Memory and the Self in Autism: A Review and Theoretical Framework

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Abstract

This paper reviews research on (a) autobiographical episodic and semantic memory, (b) the self-reference effect, (c) memory for the actions of self versus other (the self-enactment effect), and (d) non-autobiographical episodic memory in autism spectrum disorder (ASD), and provides a theoretical framework to account for the bi-directional relationship between memory and the self in ASD. It is argued that individuals with ASD have diminished psychological self-knowledge (as a consequence of diagnostic social and communication impairments), alongside intact physical self-knowledge, resulting in an under-elaborated self-concept. As a result, individuals with ASD show impaired autobiographical episodic memory and a reduced self-reference effect (which may each rely on psychological aspects of the self-concept) but do not show specific impairments in memory for their own rather than others' actions (which may rely on physical aspects of the self-concept). However, it is also argued that memory impairments in ASD (e.g., in non-autobiographical episodic memory) may not be entirely accounted for in terms of self-related processes. Other factors, such as deficits in memory binding, may also play a role. Finally, it is argued that deficits in autobiographical episodic memory and future thinking may result in a diminished temporally extended self-concept in ASD.

Keywords: (1) Autism spectrum disorder; (2) autobiographical memory; (3) episodic memory; (4) memory; (5) self

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Aspects of memory and the self are intimately and bi-directionally related. On the one hand, the ability to encode and retrieve personally significant memories arguably presupposes a concept of self (Howe & Courage, 1993). On the other hand, one's sense of self is composed of one's memories of past personal experiences, as well as knowledge of one's traits and other personally relevant information (Conway & Pleydell-Pearce, 2000; Wilson & Ross, 2003).

It is widely accepted that there are different "types" of memory and that the self is not a unitary construct. In terms of long term memory, one of the major distinctions to have been drawn is between episodic and semantic memory, which are thought to comprise functionally distinct but interacting neuro-cognitive systems (Tulving, 2001). Episodic memories are memories of personally experienced events that occurred in a particular place at a particular time. They are uniquely associated with autonoetic awareness, a type of self-conscious awareness that allows one to mentally represent and become aware of one's continuing existence across subjective time. By contrast, semantic memories are memories of timeless, de-contextualised facts, and are characterised by noetic (knowing) rather than autonoetic (self-knowing) awareness (Wheeler, Stuss, & Tulving, 1997).

Autobiographical memory refers to memory for information pertaining to the self and is often considered to be synonymous with episodic memory (Gilboa, 2004). However, the term "episodic" refers to a distinct type of memory *system,* whereas the term "autobiographical" refers to a particular type of memory *content*. Indeed, both the

episodic and semantic systems are capable of processing autobiographical content (Klein, Chan, & Loftus, 1999; Levine, 2004). Not all episodic memories are autobiographical (i.e., self-relevant) in nature and, likewise, not all autobiographical (self-relevant) memories are episodic in nature. It is therefore possible to distinguish between (a) autobiographical episodic memory (e.g., remembering what happened on one's first day of secondary school); (b) *non*-autobiographical episodic memory (e.g., remembering what was reported in the newspaper this morning); (c) autobiographical semantic knowledge (e.g., knowledge of one's date of birth or middle name); and (d) *non*-autobiographical semantic knowledge (e.g., knowledge of the boiling point of water). With the exception of non-autobiographical semantic knowledge, each of these types of memory is arguably related to the self in some way.

As stated above, the self is widely considered to be multifaceted (e.g., Lewis, 1995; Neisser, 1988; Rochat, 2003). Perhaps the most critical distinction is between the self as the *subject* of experience (the "I") and the self as the *object* of experience (the "me") (James, 1890). Only when the self becomes the object of experience can one be ascribed self-*awareness*. Further refining this distinction, Butterworth (1995) argues that "primary" self-awareness occurs when the self is the object of one's own *perception*, and "higher-order" self-awareness occurs when the self is the object of one's own *cognition*. Such higher-order self-awareness is often referred to as "explicit" or "reflexive" self-awareness. A further key distinction, which cuts across the facets of self described above, is between physical and psychological aspects of self (Gillihan & Farah, 2005).

The Relationship Between Memory and the Self

According to Tulving (2001), episodic memory is intimately related to the self. However, it is important to consider which aspects of the self are likely to be involved and whether they are likely to be involved at the point of encoding or retrieval. From a developmental perspective, Howe and Courage (1993) have argued that the emergence of autobiographical episodic memory in early childhood is critically dependent upon the development of a self-concept (which is also frequently referred to in the literature as a representational, categorical, or cognitive self). The self-concept is typically regarded as a *set of beliefs about the self* (e.g., I have brown hair, I am a child, I am silly, etc.) (Neisser, 1988), which is presumably based on semantic autobiographical knowledge. Howe and Courage's argument revolves around the idea that the self-concept acts as a fixed referent – a sort of category – around which personally experienced event memories can be organized. Thus, without a self-concept it is not possible to *encode* self-relevant, autobiographical episodic memories. The self-concept is said to reach a "critical mass" at around 2 years of age, coinciding with the onset of rudimentary autobiographical episodic memory, and indeed there is some evidence to support this claim (Harley & Reese, 1999). Once the self-concept has reached this critical mass, autobiographical episodic memory is said to improve as the self-concept continues to become more elaborate and sophisticated.

It might be argued that as well as requiring a self-concept at the point of encoding (in order to "tag" the memory as self-relevant), autobiographical episodic memory also involves the *re*-experiencing of the self as the *object* of experience (i.e., the "me") at the

point of retrieval. However, *non*-autobiographical episodic memory is unlikely to require a self-concept at the point of encoding and may merely involve *re*-experiencing the self as the *subject* of experience (the "I") at retrieval. Take for example a typical recognition memory task, in which one is presented with a list of words to study and then subsequently asked to make old-new judgments about words presented in a test list (including both studied and unstudied words). One may, for example, remember that the word "red" appeared on the study list and also that the word red appeared after the word "house". This type of retrieval appears to involve the episodic system but encoding does not seem to require a self-concept (since the memory does not need to be tagged as self-relevant) and retrieval does not seem to involve re-experiencing the self as the *object* of experience – merely re-experiencing the self as the *subject* of experience. Thus, whereas autobiographical episodic memory necessarily requires a self-concept at encoding and involves re-experiencing the self as the object of experience at retrieval, non-autobiographical episodic memory does not require a self-concept at encoding and involves re-experiencing the self as the subject of experience at retrieval. If this characterisation is correct then autonoetic or "*self-knowing*" awareness, which is considered to be the hallmark of episodic memory, differs qualitatively between autobiographical and non-autobiographical episodic memory.

The development of a self-concept is unlikely to be the only factor to play a role in the development of autobiographical episodic memory (Nelson & Fivush, 2004). For example, developmental improvements in memory "binding" are also likely to be implicated in the development of autobiographical (and *non*-autobiographical) episodic memory (Sluzenski, Newcombe, & Kovacs, 2006). Given that episodic memories

involve multiple features, the features comprising an episode must be linked together at encoding to form a coherent or "bound" representation (Chalfonte & Johnson, 1996). Thus, *featural* or *relational* binding plays a key role in episodic encoding. Correspondingly, episodic *retrieval* involves bringing multiple features together in order to re-construct a coherent event representation (Baddeley, 2000). Through enabling the re-construction of past episodes, episodic memory binding may enable one to mentally re-experience past episodes and this may entail the ability to re-experience the self as the subject or object of experience – i.e., allow one to become aware of a *past* state of self. Nevertheless, the development of a self-concept is likely to be a necessary (even if not a sufficient) step towards the emergence of autobiographical episodic memory.

Thus, a rudimentary self-concept (based on autobiographical semantic knowledge), which becomes increasingly elaborate through the course of development, may provide the foundations necessary for a child to gradually develop a collection of autobiographical episodic memories, enriching their self-knowledge base. In turn, the development of autobiographical episodic memory supports the emergence of a new, more sophisticated level of self-awareness – *[temporally] extended self-awareness* (Neisser, 1988). A temporally extended self-concept encompasses representations of present, past, and future states of self, and allows one to become aware of one's place in and continued existence through time (Povinelli, 2001). Without a store of autobiographical episodic memories such a temporally extended self-representation would not be possible (Povinelli, 2001). Here, the bidirectional relationship between memory and the self becomes apparent. Given that the temporally extended self-concept incorporates multiple, alternative representations of self that must be understood *as*

alternative representations of the same enduring self, metarepresentation (Perner, 1991) may also be a prerequisite.

Now that a theoretical framework for considering the typical relationship between memory and the self is in place, it is possible to consider how this might be applied to the case of autism spectrum disorder (ASD), a disorder which a number of researchers have suggested is characterised by diminished self-awareness (e.g., Frith, 2003; Hobson, 1990; Russell, 1997) and which is also characterised by a particular profile of strengths and weaknesses in memory (Ben Shalom, 2003; Bowler, Gaigg, & Lind, in press).

The main body of this review is presented in four unequal parts. First, is a main section on 'The Self in ASD'. This is followed by an extended main section on 'The Self and Memory in ASD', subdivided into reviews of evidence relating to 'Autobiographical memory in ASD', 'The self-reference effect in ASD', and 'Memory for the actions of self and other in ASD'. There follows a short main section on 'Non-Autobiographical Episodic Memory in ASD' and a 'Conclusions' section.

The Self in ASD

When considering the self in ASD, it is important to consider which aspects are typical and which are atypical. It seems implausible to suggest that individuals with ASD do not have subjective experiences (i.e., lack an "I", in James', 1890, terms), although it is quite possible that those subjective experiences are qualitatively distinct from those of typical individuals. It should be noted, however, that Powell and Jordan (1996) have argued that ASD involves a deficit in developing an "experiencing self", which seems to be a related

notion. It is far more probable that individuals with ASD have difficulties with becoming self-*aware* (i.e., deficits in the "me"). Precisely which aspects of self-*awareness* (primary or higher-order, physical or psychological) are problematic in ASD should also be considered.

Primary self-awareness in ASD: physical and psychological aspects

Recent evidence seems to indicate that individuals with ASD have intact primary self-awareness, at least in the physical domain. For example, Williams and Happé (2009a) found that children with ASD (of mixed intellectual ability) were able to discriminate between internally (i.e., self) and externally caused changes in their perceptual experience as effectively as comparison children. Similar results have been observed amongst high-functioning[1] adults (David et al., 2008). These findings indicate that individuals with ASD are able to become perceptually aware of physical aspects of themselves. However, difficulties with reciprocal social engagement in ASD seem to suggest that they have diminished primary awareness of psychological (or interpersonal) aspects of self (Hobson, 1990; Neisser, 1988; Tomasello, 1995).

Higher-order self-awareness in ASD: physical and psychological aspects

The mark test of mirror self-recognition (Amsterdam, 1972; Gallup, 1970) is probably the most commonly used test of higher-order self-awareness. The traditional version of the

[1] The terms "high-functioning" and "low-functioning" will be used to refer to individuals with full scale IQs of ≥ 70 and < 70, respectively.

task involves surreptitiously marking a child's face with a spot of rouge and subsequently assessing their reaction upon seeing their reflection. Here, mark-directed behaviour (i.e., touching the mark) is taken as evidence of self-recognition. Such behaviour is shown by typically developing children at a mean age of 18 months (Anderson, 1983; Courage, Edison, & Howe, 2004). Although there is some debate over exactly what the mark test measures (Hobson, 1990; Mitchell, 1997), it is generally agreed that mark-directed behaviour demonstrates that a child has a mental representation of what they typically look like – they have at least a rudimentary physical self-concept, which can become the object of their consciousness (Amsterdam, 1972; Neisser, 1995; Nielsen, Suddendorf, & Slaughter, 2006). This implies higher-order self-awareness of physical aspects of self.

Four studies have assessed mirror self-recognition in ASD, in each case employing children with ages ranging from 3.5 to 12.7 years (Dawson & McKissick, 1984; Ferrari & Matthews, 1983; Neuman & Hill, 1978; Spiker & Ricks, 1984). In three of these studies, the children appear to have had intellectual disability (in the fourth study, the intellectual ability level was not specified)[2]. In each of these studies, the majority of children with ASD (between 53% and 86% across studies) showed mirror self-recognition. Although a minority of participants in all the studies failed to show mark-directed behaviour, given that appropriate control groups and intelligence measures were not included, it is unclear whether this failure was due to an ASD-specific deficit or intellectual disability. Indeed, these studies included children with severe to profound intellectual disability, who may have had mental ages of less than 18 months. In future

[2] Dawson and McKissick's (1984) sample had a mean IQ of 57; Ferrari and Matthews' (1983) sample was described as severely to profoundly mentally retarded; Neuman and Hill (1978) did not specify the intellectual ability level of their sample; Spiker and Ricks' (1984) sample were said to have severely impaired language.

studies, it will be important to establish whether children with ASD are impaired relative to *mental* age rather than merely chronological age.

Although the evidence is not clear-cut, mirror self-recognition appears to be a relative strength for individuals with ASD (even seemingly low-functioning individuals). This suggests that they have higher-order *physical* self-awareness. Further supporting this suggestion, studies have shown that children with ASD (both high-functioning and mixed ability) do not significantly differ from age and verbal ability matched comparison children in terms of their ability to recognise delayed video images of themselves (Lind & Bowler, 2009a). Such findings may be taken as evidence of intact (higher-order) temporally extended *physical* self-awareness but do not necessarily imply intact (higher-order) temporally extended *psychological* self-awareness (see Lind & Bowler, 2009a).

Evidence from a number of sources suggests that individuals with ASD have diminished higher-order awareness of *psychological* aspects of self. For example, it is widely acknowledged that children with ASD have difficulty using first person pronouns such as "I" and "me" (Jordan, 1996; Lee, Hobson, & Chiat, 1994; Lind & Bowler, 2009a). Moreover, individuals with ASD (even high-functioning individuals) also show diminished conscious awareness of their own emotions (Ben Shalom et al., 2006; Silani et al., 2008), mental states (Williams & Happé, in press, 2009b), and autistic traits (Johnson, Filliter, & Murphy, 2009). Together, these findings suggest that children with ASD may have impoverished or atypical higher-order psychological self-awareness (alongside comparatively intact higher-order physical self-awareness).

It seems likely that deficits in higher-order psychological self-awareness are a downstream consequence of the social and communication impairments that characterise

ASD. Social and communication impairments significantly reduce opportunities for effective social engagement and consequently opportunities to acquire psychological self-knowledge (Neisser, 1988). However, such impairments would be unlikely to impact upon opportunities to acquire physical self-knowledge.

In summary, individuals with ASD appear to have impaired self-awareness at both the primary and higher-order levels in the psychological, but not physical, domain. This would seem to imply that they lack self-*knowledge* in the psychological domain and therefore have *less elaborate self-concepts than individuals without ASD*. If this is the case, it should become apparent in studies of autobiographical semantic knowledge (which arguably *directly taps* the self-concept) and autobiographical episodic memory (which arguably *relies on* a self-concept). The following sections review studies which shed light on the interrelation between memory and the self in ASD. Studies of autobiographical (semantic and episodic) memory, the self-reference effect, memory for the actions of self versus other, and (non-autobiographical) episodic memory are considered.

The Self and Memory in ASD

Autobiographical memory in ASD

Goddard, Howlin, Dritschel, and Patel (2007) assessed autobiographical memory in 37 high-functioning young adults with ASD, and 39 typical comparison adults, matched for age, verbal IQ (VIQ), performance IQ (PIQ), and full scale IQ (FSIQ), using a cueing

task and a social problem solving task. The cueing task involved presenting a series of cue words (e.g., "leisure"), designed to elicit memories of specific past personal experiences. The social problem solving task involved presenting short stories describing various social problems (e.g., falling out with friends). In this task, participants were first of all asked to describe the sequence of steps required to solve the problem at hand, in order to achieve a specified goal (e.g., how to make up with friends), and subsequently asked to report any thoughts or images that came to them during the problem solving process. In this respect, the task incidentally provided an opportunity to report specific past personal experiences.

It was found that in the cueing task, participants with ASD generated significantly fewer specific event memories than comparison participants, and were also significantly slower at doing so. With respect to the social problem solving task, it was found that although participants within each group were equally likely to report thoughts/images following the problem solving activity, these thoughts/images were significantly less likely to comprise memories of specific personal experiences within the ASD group than within the comparison group. These results suggest that high-functioning adults with ASD have impaired autobiographical episodic memory.

Further evidence for an ASD-specific impairment in autobiographical episodic memory is provided by a study of children's narrative abilities (Losh & Capps, 2003). Participants were asked to describe past personal experiences (e.g., "Can you tell me a specific time you went on vacation?") and also to describe the ongoing events in a picture book. When compared to age and verbal IQ matched typically developing children, high-functioning children with ASD were found to have few difficulties with narrating the

book, but showed significantly impoverished narratives of personal experiences. The children with ASD produced a greater number of bizarre or irrelevant responses than comparison children, and were more heavily reliant on prompting. The fact that (in this particular study) participants with ASD did not have difficulty in narrating the picture book suggests that it was not their narrative skills *per se* that were the limiting factor in reporting personal experiences but rather the (autobiographical episodic) *content* of what they were attempting to describe.

A recent study by Lind and Bowler (2009b, under review) indicates that individuals with ASD not only demonstrate impaired autobiographical *episodic memory* but also impaired autobiographical *episodic future thinking*. Episodic future thinking (or "prospection") involves mentally projecting oneself into the future in order to "pre-experience" a possible future episode, and is thought to be at least partially underpinned by the episodic memory system (Suddendorf & Corballis, 1997; Wheeler et al., 1997). Indeed, recent neuropsychological (Spreng, Mar, & Kim, 2009) and behavioural (Busby & Suddendorf, 2005; D'Argembeau, Raffard, & Van der Linden, 2008) evidence supports this hypothesis. Lind and Bowler asked 14 high-functioning adults with ASD and 14 typical comparison adults (who were matched for age, VIQ, PIQ, and FSIQ) to try to *remember* a series of events that happened to them in the past and *imagine* a series of events that might happen to them in the future. It was found that participants with ASD remembered and imagined significantly fewer specific past and future experiences than comparison participants, suggesting that both autobiographical episodic memory and future thinking are impaired in ASD.

The studies described above demonstrate that autobiographical episodic memory and future thinking are diminished in ASD, but what about autobiographical semantic knowledge? Klein et al. (1999) report a case study of R.J., a 21-year-old high-functioning individual with ASD. 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 typical individuals (with chronological ages similar to R.J.'s mental age), who generated autobiographical episodic memories 100% of the time, R.J. could only generate such recollections 20% of the time. Thus, R.J. appeared to possess intact autobiographical semantic knowledge but impaired autobiographical episodic memory. Although this represents a potentially important finding, results from such case studies do not necessarily generalise. However, two recent studies have sought to further investigate both autobiographical semantic knowledge and autobiographical episodic memory in ASD.

Crane and Goddard (2008) compared the performance of 15 high-functioning adults with ASD and 15 typical comparison adults (who were matched for age, VIQ, PIQ, and FSIQ) on autobiographical (a) interview, (b) fluency, and (c) narrative tasks. In the autobiographical interview, autobiographical episodic memory and autobiographical semantic knowledge were assessed with questions such as, "Can you tell me something that happened while you were at primary school that stands out in your mind?" and "Can you tell me the names of two of your teachers from primary school?" respectively. The autobiographical fluency task involved asking participants to generate as many events

(measuring autobiographical episodic memory) and people's names (measuring autobiographical semantic knowledge), from specified lifetime periods, as possible in a 90 second period. Letter and category fluency were also assessed. The autobiographical narrative task involved questions such as "What did you do for your last birthday?" designed to elicit detailed descriptions of autobiographical episodic memories. The results from the interview task indicated no significant group differences in either autobiographical episodic memory or autobiographical semantic knowledge. However, on the fluency task the ASD group performed significantly less well, specifically on the autobiographical episodic memory element. There were no significant group differences in performance on either the autobiographical semantic knowledge element or the letter or category fluency tasks (ruling out generativity-based explanations of the findings). With respect to the narrative task, no qualitative group differences were observed, although the ASD group were found to produce significantly fewer *specific* autobiographical episodic memories. As a whole, the results of this study suggest that autobiographical episodic memory is impaired in high-functioning adults with ASD, whilst autobiographical semantic knowledge is intact.

Bruck, London, Landa, and Goodman (2007) assessed these two aspects of memory using an autobiographical memory questionnaire in a sample of 30 high-functioning children with ASD and 38 typically developing children. The questionnaire included items to assess knowledge of personal facts (e.g., "What's your mother's name?") and memory for personally experienced events (e.g., "What happened at your last birthday party?"). They were also asked a series of yes-no life event questions such as "Have you ever been on an aeroplane?" In line with Crane and Goddard's (2008)

results, children with ASD showed significantly poorer performance than typically developing children on the questions assessing memory for personally experienced events (autobiographical episodic memory). However, in contrast to Crane and Goddard's (2008) results, participants with ASD also showed significantly poorer performance on the questions assessing knowledge of personal facts. The groups performed equally well on the yes-know life event questions[3]. The absence of a performance deficit in the ASD group may be attributable to the fact that these questions did not demand the retrieval of any episodic, contextual details (for example, a child may *know* that they have been on an aeroplane without *remembering* any event details). Thus, autobiographical semantic knowledge may have been sufficient. These results suggest that some elements of autobiographical semantic knowledge are intact in children with ASD, whilst others may be impaired. However, it should be noted that although the groups in this study were matched for age, the typically developing group had a significantly higher mean full scale IQ than the ASD group. This IQ decrement could potentially account for any significant group differences.

The results of a study by Lee and Hobson (1998) shed additional light on the autobiographical semantic knowledge of children with ASD. Damon and Hart's (1988) self-understanding interview, which assesses various domains of self-knowledge, was administered to a group of 12 adolescents with ASD who had low verbal ability and 10 age- and verbal ability-matched comparison adolescents. The interview can be considered as an index of autobiographical semantic knowledge rather than autobiographical episodic memory, given that is does not require participants to recount

[3] Although the statistics for the main effect of group on performance were not reported in the paper itself, M. Bruck (personal communication) kindly confirmed that the group difference in performance was not significant.

specific past personal experiences. It was found that participants with ASD produced significantly more, but qualitatively similar, descriptions of their physical and active characteristics, relative to comparison participants. However, their self-descriptive statements of psychological and social characteristics differed qualitatively from those of comparison participants and in the latter instance quantitatively, in that they produced significantly fewer descriptions that fell into the social category. It seems likely that such "person-related" difficulties reflect the underlying social impairments that characterise ASD. Nevertheless, these findings suggest that at least certain aspects of semantic autobiographical knowledge are atypical in children with ASD and seem to suggest specific deficits in psychological but not physical aspects of the self-concept.

Overall, the studies described above indicate that autobiographical episodic memory is impaired in both adults *and* children with ASD, whereas autobiographical semantic knowledge (which may index the self-concept) is impaired only amongst children with ASD. This seems to suggest that self-concept development is delayed (even in relation to *mental* age) in ASD but, by adulthood, (at least high-functioning) individuals appear to have "caught up" to some extent.

Goddard et al. (2007) have argued that individuals with ASD have impairments in autobiographical episodic memory as a result of poorly elaborated or perhaps fragmented self-concepts, which provide insufficient structure around which to organize personally experienced event memories or with which to tag information as self-relevant. Such an account could potentially explain why adults with ASD have difficultly with remembering events from *childhood* (when they had diminished self-concepts) but may not fully explain why they also have difficulty remembering events from *adulthood*

(when they appear to have relatively intact self-concepts and should not therefore have difficulty encoding information in relation to the self). It is possible, however, that impairments in autobiographical semantic knowledge/self-concept development in childhood impact upon autobiographical episodic memory development in such as way that the effects persist through to adulthood.

Alternatively, autobiographical episodic memory may be impaired in ASD for reasons other than (or in addition to) a diminished self-concept. For example, it is possible that established impairments in relational memory (Gaigg, Gardiner, & Bowler, 2008) mean that individuals with ASD have difficulty binding together disparate event elements to produce coherent episodic memory traces. This explanation also predicts impairments in *non*-autobiographical episodic memory. Non-autobiographical episodic memory will be considered later. First, however, studies of the self-reference effect in ASD will be reviewed.

Studies of the self-reference effect provide a direct test of the capacity of individuals with ASD to encode material in relation to the self-concept and may provide further evidence regarding whether or not individuals with ASD have intact self-concepts/autobiographical semantic memory. In this respect, they provide an *indirect* insight into whether autobiographical episodic memory difficulties can feasibly be accounted for by a diminished self-concept.

The self-reference effect in ASD

It is well established that typical individuals show enhanced memory for information that is self-relevant or encoded in relation to the self (Rogers, Kuiper, & Kirker, 1977; Symons & Johnson, 1997). This phenomenon, which is known as the *self-reference effect,* may viewed as an extension of the *depth-of-processing* effect (Craik & Tulving, 1975). The notion of depth-of-processing assumes that retrieval is a function of trace elaboration at the time of encoding, such that the deeper or more elaborate the encoding process, the more likely the information is to be later retrieved. For example, phonologically processed items are retained less well than semantically processed items, which have been encoded at a deeper level. The self is thought to act as a conceptual structure with elaborative and organisational properties that enhance the deep encoding of information within memory (Klein & Loftus, 1988; Symons & Johnson, 1997). Therefore, if individuals with ASD have a diminished or poorly integrated concept of self (i.e., impaired autobiographical semantic knowledge), there is reason to predict that they will show a reduced or absent self-reference effect (Toichi et al., 2002).

In one study, Toichi et al. (2002) investigated the depth-of-processing and self-reference effects in a sample of 18 high-functioning adults with ASD, as well as 18 comparison adults (matched for age, VIQ and PIQ). During the study phase of their experiment, participants were presented with a series of 30 target personality trait adjectives. Immediately prior to the presentation of each target word, participants were asked one of three types of question, each of which was designed to induce either phonological ("Does the word rhyme with - ?"), semantic ("Is the meaning of the word

similar to - ?"), or self-referential ("Does the word describe you?") processing of the target word. The study phase was followed by an immediate, surprise recognition test in which participants were presented with a list including the 30 target words as well as 60 distractor words, and asked to select the 30 target words that they had been presented with during the study phase. The results indicated that the comparison group showed typical levels-of-processing (phonological < semantic) and self-reference effects (semantic < self-referential), whereas the ASD group, whilst showing a levels-of-processing effect (phonological < semantic), did not show a self-reference effect (semantic ≈ self-referential). However, there were no significant between-group differences in recognition of either semantically or self-referentially processed words. Thus, although the ASD group showed an atypical pattern of performance, in failing to show a self-reference effect, their ability to encode material self-referentially was not significantly poorer than that of comparison participants.

These results should be interpreted with caution, however, given that the particular measure of recognition memory used was potentially inadequate. Toichi et al. (2002) used hit rate - i.e., the proportion of target items correctly identified as old - as their measure of recognition memory. However, hit rate offers an incomplete picture of recognition memory, summarising performance on target item trials without taking into account performance on distractor item trials. A complete picture of performance on yes-no recognition tests can only be obtained through using measures (such as D' or A') that take into account both hit rate and false alarm rate – i.e., the proportion of distractor items incorrectly identified as old (e.g., Snodgrass & Corwin, 1988). As such, Toichi et al.'s

results provide a potentially biased reflection of recognition memory performance that may not prove to be reliable.

In a more recent study, Lombardo, Barnes, Wheelwright, and Baron-Cohen (2007) used another variant of the typical depth of processing paradigm to test 30 high-functioning adults with ASD and 30 comparison adults (matched for age, VIQ, PIQ, and FSIQ). During the study phase, participants were asked to judge, on a scale of 1 to 6, how descriptive a series of trait adjectives were of either (a) themselves, (b) their best friend, or (c) the fictional character, Harry Potter. As a control condition, participants were asked to (d) judge the number of syllables contained in particular trait labels. Following a filled 30 minute delay, a surprise recognition test was administered. Item recognition was ascertained according to participants' confidence judgements regarding whether test items (including target and distractor items) were old. Confidence scores of 1 to 3 were deemed "new" judgements and scores of 4 to 6 were deemed "old" judgements. *D'* scores were subsequently calculated. It was found that participants with ASD performed at similar levels to comparison participants in the Syllable Judgement and Harry Potter conditions, but performed significantly less well in the Self and Best Friend conditions. Both groups showed depth-of-processing and, unlike in Toichi et al.'s sample, self-reference effects (Syllable < Harry Potter < Best Friend < Self). In order to investigate possible group differences in the magnitude of the self-reference effect, difference scores were calculated for (a) Self versus Best Friend and (b) Self versus Harry Potter. The difference scores for Self versus Best Friend were almost identical for both groups. However, the group difference in difference scores for Self versus Harry Potter

approached significance and a moderate effect size ($p = .07$, Cohen's $d = .49$), reflecting the fact that the ASD group showed a somewhat smaller self-reference effect.

Using a similar paradigm, Henderson et al. (2009) assessed a sample of 31 high-functioning children with ASD and 31 comparison children (matched for age, VIQ, and PIQ). In this study, three encoding conditions were used: participants were presented with a series of trait adjectives and asked either (a) "Does this word contain seven or more letters?" (designed to elicit featural level processing); (b) "Does this word describe something about Harry Potter?"; or (c) "Does this word describe something about you?" The results closely mirrored those obtained by Toichi et al. In terms of D' scores, it was found that participants with ASD did not differ significantly from comparison participants in any of the three conditions. However, whereas comparison participants showed depth-of-processing and self-reference effects (Featural < Harry Potter < Self), participants with ASD showed a depth-of-processing effect (Featural < Harry Potter/Self), but not a significant self-reference effect (Harry Potter ≈ Self). Furthermore, a regression analysis of Self versus Harry Potter difference scores revealed that children with ASD showed a significantly smaller self-reference effect than comparison children.

Thus, both Lombardo et al. (2007) and Henderson et al. (2009) found that individuals with ASD show smaller self-reference effects than comparison individuals, suggesting that they show a diminution in self-referential processing. However, whereas Henderson et al. (2009) found that *children* with ASD did not show the self-reference effect at all, Lombardo et al.'s (2007) found that *adults* with ASD showed the self-reference effect to some extent. In some respects, these results appear to mirror those observed in the studies of autobiographical semantic knowledge, described above. In

each case, the results seem to imply that whereas *children* with ASD have impaired self-concepts, *adults* with ASD do not (or have at least compensated to some extent, enabling some degree of self-referential encoding).

One key point to note is that the studies of self-referential memory, described above, required participants to make judgements about personality trait adjectives (e.g., clever, funny, cranky, etc.). This would seem to require encoding in relation to *psychological* aspects of the self-concept – precisely the facet of the self-concept that is hypothesized to be diminished in ASD. It would be interesting to test self-referential encoding in relation to physical trait adjectives. In this case, performance differences between individuals with and without ASD would not be predicted.

Moreover, the extent to which the performance diminution is *specific* to the self is somewhat unclear, given that participants with ASD in Lombardo et al.'s study also performed significantly less well than comparison participants in the Best Friend condition (unfortunately Henderson et al. did not include this condition). This would seem to suggest that individuals with ASD have difficulty with using both self *and* other as organising structures within memory, perhaps reflecting poorly integrated or elaborated psychological concepts of self and (close) others. It seems likely that the social-communicative deficits that characterise ASD impact upon the capacity to acquire both psychological self-knowledge and psychological knowledge of others, resulting in under-elaborated concepts of self and others. The ability to acquire psychological knowledge of Harry Potter does not depend on dynamic social interaction – it depends on passively reading books or watching films. Hence, individuals with ASD should be able to form a typical "Harry Potter concept". This may explain why individuals with ASD in

Lombardo et al.'s study showed diminished recognition memory in the Best Friend and Self conditions but not the Harry Potter condition.

Another aspect of the results of these studies of self-referential memory that may warrant further attention concerns why participants with ASD did not show blanket memory deficits, relative to comparison participants, across all conditions. Although performance on recognition memory tasks typically involves contributions from both episodic and semantic memory, given that single item memory (rather than memory for context) is sufficient for successful performance on these particular tasks, episodic memory need not be invoked (e.g., Wheeler et al., 1997). Thus, successful performance on such single item recognition tests does not imply intact episodic memory. However, performance on Lombardo et al.'s (2007) and Henderson et al.'s (2009) tasks does depend on intact non-autobiographical semantic memory at test, for all conditions, and for the self condition, intact autobiographical semantic knowledge (i.e., a well developed self-concept) at the time of encoding. Thus, the results (at minimum) are indicative of intact *non*-autobiographical semantic knowledge but impaired autobiographical semantic knowledge.

Memory for the actions of self versus other in ASD

It is well established that typically developing individuals show superior memory for self-performed actions as opposed to other-person-performed actions (e.g., Baker-Ward, Hess, & Flannagan, 1990) – a pattern of performance that may be referred to as the "self-enactment effect". One explanation for this retrieval advantage is that it is an extension

of the self-reference effect, such that the relatively elaborate self-concept acts as a richer, more effective structure for encoding than does the relatively less elaborate other-person-concept. Therefore, if individuals with ASD have under-elaborated self-concepts, they should show a reduced or absent memory advantage for self-performed actions (e.g., Hare, Mellor, & Azmi, 2007). A number of studies of ASD have compared memory for the actions of self and others.

One of the most frequently cited studies of memory for self and other in ASD was conducted by Millward, Powell, Messer, and Jordan (2000). Free and cued recall of activities, such as buying sweets from a shop or visiting horses in a sanctuary, performed either by self or by an accompanying peer, was assessed in a sample of 12 children with ASD (with low verbal ability) and 12 typically developing children, who were matched for verbal mental age (Study 1). The results indicated that participants with ASD recalled significantly fewer event details for self-performed activities than comparison participants, but there were no between-group differences in recall of peer-performed activities. In terms of within-group patterns of performance, the comparison group showed significantly better recall for self-performed activities than peer-performed activities (self-enactment effect), whilst the ASD group demonstrated the opposite pattern, showing significantly better recall for peer-performed activities than self-performed activities. On the basis of these results, the authors concluded that "individuals with autism have a specific difficulty in the recall of personally experienced events" (p.24). However, this interpretation may not be entirely justified.

Although the ASD and typically developing groups were matched on verbal mental age, the ASD group had a mean chronological age that was more than 7 years

above that of the comparison group. Thus, it is possible that between-group differences in levels and patterns of performance on the experimental task can be accounted for by the difference in verbal intelligence (the mean verbal IQs of the ASD and comparison groups can be estimated at 53 and 107, respectively) rather than by ASD-specific deficits.

In an attempt to overcome this limitation of the study, Millward et al. (2000) conducted a second study in which they assessed a sample of children with intellectual disability who, like the ASD group in Study 1, had lower verbal mental ages than chronological ages. However, in Study 2 no ASD or typically developing groups were included, and the group with intellectual disability in Study 2 was not comparable to the ASD or typically developing groups from Study 1, in terms of *either* verbal mental age or chronological age. Moreover, the group tested in Study 2 experienced a *different* set of events in *different* locations to those used in the first study. Therefore, any comparisons between the findings of Study 1 and Study 2 are unlikely to be informative.

More recently, Hare et al. (2007) used a "table-top tasks" paradigm to compare free and cued recall of self- versus other-performed actions amongst 12 low-functioning adults with ASD and 14 adults with intellectual disability, who were matched on receptive vocabulary and grammar. It was found that participants with ASD did not significantly differ from participants with intellectual disability in terms of either their free recall or cued recall of actions, and both groups showed a free and cued recall advantage for self-performed actions over other-performed actions.

Farrant, Blades, and Boucher (1998) assessed memory for self and other in a sample of 15 children with ASD (with low verbal ability), 15 typically developing children matched for verbal mental age, and 15 children with intellectual disability

matched for chronological and verbal mental age, using a task that involved the experimenter and participant listening to an audio recording, 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 aloud. After 28 instructions from the recording, and a short delay, the child was given a surprise recognition and source memory test. They were asked if particular (target and distractor) words were "old" or "new". For the words they identified as old, they were asked who had spoken the word aloud. Although the authors did not compare recognition memory accuracy for "self" and "other" words within or between the groups, it was found that within all groups, the proportion of correctly recognized "self" words correctly attributed to the self, and the proportion of correctly recognized "other" words correctly attributed to the experimenter did not significantly differ – that is, none of the groups showed a self-enactment effect in self-other source memory. This same pattern of performance was confirmed in a replication study of children with ASD who had moderately impaired verbal ability (Hala, Rasmussen, and Henderson, 2005).

Russell and Jarrold (1999, Experiment 1) tested a sample of 22 children with ASD (with low verbal ability) using a task in which experimenter and child took turns to place a total of 24 picture cards onto a picture lotto 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). It was found that relative to verbal ability matched typically developing children and children with intellectual disability, children with ASD

generally performed less well on the task, and also showed a different pattern of performance to the comparison groups.

For the current purposes, the most significant finding was that both comparison groups were better at remembering the correct origin of the cards they had placed on the board themselves (i.e., their cards + their doll partner's cards) than of the cards they had observed the experimenter place (i.e., experimenter's cards + experimenter's doll partner's cards) (with the difference reaching significance in the group with learning disability but not the typically developing group), whereas the ASD group were significantly better at remembering the correct origin of the cards they had observed the experimenter place on the board than of the cards they had placed themselves. Thus, whereas the comparison groups showed a self-advantage, the ASD group showed an other-advantage.

Williams and Happé (2009a) recently failed to replicate Russell and Jarrold's (1999) findings. They used a slightly modified version of the original task, in which 32 rather than 24 picture cards were used, to test a sample of 16 children with ASD (of mixed intellectual ability) and 16 comparison children (who were matched on age, VIQ, and PIQ). It was found that participants with ASD showed both a similar level and pattern of performance to comparison participants. Neither of the groups showed a self-enactment effect, with both groups showing no significant difference in memory for the origins of their own (i.e., their cards + their doll partner's cards) and the experimenter's (i.e., experimenter's cards + experimenter's doll partner's cards) cards (D. Williams, personal communication).

Finally, Lind and Bowler (2009c) assessed recognition and self-other source memory in a group of 53 children with ASD, who had mixed levels of verbal ability, and 50 comparison children (matched on age and verbal ability). The experimental task involved a picture naming game in which the experimenter and participant took turns to pick up and name picture cards. Following a two minute filled delay, recognition and self-other source memory were assessed. It was found that although participants with ASD showed similar levels of recognition memory to comparison participants, they showed significantly diminished source memory. However, crucially, it was found that both groups showed the same *pattern* of performance, with better recognition and source memory for items originally picked up and named by the child rather than the experimenter.

Clearly, studies of memory for self and other in ASD have produced mixed results. However, only two out of the seven studies outlined above found qualitatively distinct patterns of performance amongst participants with ASD, and the validity of the methods used in one of these studies was questioned. The remaining five studies have either found no difference between memory for self and other amongst participants with and without ASD or have found a typical self-enactment effect amongst participants with and without ASD. Thus, the weight of the evidence seems to suggest that individuals with ASD do not differ from individuals without ASD with respect to memory for the actions of self versus other.

In contrast to the studies of the self-reference effect, these results seem to suggest that individuals with ASD have self-concepts that have reached the "critical mass" necessary for encoding/retrieving self-relevant information. This may be because

encoding, in this case, occurs in relation to *physical* (which are hypothesized to be intact in ASD) rather than psychological aspects of the self-concept and relies only on higher-order (or perhaps even primary) self-awareness of physical (or action based) aspects of self.

Non-autobiographical Episodic Memory in ASD

It is now well established that individuals with ASD have impaired non-autobiographical episodic memory (Ben Shalom, 2003; Bowler, Gaigg, & Lind, in press). As explained above, episodic and semantic memory are associated with autonoetic (self-knowing) and noetic (knowing) awareness, respectively. These states of awareness are readily distinguished by individuals when retrieving memories. Episodic (autonoetic) retrieval, or *remembering,* is associated with a rich recollective experience in which one has a feeling of re-living the previously experienced event. Semantic (noetic) retrieval, or *knowing,* is associated with a feeling of familiarity but no sense of re-living a past episode. This ability to distinguish between autonoetic and noetic states of awareness may be exploited in order to investigate the relative contributions of episodic and semantic memory, respectively, to performance on memory tasks. In the traditional "remember-know" paradigm (Tulving, 1985), participants complete a standard recognition memory test and, for each test item they identify as old, they are asked to state whether they actually *remember* the item being presented at study or just *know* that it was presented at study. Typical individuals tend to provide a mixture of *remember* and *know* responses in recognition tests, reflecting the contribution of both episodic and

semantic memory to task performance. Thus, if individuals with ASD have impaired episodic memory, they should show less *remembering* and more *knowing* in such tests.

Bowler, Gardiner, and Grice (2000) used a *remember-know* test to assess the relative contributions of episodic and semantic memory to the recognition memory performance of high-functioning adults with ASD. Participants studied a list of 24 low-frequency and 24 high-frequency words. During the test phase, participants were asked to make *remember-know* judgements for items identified as old, and also to provide justifications of their responses (helping to ensure that reports corresponded to genuine instances of *remembering* or *knowing*). It was found that the ASD and comparison groups (who were matched for age, VIQ, PIQ, and FSIQ) showed almost identical levels of item recognition. However, the ASD group provided significantly fewer *remember* responses and significantly more *know* responses than the comparison group. This suggests that individuals with ASD are significantly less likely to retrieve rich, episodic trace information and to become autonoetically aware of their memories.

It could potentially be argued that remember-know judgments might not reflect the same underlying processes amongst individuals with ASD as amongst typical individuals – that is, amongst individuals with ASD, *remember* responses may not correspond to true instances of autonoetic awareness and *know* responses may not correspond to true instances of noetic awareness. However, Bowler et al. (2000) found that both groups showed a word frequency effect – they were more likely to give *remember* responses to recognised low-frequency words than to recognised high-frequency words. The fact that individuals with ASD respond to such experimental manipulations in the same way as comparison participants provides reassurance that their

remember-know judgments do reflect genuine instances of autonoetic/noetic awareness. These findings therefore suggest quantitative rather than qualitative differences between the groups.

These findings provide some of the clearest evidence for non-autobiographical episodic memory difficulties in ASD and imply that people with ASD experience autonoetic awareness less frequently than people without ASD. Given that performance on such *remember-know* recognition memory tasks does not require material to be processed self-referentially (although it is possible that participants may incidentally do so on occasion), it seems highly unlikely that the encoding of material requires a self-concept. Therefore, deficits on non-autobiographical episodic memory tasks, such as these, cannot be taken as evidence for diminished self-concepts in ASD.

It was argued above that whereas autobiographical episodic retrieval necessarily involves re-experiencing the self as the object of experience (the "me"), non-autobiographical episodic retrieval involves re-experiencing the self as the subject of experience (the "I"). Thus, deficits in non-autobiographical episodic memory are primarily likely to reflect deficits in re-experiencing the self as the subject of experience. However, it is important to note that although these findings suggests that individuals with ASD have difficulty *re-experiencing* themselves as the subject of experience, they do not imply that individuals with ASD do not experience themselves as the subject of experience (i.e., have subjective experiences) *online*.

One plausible explanation for these deficits in re-experiencing past states of self is that individuals with ASD have an impaired capacity for memory binding. If an individual is unable to effectively link together event features in order to reconstruct a

past episode, they simply cannot mentally re-experience that past episode in order to become aware of a past state of self. Recent evidence suggests that individuals with ASD have significant difficulties with such binding. Bowler, Gaigg, and Gardiner (2008) found that high-functioning adults with ASD showed undiminished recognition memory, relative to comparison adults (matched for age, VIQ, PIQ, and FSIQ), when required to identify items on the basis of single features (e.g., shape) but showed significantly diminished performance when required to identify items on the basis of combinations of features (e.g., colour and shape), which relies on episodic binding.

Conclusions

At the outset of this paper, it was argued that aspects of memory and the self are bi-directionally related. For example, the typical development of autobiographical episodic memory may depend on the emergence of a rudimentary self-concept, which is itself based on autobiographical semantic knowledge; and the emergence of a more sophisticated, temporally extended self-concept may depend on the development of autobiographical episodic memory (and episodic future thinking).

Research seems to indicate that certain aspects of autobiographical semantic knowledge may be impaired amongst children with ASD, implying that individuals with ASD have self-concepts, particularly in the psychological domain, which are impoverished relative to individuals without ASD. The fact that such deficits appear to selectively affect psychological but not physical aspects of the self-concept may reflect the fact that the acquisition of psychological autobiographical semantic knowledge

depends on social factors (Neisser, 1988). The fact that individuals with ASD characteristically exhibit marked social and communication impairments may, therefore, limit their opportunities for acquiring psychological self-knowledge (Lind & Bowler, 2008).

Whether or not impairments in autobiographical episodic memory are the consequence of an impaired self-concept in ASD remains an empirical question, given that no studies have directly addressed this issue. However, studies of self-referential memory provide indirect insight. Although self-referential memory tasks do not necessarily tap autobiographical episodic memory, they do shed light on the capacity to encode information as "self-relevant". Studies typically indicate that adults and children with ASD show a diminished self-reference effect. Individuals with ASD are likely to have a corresponding difficulty with encoding information as self-relevant in episodic memory. Given that such self-referential memory tasks require self-referential encoding in relation to psychological aspects of the self-concept, these results are consistent with the suggestion of specific deficits in these aspects of the self-concept in ASD.

In terms of memory for the actions of self versus other, the majority of the evidence indicates that individuals with ASD show patterns of performance that are qualitatively similar to those of individuals without ASD, suggesting that the self acts as a similarly effective organising structure in memory for individuals with and without ASD. This, it is argued, is due to the fact that the self-enactment effect in memory depends only upon higher-order (or even primary) *physical* self-awareness which appears relatively undiminished in ASD.

The majority of the evidence suggests that individuals with ASD have impairments in autobiographical episodic memory and episodic future thinking. The fact that individuals with ASD seem to have diminished memory for past personal experiences and a diminished capacity for simulating possible future experiences and, therefore, for re-experiencing past states of self or pre-experiencing future states of self, implies that they have a diminished sense of self, of personal history, and of personal continuity through time. Attenuated temporally extended self-awareness would seem to be an inevitable consequence of attenuated autobiographical episodic memory and future thinking. Interestingly, children with ASD show intact delayed self-recognition, which may indicate intact temporally extended *physical* self-awareness. Thus, individuals with ASD may have selective deficits in temporally extended *psychological* self-awareness.

Despite the accumulating evidence of impairments in psychological aspects of the self-concept and higher-order psychological self-awareness in ASD, it seems unlikely that impairments in autobiographical episodic memory could be totally accounted for in terms of impairments in the self-concept, given that there are additional impairments in *non*-autobiographical episodic memory, which is unlikely to require a self-concept. Together, these findings suggest that a diminution in self-awareness can only partially explain autobiographical episodic memory impairments in ASD. It seems likely that other factors, such as difficulties with memory binding, also play a role. Thus, although both autobiographical and non-autobiographical episodic memory are impaired in ASD, the impairment in the former (which relies on both a self-concept *and* binding) is likely to be more marked than the latter (which relies only on binding).

In summary, although memory in ASD is not wholly characterised by an "absent self" (cf. Frith, 2003), impairments in psychological aspects of the self-concept are likely to result in a reduced capacity for self-referential encoding (at least when psychological aspects of self are involved), as well as impaired autobiographical episodic memory and future thinking. These memory deficits are likely to further impact upon the self resulting, ultimately, in a diminished temporally extended (psychological) self.

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