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'Everyday Memory' Impairments in Autism Spectrum Disorders

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Abstract

'Everyday memory' is conceptualised as memory within the context of day-to-day life and~~,~~ , despite its functional relevance, ~~anecdotal evidence suggests it may be impaired in individuals with~~ has been little studied in individuals with autism spectrum disorders (ASDs). In the first study of its kind, 94 adolescents with an ASD and 55 without an ASD completed measures of everyday memory from the Rivermead Behavioural Memory Test (RBMT) and a standard word recall task (Children's Auditory Verbal Learning Test-2: CAVLT-2). The ASD group showed significant impairments on the RBMT, including in prospective memory, alongside impaired performance on the CAVLT-2. Social and communication ability was significantly associated with prospective ~~spontaneous~~ remembering in an everyday memory context but not with the CAVLT-2. The complex nature of everyday memory and its relevance to ASD is discussed.

Word count: ~~116~~ 121 (limit 120)

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'Everyday Memory' Impairments in Autism Spectrum Disorders

The term 'everyday memory' refers to the use of memory in day-to-day life and encapsulates the many fractionated components of memory (Magnussen & Helstrup, 2007). The concept is a 'catch all' for any use of memory that is pertinent to a smooth transition through everyday life. For example, remembering items to buy whilst out shopping, remembering that a particular chore has to be carried out by a particular time, remembering the name of a person you unexpectedly meet, or remembering to ask someone something. The study of everyday memory was motivated by a desire to measure and capture ecologically valid instances of remembering. As a result, focus is on the functional role of memory and the social and situational context of remembering (Cohen, 1996). Everyday memory skills are known to decline with age (e.g. Cockburn & Smith, 1991) and deficits are present in individuals with brain injury and cognitive decline, including Alzheimer's disease (Kazui et al., 2005; van Balen, Westzaan & Mulder, 1996). Further, difficulties in everyday memory have been identified in those with mild intellectual disability and Down's syndrome (Hon, Huppert, Holland & Watson, 1998; Martin, West, Cull & Adams, 2000; Wilson & Ivani-Chalian, 1995). However, the everyday memory skills of individuals with autism spectrum disorders (ASD) remain uncharacterised have received little attention. .

Parents of individuals with ASD anecdotally report difficulty in remembering information necessary to functioning well in daily life, often corresponding with concerns over a lack of common sense or 'street smart' capabilities. These features are seen alongside the cardinal difficulties with social interaction, communication and rigid and repetitive behaviours (see American Psychiatric Association [APA] Diagnostic and Statistical Manual [DSM-IV-TR, 2000]; World Health Organisation

[WHO] International Classification of Diseases [ICD-10, 1993]). During a series of interviews we conducted with families of adolescents with an ASD, one parent described how difficult it was for their child to remember simple instructions, getting confused over directions to put away particular items in different locations. Another parent spoke of their child's difficulty with remembering the routes between classrooms at school. These ostensibly simple challenges to memory are reported as incongruent with intellectual level and can contrast with parental perception of good (if not superior) memory in discrete domains (e.g. rote memory for facts and dates).

Current understanding of the memory profile in ASD suggests difficulties with some aspects, including free verbal recall of words, sentences and stories (e.g. Bennetto, Pennington & Rogers, 1996; Bowler, Gardiner, Grice, & Saavalainen, 2000a; Gaigg, Gardiner & Bowler, 2008; Minshew & Goldstein. 2001; Williams, Goldstein & Minshew, 2006), but also areas of preserved skill including recognition memory (Bennetto et al., 1996; Bowler, Gardiner & Grice, 2000b; Williams et al., 2006) and cued or supported recall (Boucher & Lewis, 1989; Bowler, Gardiner & Berthollier, 2004). However, the majority of investigations have concentrated on tasks that have low ecological validity (e.g. learning a random list of words that have no relevance to the individual) whereas, by definition, everyday memory is engaged during tasks that occur naturalistically in the 'real world'. Indeed, the distinction between the ability to compensate in standard memory tests compared to difficulty in 'real-life' scenarios has been described in an individual with Asperger syndrome (Boucher, 2007). Of those studies that align with the investigation of everyday memory, both Millward, Powell, Messer and Jordan (2000) and Boucher (1981) have reported difficulties in children and adolescents with ASD in the retrospective remembering of activities (either during a walk or during a lab-based testing session)

that they have taken part in. Further, for those with ASD, memory for events that were self-performed were remembered less well than events that were performed by a peer (Millward et al., 2000); a finding that is broadly compatible with a more recent study (Hare, Mellor & Azmi, 2007). Moreover, participants with ASD have shown to demonstrate difficulty in remembering whether the self or another person engaged in a particular activity (Russell & Jarrold, 1999). However, these studies do not tell us about everyday remembering that is prospective in nature, i.e. 'remembering to remember', which is arguably the most common manifestation of everyday memory and is tightly tied to the personal construct of having a 'good' or 'poor' memory (Baddeley, 1997). Recently, deficits in time-based prospective memory (i.e. remembering to perform an activity at a designated time) have been demonstrated in children with ASD (Altgassen et al., 2009), albeit in a small sample (n=11). However, the profile of event-based prospective memory has yet to be established in ASD.

Anecdotal reports and the modest literature on retrospective remembering in an everyday context suggest that further investigation of everyday memory abilities in those with ASD is overdue. We ~~explore the validity of these anecdotal reports using~~ turned to the Rivermead Behavioural Memory Test (RBMT: Wilson & Baddeley, 1985), a reliable instrument for detecting everyday memory impairments that reflect difficulties in 'real life' (e.g. Wilson, Cockburn, Baddeley & Hiorns, 1989), and which has yet to be tested in individuals on the autism spectrum. The RBMT takes a practical and broad approach to capturing the range of memory demands in everyday life and, unlike other measures and tasks, is not driven by theoretical constructs of how memory is structured or works. Arguably because of this, the RBMT is a more accurate indicator of the clinician-rated severity of memory impairment in individuals with brain injury than the Wechsler Memory Scale-Revised and the Luria Nebraska

Neuropsychological Battery Memory Scale (Makatura, Lam, Leahy, Castillo &

Kalpakjian, 1999). In the current study we used selected measures from the RBMT to

assess everyday memory function in a large sample of adolescents on the autism

spectrum. We also included a standard measure of verbal recall (Children's Auditory

Verbal Learning Test-2: CAVLT-2; Talley, 1993), which has previously been studied

in ASD (e.g. Bennetto et al., 1996; Minshew & Goldstein, 1993; Minshew &

Goldstein, 2001). Importantly, the inclusion of the CAVLT-2 allows comparison of

memory ability for items in an everyday context with memory ability for items

presented in a more structured and focused context, i.e. a classical memory test. We

predicted impaired everyday memory in our sample with ASD and an association

between everyday memory skills and social and communication difficulties. Although

we expected impaired performance on the CAVLT-2, we did not predict that this task

would associate with socio-communicative impairment.

Method

Participants

Ninety-four adolescents with an ASD (mean age = 15 years 6 months, SD 6 months;

85 male) and 55 adolescents without an ASD (mean age = 15 years 6 months, SD 5.7

months; 53 male) were tested. The 94 participants with an ASD (49 childhood autism;

45 other ASD) and 25 of the participants without an ASD were recruited from the

Special Needs and Autism Project cohort (SNAP; Baird et al., 2006). For this cohort,

consensus clinical ICD-10 diagnoses were made using information from the ADI-R

(Lord, Rutter & Le Couteur, 1994) and ADOS-G (Lord et al., 2000) as well as IQ,

language and adaptive behaviour measures (see Baird et al., 2006; for details). The 25

participants assigned to the non-ASD group were adolescents who did not reach

clinical criteria for an ASD (Baird et al., 2006). Rather, they had a range of primary

ICD-10 diagnoses (15 mild ~~mental retardation~~intellectual disability; 3 moderate

~~mental retardation~~intellectual disability; 3 specific reading/spelling disorder; 2

attention deficit hyperactivity disorder; 1 expressive/receptive language disorder; 1 no

diagnosis). The remaining non-ASD participants (n = 30) were recruited from local

mainstream schools. Parent and teacher report confirmed that all were typically

developing; none had a psychiatric or developmental diagnosis, a statement of special

educational needs or were receiving medication. The social communication

questionnaire (SCQ; Rutter, Bailey & Lord, 2003) was collected from parents of 27 of

the 30 adolescents; no individual scored 15 or above, the cut-off for ASD. Intellectual

ability was assessed using the WASI^{UK} (Wechsler, 1999), with the mean performance

of the groups falling within the average-to-low average range (see Table 1). There

was no significant difference in intellectual ability between the two groups (t test; all

p > .1). For the ASD group, 17 of the 94 had a FSIQ < 70 (18.1%), whilst 36 had a

FSIQ < 80 (38.3%). For the non-ASD group, 15 of the 55 had a FSIQ < 70 (27.3%),

whilst 22 had a FSIQ < 80 (40%).

The study was approved by the South East Research Ethics Committee

(05/MRE01/67) and informed consent was obtained from parents and all participants.

Table 1 about here

Tasks

Everyday memory

Despite being administered in a controlled setting, the RBMT (Wilson & Baddeley, 1991, 2nd edn) captures everyday memory skills by presenting memory challenges that are analogous to those that would be met in day-to-day life. We selected four tasks (which constitute 6 of the 11 items that comprise the RBMT) that we felt best exemplified everyday memory demands.

First and Second Name: The experimenter shows the participant a photographic picture of a person and tells them his name (Phillip Harris). The participant is asked to repeat the name aloud and told that they will be asked to recall the name later. After approximately 25 minutes the participant is shown the picture again and asked to remember the name.

Scoring of First and Second Name: First Name: 2 points awarded for first name being recalled without a prompt; 1 point for first name with a prompt (e.g. "His first name began with a P"). Maximum score = 2; Second Name: 2 points for second name without a prompt; 1 point for second name with a prompt. Maximum score = 42.

Belonging: The experimenter shows the participant a highlighter pen and says they are going to put it away somewhere (typically hidden under something on a shelf). They tell the participant that they must remind the experimenter about the pen and where it is hidden when she says, "We have finished the testing". (NB. In the original RBMT an object belonging to the participant was used; we used a neutral item for consistency and also because not all of the adolescents had objects about their person). The testing finished approximately 25 minutes later.

Scoring of Belonging: 2 points for item being recalled without a prompt; 1 point for item with a prompt (e.g. "You were going to remind me about something. Can you remember what it was?"); 2 points awarded for place without a prompt; 1 point for place with a prompt. Maximum score = 4.

Appointment: In front of the participant, the experimenter demonstrates the sound of an alarm and then sets it to go of in 20 minutes. They say that when the participant hears it go off they have to ask the experimenter, "What time is it?". The alarm is placed out of the participant's eye-line during the 20 minute countdown. Scoring of the Appointment: 2 points awarded for question asked spontaneously when alarm goes off; 1 point for question asked after a prompt (e.g. "What were you going to do when the alarm rang?"); 1 point for remembering something had to be asked but not recalling what it was. Maximum score = 2.

Route and Message: The experimenter walks a route round the room that includes explicitly visiting five separate locations, with the first location being their starting position (the chair they are sitting on). At the start of the route the experimenter takes an envelope with them that is marked with the word 'Message'. The envelope is left at the fourth location. The final stage of the route is the experimenter's starting position (therefore, location 5 is the same as location 1). Before they start, the experimenter tells the participant that they will be asked to do "the same thing" once the experimenter has finished. The experimenter verbalises what they are doing throughout the route. When the experimenter is finished they return the message to its original location and ask the participant to repeat the same path, starting from the same position (Immediate condition). Approximately fifteen minutes later the participant is asked to repeat the route (Delayed condition). Scoring of the Route: A point is awarded for each stage visited in the correct order. Any stage that is erroneously added is considered a false positive and a point is deducted. Maximum score = 5.

Scoring of the Message: 2 points awarded if the envelope is picked up spontaneously; 1 point if the envelope is picked up after a prompt (e.g. "I took something with me.

Do you remember what it was?"); 1 point if the envelope is left in the correct location. Maximum score = 3.

The same scoring procedure is used for the Route/Message Immediate and Route/Message Delayed conditions. The RBMT scoring guidelines propose that separate Route Immediate and Route Delayed scores are calculated, alongside a composite Message score (Message Immediate + Message Delayed).

Prospective Memory score: Three of the four subtests include a prospective memory (i.e. 'remembering to remember') component (Fish, Wilson & Manly, 2010; Strauss, Sherman & Spreen, 2006). As such, we also calculated a Prospective Memory score by summing the total scores for these three subtests (Appointment score + Belonging score + Message score). This approach has precedent in the literature (e.g. Cockburn & Smith, 1991) and provided a composite variable for correlation analyses.

Verbal word recall

For the Children's Auditory Verbal Learning Test-2 (CAVLT-2: Talley, 1993), a 16-item list of words (Learning List) is read to the participant and they are instructed to repeat as many items as they can recall at the end of the trial. This process is repeated a further four times (i.e. Trials 1-5). An Interference List (a different set of 16 words) is then presented, followed by immediate recall of that list (Interference Trial). The participant is then instructed to remember as many items as possible from the Learning List (without additional presentation of the words) (Immediate Recall Trial). After a 15-20 minute delay (filled with other tasks, none of which demanded memory) the participant is required to recall the Learning List for a final time (Delayed Recall Trial). Finally, the participant is read a list of 32 words and asked to indicate whether the items were in the Learning List or not (Recognition Accuracy). All 16 words from

the Learning List are included, as well as 8 items from the Interference List and 8 novel words. For each trial, a point is awarded per correct item.

To minimise the number of statistical tests, a parsimonious approach was taken when choosing variables to analyse from the CAVLT-2. We calculated the Immediate Memory Span (Trial 1 + Interference Trial), Level of Learning score (Trial 3 + 4 + 5) and Delayed Recall score (Delayed Recall Trial). All of these scores were transformed into standard scores using tabulated test norms. We also calculated the number of intrusions and the number of perseverations across all applicable trials (i.e. except Recognition Accuracy) and the Recognition Accuracy score (maximum score = 32). Standard scores were not available for these final three variables, so raw scores were used.

Design and Procedure

The participants were tested on two separate days. The CAVLT-2 and WASI were administered on day 1 (balanced for order) and the RBMT on day 2. For the RBMT the initial instructions were presented for each task in the order: First and Second Name, Belonging, Appointment, Route and Message (Immediate condition). Two computer tasks and a pen and paper task were then administered to occupy time; none of the tasks contained a memory component. The recall elements of the tasks were then initiated in the order: Appointment, Route and Message (Delayed condition), First and Second name, Belonging.

Analysis

Although the two groups were matched for IQ, IQ was strongly related to all memory scores (ASD group mean correlation = .41, range = .23 to .58 across the key CALVT-2 and RBMT variables; non-ASD group mean correlation = .50, range .26 to .72) so we took the conservative approach of also covarying out the effect of full scale IQ in

our group (ASD vs non-ASD) comparisons by using ordinal logistic regression

(RBMT; with the key RMBT variable as the ordinal dependent variable) or linear

regression (CAVLT-2; with the key CAVLT-2 variable as the continuous dependent

variable). Wald test statistics and p-values were calculated using Stata 9 (Stata, 2005).

Owing to the non-normal category distribution of the RBMT, to assess for

associations across tasks differences in mean and association we used Spearman

correlation methods in SPSS and ordinal logistic regression models in Stata. To test

the specificity of association of a covariate (full scale IQ; ADOS social

communication score) with selected variables from the RBMT and CAVLT-2, the

latter was grouped into a 7-category ordinal variable (like the RBMT) and both

variables were analysed in a bivariate correlated response ordinal logistic model (with

random intercept) fitted using adaptive quadrature in gllamm (Rabe-Hesketh, Skordal

& Pickles, 2002) and a measure by covariate interaction Wald statistic calculated.

Effect size measurements are calculated using Cohen's *d*, where .20 is a small effect

size, .50 is a medium effect size, and .80 is a large effect size (Cohen, 1992).

Results

Everyday memory

Mean scores for each group and statistical comparisons are shown in Table 2.

In summary, the ASD group were significantly worse than the non-ASD group at

remembering in the RBMT Belonging, Appointment and Immediate Route tasks.

The Message, Appointment, First and Second Name and Belonging subtests

are similar in requiring the spontaneous remembering of a piece of information

following a cue from the environment. To allow comparison across subtests, the

percentages of individuals giving specific types of response are shown in Table 3.

This also enables comparison of those remembering spontaneously, those remembering after a prompt and those who failed to remember.

For the composite Prospective Memory score, the mean score for the ASD group was 9.32 (SD=2.58) and for the non-ASD group was (10.31 (SD=2.07) (Z=-2.61; p = .009; ES = .40).

To allow for parsimonious investigation of the level of spontaneous remembering in the groups we created a composite 'Spontaneous Recall' score. This was the sum of the number of items spontaneously remembered across the four subtests (maximum score = 7: sum of Message 2 + Appointment 1 + Name 2 + Belonging 2). The mean score for the ASD group was 4.49 (SD = 1.71) and for the non-ASD group was 5.40 (SD=1.50) (Z = -3.29; p = .001; ES = .54). The ordinal logistic regression model for the RBMT (using the Spontaneous RecallProspective Memory score) with group and full scale IQ as predictors, indicated that for a participant with ASD to have a similar expected performance on the RBMT as an individual without ASD, their full scale IQ score would need to be 14.012.3 (CI 5.4, 30.0) (CI 5.3, 22.6) points higher.

Table 2 and Table 3 about here

Verbal word recall

Mean scores for each group and statistical comparisons are shown in Table 4. In summary, the group with ASD had a significantly lower mean Immediate Memory Span and Level of Learning scores.

Table 4 about here

Association between everyday memory and structured verbal word recall

To avoid multiple comparisons, analysis of the memory data was confined to two key variables: the composite ~~'Spontaneous Recall'~~prospective memory score (see above) from the RBMT, ~~reflecting the primary type of memory measured by the RBMT~~ and the Immediate memory score from the CAVLT-2. The latter sub-score was chosen as the ASD group were significantly impaired on this measure and it is more comparable to the RBMT Spontaneous Recall score than the Level of Learning score. As shown in Table 5, for the group with ASD, both experimental variables correlated significantly with full scale IQ and with each other. Once the effect of full scale IQ was accounted for, there was no significant association between the RBMT Spontaneous Recall and the CAVLT-2 Immediate Memory Span (p > .1). For the group without ASD, the pattern of significant results was similar.

Association between social and communication difficulties in ASD and everyday memory and verbal word recall

Given that we had ADOS data for only a portion of the non-ASD group, analysis was confined to the group with ASD. ~~The~~ Both the social and communication score and the repetitive behaviour score correlated significantly (negatively) with the ~~Spontaneous Recall~~Prospective Memory score from the RBMT (see Table 5), indicating that participants with higher symptom severity scores had lower ~~Spontaneous Recall~~Prospective Memory scores. Additionally, the relative strength of the correlations without and with covarying out the effect of full scale IQ was comparable (see Table 5) ~~(Spearman r_s = .37, p <.001 and r_s = .36, p < .001, respectively)~~. There were no significant correlations between the ADOS ~~social and communication~~ symptom severity scores and the CAVLT-2 Immediate Memory Span ~~and no significant correlations with the ADOS repetitive behaviour score~~. ~~The random~~

~~effects ordinal logistic model indicated that while the association of the WASI full scale IQ was of similar strength for both the RBMT and CAVLT-2 (measure by covariate interaction p=0.16) for the ADOS social-communication total the association with RBMT was significantly stronger than the association with CAVLT-2 (measure by covariate interaction p=0.01).~~A random effects ordinal logistic model indicated that the ADOS social-communication score was significantly more strongly associated with the RBMT than with the CAVLT-2 (measure by covariate interaction = .002). However, similar analysis for the ADOS repetitive behaviour score indicated that the strength of the interactions (ADOS repetitive behaviour-RBMT vs. ADOS repetitive behaviour-CAVLT-2) did not significantly differ (measure by covariate interaction p = .13). Both experimental tasks showed a similar strength of association with the WASI full scale IQ score (measure by covariate interaction p = .40).

Table 5 about here

Discussion

Everyday memory refers to the application of memory skills to meet the challenges of daily life, in contexts typically involving social and communicative meaning, and in concert with ongoing and additional cognitive processing demands. Using a large adolescent sample across a wide range of IQ, our study is the first to investigate performance on the RBMT in individuals with ASD. report everyday memory difficulties in ASD, including event-based prospective memory and remembering a route, alongside more discrete difficulties with verbal word recall. Pertinently, the social and communication score on the ADOS was a significant predictor of ~~spontaneous~~ prospective remembering within an everyday memory

context but not of remembering in the standard test of word recall. We interpret this as evidence of the impact of poor social and communication skills in ASD on prospective memory. everyday memory competence.

An everyday memory deficit in ASD

Our results from the RBMT are clear in demonstrating a significant deficit in everyday remembering amongst adolescents with ASD. Further, this was in the context of a conservative statistical approach that controlled for the mediating effect of IQ upon performance. Indeed, analysis suggests that the full scale IQ of the ASD participants would need to be almost one standard deviation higher (14 12 points) higher for their prospective memory ability spontaneous everyday remembering to match the participants without ASD. The RBMT is not focused on fractionating conceptual constructs of memory and, as such, does not encourage the types of theoretically-driven conclusions that are afforded in other memory tasks and batteries. Broadly, twoHowever, three types of everyday memory were measured. The first required the recalling of a person's name, with individuals with ASD demonstrating a performance level that was comparable to those without an ASD. Second, individuals were required to memorise a route, with the ASD group showing impairment on immediate recall of the route, although not on recall of the route following a delay. Preserved delayed recall ability reflects the pattern of performance on the CAVLT-2 in the present study. a piece of information to be spontaneously remembered following a cue, with the ASD group being impaired on two tasks of this nature (Appointment, Belonging). There was no significant difference between groups on the First and Second Name task and the Message task, where performance was at ceiling for both groups. Finally, three of the subtests (Message, Appointment and Belonging) tapped prospective memory, i.e. 'remembering to remember'. Following a cue from

the environment, the individual had to remember that they had an intention to respond to the cue and then remember what they had to do. Impairment in the ASD group was demonstrated on the Appointment and Belonging subtests. For the Message subtest performance was at ceiling across groups. However, the message was left on the table in front of the participants, which provided a salient visual cue that may have enhanced performance. As far as we are aware, this is the first study to establish event-based prospective memory impairment and difficulty in remembering a route in ASD. Aligned with previous studies that have demonstrated difficulties with retrospective remembering of activities in ASD (Boucher et al., 1981; Millward et al., 2000), the current data indicates difficulties in everyday memory in ASD across contexts and memory styles.

Notably, in the Message task the message was left on the table in front of the participant, providing a salient visual cue, which may explain the better performance. Second, individuals were required to memorise a route, with the ASD group showing impairment on immediate recall of the route, although not on recalling the route following a delay. Preserved delayed recall ability reflects the pattern of performance on the CAVLT-2 in the present study.

The RBMT is not focused on fractionating conceptual constructs of memory and, as such, does not enable the types of theoretically-driven conclusions that are afforded in other memory tasks and batteries. However, some of the subtests of the RBMT tap prospective memory, i.e. 'remembering to remember', which has not been a focus of research into memory function in ASD. Following a cue from the environment, the individual must remember that they had an intention to respond to this cue and they then need to remember the specific details (i.e. Message, Appointment and Belonging subtests). However, recently deficits in time-based

prospective memory (i.e. remembering to perform an activity at a designated time) have been shown in children with ASD (Altgassen et al., 2009). We only presented participants with 6 (First and Second Name count as 2 items; Route Immediate and Delayed count as 1 item, split into 2 parts) of the 11 items of the RBMT. Previous research in participants with varying neurological, developmental and intellectual profiles suggests that the profile of peaks and troughs in ability across items vary by population (e.g. Jambaqué et al., 2007; Kazui et al., 2005; Wilson & Ivani-Chalian, 1995). A complete performance profile on the RBMT in individuals with ASD, alongside comparison with other atypical populations would be informative.

Data from the CAVLT-2 concur with the consensus of previous literature in demonstrating word recall deficits in ASD (e.g. Bennetto et al., 1996; Bowler et al., 2000a; Gaigg et al., 2008; Minshew & Goldstein. 2001). Impairment occurred both for initial presentation of a word list and for learning over repeated trials, although delayed recall abilities were not significantly impaired. The lack of significantly greater intrusions or perseverations in the ASD group suggests that these particular types of executive dysfunction cannot account for what we interpret as a fundamental difficulty in the ability to recall words. As is commonly found, recognition memory was unimpaired (e.g. Bennetto et al., 1996; Bowler et al., 2000b; Williams et al., 2006).

Fractionating the component processes in everyday memory

Although the RBMT Spontaneous Recall score and the CAVLT-2 Immediate Memory Span both correlated strongly and similarly with full scale IQ, the two tasks showed very weak association with each other once the moderating effect of intellectual ability was accounted for. Further, this was true for both the groups with and without ASD. This leads us to question how generalisable the results from more

~~artificial and structured standard memory tasks are to an individual's ability to use memory in day-to-day functioning (see also Boucher, 2007). One obvious interpretation is that whereas standard laboratory tests of memory aim to isolate a particular component process of memory, e~~Everyday memory tasks embed memory demands within a context rich with additional social and cognitive demands, which themselves might be driving performance. Two such extraneous demands are social and communication ability and executive functions.

We hypothesised that the embedding of memory demands within a naturalistic and everyday context would lead to task performance that associates with autism symptomatology, principally social and communication difficulties. We found that performance on the social and communication items in the ADOS significantly associated with the prospective memory component ~~'Spontaneous Recall' element~~ of the RBMT; with poorer social and communicative abilities relating to diminished capacity for ~~spontaneous 'everyday'~~ prospective remembering. Further, social communication impairment was significantly more strongly related to RBMT performance than performance on the CAVLT-2. ~~The Spontaneous Recall score was a composite that encapsulated the ability to remember following an environmental cue (i.e. remembering to pick up and deliver a message, remembering to ask a question, remembering someone's name, and remembering to tell someone something).~~ Notably, IQ had little moderating effect on the strength of association between the two variables. In contrast, autism symptomatology did not predict performance on the CAVLT-2. The Immediate Recall score from the CAVLT-2 and the Prospective Memory score from the RBMT differ in specific ways (e.g. cued vs. immediate recall), which means caution should be taken with interpretation. However, the dissociation illustrates that memory scores do not indiscriminately correlate with

social and communication difficulties in this sample. ~~In requiring the recall of specific verbal information, the variables in the CAVLT-2 have resonance with the Spontaneous Recall on the RBMT. However, as only the Spontaneous Recall score associates with social and communication ability this is evidence of a~~ What remains to be established is whether the correlation with social and communication ability reflects the general ~~dissociation between the~~ demands inherent in naturalistic everyday memory ~~and the discrete and focussed assessment of memory that occurs in standard experimental memory assessments~~ or is specific to prospective memory. The degree of repetitive behaviours also correlated with prospective memory ability, although this association was not significantly stronger than for the CAVLT-2 variable. Previous investigation of the component processes of prospective memory has focussed on executive functions and memory (Groot, Wilson, Evans & Watson, 2002; Kopp & Thöne-Otto, 2003); as far as we are aware, this is the first study to demonstrate an association between social and communication ability and prospective memory skills.

The question remains as to what aspect of social and communication ability is affecting performance on the prospective memory items of the RBMT. Of course, the counter-interpretation is that poor ~~everyday~~ prospective memory impacts upon the development of social and communication skills, and this cannot be discounted using the current set of results. It is notable that the tasks selected from the RBMT required considerable amounts of imitation (e.g. repeating a ~~route~~message delivery) and communication (e.g. initiating conversation ("What time is it?") following a cue) which are core diagnostic features of ASD. In another assessment of naturalistic memory, Boucher (1981) required children and adolescents with ASD to recall tasks and activities they had taken part in over a 1 ½-2 hour testing session and found that

those with ASD fared less well. Performance was related to language level in the ASD group and it was speculated that poor verbalisation during the tasks and activities may have hindered the verbal mediation upon recall. More broadly, prospective remembering in an everyday context everyday memory relies on social motivation (Baddeley, 1997). There is an intrinsic motivational factor to everyday remembering (e.g. not letting someone down; mental-state insight into how someone would feel if you forgot; desire to be socially included) that may resonate less in individuals with ASD. Further, prospective memory is considered to be, "tied in closely with the social fabric of one's life" (p. 187, Baddeley, 1997) and explicit and implicit cues in the social environment, which individuals with ASD are generally less engaged with, often prime an individual to remember (see Andersson, Helstrup & Rönnberg, 2007). Indeed, disentangling cognitive performance on socially-administered neuropsychological tasks from social cognitive and motivational difficulties in ASD has been recognised as a challenge for autism research (see Kenworthy, Yerys, Anthony & Wallace, 2008).

The association between socio-communicative impairments and everyday prospective memory might also relate more specifically to theory of mind. It is suggested that difficulty with representing the mental states of others is paralleled by a difficulty in reflecting upon own mental states, knowledge and intentions (Frith & Happé, 1999; Happé, 2003; Williams & Happé, 2009; Williams & Happé, 2010). Particularly, individuals with ASD have difficulty in correctly recalling their prior intentions, a finding which is associated with their mentalising ablitiy (Williams & Happé, 2010). Processing and keeping track of prior intentions is essential to prospective remembering (e.g. "When I see a post box I must remember I want to post a letter"). This type of deficit is likely to impair the ability to process and keep track

of everyday memory demands, which are generally tightly tied to retaining an intention to remember, over time. The current findings, combined with evidence for poorer retrospective memory for events performed by the self compared to those performed by another person (e.g. Millward et al., 2000) suggests that self-awareness and self-monitoring (with its link to executive functions, see below) may be a key factor in the memory difficulties experienced by individuals with ASD during daily life.

The RBMT also places demands upon the executive system and at least a subset of those with ASD are known to have difficulty with executive tasks (e.g. Pellicano, 2007). Everyday memory occurs in the context of complex scenarios; sophisticated cognitive mechanisms are necessary to extract pertinent information and to integrate and organise this information, while inhibiting distracting and unnecessary detail. The four RBMT tasks were presented consecutively, creating a scenario in which independent and competing pieces of information had to be retained. Planning, monitoring and inhibition will all have been important and the Route paradigm included a spatial working memory component. It has previously been suggested that memory impairments in ASD might be underpinned by difficulty with using organisational strategies (e.g. Minshew & Goldstein, 2001) and multi-tasking is an area of difficulty in ASD (Mackinlay, Charman & Karmiloff-Smith, 2006). Further, executive functions are known to be important in prospective memory (e.g. Marsh & Hicks, 1998Groot et al., 2002; Kopp & Thöne-Otto, 2003). Thus, it might be productive in future studies to monitor the executive load (e.g. number of separable and parallel everyday memory tasks) that is being placed on everyday memory.

Concluding comments

We hypothesise that everyday memory problems in ASD occur when a 'tipping point' is reached. Remembering what to do on a day-to-day basis involves a diverse range of factors including: memory, executive functions, social and communication skills, and a motivation to remember that is often social in flavour. Individuals with ASD can have difficulties with all of these factors, meaning that their everyday memory system is more vulnerable than that of a person without ASD, although this does not mean that such memories cannot be constructed in favourable circumstances. There is scope for developing tests that manipulate the degree of social-communicative demand or executive load within a memory paradigm in a controlled manner. However, the interplay between these factors is likely to be complex and will make teasing them apart challenging. For example, difficulty in reflecting on one's own mental states is likely to impact negatively on executive skills, particularly planning and monitoring (see Frith & Happé, 1999; Happé, 2003).

These results also highlight the importance of considering the 'real world' application of memory rather than merely focussing on the relevance of theoretical constructs of memory to ASD. There is particular significance in highlighting everyday memory difficulties in adolescents at the cusp of transitioning into adulthood. Many parents we interviewed spoke of concern with how their child would cope with the move to the adult world, where the tightly structured routine of school and college is left behind. Given this, focus on the functional consequences of an individual's everyday memory skills might be relevant to predicting and aiding transition to the 'adult world'. Pertinently, everyday memory impairments predict ability to cope independently in patients with amnesia (Wilson, 1991). Everyday memory is often impaired in patients with acquired brain injury and remedial aid includes the use of personal organisers, list-writing etc, as well as encouraging

awareness of and insight into specific difficulties (see Fish et al., 2010). Related to this, the task support hypothesis of Bowler and colleagues (e.g. Bowler et al., 2004) has demonstrated how memory performance in ASD is augmented when appropriate support is given to aid recall. Delineating the underlying factors that contribute to everyday memory difficulties in ASD and exploration of how these deficits may be supported and ameliorated may bring real benefit to individuals with ASD and their families.

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Table 1

Mean IQ (SD in brackets) and range of IQ for all participants

	ASD N = 94		non-ASD N = 55	
	Mean (SD)	Range	Mean (SD)	Range
WASI verbal IQ	82.2 (17.6)	55-120	86.9 (20.11)	55-140
WASI performance IQ	91.2 (18.3)	53-126	92.0 (21.6)	58-125
WASI full-scale IQ	85.4 (17.7)	50-119	88.7 (22.1)	54-133

Table 2

Mean scores on the RBMT subtests for the ASD and non-ASD groups (SD in brackets); alongside the Z statistic (Z), p-value and effect size (ES)

		ASD N = 94	non-ASD N = 55	Z	p-value	ES
First Name	**(/2)**	1.46 (.86)	1.71 (.69)	-1.74	.08	.31
Second Name	**(/2)**	1.14 (.99)	1.38 (.93)	-1.45	.15	.25
Belonging	**(/4)**	2.61 (1.42)	3.09 (1.22)	-1.98	.05	.35
Appointment	**(/3)**	1.23 (0.74)	1.56 (0.74)	-2.74	.006	.44
Route: Immediate	**(/5)**	3.56 (2.10)	4.33 (1.58)	-2.39	.02	.40
Route: Delayed	**(/5)**	3.51 (2.13)	4.00 (1.81)	-1.00	.32	.24
Message	**(/6)**	5.48 (1.23)	5.65 (0.82)	-0.71	.48	.16

Table 3

Percentage of individuals (i) spontaneously remembering (ii) remembering following a prompt or (iii) failing to remember, for both the ASD and non-ASD groups. Note that for illustrative purposes we present data for the Message: Immediate Recall and Message: Delayed Recall subtests separately.

		ASD N = 94	non-ASD N = 55
First Name	**Spontaneous**	**70.2**	**83.6**
	Prompted	5.3	3.6
	Forgotten	24.5	12.7
Second Name	**Spontaneous**	**56.4**	**69.1**
	Prompted	1.1	0.0
	Forgotten	42.6	30.9
Belonging: Place	**Spontaneous**	**54.3**	**69.1**
	Prompted	30.9	23.6
	Forgotten	14.9	7.3
Belonging: Item	**Spontaneous**	**44.7**	**58.2**
	Prompted	33.0	30.9
	Forgotten	22.3	10.9
Appointment	**Spontaneous**	**41.5**	**70.9**
	Prompted	11.7	9.1
	Forgotten	46.8	20.0
Message: Immediate Recall	**Spontaneous**	**93.6**	**98.2**
	Prompted	3.2	1.8
	Forgotten	3.2	0
Message: Delayed Recall	**Spontaneous**	**88.3**	**90.9**

Prompted	4.3	5.5
	7.4	3.6

Table 4

Mean scores on the CAVLT-2 for the ASD and non-ASD groups (SD in brackets);

alongside the t statistic (t), p-value and effect size (ES)

	ASD N = 94	non-ASD N = 55	t	p-value	ES
Immediate memory span	92.15 (20.61)	103.49 (22.60)	-3.13	.002	.52
Level of learning	92.28 (19.22)	99.69 (20.43)	-2.05	.04	.37
Delayed recall[a]	91.73 (20.49)	97.64 (17.37)	-1.53	.13	.30
Number of intrusions	7.60 (11.90)	4.36 (5.52)	1.65	.10	.32
Number of perseverations	8.21 (11.05)	6.98 (6.10)	0.70	.49	.13
Recognition accuracy[b]	28.63 (4.20)	29.71 (2.88)	-1.41	.16	.29

[a] ASD group N=93 for Delayed recall

[b] ASD group N=89; non-ASD group N=52 for Recognition accuracy

Table 5

Correlations for the ASD group ~~and non-ASD groups~~ between key variables from the RBMT and CAVLT-2 and the ADOS, both (a) without and (b) with the effect of full scale IQ partialled out.

	FSIQ	ADOS-SC	ADOS-R
(a) Spearman's rho			
RBMT: Prospective Memory	.53***	-.39***	-.21*
CAVLT-2: Immediate Memory Span	.48***	-.09	-.07
(b) with FSIQ partialled out			
RBMT: Prospective Memory		-.37***	-.21*
CAVLT-2: Immediate Memory Span		-.02	-.04

* p < .05 *** p <.001

ADOS-SC: ADOS social and communication; ADOS-R: ADOS repetitive behaviour;

FSIQ: full scale IQ