

Abstract Autobiographical memory difficulties have been widely reported in adults with autism spectrum disorder (ASD). The aim of the current study was to explore the potential correlates of autobiographical memory performance (including depressed mood, rumination, working memory and theory of mind) in adults with ASD, relative to a group of typical adults matched for age, gender and IQ. Results demonstrated that the adults with ASD reported higher levels of depressed mood and rumination than the typical adults, and also **received lower scores** on measures of theory of mind and working memory.

Correlational analysis suggested that theory of mind and working memory were associated with autobiographical memory performance in the adults with ASD, but no significant relationships were observed between autobiographical memory, depressed mood and rumination in this group. To explore these patterns further, two cases of adults with a dual diagnosis of ASD and depression are discussed. These participants present a profile in line with the idea that depressed mood and rumination do not have the same influence on autobiographical memory in adults with ASD as they do in typical adults.

Keywords autism, autobiographical memory, depressed mood, rumination, working memory, theory of mind

Autobiographical memory in adults with autism spectrum disorder: the role of depressed mood, rumination, working memory and theory of mind

The retrieval of specific autobiographical memories (memories of single events, lasting no longer than a day, e.g., *'my first day at University'*) is an important predictor of healthy psychological functioning (Goddard et al., 2007) and difficulties in the retrieval of such memories have been reported in several clinical conditions, including autism spectrum disorder (ASD). A number of studies have now demonstrated that individuals with ASD generate fewer specific autobiographical memories than typical adults and take significantly longer to do so (Goddard et al., 2007; Lind and Bowler, 2010; Crane and Goddard, 2008; Crane et al., 2009; Crane et al., 2010; Tanweer et al., 2010). This reduction in memory specificity leads to an increase in the number of overgeneral categoric memories (memories of repeated events, e.g., *'lectures at University'*), but not overgeneral extended memories (memories of single events, lasting longer than a day, e.g., *'my first year at University'*), retrieved by this group.

Despite several studies documenting specific memory difficulties in adults with ASD, the factors associated with autobiographical memory retrieval in this group have not been widely researched. One recent study suggested that theory of mind (ToM) – the understanding that other people can have thoughts, beliefs and emotions that can differ from one's own, and also from reality (Premack and Woodruff, 1978) – is predictive of autobiographical memory difficulties in ASD (Adler et al., 2010). Indeed, ToM abilities have previously been associated with autobiographical memory retrieval in both typical (Perner and Ruffman, 1995) and clinical (Corcoran and Frith, 2003) samples. This is

thought to be due to both ToM and autobiographical memory necessitating auto-noetic consciousness – the ability to be aware of, and mentally represent, experiences from one’s past and present into one’s future (Wheeler et al., 1997). However, a regression analysing the role of ToM on autobiographical memory performance in Adler et al’s (2010) study did not reach statistical significance in the adults with ASD ($p = .07$). In addition, significant correlations were not found between all indices of ToM and autobiographical memory in their sample. Therefore further research is needed to explore this relationship.

Another potential correlate of autobiographical memory performance in ASD is working memory – a “*fundamental capacity required by complex activities*” (Lépine et al., 2005 165). In particular, the episodic buffer component of working memory is thought to be involved in binding together disparate elements of an event to form a coherent long-term memory (Baddeley, 2000). Consistent with this suggestion, working memory performance has been associated with autobiographical memory retrieval in a range of clinical conditions, as well as typical samples (e.g., Birch and Davidson, 2007; Ros et al., 2010; Piolino et al., 2010). It is of particular interest to examine this relationship in ASD given that binding is known to be atypical, and linked to impaired episodic memory, in this group (see Bowler et al., 2011, for a review).

Two other factors that have been previously shown to influence autobiographical memory retrieval in typical samples include depressed mood and a ruminative focus on the self. The role of these variables has been formalised in Williams’ (2006) CarFAX model (capture and rumination, functional avoidance and executive function difficulties). This outlines how patients who are depressed typically access a general categoric autobiographical memory (e.g., “*I am not good at my job*”) and, due to high levels of

rumination, activate other similar negative self-descriptions at this categoric level (e.g., “*I am a failure*”). Whilst typical adults can overcome this categoric stage to retrieve specific autobiographical memories, the reduced executive resources of depressed individuals (Fossati et al., 2002) render them unable to overcome this influx of general, negative memories. Retrieval then becomes ‘deadlocked’ at the categoric stage of retrieval (Williams, 1996). This model, and the role of both depressed mood and rumination on autobiographical memory, have been confirmed in several empirical studies (e.g., Raes et al., 2006; Dalgleish et al., 2007). Although a high incidence of depression has been reported in individuals with ASD (Stewart et al., 2006), to date, no studies have examined the interplay between autobiographical memory, mood state and ASD.

The aim of the current study was to provide a preliminary assessment of the correlates of autobiographical memory in adults with ASD, relative to a typical comparison group matched for age, gender and IQ. In this study, adults with ASD were compared to typical adults on measures of autobiographical memory, depressed mood, rumination, working memory and ToM; each of which have been previously associated with autobiographical memory performance in typical or clinical groups. Within-group correlational analyses were also conducted, to explore potential associations between these variables. In line with previous research, it was predicted that the adults with ASD would generate fewer specific autobiographical memories than the typical adults, and would take significantly longer to do so. Group differences were also predicted on measures of working memory and ToM, as several studies have reported adults with ASD to experience difficulties on such measures relative to typical adults (see Hill, 2004; Baron-Cohen et al., 1985). It was also hypothesised that the adults with ASD would report higher levels of

depressed mood than the typical adults (as found by Hill et al., 2004), but no hypotheses were made regarding levels of rumination, as this variable has not been previously assessed in ASD. Regarding the associations between these variables and autobiographical memory, it was predicted that working memory, ToM, depressed mood and rumination would correlate with autobiographical memory in the typical adults (cf. Dalgleish et al., 2007; Ramponi et al., 2004; Watkins and Brown, 2002; Perner et al., 2007). However, as there have been few studies assessing the correlates of autobiographical memory in ASD, and given the exploratory nature of the current study, no firm predictions were made regarding the relationships between these variables and autobiographical memory in the ASD group.

Method

Participants

A total of 56 adults participated in this study: 28 adults with a formal diagnosis of ASD (14 male, 14 female) and 28 typical adults (14 male, 14 female)¹. The adults with ASD were recruited via the National Autistic Society (UK), as well as local organisations, support groups and web pages for adults in the UK. Criteria for inclusion in the study included a formal diagnosis of Asperger syndrome (n = 25) or high functioning autism (n = 3) from a Psychologist or Psychiatrist who was an expert in the area. A review of clinical records confirmed that all participants with ASD met DSM-IV (American Psychiatric Association, 2000) or ICD-10 (World Health Organisation, 1990) criteria for Asperger syndrome or high functioning autism, excluding the requirement of an absence of early language delay (for the adults with Asperger syndrome), as this information was often unavailable. Despite this, none of the participants demonstrated any obvious abnormalities

in structural/syntactic aspects of their language. To support their diagnoses, the Autism-Spectrum Quotient (AQ) (Baron-Cohen et al., 2001) was administered. The AQ is a 50-item self-report measure of autistic traits. Scores of 32 or above on this measure are indicative of clinical levels of autistic traits (Baron-Cohen et al., 2001), although a score of 26 or above has more recently been proposed as a useful cut-off for a clinic-referred sample (Woodbury-Smith et al., 2005). The participants with ASD achieved scores (mean = 34.93, SD = 6.90) that were significantly higher than those of the comparison group (mean = 14.64, SD = 7.46) on this measure of autistic symptomatology [$t(54) = 10.56, p < .01 (r = .82)$, one-tailed]. In addition, whilst 26/28 (92.86%) of the participants with ASD scored above the suggested cut-off of 26 on this questionnaire (Woodbury-Smith et al., 2005), none of the comparison participants did. The typical comparison group was recruited from local Further or Higher Education colleges and social groups. They were group matched to the participants with ASD on the basis of verbal, performance and full-scale IQ (as assessed on the WASI, Wechsler, 1999), and were individually matched on the basis of age and gender (see Table 1 for participant demographics).

[place Table 1 about here]

Materials

Autobiographical memory cueing task: In the autobiographical memory cueing task (Williams and Broadbent, 1986), participants are presented with a cue word, to which they are instructed to recall a specific autobiographical memory, at speed. In this version of the task, five positive (*happy, safe, interested, successful* and *surprised*), five negative (*sorry,*

angry, clumsy, hurt and lonely) and five neutral (*grass, gigantic, absence, wildlife and bread*) words were used. First responses were coded as either a specific memory (an individual event, lasting no longer than a day), a categoric general memory (a repeated event), a categoric extended memory (an individual event lasting longer than a day), or a memory failure (in which no memory was retrieved). In the event that a participant failed to produce a specific memory in response to a cue word (i.e., they failed to respond, or responded with a general occurrence), they were prompted until they could retrieve a specific memory (*'Can you think of a specific time – one particular instance?'*) or until the time limit (one minute) elapsed. The clock was started when the experimenter began the stopwatch and stopped when the participant began to speak. If a participant failed to generate a specific memory within the one-minute time limit, a maximum latency of 60 seconds was recorded. At the start of the task, participants were provided with examples of appropriate specific (and inappropriate general) memories, and at least two practice words were administered, to ensure that all participants fully understood the task instructions. At the end of the task, participants were also asked to confirm the task instructions to the experimenter (cf. Dagleish et al., 2007), which all participants were able to do.

The dependent variables on this task were the total number of specific memories provided as first responses (max = 15), the total number of error responses (general categoric memories, general extended memories or memory failures) provided as first responses (max = 15), and cumulative mean latencies to specific memory retrieval (max = 60s, measured to the nearest second). The latency measure accounted for the time it took to produce the specific memory either spontaneously or following a prompt. Inter-rater reliability using this coding scheme was checked by two raters (one of whom was blind to

group membership) on all scripts and Cohen's k revealed this to be satisfactory ($k = .75$).

Disagreements were resolved by discussion.

Working memory: The Letter-Number Sequencing (LNS) and Spatial Span subtests of the Wechsler Memory Scale (WMS-III) (Wechsler, 1998) were combined to provide a measure of working memory. These tasks have previously been used to index working memory in studies exploring the relationship between autobiographical and working memory in clinical samples (e.g., Birch and Davidson, 2007). In the LNS task, participants were presented with strings of letters and numbers (ranging from two to eight items in length). Participants were asked to recall the numbers in numerical order, followed by the letters in alphabetical order (e.g., the letter-number string 'R-4-D' should be recalled as '4-D-R'). The Spatial Span task involved a board with ten blocks presented in a random arrangement. The experimenter tapped a sequence on the blocks, starting with two taps and gradually increasing to nine. The participants were required to tap these blocks in the order demonstrated by the experimenter. A 'backward' version of the task was also administered (sequence lengths ranging from two to nine blocks), in which the experimenter tapped a pattern on the blocks and the participant was required to tap the blocks in the reverse order. Scores on the forward and backward versions of this task were combined to produce an overall index of spatial working memory. LNS and spatial span scores were scaled according to established age-related norms. Combining the scores on these tasks provides a scaled working memory score (taken from the WMS-III manual) and this score was taken as the dependent variable.

Theory of mind task: In the Strange Stories task, participants were presented with eight 'social' stories, eight 'physical' stories, and eight 'jumbled' stories (taken from Happé

et al., 1996). Although the ‘physical’ and ‘jumbled’ stories were administered to participants in this study, the results are not presented in this paper, as it is only the social stories that are of interest here (as these measure ToM ability). The social stories were short vignettes about everyday situations, covering topics such as white lies, double bluffs, misunderstandings, sarcasm and deception. Participants were asked to read the stories and then answer a question about them, with a successful response requiring an appreciation of the mental states of another person (scores ranged from 0-2).

Each story was presented on one side of an A5 sized card. Participants were asked to read the story and then turn over the card for the associated question. It was stressed to participants that they should fully understand the story before turning over the card, as it was not possible to revisit the story once the question had been read. Although this procedure added a memory demand to the task, the participants in the study were high functioning with adequate working memory abilities (as assessed as part of the current battery of tasks). In addition, the stories were short and easily digestible. In line with the procedures used by Happé et al. (1996), the total score (max = 16) was taken as the dependent variable.

Beck Depression Inventory (BDI): The BDI (Beck et al., 1961) is a 21-item, multiple-choice, self-report questionnaire that measures items related to symptoms of depression (e.g., hopelessness, feelings of guilt, weight loss) over the past week. Each item on the questionnaire is assigned a score of severity (ranging from 0-3) and a total score is derived (ranging from 0-63). Established clinical cut-offs regard a score of less than ten as indicative of no depression, a score of 11-14 suggesting the presence of dysphoria, 15-19

indicating dysphoria or depression and a score of 20 or above indicating clinically significant levels of depression.

Ruminative Response Scale (RRS): The RRS (Nolen-Hoeksema and Morrow, 1991) is a 22-item self-report questionnaire assessing ruminative responses to depressed mood. Participants are asked to indicate on a four-point scale (almost always, often, sometimes, almost never) how often they think or do each statement when feeling down, sad or depressed. Scores on this measure range from 22 to 88, with scores below 40 indicating low rumination, scores of 40-50 suggesting normal levels of ruminative responses, scores of 50-60 suggesting above normal levels of rumination and scores of 60 or above falling within the clinical range.

Procedure

This study was conducted as part of a larger investigation into autobiographical memory in adults with ASD. The AQ and a questionnaire unrelated to the current study were completed and returned by post before the testing session. One week later, participants were tested individually in a quiet room either at Goldsmiths, University of London, or in their own homes. During the testing session, the WASI was administered first, followed by a general memory task unrelated to the current study (lasting approximately ten minutes). Next, the working memory and ToM tasks were administered, followed by the autobiographical memory cueing task and a memory task unrelated to this study (lasting approximately ten minutes). Finally, the BDI, RRS, and a series of unrelated questionnaires were presented.

Results

Group analyses

As gender has previously been shown to influence autobiographical memory (Rubin et al., 1999; Goddard et al., 1998), this variable was included in the following analyses.

However, gender was only found to have an effect on levels of depressed mood. The non-significant effects of gender on the other variables are not reported in the following section.

Autobiographical memory cueing task

To examine the total number of specific memories retrieved (as a first response) to cue words, a 2 (group: ASD or comparison) x 3 (cue valence: positive, negative or neutral) mixed-design analysis of variance (ANOVA) was conducted (see Figure 1). This revealed that the ASD group (mean = 3.70, SD = 1.03) generated fewer specific memories than the comparison group (mean = 4.48, SD = .58) overall [$F(1, 54) = 12.00, p = .001 (\eta_p^2 = .18)$]. There was no significant effect of cue valence [$F(2, 108) = 1.45, p = .24 (\eta_p^2 = .03)$], nor was there a significant interaction effect [$F(2, 108) = .26, p = .77 (\eta_p^2 = .005)$].

(place Figure 1 about here)

The ASD group (mean = 2.75, SD = 2.52) were also found to retrieve a significantly greater number of general (categoric) memories (as a first response to cue words) than the comparison group (mean = 1.00, SD = 1.30) [$F(1, 53) = 10.36, p = .002 (\eta_p^2 = .16)$], but cue valence did not appear to affect categoric memory retrieval [$F(2, 106) = 2.00, p = .14$].

($\eta_p^2 = .04$), nor was there a significant interaction effect [$F(2, 106) = .22, p = .80$ ($\eta_p^2 = .004$)].

Due to the relatively small numbers of extended memories (ASD mean = .50, SD = .75; Comparison mean = .50, SD = .88) and memory failures (ASD mean = 1.14, SD = 1.78; Comparison mean = .39, SD = .79) reported by participants as a first response to cue words, these were not analysed as a function of cue valence. In addition, as this data violated assumptions of normality, non-parametric tests were used to interpret the data. Mann Whitney U tests revealed that there were no significant differences between the number of extended memories (ASD mean rank = 28.96; comparison mean rank = 28.04) [$U = 379.00, p = .78$] or memory failures (ASD mean rank = 31.55; comparison mean rank = 25.45) [$U = 306.50, p = .10$] retrieved by the ASD and comparison groups.

Examination of mean latencies to memory retrieval (in seconds) as a function of cue valence revealed that the ASD group (mean = 19.20, SD = 10.49) took significantly longer than the comparison group (mean = 9.18, SD = 5.81) to retrieve specific autobiographical memories [$F(1, 54) = 19.53, p < .001$ ($\eta_p^2 = .27$)]. However, no significant effect of cue valence was observed [$F(2, 108) = .25, p = .78$ ($\eta_p^2 = .005$)], nor was there a significant interaction effect [$F(2, 108) = 2.61, p = .08$ ($\eta_p^2 = .05$)].

Working memory:

An independent samples t-test revealed that the scores of the ASD group (mean = 10.16, SD = 3.13) were lower than those of the comparison group (mean = 11.89, SD = 1.92) on the working memory tasks [$t(54) = -2.29, p = .03$ ($r = .30$)]. However, it is

important to note that although this analysis demonstrated a significant reduction of working memory scores in the ASD group (relative to the comparison group), the mean performance of the adults with ASD was within the typical range (i.e., within one standard deviation of the mean); it was just lower than expected for a group with relatively high cognitive abilities. It is therefore important to treat this finding as a *reduction* in working memory abilities in ASD, rather than as a cognitive *deficit*.

Theory of mind:

An independent samples t-test revealed that the scores of the ASD group (mean = 12.26, SD = 3.47) were significantly lower than those of the comparison group (mean = 13.96, SD = 2.22) on the social stories task [$t(54) = 2.20, p = .03 (r = .29)$].

Depressed mood:

On the BDI, the mean score of the ASD group was 13.54 (SD = 9.34) and the mean score of the comparison group was 5.93 (SD = 4.95). Fourteen participants in the ASD group had normal levels of depressed mood (scoring 1-10), three scored in the range for dysphoria (scoring 11-14), one scored in the range for dysphoria/depression (scoring 15-19) and ten met the criteria for severe depression (scoring 20 or above). In contrast, none of the comparison group scored in the severe depression range, with 23 scoring in the normal range, three meeting criteria for dysphoria and two reporting dysphoria/depression.

Mean scores on the BDI were analysed using a 2 (group: ASD or comparison) x 2 (gender: male or female) univariate ANOVA. This revealed that there were significant main effects of group [$F(1, 52) = 17.87, p < .001 (\eta_p^2 = .26)$] and gender [$F(1, 52) = 8.98, p$

= .004 ($\eta_p^2 = .15$), which were qualified by a significant interaction effect [$F(1, 52) = 5.56$, $p = .02$ ($\eta_p^2 = .10$)]. Within samples ANOVAs revealed that this was due to there being no significant effect of gender on depressed mood in the comparison group (male mean = 5.36, SD = 5.88; female mean = 6.50, SD = 3.96) [$F(1, 26) = .36$, $p = .55$ ($\eta_p^2 = .01$)], whereas females (mean = 18.36, SD = 9.52) had significantly higher scores on the BDI than males (mean = 8.71, SD = 6.37) in the ASD group [$F(1, 26) = 9.93$, $p = .004$ ($\eta_p^2 = .28$)].

Rumination:

The adults with ASD (mean = 50.11, SD = 15.01) reported higher levels of ruminative self-focus on the RRS than the comparison group (mean = 41.75, SD = 10.60) [$t(54) = 2.41$, $p = .02$ ($r = .31$)]. Of the ASD group, only four scored within the normal range (40-50) on the RRS. Eight displayed low levels of rumination (<40), nine displayed above normal levels of rumination (50-60) and seven displayed clinical levels of rumination (60+). In the comparison group, none of the participants displayed clinical levels of rumination. Eight scored within the normal range on this measure, while 14 displayed low levels of rumination and six displayed above normal levels of rumination.

Correlational analyses

Correlational analyses were used to provide a preliminary exploration of the relationships between autobiographical memory, working memory, ToM, depressed mood and rumination in the ASD and comparison groups (see Table 2). Due to the high number of correlations conducted in this analysis, a p value of .01 was set, to reduce the likelihood

of committing a Type I error. However, p values $< .05$ are also highlighted. In addition, only the correlations of interest (those exploring the relationships between autobiographical memory and the other variables, as well as the relationship between rumination and depressed mood) are reported.

These correlations revealed that measures of depressed mood and rumination were moderately (positively) correlated with ceneric autobiographical memory retrieval in the comparison group, although these correlations did not reach statistical significance in the ASD group. Working memory was, however, a common correlate of autobiographical memory in both adults with and without ASD; high working memory scores were associated with high levels of specific autobiographical memory retrieval, but low levels of general autobiographical memory retrieval, in both groups. ToM scores were positively related to specific autobiographical memory retrieval (and negatively related to general autobiographical memory retrieval) in the ASD group, but these correlations did not reach significance in the comparison group. Importantly, there were no significant differences between the correlation coefficients in the ASD and comparison groups on any of the variables ($ps > .05$) and these correlations remained broadly the same even when the effects of IQ were partialled out (only the correlation between specific autobiographical memory retrieval and ToM scores in the ASD group was no longer significant).

(place Table 2 about here)

Discussion

The current study aimed to explore the correlates of autobiographical memory in adults with ASD, focusing on the roles of working memory, ToM, depressed mood and rumination. In line with predictions, the ASD group generated fewer specific autobiographical memories than comparison participants, and also took significantly longer to do so. Regarding the potential correlates of autobiographical memory performance, the ASD group reported higher levels of depressed mood and ruminative self-focus than the comparison group, and also yielded scores that were lower than those of the comparison group on measures of working memory and ToM. Within-group correlational analyses revealed that autobiographical memory retrieval was correlated with working memory, depressed mood and rumination in the comparison group; a pattern consistent with a comprehensive body of previous research in this area. In contrast, autobiographical memory performance appeared to be related to both ToM and working memory in adults with ASD. However, autobiographical memory was not related to depressed mood or rumination in this group.

The autobiographical memory assessment in the current study confirmed reports of specific autobiographical memory retrieval difficulties in adults with ASD; not only did this group generate fewer specific memories than the comparison adults, they also took significantly longer to do so (although this latter result must be treated with caution due to slower response times in individuals with ASD in general). Although this pattern is similar to that observed in individuals with depression (Williams, 1996), further inspection of these data suggested that there were subtle differences between the autobiographical memory profiles of groups with ASD and depression. First, the reduction in memory specificity observed in the adults with ASD resulted in an increased incidence of categoric, but not

extended, autobiographical memories, as well as a high proportion of memory failures. Although this pattern is also seen in groups with depression (Williams, 1996), the levels of categoric memory retrieval in the adults with ASD were not as high as those typically noted in depressed samples. Second, the ASD group did not display a mood congruent bias (a facilitation of the recall of memories to negative cues), as is commonly observed in adults with depression (Williams, 1996). Together, these observations suggest that there is a distinctive profile of autobiographical memory in individuals with ASD.

Regarding the potential correlates of autobiographical memory retrieval explored in this study, it was found that (consistent with predictions and with previous research) the scores of the comparison group were higher than those of the adults with ASD on measures of working memory and ToM. In addition, levels of depressed mood and ruminative self-focus were reported to be significantly higher in the ASD group, relative to the typical adults. Although high levels of depressed mood have previously been observed in ASD (Hill et al., 2004), this study is the first to have demonstrated high levels of rumination in this group. This is perhaps a surprising finding given that impairments in introspection have been noted in ASD (cf. Lombardo and Baron-Cohen, 2010). However, this must be balanced against the high levels of egocentrism often observed in individuals with this disorder (Frith and de Vignemont, 2005).

A further interesting finding regarding these variables concerns the interaction between diagnosis, depressed mood and gender. Whilst there was no effect of gender on depressed mood in the comparison group, females with ASD reported higher levels of depressed mood than males with ASD. The lack of a gender effect in the comparison group is surprising, given the heightened incidence of depression in women (Nolen-Hoeksema,

1987), although it should be noted that gender differences on the BDI in the general population have been mixed (Beck et al., 1988). Regarding the gender difference in the ASD group, it is important to treat this result with caution, as the subgroups of men and women in the sample were not matched for age or IQ. However, this novel finding warrants discussion and is open to several possible interpretations. First, it may be that women with ASD experience different, and perhaps more severe, emotional difficulties than men with ASD. Second, this finding may be related to how females may be more able to express their feelings and emotions than males; this could be true of both the general population and adults with ASD. However, due to the lack of empirical research on emotion processing in women with ASD, as well as a lack of direct comparisons between men and women with ASD, the reason for this result is unclear. Further research is needed to explore gender differences within ASD to confirm this preliminary finding.

Regarding the correlates of autobiographical memory explored in this study, within-group correlational analyses suggested that working memory, depressed mood and rumination correlated with autobiographical memory in the typical comparison group. This is consistent with a large body of previous research and suggests that the comparison group in the current study are a representative sample of typical adults. These results also confirm Williams' (2006) CarFAX model, which stresses the importance of mood, rumination and executive control on autobiographical memory retrieval. However, surprisingly, ToM was not associated with autobiographical memory in the typical adults. This may have been due to the low variance on the scores obtained on the social stories task in this group (although see Adler et al., 2010, for a similar finding). Future research therefore needs to use more

sensitive measures of mentalising ability to correlate with autobiographical memory performance.

Regarding the correlations observed in the ASD group, this revealed that ToM and working memory were associated with autobiographical memory performance. Although this appears to confirm the importance of both auto-noetic awareness and cognitive operations that integrate elements of an event in the retrieval of autobiographical memories in adults with ASD, it should be stressed that ToM was not associated with specific autobiographical memory retrieval once the role of IQ was partialled out. This non-significant finding is similar to that observed by Adler et al (2010) and stresses the need for future research to explore this relationship further.

Importantly, there appeared to be no relationship between depressed mood, rumination and autobiographical memory in the adults with ASD. This latter finding may be due to adults with ASD experiencing difficulties with the self-reporting of emotional states, yet previous studies have reported this group to provide adequate responses on such measures (Hill et al., 2004). Therefore, although these results are correlational, and further research is necessary to confirm these findings, it does appear that the relationship between depressed mood, rumination and autobiographical memory may be different in adults with ASD, relative to typical adults.

To explore this issue further, it is important to highlight the issue of diagnostic overlap between ASD and depression in the current sample. Many of the adults with ASD in the current study reported higher levels of depressed mood than the comparison group on the BDI, with several scoring within a clinical range. This is also consistent with previous research that has used this tool in an ASD sample (Hill et al., 2004). The decision was made

not to remove participants with severe levels of depression from the analysis on the basis of scores on the BDI, considering that this measure has not been validated in an ASD sample. However, two participants with ASD were diagnosed with clinical depression at the time of testing. Again, the decision was made not to exclude these participants, given that other participants in this group may have had undiagnosed depression. Although it is likely that the presence of comorbid depression had little effect on the current results (since no significant correlation was observed between BDI scores and autobiographical memory performance in the ASD group and the removal of these two participants from the analysis did not affect the results), it is of interest to explore the responses of these participants in greater depth, to provide a preliminary analysis of the patterns of autobiographical memory in those with a dual diagnosis of ASD and depression. One participant (S.S.) was a 49-year-old man with HFA, another (K.F.) was a 52-year-old woman with AS (see Crane, 2010, for further details of these participants). **These data are presented in the Appendix.**

Two key findings are apparent here. First, the two cases appear to present two very different autobiographical memory profiles (in terms of memory specificity, memory errors and memory latencies). Although S.S displayed very low specificity in response to word cues, and presented with very long response latencies, the majority of his error responses represented failures to retrieve memories. Regarding K.F, her error responses were entirely categoric in nature. This difference may reflect the cognitive heterogeneity associated with ASD (Jones and Klin, 2009). Second, these cases displayed memory profiles that differed to those observed in depressed samples, as the level of categoric memory retrieval was lower in the two cases than is commonly seen in typical samples. Despite this, one commonality was observed between the two case studies and groups with depression, in

that both appeared to display a mood congruent bias. Specifically, S.S and K.F generated a higher number of specific memories to negative word cues and also took less time to retrieve memories to negative word cues. This bias, which is consistently observed in depressed samples (Williams and Broadbent, 1986; Williams, 1996), is due to individuals with depression finding it easier to retrieve memories that are consistent with their current mood state. This is perhaps not a surprising finding, given that one would expect these adults to be experiencing negative life events that would, consequently, be more easily accessible than positive experiences. Yet this is one way in which depressed mood appears to exert an effect on autobiographical memory in adults with ASD.

Several questions remain unanswered regarding these two cases. For example, it is unclear why S.S. displayed more profound autobiographical memory difficulties than K.F., or why these two adults did not display a characteristic pattern of autobiographical memory (as displayed by either adults with ASD or adults with depression). **Inspection of these data** reveal that these questions are not well addressed by exploring the role of gender, levels of cognitive functioning, scores on the measures of mood and rumination, or levels of familiarity with the autobiographical memory cueing task. Future research is therefore needed to explore the effects of depression on autobiographical memory in adults with ASD that utilises larger samples of adults with ASD and comorbid depression. This could shed further light on the factors underlying autobiographical memory retrieval in ASD.

Acknowledgements

This work was supported by grants from the Economic and Social Research Council (PTA-030-2005-00091); and the University of London Central Research Fund. We would like to thank all those who participated in this study, especially K.F and S.S, as well as the reviewers of this paper for their insightful comments and suggestions.

Appendix

Scores on the autobiographical memory cueing task of participants S.S and K.F

		S.S	K.F
		<i>n/mean</i>	<i>n/mean</i>
Specific memories	Positive cues (max = 5)	1	3
	Negative cues (max = 5)	2	5
	Neutral cues (max = 5)	0	3
Categoric memories	Positive cues (max = 5)	0	2
	Negative cues (max = 5)	1	0
	Neutral cues (max = 5)	0	2
Extended memories	Positive cues (max = 5)	0	0
	Negative cues (max = 5)	0	0
	Neutral cues (max = 5)	0	0
Memory failures	Positive cues (max = 5)	4	0
	Negative cues (max = 5)	2	0
	Neutral cues (max = 5)	5	0
Memory latencies	Positive cues (max = 60s)	49.84	20.63
	Negative cues (max = 60s)	4.44	15.74
	Neutral cues (max = 60s)	60.00	19.55

References

- Adler N, Nadler B, Eviatar Z, et al. (2010) The relationship between theory of mind and autobiographical memory in high-functioning autism and Asperger syndrome. *Psychiatry research* 178: 214-216.
- American Psychiatric Association. (2000) *Diagnostic and Statistical Manual of Mental Disorders Text Revision (DSM-IV-TR)*, Washington, D.C.
- Baddeley AD. (2000) The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences* 4: 417-423.
- Baron-Cohen S, Leslie AM and Frith U. (1985) Does the autistic child have a "theory of mind" ? *Cognition* 21: 37-46.
- Baron-Cohen S, Wheelwright S, Skinner R, et al. (2001) The Autism-Spectrum Quotient (AQ): Evidence from Asperger Syndrome/High-Functioning Autism, Males and Females, Scientists and Mathematicians. *Journal of Autism and Developmental Disorders* 31: 5-17.
- Beck A, Steer RA and Carbin MG. (1988) Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. *Clinical Psychology Review* 8: 77-100.
- Beck A, Ward C and Mendelson M. (1961) Beck Depression Inventory (BDI). *Archives of General Psychiatry* 4: 561-571.
- Birch LS and Davidson KM. (2007) Specificity of autobiographical memory in depressed older adults and its relationship with working memory and IQ. *British Journal of Clinical Psychology* 46: 175-186.
- Bowler D, Gaigg SB and Lind S. (2011) Memory in autism: Binding, self and brain. In: Roth I and Rezaie P (eds) *Researching the autism spectrum: Contemporary perspectives*. Cambridge: Cambridge University Press, 316-346.
- Corcoran R and Frith CD. (2003) Autobiographical memory and theory of mind: evidence of a relationship in schizophrenia. *Psychological Medicine* 33: 897-905.
- Crane L. (2010) Autobiographical memory in adults with autism spectrum disorder. University of London.
- Crane L and Goddard L. (2008) Episodic and Semantic Autobiographical Memory in Adults with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders* 38: 498-506.
- Crane L, Goddard L and Pring L. (2009) Specific and general autobiographical knowledge in adults with autism spectrum disorders: the role of personal goals. *Memory* 17: 557-576.
- Crane L, Goddard L and Pring L. (2010) Self-defining and Everyday Autobiographical Memories in Adults with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders* 40: 383-391.
- Dalgleish T, Williams JMG, Golden AMJ, et al. (2007) Reduced specificity of autobiographical memory and depression: The role of executive control. *Journal of Experimental Psychology-General* 136: 23-42.
- Fombonne E. (1999) The epidemiology of autism: a review. *Psychological Medicine* 29: 769-786.
- Fossati P, Ergis A and Allilaire J. (2002) Executive functioning in unipolar depression: a review. *Encephale* 28: 97-107.

- Frith U and de Vignemont F. (2005) Egocentrism, allocentrism, and Asperger syndrome. *Consciousness and Cognition* 14: 719-738.
- Goddard L, Dritschel B and Burton A. (1998) Gender differences in the dual-task effects on autobiographical memory retrieval during social problem solving. *British Journal of Psychology* 89: 611-627.
- Goddard L, Howlin P, Dritschel B, et al. (2007) Autobiographical memory and social problem-solving in Asperger syndrome. *Journal of Autism and Developmental Disorders* 37: 291-300.
- Happé F, Ehlers S, Fletcher P, et al. (1996) 'Theory of mind' in the brain: Evidence from a PET scan study of Asperger syndrome. *Neuroreport* 8: 197-201.
- Hill EL. (2004) Evaluating the theory of executive dysfunction in autism. *Developmental Review* 24: 189-233.
- Hill EL, Berthoz S and Frith U. (2004) Brief Report: Cognitive Processing of Own Emotions in Individuals with Autistic Spectrum Disorder and in Their Relatives. *Journal of Autism and Developmental Disorders* 34: 229-235.
- Jones W and Klin A. (2009) Heterogeneity and Homogeneity Across the Autism Spectrum: The Role of Development. *Journal of the American Academy of Child & Adolescent Psychiatry* 48: 471-473.
- Lépine R, Parrouillet P and Camos V. (2005) What makes working memory spans so predictive of high-level cognition? *Psychonomic Bulletin & Review* 12: 165-170.
- Lind S and Bowler D. (2010) An investigation of episodic memory and episodic future thinking in adults with autism. *Journal of Abnormal Psychology* 119: 896-905.
- Lombardo MV and Baron-Cohen S. (2010) Unraveling the paradox of the autistic self. *Wiley Interdisciplinary Reviews: Cognitive Science* 1: 393-403.
- Nolen-Hoeksema and Morrow J. (1991) A prospective study of depression and post-traumatic stress symptoms after a natural disaster: The 1989 Lorna Prieta earthquake. *Journal of Personality and Social Psychology* 61: 115-121.
- Nolen-Hoeksema S. (1987) Sex differences in unipolar depression: Evidence and theory. *Psychological Bulletin* 101: 259-282.
- Perner J, Kloo D and Gornik E. (2007) Episodic memory development: Theory of mind is part of re-experiencing experienced events. *Infant and Child Development* 16: 471-490.
- Perner J and Ruffman T. (1995) Episodic Memory and Autonoetic Consciousness: Developmental Evidence and a Theory of Childhood Amnesia. *Journal of Experimental Child Psychology* 59: 516-548.
- Piccinelli M and Wilkinson G. (2000) Gender differences in depression: Critical review. *British Journal of Psychiatry* 177: 486-492.
- Piolino P, Coste C, Martinelli P, et al. (2010) Reduced specificity of autobiographical memory and aging: Do the executive and feature binding functions of working memory have a role? *Neuropsychologia* 48: 429-440.
- Pohl R, Bender M and Lachmann G. (2005) Autobiographical memory and social skills of men and women. *Applied Cognitive Psychology* 19: 745-759.
- Premack D and Woodruff G. (1978) Does the chimpanzee have a theory of mind? *Behavioral and Brain Sciences* 1: 515-526.

- Raes F, Hermans D, Williams JMG, et al. (2006) Is overgeneral autobiographical memory an isolated memory phenomenon in major depression? *Memory* 14: 584-594.
- Ramponi C, Barnard PJ and Nimmo-Smith I. (2004) Recollection deficits in dysphoric mood: An effect of schematic models and executive mode? *Memory* 12: 655-670.
- Ros L, Latorre JM and Serrano JP. (2010) Working memory capacity and overgeneral autobiographical memory in young and older adults. *Aging, Neuropsychology, and Cognition* 17: 89-107.
- Rubin DB, Schulkind M and Rahhal T. (1999) A Study of Gender Differences in Autobiographical Memory: Broken Down by Age and Sex. *Journal of Adult Development* 6: 61-71.
- Stewart ME, Barnard L, Pearson J, et al. (2006) Presentation of depression in autism and Asperger syndrome A review. *Autism* 10: 103-116.
- Tanweer T, Rathbone CJ and Souchay C. (2010) Autobiographical memory, auto-noetic consciousness, and identity in Asperger syndrome. *Neuropsychologia* 48: 900-908.
- Watkins E and Brown RG. (2002) Rumination and executive function in depression: an experimental study. *Journal of Neurology Neurosurgery and Psychiatry* 72: 400-402.
- Wechsler D. (1998) *Wechsler Memory Scale*, London: Psychological Corporation.
- Wechsler D. (1999) Wechsler Abbreviated Scale of Intelligence. In: Corporation TP (ed). San Antonio: Harcourt Brace & Company.
- Wheeler MA, Stuss DT and Tulving E. (1997) Toward a theory of episodic memory: The frontal lobes and auto-noetic consciousness. *Psychological Bulletin* 121: 331-354.
- Williams JMG. (1996) Autobiographical memory in depression. In: Rubin DC (ed) *Remembering our past: studies in autobiographical memory*. Cambridge: Cambridge University Press, 244-270.
- Williams JMG. (2006) Capture and rumination, functional avoidance, and executive control (CaRFAX): Three processes that underlie overgeneral memory. *Cognition & Emotion* 20: 548 - 568.
- Williams JMG and Broadbent K. (1986) Autobiographical Memory in Suicide Attempters. *Journal of Abnormal Psychology* 95: 144-149.
- Woodbury-Smith MR, Robinson J, Wheelwright S, et al. (2005) Screening Adults for Asperger Syndrome Using the AQ: A Preliminary Study of its Diagnostic Validity in Clinical Practice. *Journal of Autism and Developmental Disorders* 35: 331-335.
- World Health Organisation. (1990) *Ch V. Mental and behavioural disorders (including disorders of psychological development). Diagnostic criteria for research.*, Geneva: World Health Organisation.

Table 1: Participant demographics

	ASD group		Comparison group		Statistics		
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>t</i>	<i>p</i>	<i>r</i>
Age	41.57	16.49	40.53	17.20	.23	.82	.03
Verbal IQ	115.39	12.10	110.68	13.35	1.38	.17	.18
Performance IQ	114.96	15.55	116.64	11.45	-.46	.65	.06
Full scale IQ	117.18	13.47	115.11	11.67	.61	.54	.08

Table 2: Correlations between the independent variables in the comparison and ASD groups (two-tailed)

	Comparison group				ASD group			
	BDI	RRS	WM	ToM score	BDI	RRS	WM	ToM score
ABM Specific	-.21	-.01	.46*	.01	-.06	-.02	.23	.38*
ABM General (categoric)	.49***	.34*	-.27	-.10	.05	.05	-.38*	-.48*
ABM Latency	-.23	-.23	-.30	-.11	.06	.05	-.17	-.13
BDI	--	.55**	--	--	--	.65***	--	--

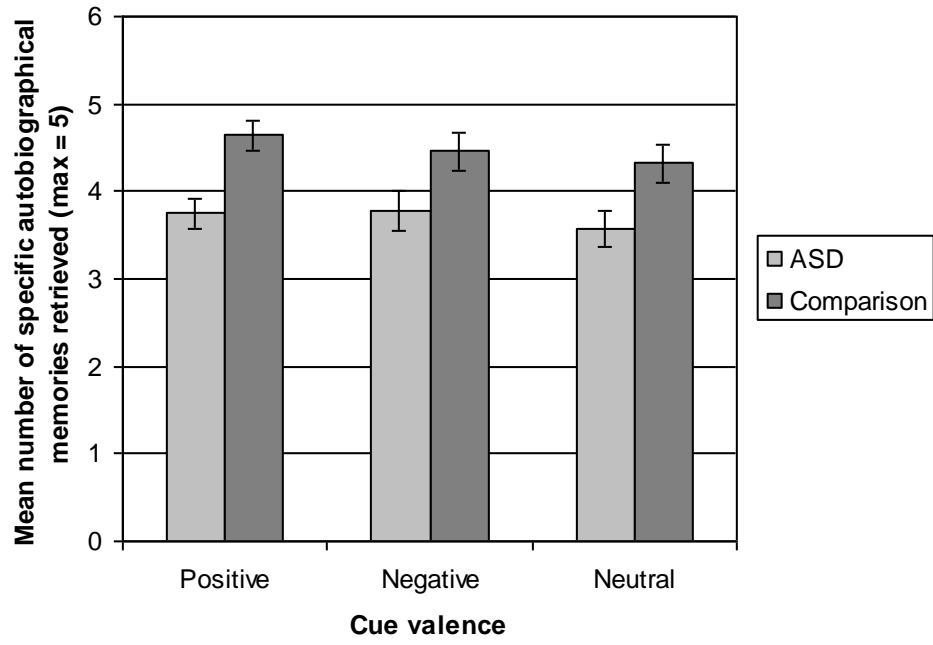
Key: ABM = autobiographical memory; BDI = Beck Depression Inventory; RRS = Ruminative Response Scale; WM = working memory; ToM = theory of mind

* = $p < .05$; ** = $p < .01$; *** = $p < .001$

Figure captions

Figure 1: Mean number of specific memories retrieved as a function of cue valence in the ASD and comparison groups

Figure 1 - top



Footnotes

¹ Despite the gender ratio of approximately 4:1 (males: females) in ASD, with ratios of around 6:1 reported for higher functioning samples (Fombonne, 1999), an equal number of males and females participated in the current study. This was to assess the role of gender on autobiographical memory and related variables in adults with ASD, in view of gender differences being previously reported on autobiographical memory tasks (e.g., Goddard et al., 1998; Pohl et al., 2005) and in depression (Piccinelli and Wilkinson, 2000). However, the current study found no significant effects of gender on any of the variables in the current study (except depressed mood, as outlined in the results section), in either the ASD or comparison group (p values ranged between .20 and .81; η_p^2 values ranged between .009 and .05).