨	▨	▨	▨		▨			▨					▨					

Participant ID	Tasks with valid data						Experiment												
	Item/source memory	DSR	Smarties	Sally-Anne	See-know	Complement syntax		1	2	3	4	5	6	7	8	9	10	11	12
Comp33	▨	▨	▨	▨	▨	▨													▨
Comp34	▨	▨	▨	▨	▨	▨			▨	▨				▨		▨			
Comp35	▨	▨	▨	▨	▨	▨		▨						▨					▨
Comp36	▨	▨		▨	▨	▨								▨		▨	▨		
Comp37		▨	▨	▨	▨	▨													
Comp38	▨	▨	▨	▨	▨	▨			▨							▨		▨	
Comp39	▨	▨	▨			▨		▨	▨			▨			▨	▨		▨	
Comp40	▨							▨											
Comp41	▨		▨	▨	▨	▨		▨			▨	▨	▨	▨	▨		▨	▨	
Comp42	▨	▨	▨	▨	▨	▨		▨	▨	▨				▨	▨	▨	▨		▨
Comp43	▨		▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨
Comp44																			
Comp45	▨		▨	▨	▨	▨				▨				▨			▨	▨	
Comp46	▨		▨	▨	▨	▨		▨				▨			▨		▨		
Comp47	▨	▨	▨	▨	▨	▨		▨	▨	▨		▨		▨	▨	▨	▨		▨
Comp48	▨							▨	▨									▨	
Comp49	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp50	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨
Comp51		▨	▨	▨	▨	▨			▨	▨	▨	▨	▨	▨	▨				
Comp52	▨	▨	▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp53		▨	▨	▨	▨	▨					▨	▨	▨	▨	▨				
Comp54	▨		▨	▨	▨	▨				▨	▨	▨	▨	▨	▨			▨	▨
Comp55	▨	▨	▨	▨		▨					▨	▨	▨	▨	▨				
Comp56	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp57	▨		▨	▨	▨	▨		▨			▨	▨	▨	▨	▨		▨	▨	▨
Comp58	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp59	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp60	▨		▨	▨	▨	▨				▨		▨			▨		▨	▨	▨
Comp61	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp62	▨	▨	▨	▨	▨	▨		▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	
Comp63	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp64	▨		▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨

Participant ID	Tasks with valid data							Experiment											
	Item/source memory	DSR	Smarties	Sally-Anne	See-know	Complement syntax		1	2	3	4	5	6	7	8	9	10	11	12
Comp65	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Comp66	▨		▨	▨	▨			▨		▨	▨	▨	▨	▨	▨			▨	▨
Comp67	▨		▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨
Comp68	▨		▨	▨		▨		▨			▨	▨	▨	▨	▨		▨	▨	
Comp69	▨		▨	▨	▨	▨		▨		▨	▨	▨	▨	▨	▨		▨	▨	▨