Effects of Related and Unrelated Context on Recall and Recognition by Adults with High-Functioning Autism Spectrum Disorder

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Abstract

Memory in autism spectrum disorder (ASD) is characterised by greater difficulties with recall rather than recognition and with a diminished use of semantic or associative relatedness in the aid of recall. Two experiments are reported that test the effects of item-context relatedness on recall and recognition in adults with high-functioning ASD (HFA) and matched typical comparison participants. In both experiments, participants studied words presented inside a red rectangle and were told to ignore context words presented outside the rectangle. Context words were either related or unrelated to the study words. The results showed that relatedness of context enhanced recall for the typical group only. However, recognition was enhanced by relatedness in both groups of participants. On a behavioural level, these findings confirm the Task Support Hypothesis (Bowler, Gardiner & Berthollier, 2004), which states that individuals with ASD will show greater difficulty on memory tests that provide little support for retrieval. The findings extend this hypothesis by showing that it operates at the level of relatedness between studied items and incidentally-encoded context. By showing difficulties in memory for associated items, the findings are also consistent with conjectures that implicate medial temporal lobe and frontal lobe dysfunction in the memory difficulties of individuals with ASD.

It is now generally agreed that autism spectrum disorder (ASD) covers a range of conditions including the categories of autistic disorder and Asperger disorder (DSM-IV TR; American Psychiatric Association, 2000). The first of these conditions is often accompanied by global intellectual disability, whereas the latter is characterised by normal intelligence and an absence of language difficulties. The failure of many attempts to differentiate the two conditions on measures that are not related to those used to classify them in the first place (see Macintosh & Dissanayake, 2004) has led several researchers to divide ASD conditions into those that are accompanied by global cognitive difficulties (low-functioning autism; LFA) from those that are not (high-functioning autism: HFA).

Experimental investigations of memory in individuals with LFA and HFA have shown a pattern of findings characterised by relatively diminished performance on tasks such as free recall, where there is little support for memory at test, especially when semantic or associative relations among studied items can be used to aid recall (Bowler, Matthews & Gardiner, 1997; Bowler, Gardiner, Grice & Saavalainen, 2000b, Tager-Flusberg, 1991, but see Lopez and Leekam, 2003). There is also relatively undiminished performance on tasks such as cued recall, where support is present (Boucher & Warrington, 1976; Bowler, Matthews & Gardiner, 1997). Recognition memory, a supported test procedure, has produced more mixed results, with the majority of studies of HFA individuals showing undiminished performance (Bowler, Gardiner & Grice, 2000a; Bowler et al., 2000b; Gardiner, Bowler & Grice, 2003, but see Bowler, Gardiner & Berthollier, 2004). Level of recognition by individuals with LFA tends to depend on the precise procedure used (see Bowler et al., 2004 for review) but the majority of studies show no evidence of reduced performance. The patterning of memory performance across supported and unsupported test procedures led Bowler et al., (1997) to formulate the Task Support Hypothesis (TSH) which states that individuals with ASD will tend to perform at typical levels on any memory task where support is provided at test. When support is absent, then levels of performance will decline relative to typical comparison participants.

There is also some evidence that individuals with HFA have diminished memory for source or incidentally-encoded context, especially when that context has to be recalled rather than recognised (see Bowler et al., 2004). Diminished 'remember' responses have also been documented in this population (Bowler et al., 2000a; Bowler, Gardiner & Gaigg, 2007). 'Remember' responses are thought to reflect the operation of the episodic memory system (Tulving, 1985), which Tulving (2001) argues involves the individual mentally travelling back in time to re-create the spatio-temporal context of the recollected episode.

The patterning of memory performance in ASD is strongly suggestive of involvement of the medial temporal and the frontal lobes of the brain. Good recognition in the presence of impaired recall has been documented in individuals with damage to the hippocampus (Aggleton, Vann, Denby et al., 2005; Mayes, Holdstock, Isaac et al., 2002). A similar pattern of impaired recall and recollection with spared recognition and semantic memory has been reported in children with early damage to the hippocampus (Brandt, Gardiner, Vargha-Khadem et al., 2006; Vargha-Khadem, Gadian, Watkins et al., 1997). The hippocampus is thought to be responsible for the integration and relation of elements of experience that are stored elsewhere (Aggleton & Brown, 1999). Such integration underlies the creation of episodic memories and the recall of item-context relations. The frontal lobes are another area of the brain that have been implicated in memory function. Damage to the frontal lobes, although often not producing obvious amnesia, does give rise to a patterning of spared and impaired memory functions that is similar to that seen in ASD (Shimamura, 1996; Wheeler & Stuss, 2003), and ASD is characterised by diminished performance on some executive function tasks that are mediated by the frontal lobes (see Hill, 2004). Moreover, when typical ageing is accompanied by a decline on executive function tasks that are thought to measure frontal lobe function, difficulties with source memory and an increasing need for task support are observed (Craik & Anderson, 1999). Although there have been no direct tests of the relation between memory and medial temporal, hippocampal or frontal function in individuals with ASD, there is some neuropathological and imaging evidence that shows abnormalities in these structures in this population (Bauman & Kemper, 1994; Boucher, Cowell, Howard et al., 2005; Casanova, Buxoeveden, Switala & Roy, 2002; Salmond, Ashburner, Connelly et al., 2005). In view of the structural findings and the patterning of memory performance, it is reasonable to hypothesise that individuals with ASD will experience difficulties on memory tasks that involve the integration of disparate elements of experience.

This hypothesis has been supported by several investigations. Bowler et al. (2004) have shown intact recognition but diminished recall for incidentally-encoded contextual material in adults with HFA. Context in that study was entirely episodically defined, i.e. it consisted of what happened when participants studied individual items. However, context can also be thought of as including semantically or associatively activated representations of a studied item or of such links among studied items. In this respect, Baddeley (1982) makes the distinction between *independent* context, which does not affect the meaningful interpretation of the studied material and *interactive* context, which does. Mayes, MacDonald, Donlan, Pears & Meudell (1992) have shown that typical individuals, in contrast to amnesics with extensive medial temporal lobe damage show greater recognition of target words that had been studied in the presence of interactive context words (e.g. ‘grain’ in the presence of ‘crop’) than words that had been studied alone. On the basis of existing findings on memory in ASD as well as on the the consequences for episodic memory of medial temporal and hippocampal damage, it can be argued that diminished episodic memory in ASD is partly the result of a failure of the influence of context on recall of studied material, especially when the context and the studied items are conceptually related. In the two experiments presented here, we adapted the method developed by Mayes et al. and asked participants with and without HFA to study lists of words, each of which was presented together with either a conceptually related or unrelated word. Participants were instructed to pay attention only to the studied word. At test, participants were asked either to recall (Experiment 1) or to recognise

(Experiment 2) as many words as they could, irrespective of whether the words occurred inside or outside the box at study. We predicted that for comparison participants, recall and recognition would be higher when studied and context words were related than when they were unrelated. For the HFA participants, we predicted a significantly diminished effect of context on recall but, on the basis of the TSH, no diminished effect under recognition. Because of participant overlap across experiments due limited participant availability, the two experiments were carried out 18 months apart.

EXPERIMENT 1

Method

Participants

Twenty individuals with HFA (3 female, 17 male) and twenty typical individuals (4 female, 16 male) participated in this experiment. Participants with and without HFA were individually matched to within 6 points of Verbal IQ as measured by the WAIS-R or WAIS-III^{UK} (The Psychological Corporation) and as closely as possible in terms of their Performance IQ, Full scale IQ and age. Table 1 summarises these data. All individuals with HFA had been diagnosed by experienced clinicians according to a range of criteria, and a review of records confirmed that all met DSM-IV criteria for Asperger’s disorder apart from the requirement for absence of clinically significant abnormalities in language or communication development. The Comparison group was recruited via local newspaper advertisement and brief interviews ensured that none had any neurological condition or had a family history of psychiatric illness. Apart from two individuals with HFA who had prescriptions for antidepressant medication, all participants were free of medication. The removal of the data from the medicated participants did not significantly alter the results so these data were included in the analysis. All participants gave their informed consent to take part in the study, which was cleared by the university senate ethical committee.

Design

The design was adapted from that of Mayes et al. (1992) with the following changes. Instead of selecting 320 words from the Kucera & Francis (1967) norms, we selected 40 words from the Nelson, McEvoy and Schreiber (1998) association norms with which we formed two sets of 10 word pairs (Set A, Set B) comprising moderately related items. One of the items in each pair was designated the 'Target' and one the 'Context' item. Target and context items were matched according to letter length and written frequency (Kucera & Francis, 1967) both across and within the two study sets. In addition, the word pairs from Sets A and B were matched according to the forward and backward associative strengths of the items within each pair, which ranged between 0.02 and 0.128 (see Nelson et al., 1998 for further details). Forward and backward associative strengths are indices of how likely the target and context items elicit each other as responses in free association paradigms and we arranged items within each pair in such a way that target and context items were matched on both measures.

For the formation of the study lists, the items from one of the sets of word pairs were re-arranged in order to break the relatedness of the items in each pair. These unrelated pairs were presented together with the related pairs of the other set in pseudorandom order with the constraint that no more than two pairs of the same type were presented in succession. Examples of related and unrelated pairs are GRAIN/CROP, JOURNAL/MAGAZINE, DISHES/PLATES and GRAIN/SINK, RICE/HORN, FLAG/BRICK respectively. Following pilot testing to determine presentation rates that avoided floor and ceiling effects, the rate of presentation was set at 4000 ms / pair with a 1000 ms blank screen separating trials. During the study phase, one word – the 'Target' – was presented in 36 point bold Arial capital letters inside a red frame (102mm x 27mm) in the centre of a 15" Sony laptop monitor. The other word of the pair served as the 'Context' and was located below the frame in the same font approximately 10 mm below the target item. The materials were counterbalanced across participants so that each word appeared equal times as the target and context item of a related and unrelated pair.

Procedure

Participants were tested individually in a sound attenuated laboratory. They were informed that they would be presented with a series of word-pairs on a computer screen with one word written inside a red box and another just below that. Written instructions explained that their task was to try to remember as many of the words inside the red box as possible. It was emphasized that their memory would only be tested for the words inside the red box and that they could ignore the words that were written underneath them. To reinforce these instructions and ensure that all participants attended to the target items similarly, individuals were asked to read the words inside the red box out loud. Immediately after the presentation of the 20 pairs, participants were instructed to free recall orally as many items as they could. It was emphasised that although instructions asked participants only to remember the words from inside the red box, they should try and say all the words they could remember even if they had been presented underneath the red box during the study phase.

Results and Discussion

We computed proportions of correctly recalled target and context items for the related and unrelated word pairs. Mean numbers of intrusions were 0.4 (S.D. = 0.75) for the HFA participants and 0.25 (S.D. = 0.56) for the comparison group ($t = 0.72$, d.f. = 38, n.s.). This comparable level of intrusions across groups makes it unlikely that any of the later findings were an artefact of poor inhibitory control on the part of the HFA participants. Figure 1 illustrates the recall data, which were analysed via a 2 (Group) x 2 (Word Type) x 2 (Pair Type) mixed ANOVA. Participants recalled significantly more target than context items ($F(1,38) = 94.59$, $p < .001$) and more items from related than unrelated pairs ($F(1,38) = 6.82$, $p < .02$). Although Figure 1 suggests that the effect of relatedness was more pronounced in the comparison than the HFA group, this interaction was not significant. Planned comparisons, however, revealed that whereas the comparison group recalled significantly more target (t =

2.37, df = 19, $p < .05$) and context (t = 3.04, df = 19, $p < .01$) items that were presented in related as compared to unrelated pairs, HFA participants recalled similar numbers of items from both types of pair (target items; t = 0.34, df = 19, ns; context items; t = 0.96, df = 19, ns). A closer look at individual data revealed that the lack of an interaction between Group and Pair Type was mostly attributable to one typical participant who recalled 8 target and 1 context item from the unrelated pairs but only 2 target and 1 context item from the related pairs. In order to assess how unusual this recall pattern was, we computed difference scores by subtracting the proportion of correctly recalled items from related pairs from the proportion of correctly recalled items from unrelated pairs. This difference averaged 0.04 (SD = .29) for the HFA and 0.19 (SD = .28) for the comparison group. Thus the difference score of -.60 for the participant mentioned above falls nearly 3 standard deviations below the group mean, suggesting that this participant may have engaged in an atypical strategy for memorising the presented items. In, addition it is worth noting that the value of 0.04 for the HFA group did not differ significantly from 0 (t = 0.61, df = 19, ns) indicating no recall advantage for items from related pairs. For the comparison group on the other hand, the same analysis revealed that a difference of 0.19 was significantly above 0 (t = 3.01, df = 19, $p < .01$) confirming that the relatedness of items enhanced recall in this group despite the inclusion of the participant who may be considered a statistical outlier.

In order to confirm that the lack of an interaction between Group and Pair Type in our original analysis was attributable to the participant described above, we re-analysed our recall data, excluding this participant and matched HFA participant. The 2 (Group) x 2 (Pair Type) x 2 (Word Type) analysis again revealed main effects for Word Type ($F(1,36) = 85.48$, $p < .001$) and Pair Type ($F(1,36) = 9.91$, $p < .01$) but also yielded the expected interaction between Group and Pair Type ($F(1,36) = 5.22$, $p < .05$). It thus appears that the relatedness of words enhanced memory for typical but not HFA participants when free recall was tested. This finding confirms earlier reports of diminished use of semantic relatedness in the aid of free recall by individuals on the autism spectrum. To test the prediction of the TSH, namely that the effects reported in this experiment would be less in evidence when a more supported test procedure was used, we repeated the experiment using recognition at test.

EXPERIMENT 2

Method

Participants

Twenty individuals with HFA (7 female, 13 male) and 20 typical individuals (7 female, 13 male) took part in this experiment. Six individuals from the HFA and two from the comparison group had also participated in Experiment 1. All participants were selected and matched according to the same criteria outlined for Experiment 1. Age and psychometric data for the two groups are set out in Table 2. Apart from one HFA individual who was taking antidepressant medication, all of the participants were free from medication. As the exclusion of the data for the medicated individual did not significantly alter the results of the current experiment, data are presented for the entire sample. As in Experiment 1, all participants gave their informed consent to take part in the study, which was cleared by the university senate ethical committee.

INSERT TABLE 2

Design and Materials

We selected 320 concrete nouns from the Kucera and Francis (1967) norms. These were between 4 and 8 letters in length and had written frequencies in the range of 10-70 per million. Eighty items from this pool were used to form 40 word pairs that served during the study phase of the experiment. Unlike in the Mayes et al. (1992) study, however, only 20 of these pairs comprised moderately related words (e.g. “Dishes” and “Plates”) whilst the remaining 20 pairs consisted of words that were not related in any obvious way (e.g. “Stairs” & “Chest”) based on Nelson et al’s (1998) word association norms . Items comprising the related, unrelated and lure items were closely matched on frequency and letter length. On the basis of the results of pilot testing, the pairs were presented for 2000 ms each with a 500 ms blank screen separating trials. The use of items as targets or contexts was counterbalanced across participants and related and unrelated word pairs were presented in pseudo-random order, with the constraint that no more than 3 pairs of the same type were presented in succession.

During the forced choice recognition test, each of the 80 items from the study phase was presented alongside 3 lures, which were chosen to be unrelated to each other and the studied item. Thus memory was assessed for both the target and context items from each of the related and unrelated word pairs. The four words within each recognition trial were presented in a single centred column with each word appearing in the same format (including the red frame) as the targets during the study phase. None of the items, however, appeared in the original locations of either target or context words and the list positions of the studied items were equally distributed across the recognition trials.

Procedure

The study procedure was identical to that of Experiment 1. Immediately following the presentation of all 40 word pairs, participants were asked to complete a series of simple subtraction problems for approximately 1 minute as an interpolated distracter task. Participants were then given brief on-screen instructions about the ensuing 4 alternative forced choice recognition task. They were told that they would see groups of four words and that each group contained one of the words from the study phase. At this point participants were also partially debriefed and told that their memory would be tested for both target and context items. No mention was however made about the manipulation of the relatedness of the words in each pair. Participants were asked to try and identify which of the words had been presented during study or guess if they were unsure. The participants' oral responses were recorded via response-keys and stored for later analysis.

Results and Discussion

For the analysis of the data four recognition scores were computed for each participant. These were the proportions of correctly identified target items from related and unrelated word pairs and the respective proportions of correctly identified context items from these pairs. The data set out in Figure 2 depict the group averages for these data and a preliminary analysis showed that recognition performance for all four classes of stimuli was significantly above the 25% chance level (all ts > 3.1, d.f. = 19, p < 0.02). A 2 (Group) x 2 (Word Type) x 2 (Pair Type) mixed ANOVA of the data set out in Figure 1, revealed main effects for Word Type ($F(1,38) = 96.96$, $p < .001$) and Pair Type ($F(1,38) = 18.19$, $p < .001$) indicating that participants recognised more target than context items and that their performance was better for items from related compared to unrelated word pairs. None of the other main effects or interactions was significant (all F's < 2.00). This pattern of results accords with work that shows that explicit memory of items is unimpaired in HFA under highly supported test procedures (Bowler, Gardiner & Berthollier, 2004). In line with our predictions, there were no significant effects or interactions involving the group factor indicating that memory for target and context items was similar across groups regardless of whether these items were meaningfully related or not.

Figure 2 about Here

It is clear from these findings that conceptual relations between studied and context words significantly increase rates of recognition. Contrary to the findings of Experiment 1 but in line with the TSH this effect was not attenuated in the participants with HFA, who were as affected by target-context relations as the comparison participants. This pattern of findings shows that the diminished use of semantic relations to aid free recall by such individuals does not extend to recognition, and supports the contention that semantic relatedness is, at least to some extent, encoded by people with HFA. This contrast between the influence of semantic relatedness on recall and recognition suggests that the way in which semantic relations are encoded in HFA is not adequate for these relations to be recruited to aid free recall.

General Discussion

Taken together, the findings of the two experiments show that when typical individuals are asked to study words in the presence of related or unrelated items, the degree of relatedness of the non-studied items affects levels of recall and recognition. For the participants with HFA however, the picture is somewhat different. Whereas their pattern of performance was similar to that of the comparison group when the test procedure involved recognition, relatedness of context did not enhance their performance when recall was required. This finding is in line with two phenomena documented in the literature on memory in ASD. The first is that conceptual relatedness tends not to enhance free recall either in high- or low-functioning individuals with ASD (Bowler et al., 1997; 2000b; Hermelin & O'Connor, 1967; Smith, Gardiner & Bowler, 2007; Tager-Flusberg, 1991, but see López & Leekam, 2003). The second phenomenon is that performance on memory tasks by people with ASD tends to be better when supported test procedures such as cued recall or recognition are employed, hence the Task Support Hypothesis (TSH). The present findings not only confirm an earlier study showing that the TSH applies to recognition and recall of incidentally-encoded material (Bowler et al., 2004), they also extend our understanding by showing that task support also operates at the level of *relatedness* between studied and incidentally encoded material. It would appear that although some aspects of the semantic relatedness are encoded by the HFA participants (otherwise target-context relatedness would not have enhanced recognition in Experiment 2), the manner in which these aspects are encoded is not sufficient to enhance free recall. The evidence for semantic effects in recognition is also in line with the majority of studies of associatively generated illusory memories which show that adults with HFA, when asked to study a list of strong associates of a non-studied target word will later falsely recognise the non-studied item (Bowler et al., 2000b; Gaigg & Bowler, 2007, but see also Beversdorf, Smith, Crucian, Anderson et al., 2000). It could be argued that the data shown in Figure 1 do not replicate the findings of Bowler et al, 2004, in that there is no diminished recall of either type of context in the HFA group. However, overall rates of context recall are low (<15%) and any differences may have been obscured by floor effects. It could also be argued that inspection of Figure 2 shows no relatedness effect for target items in Experiment 2. However, this observation is consistent with the TSH and with the majority of the evidence on recognition memory in HFA (Bowler et al., 1997; 2000a,b; Minshew & Goldstein, 2001). The TSH posits that HFA memory performance is undiminished when highly supported test procedures such as recognition are utilised. What the findings of Experiment 2 show is that despite the strong support provided at test, incidentally-encoded context was better recognised when it was related to the target items than when it was unrelated to them.

By confirming the TSH, the present findings further confirm the view that cognition in ASD is more rooted in the here-and-now rather than in information that has to be brought to mind in a way that is not immediately cued by the current situation. This characterisation of autistic cognition has potentially important implications for the design of intervention programmes, where attention needs to be paid to minimising the demands made on the individual's recall capabilities.

The differential effect of semantic relatedness on recognition and recall suggests that the conclusion made by Hermelin and O'Connor (1970) that children with autism fail to encode stimuli meaningfully may need to be revised. Rather than not encoding stimuli meaningfully, their meaningful encoding of material seems to occur in a manner that is less effective for unsupported retrieval. On the basis of current evidence, it is not possible to determine why this recall-recognition difference occurs. But if we consider the pattern of findings across tasks we can make some conjectures. Semantic relatedness seems to pose difficulties for people with ASD on tasks that involve free recall. Recognition-based tasks, such as those used to generate memory illusions reveal no such differences. In a recognition-based memory illusion task, participants study a list of strong associates of a non-studied word. In a later recognition test, they usually report having studied that non-studied common associate. The usual interpretation of such findings (Beversdorf, Narayanan, Hillier & Hughes, in press) is that studied words activate a set of associated words and that the sets activated by each studied word overlap to some extent. The most activated associate of all the studied words is the illusory item, which is then falsely recognised. When recalling a set of semantically related items, participants face a more complex task; they have to bring words to mind, and relate each such word to its predecessors and to stored representations of what the predecessors might have had in common both amongst themselves and with the current item (category labels). The illusions paradigm involves a many-to-one relation between each studied word and its activation set, what Halford (1992) calls *binary relations*. By contrast, recall of related items involves processing not only inter-word relations, but also relations between each word and its category label. Processing of this kind involves what Halford calls *ternary relations*. There is some evidence that children with ASD are delayed in their mastery of problems involving ternary relations, such as unexpected transfer, 'Sally-Anne' type false belief tasks (Baron-Cohen, Leslie & Frith, 1985). Such tasks, although commonly thought of as measures of mental state understanding, have been shown to embody ternary relations (Andrews, Halford, Bunch et al., 2003), and correlate highly with similar, equally complex tasks that do not embody either mental states (Sabbagh, Moses & Shiverick, 2006) or people (Bowler, Briskman, Gurvidi & Fornells-Ambrojo, 2005). Bowler et al. (2005) also showed that children with ASD were as delayed in their performance on non-mental-state as they were on mental state versions of such tasks, suggesting that it was the ternary complexity that was problematic for them. The identification of ternary complexity as a possible explanation for the patterning of memory in ASD further refines the conclusions of Minshew and colleagues (e.g. Minshew & Goldstein, 2001) who argue that individuals with ASD only become evident when the complexity of the to-be-remembered material increases.

The findings of the present two experiments are also consistent with the speculation by Minshew and Goldstein about the differential involvement of hippocampal and frontal systems in memory in ASD. The diminished performance on recall but not recognition has parallels with patterns seen in individuals with frontal lobe damage and the link with semantic relatedness implicates the medial temporal lobe and the hippocampus in particular. Medial temporal lobe structures such as the parahippocampal gyrus and the perirhinal cortex are generally thought to be implicated in memory for individual items of experience, whereas the hippocampus is responsible for memory for episodically-defined clusters of these items. Our finding of diminished memory for context only when it was semantically related to study items and only at recall suggests limited hippocampal involvement. Because this structure is implicated in episodic relational encoding, more extensive involvement would have affected recognition both of related and unrelated context. Intact recognition suggests that adjacent structures, such as perirhinal cortex , which typically encode individual items, are intact. What remains to be explained in neuropsychological terms is how relatedness between studied and context items continues to exert an enhancing effect on recognition despite its relative ineffectiveness in recall. Although there is evidence that hippocampal damage can produce impairments in recognising which of two studied items had been paired with a test item (Brown & Aggleton, 2001), this was not exactly what was tested here. Experiment 2 measured recognition of individual items rather than their specific relations, and as such, was not directly testing the relational processing thought to be mediated by the hippocampus. The present findings might better be accounted for by the argument made earlier, that the difficulty may lie with the more complex nature of the recall task. This account suggests that the difficulty lies in the area of executive functions that are mediated by the frontal lobes.

To conclude the findings of the present two studies confirm the fact that people from the autism spectrum have greater need of task support in situations where semantic relations between incidentally-encoded and studied material are of a kind that typically enhance memory. As such the findings represent an extension of the task support hypothesis to the role of meaningfulness in memory for context. They are also consistent with frontal lobe as well as some limited medial temporal lobe involvement. The question of why support is needed and why its absence diminishes the role of relatedness on recall is not answered by the current findings, but they are consistent with an analysis of recognition and recall tasks in terms of the complexity of processing they require.

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Table 1

Age and IQ scores for the HFA and Comparison groups in Experiment 1

	HFA (N = 20)		Comparison (N = 20)	
	Mean	SD	Mean	SD
Age (yrs)	35.66	13.66	34.38	12.16
VIQ[a]	107.35	18.10	106.96	14.32
PIQ[b]	108.58	21.35	106.28	18.56
FIQ[c]	108.79	21.63	107.22	17.27

[a]Verbal IQ (WAIS-R$^{\text{UK}}$ or WAIS-III$^{\text{UK}}$)

[b]Performance IQ (WAIS-R$^{\text{UK}}$ or WAIS-III$^{\text{UK}}$)

[c]Full-Scale IQ (WAIS-R$^{\text{UK}}$ or WAIS-III$^{\text{UK}}$)

Table 2

Age and IQ scores for the HFA and Comparison groups in Experiment 2

	HFA (N = 20)			Comparison (N = 20)	
	Mean	SD		Mean	SD
Age (yrs)	31.80	11.23		34.52	11.92
VIQ[a]	100.35	17.88		103.45	16.06
PIQ[b]	94.79	19.04		101.05	12.38
FIQ[c]	96.16	18.25		101.06	13.25

[a]Verbal IQ (WAIS-R^{UK} or WAIS-III^{UK})

[b]Performance IQ (WAIS-R^{UK} or WAIS-III^{UK})

[c]Full-Scale IQ (WAIS-R^{UK} or WAIS-III^{UK})

Figure 1

Proportions of correctly recognised Target and Context items as a function of Pair Type and Group in Experiment 1.

Figure 2

Proportions of correctly recognised Target and Context items as a function of Pair Type and Group in Experiment 2.

Figure 1

Proportions of correctly recalled Target and Context items as a function of Pair Type and Group in Experiment 1.

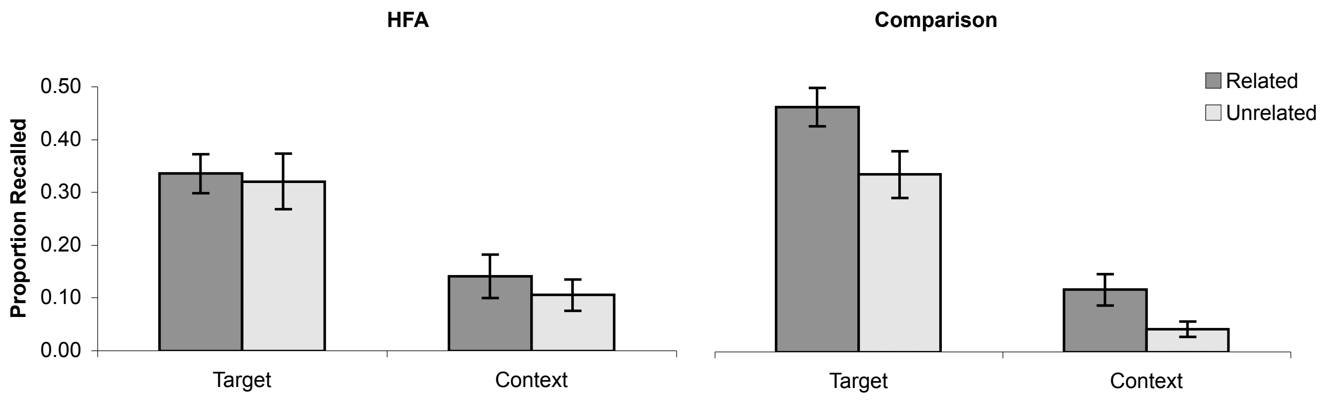

Figure 2

Proportions of correctly recognised Target and Context items as a function of Pair Type and Group in Experiment 2.