Factors Affecting Conscious Awareness in the Recollective

Experience of Adults with Asperger's Syndrome

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Abstract

Bowler, Gardiner and Grice (2000a) have shown a small but significant impairment of autonoetic awareness or remembering involved in the episodic memory experiences of adults with Asperger's syndrome. This was compensated by an increase in experiences of noetic awareness or knowing. The question remains as to whether the residual autonoetic awareness in Asperger individuals is qualitatively the same as that of typical comparison participants. Three experiments are presented in which manipulations that have shown differential effects on different kinds of conscious awareness in memory in typical populations are employed with a sample of adults with Asperger's syndrome. The results suggest that the experiences of remembering reported by such individuals, although reduced in quantity, are qualitatively similar to those seen in the typical population. The results are discussed in the context of current theories of awareness in episodic memory.

Factors Affecting Conscious Awareness in the Recollective

Experience of Adults with Asperger's Syndrome

It is now widely accepted that autism comprises a spectrum of disorders. These range from a syndrome comprising severe social withdrawal, absence of language, motor stereotypes all accompanied by a degree of global cognitive impairment, to a condition characterised by more subtle social oddities, good language, repetitive behaviours that take the form of highly specialised interests and with normal or higher than normal levels of intelligence. The first of these is typified by the cases described by Kanner (1943), whereas the second type exemplifies the cases described by Asperger (1944, 1991), which are sometimes given the name Asperger's syndrome. Although current diagnostic and classification systems make the distinction between 'autism' and 'Asperger's Disorder' (DSM-IV) or 'Asperger's Syndrome' (ICD-10), the debate about whether non-cognitively impaired individuals who fit either of these sets of criteria for autism are different from those who fit the criteria for Asperger's syndrome still continues (see Frith, 2004; Volklmar & Klin, 2000). Yet despite the debate, it is widely accepted that all manifestations of the autistic spectrum result from some form of brain impairment that impacts on psychological functioning.

One area of psychological functioning that has received growing attention in recent years is memory. Clinical accounts both of classic autism and of Asperger's syndrome have reported often prodigious memory capacities, with individuals capable of rote memorising large quantities of information (Kanner, 1943; Wing, 1981), Experimental studies of memory in people with autistic spectrum disorders have revealed a particular pattern of spared and impaired capacities. While immediate memory span seems to be unimpaired (Hermelin & O'Connor, 1970; but see Poirier, Gaigg and Bowler, 2004), free recall is often impaired. This is true especially when structural features of the stimulus material such as semantic relatedness of items, can be used to aid recall (Bowler, Gardiner & Grice, 2000a; Bowler, Matthews & Gardiner, 1997; Smith, Gardiner & Bowler, 2004 in preparation; Tager-Flusberg, 1991). Other measures of memory, such as cued recall (Boucher & Lewis, 1989; Boucher & Warrington, 1976; Tager-Flusberg, 1991) and recognition, at least in individuals without global cognitive impairment (Barth, Fein and Waterhouse, 1995; Minshew, Goldstein, Muenz & Payton, 1992, Minshew, Goldstein, Taylor & Siegel, 1994 but see Bowler, Gardiner & Berthollier, 2004) are unimpaired.

Tulving (1983; 1985) argues that human memory comprises several distinct systems, each characterised by a particular type of conscious

awareness. Two of these systems are the semantic system, which is accompanied by noetic conscious awareness, and the episodic system, which is accompanied by autonoetic conscious awareness. The semantic system contains an individual's store of 'timeless facts' (Tulving, 2002), awareness of which is not tied to any particular spatio-temporal or self-referential context. Operation of the episodic system by contrast, involves 'mental time travel' (Tulving, 2002) in which conscious awareness of the subject contains a re-construction of the spatio-temporal and self-referential context of the recalled material. Tulving argues that measures such as free recall rely mainly on the operation of the episodic system whereas measures such as cued recall and recognition draw more heavily on the semantic system. The operation of the episodic and semantic systems can be separated experimentally in recognition memory experiments by the use of the 'Remember/Know' (R/K) procedure (Tulving, 1985) in which participants are asked to study a list of words, and after a short delay, are re-presented with these words, one by one, interspersed with other, non-studied words. At each presentation they are asked if they have seen the word before and if they say that they have, they are then asked if they remember (R) the episode of having seen the word, or if they merely know (K) that they saw the word, without any specific recollection of the episode.

Reduced rates of R responses using this paradigm have been reported for a number of populations with clinical conditions, including schizophrenia (Huron, Danion, Giacomoni, Grange, Robert & Rizzo, 1995) and people with frontal lobe lesions (Wheeler & Stuss, 2003). This last group is of interest here, because individuals with frontal impairments show a similar memory profile to that of individuals from the high-functioning end of the autistic spectrum, i.e. they are typically impaired on free recall tasks and less impaired on tasks such as cued recall and recognition (Schacter, 1987). Moreover, individuals on the autistic spectrum are characterised by impairments on certain executive tasks such as the Wisconsin Card Sorting Test and the Tower of Hanoi, which are thought to implicate the frontal lobes (see Russell, 1997). On this basis, as well as on the basis of their deficits in free recall relative to cued recall and recognition, Bowler et al. (2000a) predicted that individuals with Asperger's syndrome would show less remembering on recognition memory tasks that use the R/K procedure.

Another reason that led Bowler et al (2000a) to predict that Asperger individuals would report less remembering in memory tests came from Perner's theoretical analysis of the relationship between the development in young children of episodic memory and their understanding of the representational nature of beliefs – often referred to as a 'theory of

mind' (Perner, 1990; Perner & Ruffman, 1995). Perner argues that in order to have memories that are truly episodic, i.e. that involve the self in relation to the material being remembered, children have to understand two things. First, they must be able to recall a past event and in particular, a past event that involved themselves. They must then be able to represent this event as having occurred to themselves, that is, a child needs to represent to him or herself the fact that their own memory of an event is a representation of that event. This ability is an example of what Perner calls 'metarepresentation', which does not typically develop until about four years of age. For Perner, the development of metarepresentational ability is also central to a child's developing 'theory of mind', that is an ability to understand mental states in self and in others. Once children can engage in metarepresentation, then they can grasp both that beliefs can be true or false representations of reality and that it is possible to have memories of personally-experienced events that are representations of those events. Children with autism have been shown to be delayed in their development of an understanding of the representational nature of mental states (Baron-Cohen, Leslie & Frith, 1985) and, even though older and higher-functioning individuals with autism and Asperger's syndrome often pass false belief tasks (Bowler, 1992), this may happen because they bring different underlying processes to the tasks (Bowler, 1992; 1997; Happé, 1995). As Bowler et al. (2000a)

argue, if the apparent lack of difficulty on 'theory of mind' tasks seen in

higher-functioning individuals with autism results from the operation of

different mechanisms, then we would predict impaired performance on

tasks, such as the R/K procedure, since remembering and 'theory of mind'

are theoretically linked in typical development.

Bowler et al. (2000a) demonstrated such impaired performance in a

recognition memory experiment using the standard R/K procedure. To

cover the possibility that their Asperger participants may have generated R

responses using processes that were different from the typical case,

Bowler et al. Included a manipulation based on word frequency. Earlier

studies (e.g. Gardiner & Java, 1990; Gardiner, Richardson-Klavehn, &

Ramponi, 1997; Kinoshita, 1995; Strack & Forster, 1995) had shown that

typical participants produced more R responses for low frequency than for

high frequency words. Bowler et al. (2000a) report a similar finding for

their Asperger participants, supporting the view that the R responses of

this group were qualitatively similar to those of controls.

Despite the word-frequency findings of Bowler et al., it remains

possible that their Asperger participants were generating R responses on a

basis that was different from that of controls, and that these different

processes still yielded the word frequency effect described above. The

present series of experiments was designed to provide further evidence on

the nature of the R responses made by Asperger participants by

manipulating a range of variables that have been shown to affect levels of

remembering and knowing differently. The first experiment uses Gardiner

and Parkin's (1990) finding that dividing attention at study should diminish

R but not K responses at test. Experiment 2 capitalised on the

observation that shifting modality of presentation from study to test in

the context of a task that encourages perceptual fluency affects K but not

R responses (Gregg & Gardiner, 1994). The third experiment reported

here is based on a study by Dewhurst and Hitch (1997) who presented

participants with words and non-words, the latter being derived from real

words by means of either an early- or a late-occurring phoneme change.

Items were also presented at study either once or three times. At test,

words that had been presented at study more often were more likely to be

judged as R, and false alarms to late rather than early phoneme change

were more likely to be given a K judgment. Our argument is that if

individuals with Asperger's syndrome are making R responses on the same

basis as controls – albeit at a lower level – then they should respond

similarly to controls to the experimental manipulations. By contrast, if

their R responses are mis-labelled K experiences, then manipulations that

should only affect participants' R responses should be ineffective in a

group of individuals with Asperger's syndrome. Similarly, manipulations

that should only affect K responses, would also affect R responses in an
Asperger group.

Experiment 1

Drawing on a body of evidence that showed that dividing attention
at study adversely affected performance on explicit but not implicit
memory tasks, Gardiner & Parkin (1990) argued that requiring participants
to divide their attention at study should also adversely affect R but not K
responses in an explicit recognition memory test. Using typically developed
participants, they compared recognition memory for words that had been
studied under full and divided attention conditions. The divided attention
condition consisted of asking participants to label a series of tones of high,
medium and low pitch presented at random intervals during the study
phase. Dividing attention at study was found to reduce overall recognition
only for R responses. The rate of recognition for K responses remained
unaffected by the manipulation.

On the basis of the argument that individuals with Asperger's syndrome
have qualitatively similar experiences of remembering to a typical
comparison group, we hypothesised that dividing attention at study would
have the same effect on their R recognitions as found in comparison
participants, and should not affect their K responses. If, however, their R
responses are mis-labelled K experiences, then the experimental

manipulation should have a minimal effect on their rate of reported

remembering. In Experiment 1 we replicated Gardiner and Parkin's study

with a sample of individuals with Asperger's syndrome and a group of

individually matched typical participants.

Method

Participants

Eighteen adults with Asperger's syndrome (14 men and 4 women) and 18

typical controls (15 men and 3 women) who could be closely matched on

chronological age (CA) and WAIS-III verbal IQ (VIQ) took part in this

experiment. Table 1 provides psychometric data for the participant groups.

All participants with Asperger's syndrome had been diagnosed according

to a range of criteria, and a review of records confirmed that all met ICD-

10 criteria for Asperger syndrome excluding the requirement for an

absence of clinically significant developmental problems of language. None

had any present-state abnormalities of syntactic or semantic aspects of

language. The typical group was recruited from the local community

through press advertisements. Participants from either group who were on

psychotropic medication were excluded, as were any control participants

who had a psychiatric diagnosis or issues with substance abuse.

Design

<u>Stimuli</u>

The investigation used a 2 (Group) x 2 (Full vs Divided attention) x 2 (R/K) mixed repeated measures design, with repeated measures on the last two factors. Seventy-two words were selected from those used by Gardiner and Parkin, who used a word list developed by Tulving, Schacter and Stark (1982). These were divided into 3 blocks of 24 words each. Allocation of blocks to full and divided attention conditions was counterbalanced across participants, with the remaining, unpresented block serving as lures during the recognition test. A Visual Basic (VB 6.0; Microsoft Corp. 1987-1998) programme controlled the presentation of the stimuli. Words appeared in size 48, bold, Times New Roman font, in the centre of a 38 cm TFT screen on a Sony Lap-top computer. Within each block words appeared in random order at a rate of 2 s per word with no interval between stimuli. During the divided attention condition, tones were presented via loudspeakers. The tones appeared at semi-random intervals between 3 and 5 s and were of either 'High' (ca. 1600 Hz), 'Medium' (ca 800 Hz) or 'Low' (ca. 450 Hz) frequency.

<u>Procedure</u>

Unlike Gardiner and Parkin (1990), we presented the study condition (full vs. divided attention) within rather than between subjects. This was because not enough participants were available to run a between-subjects

design with sufficient power. Each individual studied one block of words under the full attention condition and another block under the divided attention condition. The order of conditions was counterbalanced across participants. The divided attention condition commenced with 3 tones without any words, after which words and sounds appeared as described above. Before the start of the experiment participants were told that they would be presented with a series of words that they should try to remember. They were informed that they would see half of the words unaccompanied by tones, whilst hearing some tones during the presentation of the other half of words. Participants were instructed to label any tones they might hear as either 'High', 'Medium' or 'Low'. It was made clear that the individual should try to remember all of the words, not only the unaccompanied ones. Individuals were familiarised with the tones and given training trials until they labelled at least 5 random consecutive tones correctly. Finally, individuals were informed about whether to expect tones during the presentation of the first half of the words. After the first block of words the experimenter chose the appropriate block of words and condition to present next. Again participants were informed about whether to expect any tones and were reminded to try and remember as many words as possible.

During the five minutes immediately following the study period, the R/K procedure was explained to the participant using the procedure described by Bowler et al. (2000a). Participants were told that they would see a series of words presented one by one on the screen, and that under each word was a 'yes' and a 'no' button. If they recognised having seen the word at study, they were to press the 'yes' button, otherwise they should press the 'no' button. If they pressed 'yes', then two further buttons, labelled 'Type A' and 'Type B' appeared. Participants had already been briefed that a Type A memory meant that in addition to recognising having seen the word at study, that they also remembered something about it, such as where it was in the list, how it appeared on the screen, something about a time when they used the word or the object represented by the word etc. A type B judgment should be made when there is confidence that the word was studied, but nothing can be remembered about the word or the time it was studied.

At test, all 72 items (48 studied, 24 lures) were presented in random order. After each word, participants were asked to indicate if they remembered having studied the word, and if they answered 'yes', they were asked to make a R/K judgment as described in Bowler et al. (2000a). When the R or K response was given, in order to ascertain whether or not participants were making R and K judgments in accordance with the

instructions they were given, they were asked to give a brief description

why they made the judgment. These descriptions were tape-recorded for

later transcription and analysis.

Results

Both groups were equally successful at labelling the tones during the

divided attention condition. The Asperger group correctly labelled 74% of

the tones, compared to 79% correct for the comparison group. On the

memory task, corrected hit rates were calculated by subtracting each

participant's proportion of false alarms from their proportion of hits,

separately for R and K responses. Since none of the dependent variables

was affected by order of testing (full-divided vs divided-full, maximum t =

1.18, df = 34, ns), the data were collapsed across all individuals within a

group. The results, set out in Table 2 were analysed using a 2 (Group) x 2

(Full/Divided) x 2 (R/K) mixed, repeated-measures ANOVA. Significant

main effects were found for the Full/Divided ($F(1,34)$ = 88.22, $p < .001$)

and the R/K ($F(1,34)$ = 42.04, $p < .001$) factors. Mean corrected

recognition rates for the Full and Divided attention conditions were .61 (SD

= .20) and .27 (SD = .16) respectively. Mean rates for R and K responses

were .31 (SD = .16) and .10 (SD = .09) respectively. Significant

interactions were found between the R/K and Group factors ($F(1,34)$ =

5.69, $p < .05$) and for the Full/Divided and R/K factors ($F(1,34)$ = 32.16,

$p < .001$). None of the other main effects or interactions was significant.

Most importantly, the Group x Full/Divided x R/K interaction was not

significant ($\underline{F}(1,34) = 0.782$, $\underline{ns}$), indicating that the effects of dividing

attention on R and K responses were statistically similar for the two

groups.

TABLE 2 ABOUT HERE

Post-Hoc comparisons revealed that the Group by R/K interaction arose

mostly from the fact that individuals with Asperger's syndrome recorded

fewer R responses than comparison participants ($\underline{t} = 2.32$, $\underline{df} = 34$, $\underline{p} <$

$.05$). The mean corrected rate of R responses for Asperger and

comparison participants, summed over full and divided attention

conditions, were .25 ($SD = .12$) and .36 ($\underline{SD} = .17$) respectively. The

Asperger group also tended to produce more K recognitions ($\underline{M} = .12$; $\underline{SD}$

$= .08$) than the comparison group ($\underline{M} = .08$; $\underline{SD}. = .09$), but this difference

did not reach significance ($\underline{t} = 1.37$, $\underline{df} = 34$, $\underline{ns}$). Although the two groups

did not differ on Performance IQ, there was a substantially greater

difference between them on this measure than Verbal IQ. Therefore, to

exclude the possibility that the Group by R/K interaction was due to

influences of Performance IQ we also conducted a 2 (Group) by 2 (R/K)

ANOVA with PIQ as a covariate. Results confirmed the initial analysis and

the Group by R/K interaction remained significant ($\underline{F}(1,33) = 4.75$, $\underline{p} <$ .05).

As expected, the interaction between the R/K and Full/Divided factors arose from a larger decrement in R than in K responses when attention was divided at study. Rates of R responses dropped from .45 ($\underline{SD} = .22$) to .16 ($\underline{SD} = .14$) when words were studied under divided attention ($\underline{t} = 8.27$, df = 35, p < .001). The respective values for rates of K responses were .12 ($\underline{SD} = .11$) for words studied under full attention and .08 ($\underline{SD} = .10$) for words studied under divided attention. This last difference also proved to be significant ($\underline{t} = 2.18$, df = 35, p < .05).

Discussion of Experiment 1

The results of this experiment confirm Bowler et al.'s (2000a) finding that individuals with Asperger's syndrome make fewer R responses than comparison participants. The findings also show that dividing attention at study produces similar effects on the performance of the two groups; overall recognition is reduced under divided attention and this reduction is greater for R than for K responses. As such, these findings lend further support to the idea that in individuals with Asperger's syndrome, although the overall quantity of self-related recollective experience is diminished, it is qualitatively similar to that of a typical

comparison group. In relation to the finding of reduced remembering, it is worth noting that out of the 18 individuals with Asperger's syndrome in the current experiment, only 5 had previously taken part in the Bowler et al., (2000a) study, suggesting that the deficit in remembering is widespread in the Asperger population.

Experiment 2

Manipulations involving perceptual or conceptual processing of studied material were initially found to affect K and R responses respectively (Rajaram, 1993; see too, Blaxton & Theodore, 1997) and it is clear that episodic memory depends heavily on conceptual processes, even though there are some perceptual or conceptual manipulations that have more recently been found to affect R and K responses respectively (e.g., Rajaram, 1996, Rajaram & Geraci, 2000). Repetition test priming was among the first of the perceptual manipulations shown to selectively affect K responses (Rajaram, 1993). Rajaram used a standard visual recognition memory procedure, but at test, half the studied items were preceded by a masked prime word that was either identical to the test word or quite unrelated to it. Inclusion of an identical test prime increased the proportion of K responses, while leaving rates of R responses unchanged. Rajaram concluded that identical test primes enhanced perceptual fluency for the test words, resulting in greater attributions of familiarity and therefore a

greater likelihood of a K response. In contrast, manipulations of study and test modality -- for example, when study words are presented visually and test words are presented either visually or auditorily -- do not usually affect levels of remembering or knowing (Gregg & Gardiner, 1994). But Gregg and Gardiner (1994) argued that K responses might be selectively affected by same versus different study-test modality if the memory task at study was designed to maximise perceptual fluency, and hence K responses, since K responses are argued to be a consequence of perceptually fluent processing. To test this hypothesis, Gregg and Gardiner (1994) gave participants a highly perceptually-oriented task in which they were asked to count the number of blurred letters in study words that were rapidly presented on a screen (though none of the words actually included any letters that were blurred). In a subsequent surprise recognition test, participants were presented with study words and lures either in exactly the same visual modality, or auditorily, and were asked to make R/K judgements. The results confirmed Gregg and Gardiner's hypothesis, by showing that same versus different modality at study and test, selectively increased K responses leaving R responses unchanged. In Experiment 2 we replicated Gregg & Gardiner's procedure using a sample of individuals with Asperger's syndrome and individually matched typical controls. Our hypothesis was based on the argument that if Asperger participants' R responses are, in fact, mis-labelled K responses, then the

manipulation used here should affect both the R and the K responses for this group. Controls, by contrast, would show an effect only for the K responses. If the Asperger participants were making R responses on a similar basis to that of controls, then the manipulations should not affect their level of remembering.

Method

Participants

Twenty-four individuals with Asperger's syndrome (18 men, 6 women), selected according to the criteria outlined in Experiment 1, and 24 typical comparison individuals (17 men, 7 women), individually matched for WISC-R verbal IQ (VIQ) participated in the study. Age and psychometric details of the two groups are set out in Table 3, which illustrates that groups were also well matched on chronological age (CA), WISC-R performance and full-scale IQ. Eight Asperger and eleven comparison participants had taken part in Experiment 1.

TABLE 3 ABOUT HERE

In order to match groups more closely on PIQ than in Experiment 1, an attempt was made not to include individuals with Asperger's syndrome whose VIQ-PIQ difference exceeded 21 points (i.e. 1.5 standard

deviations). Since, by definition, it is not possible to find typical matches

for such individuals (see Wechsler, 1981) and as Ozonoff, Rogers &

Pennington (1991) have suggested that such VIQ- PIQ differences might

be one of the factors that distinguish individuals with autism as described

by Kanner (1943) and those described by Asperger (1944), excluding

participants in this way not only allows closer overall matching between

groups but also results in a more homogeneous clinical group.

Design and Materials

        The design consisted of a 2 (Group) x 2 (Auditory vs Visual test) x 2

(Remember vs Know) mixed, repeated measures design, the last two

factors being within-subjects. Sixty-four low frequency words (mean

frequency approximately 5 per million; Thorndike & Lorge, 1944; Kucera &

Francis, 1967) were selected from the 80 words used by Gregg and

Gardiner (1994). The reduction in the number of words was necessary

because pilot studies indicated that a design based on 80 words was too

difficult. The lowest frequency words were dropped from the original pool.

The resulting 64 words were split into two lists (A and B) of 32 words

each. A single random order of either set A or B was presented to

individuals during the incidental learning phase (old-on recognition) while

the other set was not presented (new-on recognition). Presentation was at

a rate of 500 ms per word with 300 ms interstimulus intervals on a 38 cm

Sony Lap-top TFT computer screen. Words appeared in black, 48-point

Arial font on a white background in the centre of the screen.

During the recognition test, half of each set of words was presented

visually whereas the other half of words was presented auditorily. Thus 32

words (16 old, 16 new) were tested in the visual modality and 32 words

(16 old, 16 new) were tested in the auditory modality. Half of the

participants were tested in the auditory modality first whereas the other

half of participants was tested in the visual modality first. Words were

counterbalanced across test conditions so that each word was tested in

each modality equally often. Within each modality words were presented in

a different random order for each participant. For the visual test, words

appeared in the same manner as during presentation. During the auditory

test, recordings of the individual items were presented in a female voice

via loudspeakers.

Procedure

Before the beginning of the task individuals were informed that they

were about to take part in an experiment concerned with visual perception.

They were instructed to look carefully at the screen and monitor the

rapidly presented words for the occurrence of blurred letters. They were

told that their task was to count the number of blurred letters they would

see. Following these instructions individuals were presented with a practice list of 10 words, of which three contained a single blurred letter. Following the practice trial, participants were presented with the test list proper. During a five-minute break individuals were briefed about the actual purpose of the test and the R/K procedure was explained. Subsequently the test list was presented as outlined above. During the visual test modality words remained on the screen until the individual gave a response. During the auditory modality words were repeated if the individual indicated that s/he did not hear the word properly. Each participant's yes/no and R/K responses were recorded by means of mouse clicks on response buttons on the computer screen. As in Experiment 1, on each trial, participants were asked to describe why they made an R or a K judgment. The descriptions were tape-recorded for later transcription and analysis.

Results

All individuals correctly counted the 3 blurred letters during the practice trials and none of them reported seeing any during the actual study list. Mean corrected hit rates for both group's R and K responses under auditory and visual tests were calculated by subtracting the proportion of false recognitions within a test modality from the proportion of correct recognitions within that modality. To check for order effects,

these data, set out in Table 4, were first analysed using a 2 (Group) x 2 (Order) x 2 (Auditory/Visual Test) x 2 (R/K) mixed repeated measures ANOVA. This revealed a significant main effect for Auditory/Visual ($F_{(1.44)} = 15.12$, $p < .001$) and marginally significant effects for Order ($F_{(1,44)} = 3.29$, $p < .08$) and R/K ($F_{(1,44)} = 3.44$, $p < .08$). Significant two-way interactions were found for Auditory/Visual x Group ($F_{(1,44)} = 7.25$, $p < .02$), Auditory/Visual x Order (($F_{(1,44)} = 25.86$, $p < .001$) and Auditory/Visual x R/K ($F_{(1,44)} = 7.34$, $p < .02$). Three-way interactions emerged for Auditory/Visual x Group x Order ($F_{(1,44)} = 9.31$, $p < 0.005$), Auditory/Visual x R/K x Group ($F_{(1,44)} = 6.38$, $p < .02$) and Auditory/Visual x R/K x Order ($F_{(1,44)} = 7.34$, $p < .02$). None of the other main effects or interactions approached significance.

Table 4 ABOUT HERE

It is clear that the typical participants' responses to the memory task are heavily influenced by the order of presentation of conditions, suggesting that they were actively adopting strategies during the task. This may have resulted from the fact that the participants who took part in the present experiment found the memory task more difficult than did those who took part in the original Gregg and Gardiner study, despite the number of items having been reduced. The mean overall recognition rate

for the comparison group in the present study was .22 as opposed to a

rate of .32 in the original study. This difference probably results from the

fact that the controls used here had average IQs of 103, whereas the

undergraduate students who took part in Gregg and Gardiner's study

would have had substantially higher IQs.

To test the possibility that participants with poorer memory were

adopting performance-enhancing strategies that might have modulated the

effects of the experimental manipulation, we performed a median split on

participants' overall recognition memory performance and analysed the

data from the top 13 participants in each group using a 2 (Group) x 2

(Auditory/Visual Test) x 2 (R/K) mixed repeated measures ANOVA. The

data are set out in Table 5 and reveal a significant main effect for

Auditory/Visual Test ($\underline{F}$ (1,24) = 12.65, $\underline{p}$ < .005) and R/K ($\underline{F}$, (1,24) =

4.93, $\underline{p}$ < .05). The interaction between Auditory/Visual Test and R/K was

also significant ($\underline{F}$ (1,24) = 9.00, $\underline{p}$ < .01). None of the other main effects

or interactions approached significance. Post-hoc analysis of the

interaction showed that changing test modality significantly influenced

'Know' responses ($\underline{t}$ = 3.65, df = 25, p < .005) whereas 'Remember'

responses were not influenced significantly ($\underline{t}$ = 0.65, $\underline{ns}$). This analysis on

the higher-performing participants shows that both the comparison and

Asperger participants responded to the experimental manipulation in a manner similar to that reported by Gardiner and Gregg.

TABLE 5 ABOUT HERE

Discussion of Experiment 2

The results of this experiment show that for the Asperger group, using an auditory test modality for words that had been studied in the visual modality decreased the number of K responses compared to a condition where the test words were presented visually.   This replicates the findings of Gregg and Gardiner (1994) and further supports the argument that the memory experiences reported by individuals with Asperger's syndrome are qualitatively similar to those of typical individuals.

 If this group's R experiences had been mis-labelled K responses, then we would have expected the manipulation to have affected both these categories of response. However, as we have seen, the effect of the manipulation was not as strong for the comparison as for the Asperger group. This unexpected effect appears to have resulted from two factors. The first relates to the order of presentation of conditions. Whereas this factor had little effect on the Asperger participants, comparison individuals performed better on the first part of the recognition task. Thus comparison but not Asperger individuals, who were presented with the

auditory test first, achieved higher auditory than visual recognition rates. Similarly, those who were presented with the visual test first achieved higher visual recognition scores. This effect caused the 3-way interaction between the modality, order and group factors reported above. The second relates to the overall level of recognition of the participants, which was lower than in Gregg and Gardiner's original study with undergraduate students. It would appear that when the typical (but not the Asperger) participants experienced difficulty with the memory task, they adopted a strategy to improve their performance, which overrode any effects due to the manipulation. Those for whom the memory demands of the task were less onerous were affected by the manipulation in a similar manner to all the Asperger participants as well as to those of Gregg and Gardiner. In addition to showing that the R responses of the Asperger participants were insensitive to a manipulation that typically only affects K responses, the present findings also show that this group do not spontaneously engage in compensatory strategies when they experience difficulties on a memory task. This may be because they are unaware of their poor performance or because they are unable to generate or to choose an appropriate strategy. It is a finding that echoes those of studies in other areas of autistic functioning such as pretence (Jarrold, Boucher & Smith, 1996; Lewis & Boucher, 1988; 1995) and category exemplar generation

(Turner, 1999). In the context of memory, this is an issue that merits further research.

Experiment 3

It is now well established that when words are studied that are all associates of another unstudied word, the unstudied item is frequently falsely recognised at test, and is often given an R rather than a K judgment (see Roediger & McDermott, 1995). Bowler et al. (2000b) have shown that similar false recognition effects accompanied by R judgments can also occur in individuals with Asperger's syndrome. This false recognition effect is usually explained by the fact that the studied words activate representations of the associated, non-studied word to such an extent that participants mistakenly report having seen the item when presented with it at test.

A large number of investigations have been carried out in an attempt to establish the determinants of false recognition. Among these is a study by Wallace, Stewart, Sherman and Mellor (1995), who asked participants to engage in a lexical decision task in which they had to decide whether presented items were words or non-words. Non-words were generated by changing either an early-occurring or a late-occurring phoneme of a real

word (or base word), e.g. 'paradise' became either 'faradise' or 'paradife'.

Participants were then given a surprise memory test in which they were

shown the words they had studied and the words from which the non-

words they had studied were derived. Walker et al. found that false

identification was more likely for late-phoneme change items, and also if

the items had been studied three times rather than just once. They

attributed the late phoneme effect to a cohort activation effect (Marslen-

Wilson, 1987), in which late phoneme-change items provide greater

exposure to words from which they are derived than do early phoneme-

change items, which typically result in rejection of the item as a word

before a full representation of it has been formed.

Dewhurst and Hitch (1997) repeated Wallace et al.'s procedure with the

addition of a R/K judgment at test. As well as predicting that repeated

exposure at study would lead to more R responses, Dewhurst and Hitch

argued that if the activation of the base words brought about by the

phoneme change was an implicit process, then position of the changed

phoneme should impact upon K responses at test. If such activation is

explicit, then it should impact on R responses. Their results showed that

repetition of studied words selectively improved the rate of R responses

whereas the position of the phoneme change selectively affected K

responses to false recognitions of the base words from which the

phonemically changed non words used at study had been derived. On the basis of the arguments set out earlier on, we hypothesised similar effects for individuals with Asperger's syndrome.

Method

Participants

Twenty individuals with Asperger's syndrome meeting the criteria set out for Experiment 1, and 17 typically developed people were recruited for this experiment. Four Asperger and 1 comparison participant were excluded from the analysis either because of excessive errors during the lexical decision task or near chance performance on the recognition test (see results for more details). Of the remaining 32 participants (16 Asperger, 16 comparison), all but one individual with Asperger's syndrome had taken part in at least one of the experiments reported above. Participants were individually matched on Verbal IQ and as Table 6 illustrates, groups were closely matched on Performance IQ, Full-Scale IQ and chronological age. For reasons discussed in Experiment 2 we excluded individuals who had a VIQ-PIQ difference of more than ± 21 points.

TABLE 6 ABOUT HERE

Design and Materials

The investigation used a 2 (Group) x 2 (1 vs 3 repetitions at study) x 3 ('base' vs 'early' vs 'late' phoneme change) x 2 (R/K) mixed repeated measures design. All factors except for Group were within-subjects. A set of 80 3- and 4-syllable English words was drawn from the list of Wallace, Stewart, Sharman and Mellor (1995). For each of these 'base' words, two non-words were generated: 'early' non-words, in which an early-occurring phoneme was changed, and 'late' non-words in which a late-occurring phoneme was changed. Thus, 'paradise' became 'faradise' or 'paradife'. In the lexical decision task, which constituted the study phase of the experiment, 60 of these words were chosen, of which 20 were presented as base words, 20 as early non-words and 20 as late non-words. Phoneme change was counterbalanced across participants so that each word appeared in each form for equal numbers of individuals. In addition, half the words from each category ('base', 'early' and 'late') were presented once and half three times (this repetition was again counterbalanced across items), giving a total study list of 120 presentations. All study list items were spoken in a female voice presented in a pseudo-random order (to avoid proximity of repeated items) on a Sony laptop computer through loudspeakers. At test, each participant heard all 80 items in their base form. Words were presented in the same female voice as that of the lexical decision task and a single random order was used for all participants.

<u>Procedure</u>

Participants were told that they were about to take part in a language task, in which they would have to listen to some words and judge whether what they heard was or was not a real word. They were instructed to listen carefully to the words they would hear as it would not be possible to go back and listen to a word again. Individuals were asked to respond quickly by saying 'Yes' if they thought the word they heard was an English word and 'No' if they did not. Following these instructions, words were presented with each new word occurring after the participant's response to the previous word had been recorded on response sheets.

Following the lexical decision task individuals were briefed about the nature of the experiment and the R/K procedure was explained. Participants were told that they would again hear some words and that some of them would be ones they had heard before whereas others would be new. Pilot testing indicated that several individuals gave an R response because they recollected hearing the word pronounced incorrectly. Thus we informed all participants only to give a 'Yes' response if they heard the word pronounced in the same way as before. This procedural change eliminated the problem, with no participant reporting recollection of mispronunciation. Yes/no and R/K responses were recorded by mouse

clicks on a computer screen and explanations of R/K decisions were tape recorded.

Results

Performance on the lexical decision task (after exclusion of three individuals - 2 Asperger and 1 comparison - whose accuracy on the lexical decision task was only 80%, 75% and 73%) was similar for the two groups. For base words Asperger individuals labelled 96% correct and comparison participants 94% (t = 1.34, df = 30, ns). Respective values for labelling non-words were 92% correct for the Asperger group and 94% correct for the comparison group (t = 1.65, df = 30, ns).

Following Dewhurst and Hitch (1997), responses to words that had been studied as base words were counted as hits only if they had been correctly labelled as words at study. Likewise, false positives to test words that had been studied as non-words were counted only if the studied non-word had been correctly identified as such at study. Mean rates of false hits to lures for the Asperger and comparison groups were .03 (SD = .05) and .04 (SD = .06) respectively. This difference was not significant (t = 0.47, df = 30, ns). Corrected proportions of correctly recognised words broken down by number of presentations at study and R/K response are presented for both groups of participants in Figure 1.

Analysis of these data using a 2 (Group) x 2 (No of Presentations) x 2

(R/K) ANOVA, showed significant main effects for No of Presentations ($\underline{F}$

(1,30) = 37.5, $\underline{p}$ < .001) and R/K ($\underline{F}$ (1,30) = 12.9, $\underline{p}$ < .01) as well as for

the No of Presentations x R/K interaction ($\underline{F}$ (1,30) = 7.61, $\underline{p}$ < .05). None

of the other main effects or interactions was significant. Inspection of

Figure 1 shows that more R responses were made to items that had been

studied three times than to items than had been studied only once ($\underline{t}$ =

5.33, $\underline{df}$ = 31, $\underline{p}$ < .001). Repeated study had no effect on K responses ($\underline{t}$

= 1.63, $\underline{df}$ = 31, $\underline{ns}$). This pattern of results is similar for the two groups of

participants, suggesting that the manipulation operated similarly for them

both.

Table 7 provides raw proportions of false R and K recognitions as a

function of position of phoneme change and repetition. Because these

responses represent memory illusions rather than veridical memories, it

would not be justifiable to correct these false hit rates with false alarms to

lures.

<div align="center">TABLE 7 ABOUT HERE</div>

Following Dewhurst and Hitch (1997) we analysed the effect of phoneme

change on false recognition separately for R and K responses via 2 (group)

x 2 (early / late) x 2 (No of presentations). Analysis of the R responses

revealed a main effect of repetition ($\underline{F}$ (1,30) = 11.89, $\underline{p}$ < .01) and an

unexpected main effect of position of phoneme change (F (1,30) = 7.46, p < .05). No other main effects or interactions were significant. Analysis of the K responses, on the other hand, revealed a main effect only for position of phoneme change (F (1,30) = 9.03, p < .01) with all other main effects and interactions being non-significant.

Discussion of Experiment 3.

The results of this experiment confirm the findings of earlier studies (Dewhurst & Hitch, 1997; Dewhurst & Anderson, 1999) by showing that greater exposure to study material enhanced the rate of R responses, and that this effect occurred equally in both groups of participants. Moreover, late phoneme change tended to result in more false recognitions of the relevant base word being given a K response at test than early phoneme change. Again, this effect was found in both groups of participants. Taken together, these two findings show that manipulations that affect remembering and knowing in typical individuals have the same effects on individuals with Asperger's syndrome. These findings serve to reinforce the notion that although people with Asperger's syndrome have fewer experiences of remembering in memory tests, those remember experiences that they do have, whilst quantitatively lower, are qualitatively similar to those experienced by the typical population. The findings differ somewhat from those of Dewhurst and Hitch in that position of phoneme change was

found to affect R as well as K responses in both groups. This may have

resulted from the fact that the data for these analyses are false alarm data

(they relate to the number of times someone wrongly recognises, say,

'paradise', when they actually studied either 'faradise' or 'paradife') and as

such, response rates are low. Inspection of the data in Table 7 shows that

under the 'early change, three repetitions' condition, control participants

made fewer false alarms than did those with Asperger's syndrome. The

data reported in Table 7 approach floor (maximum score < 0.2), and in

circumstances like these, each additional false recognition has a

considerable relative effect on the magnitude of the score in any particular

cell. There is the possibility that participants' R responses may have been

inflated by their having developed an expectation of a memory test

through their participation earlier experments in our lab. However, this is

true only for the Asperger participants; there is little or no overlap

between the comparison participants who took part in these studies. What

is important in the present context is that both groups were affected

similarly by the manipulation, thus supporting the contention that they

share common experiences of remembering and knowing.

General Discussion

The key question behind the rationale for the three studies reported here was whether or not the residual level of episodic remembering in Asperger's syndrome reported by Bowler et al. (2000a,b) was qualitatively similar or qualitatively different from that of typical individuals. The findings reported here provide support for the conclusion of qualitative similarity in episodic awareness. In all, four manipulations were used, and all four were found to affect either R or K responses in a similar manner in both groups of participants. These observations are in addition to the demonstration by Bowler et al. (2000a) of a word frequency effect, where low frequency words tend to produce more R judgments in both Asperger and comparison participants. Moreover, Bowler et al. (2000a) could find no differences between the explanations offered by Asperger and comparison participants for their R and K responses. A detailed analysis of the explanations offered by the participants in the three experiments reported here will be presented in another paper, but preliminary inspection of these data reveals similar patterns of responding across the two groups. Explanations relating to conceptual or meaningful aspects of the studied items, the sound or other physical features of the words or their positions in the study list were made both by Asperger and by comparison participants. All responses reflected an adequate understanding of the R/K distinction. Examples of explanations are given in the Appendix.

Taking all these findings together, we can be reasonably confident that individuals with Asperger's syndrome are capable to some extent of what Tulving (2002) calls 'mental time travel', i.e. that when remembering past events, they can re-constitute some of the spatio-temporal context and the self-referential aspects of the episode, albeit to a lesser extent than typically developed individuals.

From both theoretical and applied perspectives, this finding of qualitative similarity of recollective experiences is important. Theoretically, it suggests that the episodic memory system is intact to the extent that it can still generate sufficient autonoetic conscious awareness to be affected by the manipulations used here and by Bowler et al. (2000a). From an applied perspective, the findings inform clinicians and educators that although episodic awareness is impaired in autism, interventions designed to increase such awareness can capitalise on the fact that some such awareness remains in this population. What now needs to be explained is why there should be a quantitative impairment in remembering in Asperger individuals.

It can be argued that the present findings provide some support the ideas of Perner (1990; 2000), who argued that an ability to understand

the representational nature of mental states was a prerequisite for autonoetic conscious awareness. Drawing on the work of Nelson (1989; 1990; 1996) on the development of episodic and autobiographical memory in typical children, Perner noted that memory for personally experienced events does not emerge until about four years of age, which is the same time that children develop an awareness of the representational nature of mental states in others (Wimmer & Perner, 1983). From this perspective, understanding mental states can be seen as a necessary but not sufficient condition for having R experiences. Studies of mental state understanding in Asperger's syndrome provide a mixed picture. The first studies employed measures that tested second-order false belief understanding (Perner & Wimmer, 1986), i.e. the ability to predict the actions of one protagonist who held a false belief about the thoughts of another. The consistent finding was that individuals with Asperger's syndrome similar to those in the samples employed here are unimpaired on such tasks (Bowler, 1992; 1994, Buitelaar, Swaab, Van der Wees, Wildschut & Van der Gaag. 1996; Dahlgren & Trillingsgaard, 1996). Given that it is likely that the samples used here would pass similar tasks, yet were impaired to some extent on remembering, the findings reported here support Perner's necessity but not sufficiency argument. However, studies using procedurally different measures that are proposed to represent mental state understanding have shown impairment in Asperger

participants. For example, Happé (1994) found that high-functioning

adolescents with autism had difficulties compared to a matched

comparison group on 'strange stories' in which participants said things that

they did not mean. So when told a story about someone who had just

started out on a walk in the country and who said "Isn't this great, it's

raining", typical participants appreciated the irony, whereas those with

autism did not. Jolliffe and Baron-Cohen (1999) replicated these findings

with adults with high-functioning autism and Asperger's syndrome. Claims

for impaired mental state understanding in people with autistic spectrum

disorders have also been made on the basis of a procedure that asks

participants to state either the gender or the mental state of photographs

of the eye region of a range of faces (Baron-Cohen & Cross, 1992; Baron-

Cohen, Wheelwright & Jolliffe, 1997; Baron-Cohen, Wheelwright, Hill, Raste

& Plumb, 2001). Participants with autism have greater difficulty relative

to typical individuals in accurately inferring mental states but not in

identifying gender. Such evidence of impaired mental state understanding

in the autistic spectrum at first sight appears to cast doubt on Perner's

account of the relation between that capacity and episodic remembering.

But there is a marked conceptual difference between Perner's

characterisation of mental state understanding as the capacity to grasp

the representational nature of mental states and looser concepts such as

'mindblindness' (Baron-Cohen, 1995) and 'mentalising' (Fletcher, Happé,

Frith et al., 1995), the operationalisation of which lumps together affective mental states such as regret with epistemic states such as knowing, the precise logical properties of which form the cornerstone of Perner's analysis. Before drawing any definitive conclusions on Perner's contentions, cross-sectional and longitudinal studies are needed to determine what if any relations and developmental contingencies exist among the understanding of epistemic and non-epistemic mental states on the one hand and episodic remembering on the other in samples of participants both with and without autism.

In contrast to attempts to explain the development of episodic memory in terms of domain-specific concepts such as 'theory of mind' or 'metarepresentation', there is also a range of theory and research based on more general psychological processes. An important example of this approach is the analysis of the psychological requirements for the development of episodic memory carried out by McCormack and Hoerl (Hoerl, 2001; Hoerl & McCormack, 2001; McCormack, 2001; McCormack & Hoerl, 1999) They identify two aspects of understanding that must develop in order for an individual to have the kinds of experiences Tulving (2002) describes as essential to episodic remembering. An individual needs first to master the notion that events can take place at different, particular times, and second, develop some awareness that remembering

events from other time periods involves remembering self-involvement in those events. In the latter respect, they argue that an individual must be capable of <u>temporal decentering</u>, whereby not only does the individual switch from one time perspective to another, but is also able to retain an awareness both that the self is the anchor point of each new perspective and that the self at each perspective point is, in the terms of Neisser (1990) and Povinelli, Landau and Perrilloux (1996) the <u>temporally extended self</u>, that is to say that the "I" that we experience now is the same "I" involved in personally-experienced events from the past..

In the context of the question raised by the findings reported here, namely, what difficulties do people with Asperger's syndrome have that make them less likely to have experiences of episodic remembering, McCormack and Hoerl's analysis provides some pointers for future research. The notion of temporal decentering involves an ability to consider the present in relation to the past, and to relate specific points in the past to other points in the past or the future. These abilities can be considered specific instances of a more general capacity to evaluate one event in relation to the outcome of some prior event. There are studies that show that children with autism have difficulties with this kind of reasoning. Zelazo, Frye and colleagues have shown a developmental progression in typical children's ability to embed 'if-then' rules (Frye,

Zelazo & Burack, 1998; Frye, Zelazo & Palfai, 1995; Zelazo, Burack,

Benedetto & Frye, 1996, Zelazo, Burack, Boseovski, Jacques & Frye, 2001;

Zelazo & Frye, 1998). In a task where children have to sort red triangles,

blue triangles, red circles and blue circles according to colour or shape,

younger children (under about four years) can sort according to a single

pair of rules (if this is a circle it goes in the circle pile, if it's a triangle it

goes with the triangles) but find it hard to switch to sorting according to a

different pair of rules (if this is red it goes in the red pile, if it is blue, it

goes in the blue pile). Performance on tasks like these has been found to

correlate with performance on false belief tasks (thought to measure

'theory of mind') in typical children (Frye et al., 1995), children with Down

syndrome (Zelazo, Jacques, Burack & Frye, 2001) and children with autism

(Colvert, Custance & Swettenham, 2002; Zelazo et al., 2001), suggesting

that understanding mental states in others may be linked to episodic

memory impairment by a common mechanism that also manifests itself in

the capacity to embed 'if-then' rules. The development of this mechanism

is delayed in children with autism, and it may well be the case that there is

some residual impairment in individuals from the higher-functioning end of

the autistic spectrum. The observation of qualitatively similar but

quantitatively diminished remembering in this population may well be the

consequence either of late development or residual impairment in this

common mechanism.

Zelazo and Frye (1998, see also Zelazo et al., 2001) have also used their observations to develop a theory of Cognitive Complexity and Control (CCC) in which they argue that the increasing executive ability that enables switching between rules results from higher levels of conscious awareness culminating in the kinds of reflexive conscious awareness that permit children to understand other people as having awareness of the world that can differ from the child's own awareness. Such understanding underpins inter alia a comprehension of mental states in others as well as an ability to engage in temporal decentering, thus accounting for the two elements that McCormack and Hoerl argue are central to Tulving's notion of episodic remembering. The evidence from the experimental work of Frye, Zelazo and colleagues suggests that the mechanisms thought to lie behind reflexive conscious awareness is impaired in children with autism, and their theoretical analysis also suggests that there may be an impairment of the temporally extended self in individuals with autism. Future research needs to determine the capacity for reflexive conscious awareness in Asperger's syndrome as well as presence of an intact temporally extended self in people from all parts of the autistic spectrum. The findings reported here and elsewhere (Bowler et al., 2000a,b) suggest that both these processes may be impaired.

Several theoretical accounts of remembering and knowing emphasize the importance of elaborative conceptual processes for the operation of the episodic memory system (e.g., Gardiner, 1988; Rajaram, 1993). Both these investigators found that deeper levels of processing of studies matierial and manipulations involving generation of material (both of which entail a conceptual elaboration of the items) enhanced the rate of R responses in recognition memory. Such observations make elaborative and conceptual encoding an additional candidate for explaining the quantitative impairments in remembering observed in the present experiments. But the evidence on conceptual processing in autistic spectrum disorders is mixed. The assertions of impaired conceptual processes by early commentators (Scheerer, Rothman & Goldstein, 1945; Rimland, 1964) have received some empirical support. Dunn, Vaughan, Kreuzer and Kurtzberg (1999) found diminished ERP responses to category labels in high-functioning children with autism. Shulman, Yirmiya and Greenbaum (1995) found low-functioning children with autism made more category sorting errors than controls, and both adults with Asperger's syndrome (Bowler et al. 1997; 2000) and children with autism (Tager-Flusberg, 1991) have been found to make less use of category and associative relations among items when engaging in free recall. Awareness of associative relations among studies items can give rise to illusory memories (Roediger & McDermott, 1995), a phenomenon that was reported to be significantly decreased in autism

(Beversdorf, Smith, Crucian, Anderson, Keillor, Barrett, Hughes et al., 2000). Yet other studies have shown no impairments on categorisation tasks in both high-functioning (Tager-Flusberg, 1985a,b) and low-functioning (Ungerer & Sigman, 1987) individuals with autism, and Bowler et al. (2000b), in contrast to Beversdorf et al. (2000) found that adults with Asperger's syndrome are subject to associatively-generated illusory memories. The findings of investigations into the ability to abstract categorical prototypes from sets of category exemplars are equally mixed. Klinger and Dawson (1995) found impaired prototype abstraction in low-functioning children with autism, whereas Molesworth, Bowler and Hampton (in press) found no such difficulty in high-functioning adolescents with autism and Asperger's syndrome. In addition to the obvious difference in the ability level of the participants in these two studies, Molesworth et al. also point out that procedural differences (requiring participants to make classification judgments in one study, asking them to make recognition judgments in the other) may have contributed to the different findings. The contrasting findings on illusory memories between Beversdorf et al. (2000) and Bowler et al. (2000b) may also be the result of procedural differences between the two investigations. The fact that individuals from the autistic spectrum show greater susceptibility to minor procedural changes in investigations suggests that their encoding of material for subsequent use in conceptual processing may differ from the encoding

processes of typical individuals. These differences may impact on both relational processes that enable conceptual representations, and on the flexibility of processing that enables the kinds of conscious awareness that Zelazo and colleagues argue underpins flexible rule use. Impairments in both these sets of processes are likely to influence the way people from the autistic spectrum construct episodic memories, resulting in the kinds of impaired remembering reported here and in earlier studies.

To conclude, we have produced further evidence that adults with Asperger's syndrome have less episodic remembering that is nevertheless qualitatively similar to that of individuals. These observations lead us to speculate that people with Asperger's syndrome may have subtle differences in the way they encode stimulus material and that these encoding differences can compromise without destroying their ability to store information in a manner that allows episodic retrieval. In particular, the encoding differences may affect the way individual items of information are inter-related, thus compromising category formation and use. These differences may also affect the extent to which information can be manipulated flexibly and in a manner that is thought to contribute directly to the development of self-conscious awareness. These speculations lead us to predict correlations among measures of remembering and measures of categorising ability, prototype formation and embedded rule use.

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Author Notes

Table 1: Age and IQ scores for the Asperger and comparison group.
Experiment 1.

	Asperger (N=18)			Comparison (N=18)		
	M	SD	Range	M	SD	Range
Chronological Age (years)	33	10.7	16-54	34	8.7	18-45
VIQ[a]	102	16.9	74-134	102	15.0	75-130
PIQ[b]	94	18.6	63-129	101	12.9	84-127
FIQ[c]	98	17.1	73-126	102	14.9	77-133

[a] Verbal IQ (WAIS-R UK)
[b] Performance IQ (WAIS-R UK)

[c] Full-Scale IQ (WAIS-R UK)

Table 2: Proportion of corrected hit rates for each group's R and K

recognitions under full and divided attention study conditions: Experiment

1.

		Asperger (N=18)		Comparison (N=18)		Total (N=36)	
Study Condition	Recognition	M	SD	M	SD	M	SD
Full Attention	Remember	.39	.21	.51	.22	.45	.22
	Know	.16	.11	.09	.11	.12	.11
	Remember + Know	.57	.19	.64	.21	.61	.20
Divided Attention	Remember	.11	.08	.20	.18	.16	.14
	Know	.09	.09	.07	.11	.08	.10
	Remember + Know	.23	.12	.32	.18	.27	.16

Table 3: Age and IQ scores for the Asperger and comparison group.

Experiment 2

	Asperger (N=16)			Comparison (N=16)		
	M	SD	Range	M	SD	Range
Chronological Age (years)	33	11.5	18-56	33	10.4	19-45
VIQ[a]	103	14.3	83-135	103	12.7	84-137
PIQ[b]	103	18.8	74-136	104	13.1	87-134
FIQ[c]	103	16.9	80-140	103	13.2	89-140

[a] Verbal IQ (WAIS-R UK)

[b] Performance IQ (WAIS-R UK)

[c] Full-Scale IQ (WAIS-R UK)

Table 4: Corrected recognition rates for Asperger and comparison

individuals. as a function of test modality. Experiment 2

Measure	Order	Asperger		Comparison		Total	
		M	SD	M	SD	M	SD
Remember visual	aud_vis	.08	.07	.03	.04	.06	.06
	vis_aud	.07	.10	.18	.11	.12	.12
	Total	.08	.09	.10	.11	.09	.10
Know visual	aud_vis	.16	.16	.05	.11	.11	.15
	vis_aud	.23	.13	.20	.15	.22	.14
	Total	.20	.15	.13	.15	.16	.15
Remember auditory	aud_vis	.07	.08	.07	.07	.07	.07
	vis_aud	.09	.05	.11	.12	.10	.09

Recollective awareness in Asperger's syndrome.

	Total	.08	.07	.09	.10	.09	.08
	aud_vis	.08	.12	.16	.11	.12	.12
Know auditory	vis_aud	.03	.13	.06	.07	.04	.10
	Total	.05	.12	.11	.10	.08	.12

Table 5: Corrected recognition rates for top 50th Percentile of Asperger and comparison individuals as a function of test modality. Experiment 2.

Group	Response	Auditory Test		Visual Test	
		M	SD	M	SD
	Remember	.09	.07	.10	.09
Asperger (N = 12)	Know	.10	.11	.28	.10
	Total	.19	.14	.38	.09
	Remember	.13	.10	.15	.12
Comparison (N = 13)	Know	.13	.13	.21	.13
	Total	.26	.11	.36	.19

Table 6: Age and IQ scores for the Asperger and Comparison group .
Experiment 3.

|	Asperger (N=16)			Comparison (N=16)		
	<u>M</u>	<u>SD</u>	Range	<u>M</u>	<u>SD</u>	Range
Age (years)	35	10.5	18-54	35	8.8	20-46
VIQ[a]	100	13.0	85-121	102	12.1	88-128
PIQ[b]	99	16.0	74-129	101	10.4	89-122
FIQ[c]	99	14.5	80-122	102	11.7	89-129

[a] Verbal IQ (WAIS-R UK)

[b] Performance IQ (WAIS-R UK)

[c] Full-Scale IQ (WAIS-R UK)

Table 7: Proportions of false Remember and Know recognitions as a function of position of phoneme change and repetition. Experiment 3.

Group	Response	Early phoneme change				Late phoneme change			
		1 presentation		3 presentations		1 presentation		3 presentations	
		M	SD	M	SD	M	SD	M	SD
	Remember	.03	(.05)	.17	(.22)	.09	(.13)	.18	(.21)
Asperger	Know	.07	(.10)	.10	(.14)	.13	(.13)	.16	(.26)
	R + K	.05	(.08)	.09	(.18)	.11	(.13)	.17	(.24)
Compar-	Remember	.03	(.06)	.07	(.11)	.11	(.16)	.14	(.16)
ison	Know	.06	(.07)	.07	(.08)	.09	(.14)	.13	(.10)
	R + K	.05	(.07)	.07	(.05)	.10	(.15)	.14	(.13)

Figure 1: Corrected Remember and Know recognitions as a function of item repetition for Asperger and Control groups. Experiment 3.
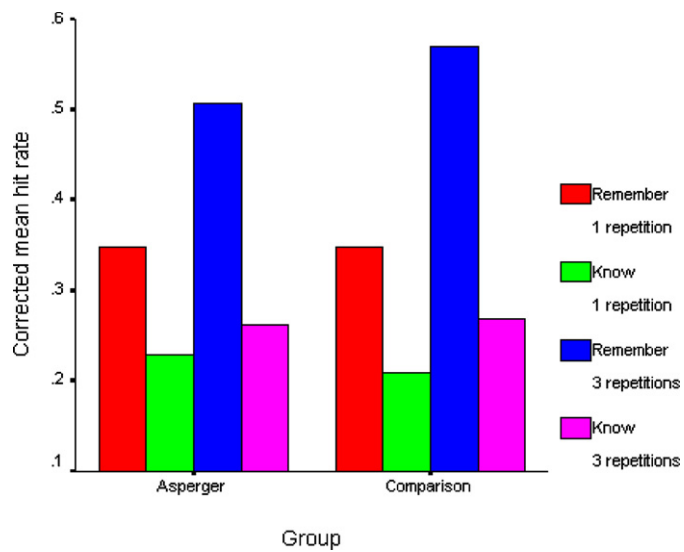
Appendix

Examples of justifications for R responses given by Asperger and comparison participants.

<u>Asperger</u>

Because I put that together with things that I've done, which are bad behaviour.

<u>Comparison</u>

When I saw the word dinosaur I thought of the pre-historic creature.

Yes I remember Insomnia being up there because I had it sometime.

Because I remember thinking, I associate a rainbow with colours,

Because phoenix is a bird that rises out the ashes.

Because it's a creature.

Again it was association of a loaf of bread so.

Cause I remember thinking it was the first word and I got to remember it.

I thought of antiques in general.

Yeah, it's the first word I saw. So that would be type A. Yeah.