Different Verbal Learning Strategies in High-Functioning Autism: Evidence from the Rey Auditory Verbal Learning Test.

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Abstract

The Rey Auditory Verbal Learning Test, which requires the free recall of the same list of 15 items over 5 trials, was administered to a group of high-functioning adolescents and adults with autism spectrum disorder (PDD) and a group of matched typical individuals. Overall levels of free recall were comparable in the two groups, as were the rates of learning over trials. Both groups also subjectively organised their recall to a similar extent. However, the serial position curve of the PDD participants, although similar to that of the comparison group on the first trial, became flatter on subsequent trials and was characterised by a slower growth in the primacy effect. Growth in the middle and recency portions of the curve was comparable in both groups. The findings are discussed in the light of current models of serial position effects and their implications for memory in ASD.

The memory capabilities of individuals with ASD and average intelligence (PDD) , show a particular profile of performance across test procedures. Levels of performance that are generally comparable to those of typical individuals are seen on single-trial measures of free recall (Bowler, Matthews & Gardiner, 1997; Minshew & Goldstein, 1993; 2001), recognition (Bowler, Gardiner & Grice, 2000a; Bowler, Gardiner, Grice & Saavalainen, 2000b; Bowler, Gardiner & Gaigg, 2007, but see Bowler, Gardiner & Berthollier, 2004), cued recall (Bowler et al., 1997), recognition of source (Bowler et al., 2004), perceptual priming (Bowler et al., 1997) and conceptual priming (Gardiner, Bowler & Grice, 2003). There is, however, a difficulty with free recall when semantic relations among the studied words are available to aid recall (Boucher & Warrington, 1976; Bowler et al., 1997; 2000b; Smith, Gardiner & Bowler 2007, Tager-Flusberg, 1991 but see Leekam & Lopez, 2003). Recall of unrelated items is also diminished on the later trials of multi-trial, free recall learning paradigms (Bowler, Gaigg & Gardiner, in press; Minshew & Goldstein, 1993). There is also some evidence that even when overall free recall performance is undiminished, serial position effects are different in individuals with PDD (Renner, Klinger & Klinger, 2000) with the PDD group exhibiting diminished primacy and enhanced recency effects.

The interpretation of this pattern of serial position effects depends on the theoretical perspective taken on why serial position effects occur in free recall. The classic two-store or modal model of memory (Atkinson & Shiffrin, 1968) argues that recency effects reflect the contents of a short term store and that primacy effects result from transfer of learned information to longer-term

memory through a process of elaborative rehearsal. Other theorists, such as Bjork and Whitten (1974) and Crowder, 1976) eschew the distinction between short and long term memory stores and argue that serial position effects result from factors such as distinctiveness of studied items; more recently studied items are more distinctive than those studied at the start of the list. According to this view, rehearsal during learning serves to enhance the distinctiveness of rehearsed items, and Tan & Ward (2000) have shown that primacy effects result from a patterning of rehearsal that repeats only the earlier list items, thereby enhancing their distinctiveness. Both the multi-store, modal model and the distinctiveness account share the view that rehearsal is an important determinant of primacy effects, and the diminished primacy effects sometimes seen in ASD would suggest atypical patterns of rehearsal in this population. The only systematic study of rehearsal in individuals with ASD is that of Smith et al. (2007) who found no differences either in rehearsal set size or number of rehearsal repetitions by adults with PDD in a free recall paradigm, but Smith et al. did not analyse rehearsal behaviour in terms of serial position effects.

The notion that individuals with PDD process items differently in paradigms involving multiple free recall trials is supported by the findings of Bowler et al. (in press), who employed a procedure developed by Tulving (1962). This procedure involved presenting adults with PDD with the same16-item list of unrelated words in a different order on 16 trials and asking them to free recall as many items as possible after each presentation. Typical participants recalled more items on each trial and showed subjective organisation of the

learned material, that is, the order in which they recalled items tended to be similar across trials. Moreover, their subjective organisation tended to converge over trials, suggesting that shared semantic categories were used to constrain recall in the non-autistic sample. Individuals with PDD, however, learned the list less effectively over trials. And although they subjectively organised the material, their inter-participant patterns of organisation did not converge over trials in the same way as in typical individuals. This suggests that each individual PDD participant organised their recall on the basis of idiosyncratic stimulus features. We can speculate that such idiosyncratic organisation patterns may have implications for the patterning of these participants' serial position curves.

Atypical patterning of serial position curves has also been reported in other clinical groups. In the context of ASD, the findings of Eslinger and Grattan (1994) on patients with frontal lobe damage are of particular interest. Damage to the frontal lobes produces a similar patterning of memory processes (generally spared recognition and cued recall, with some impairment to free recall) as is seen in PDD. Eslinger and Grattan administered the Rey Auditory Verbal Learning Test (RAVLT) to adult participants with lesions to the frontal or non-frontal (temporal, parietal and occipital) regions of the brain. The RAVLT involves asking participants to recall a list of 15 semantically unrelated words presented orally in the same order on five consecutive trials. Although overall rates of recall were similar for frontal and non-frontal groups, the frontal group showed flatter serial position curves on later trials. Learning by the non-frontal participants tended to occur

in the primacy and recency portions of the curve in contrast to the frontal group, where it occurred in the middle items. Eslinger and Grattan also report marginally diminished subjective organisation in the frontal group, in particular those with dorsolateral rather than orbital-frontal lesions.

As individuals with all forms of ASD have been shown to have diminished performance on some tests of executive functioning that are thought to be mediated by the frontal lobes (see Hill, 2004), we can predict that they would show similar patterns of performance on the RAVLT as were found for frontal patients by Eslinger and Grattan (2004).To test this prediction, we administered the RAVLT to a group of adolescents and young adults with high-functioning ASD and a comparison group matched on verbal IQ and chronological age.

Method

Participants

Twenty-one adolescents and young adults with ASD and average intelligence (including Asperger's syndrome) and 21 comparison participants took part in the study. The ASD participants were extracted randomly from the database maintained by the Clinique spécialisée des troubles envahissants du développement of Hôpital Rivière-des-Prairies in Montreal. All had a diagnosis of autistic disorder based on the Autism Diagnostic Interview (ADI) and the Autism Diagnostic Observation Schedule (ADOS). A diagnosis of Asperger syndrome was given in the absence of language delay (as measured by the ADI) and of echolalia, pronoun reversal or evident stereotyped language. Comparison participants with typical development and absence of history of autism of main psychiatric conditions in first degree relatives were recruited from a panel of typical participants maintained by the same institution. PDD and comparison participants were group matched on Verbal Mental Age, measured by Wechsler VIQ and chronological age. Details of age and psychometric scores are given in Table 1. None of the between-group differences was significant (all *t*'s < 1.4, d.f. = 40, all *p*'s > .2. All participants had French as their first language.

Procedure

Participants were administered the French version of the RAVLT (Lezak, 1983; Rey, 1964). This consists of a list of 15 words - TAMBOUR, RIDEAU, CLOCHE, CAFÉ, ÉCOLE, PARENT, LUNE, JARDIN, CHAPEAU, FERMIER, NEZ, DINDE, COULEUR, MAISON, RIVIÈRE (drum, curtain, bell, coffee,

school, present, moon, garden, hat, farmer, nose, turkey, colour, house, river). Participants were told that they would hear a list of words read out by the experimenter and that at the end of each list, they should try to say as many of the words they could remember. The list was then read out by the experimenter and the participant's responses recorded. This procedure was repeated on four further trials.

Results

Mean numbers of repetitions (PDD Mean = 1.00 (S.D. = 1.94), Comparison Mean = 0.62 (S.D. = 1.36)) (t < 1, n.s.) or extra-list intrusions (PDD Mean = 2.76 (S.D. = 2.59), Comparison Mean (2.52 (S.D. = 2.44)) (t < 1, n.s.) did not differ between groups. Mean recall rates for the first, middle and last 5 serial positions on trials 1 to 5 are summarised in Table 2. Analysis of these data using a 2 (Group) by 3 (Early, Middle, Late Serial Position) x 5 (Trial) mixed repeated measures ANOVA yielded significant main effects for Serial Position (F = 30.73, d.f. = 2,39, p < .001) and Trial (F = 95.99, d.f. = 2,39, p < .001) and the Group x Serial Position by Trial interaction (F = 2.48, d.f = 2,39, p < .035). None of the other main effects or interactions was significant (all F-values < 1.32). To illustrate the 3-way interaction, serial position curves for both participant groups over all trials are set out in Figure 1. These data are smoothed by averaging each serial position with the two adjacent to it. Inspection of these curves shows similar serial position effects for both groups on Trial 1. On Trial 3, the serial position effect is flatter for the PDD than the comparison participants and on Trial 5, both groups show similar performance on the recency and middle serial positions but the PDD group show a diminished primacy effect. Separate analyses of the serial position data (aggregating the first, middle and last 5 positions) for Trials 1, 3 and 5 for the PDD and comparison groups yielded the following results. On Trial 1, the PDD group showed a significant serial position effect (F = 5.71, d.f. = 2, 19, p < .02) and a significant quadratic trend (F = 10.20, d.f. = 1, 20, p < .01). The comparison group also showed a significant serial position effect (F = 5.07, d.f. = 2, 19, p < .02) and quadratic trend (F = 9.03, d.f. = 1, 20, p < .01). On

trial 3, the PDD group showed neither a significant serial position effect nor a quadratic trend (both *F*'s < 0.1). By contrast, the comparison group showed a significant serial position effect ($F = 9.20$, d.f. = 2, 19, $p < .001$) and quadratic trend ($F = 15.94$, d.f. = 1, 20, $p < .002$). On Trial 5, the PDD participants showed no significant serial position effect ($F = 2.77$, d.f. = 2, 19, *n.s.*) but a significant quadratic trend ($F = 3.18$, d.f. = 1, 20, $p < .04$) whilst the comparison participants showed both a significant serial position effect ($F = 4.53$, d.f. = 2, 19, $p < .03$) and quadratic trend ($F = 8.06$, d.f. = 1, 20, $p < .02$). In none of the analyses were the linear trends significant.

These results show that both groups show the expected serial position effect in free recall on Trial 1 but that over subsequent trials, although both groups learned an increasing number of words, the patterning of their recall is different, with the PDD group showing a flattening of the serial position curve and a slower evolution of the primacy effect over trials.

Subjective organisation was analysed using the method developed by Tulving (1962) including repetitions but ignoring extra-list intrusions. Mean subjective organisation did not differ between the two groups (PDD Mean = .29 (S.D. = .12), Comparison Mean = .29 (S.D. = .11) ($t < 1$, n.s.).

Discussion

The findings of the present investigation confirm and extend existing work on free recall learning in individuals with PDD. Earlier work has shown undiminished free recall on single trials for unrelated items in this population (Bowler et al., in press; Minshew & Goldstein, 2001; Renner et al., 2000). At first sight, the present findings appear to contradict those of the only other investigation of free recall learning in people with PDD (Bowler et al., in press). In that study moderately diminished recall in free recall learning was observed but the method differed from the one used here in two respects. First, there were fewer trials in the present study (5 vs 16); differences in the Bowler et al. study did not emerge until about the fifth trial. Second, Bowler et al. (in press) presented words in a different order on each trial, thereby making greater demands on memory processing. In fact, it could be argued that the Bowler et al. procedure was similar in its task demands to the recall of categorised lists, where items have to be re-ordered if recall is to be maximised. Thus the present findings contribute further evidence in support of the view that recall of semantically unrelated items is undiminished in PDD and that such individuals experience difficulty only when studied material has to be re-arranged in some way in order to maximise recall.

The levels of subjective organisation in the two groups are comparable to those reported by Bowler et al. (in press) and suggest that the PDD participants were engaging in some re-arrangement of the learned material over trials. It remains possible that the two groups were organising their

output on different bases, a speculation that becomes more plausible when we consider serial position effects.

The patterning of serial position effects over trials extends our understanding of underlying memory processes in PDD. In contrast with earlier findings such as those of Renner et al (2000), the PDD group did not show a diminished primacy effect on the early learning trials. However, on later trials, the difference between the early, middle and late serial positions diminished in this group and there was clear evidence of a reduction in primacy effects. This flattening of the serial position curve over trials, although not as dramatic as that observed by Eslinger and Grattan (1994) in frontal patients, nonetheless suggests that individuals with PDD process material differently during learning.

Neither the findings of the current study nor those of Bowler et al. (in press) can explain why individuals with ASD show diminished primacy effects. All we can say at present is that the patterning of their serial position effects over repeated learning trials makes their learning appear to be an extension of the recency effect. On the basis of both modal (Atkinson & Shiffrin, 1968) and distinctiveness (Crowder, 1976), rehearsal is thought to play an important part in the genesis of primacy effects. It may be the case that individuals with ASD do not engage in the semantic re-coding needed to transfer information to longer-term store, and that they rely instead on more perceptual aspects of the studied material. Alternatively, the patterning of their rehearsal may not enhance the distinctiveness of earlier list items. These two possibilities are

not mutually exclusive, and each has resonances with other theoretical positions in autism and memory research.

The enhanced perceptual functioning (EPF) hypothesis put forward by Mottron and colleagues (Mottron, Dawson, Soulières et al., 2006) argues that many psychological processes that occur at a higher, cognitive level in typical individuals are mediated by lower-level, perceptual processes in individuals with ASD. In the present context, increased recall on later trials would be mediated by perceptual aspects of the studied material rather than by its recoding into semantic categories that draw on existing knowledge from long term stores. This argument is supported by evidence from Bowler et al. (in press) who report a lack of convergence of subjective organisation in their PDD participants, by contrast with their typical group, whose organisation converged significantly over trials.

Not all free recall tasks yield primacy and recency effects. Recall of sequences of tasks performed by the participant (subject-performed tasks – SPTs) usually show diminished primacy and extended recency effects similar to those shown here on later trials by the ASD group. Zimmer, Helstrup and Engelkamp (2000) argue that the patterning of serial position effects seen in memory for SPTs is due to the fact that asking participants to recall enacted events promotes item-specific encoding and inhibits the relational encoding that is needed for the generation of primacy effects. In the context of ASD, a study by Gaigg, Gardiner & Bowler (in press) has shown diminished relational encoding and enhanced item-specific encoding in this population. It is

possible to speculate that in a verbal free recall task, participants with ASD may be treating the words as a series of motor acts or perceptual configuration, thereby without the mandatory activation of their semantic content. This would allow focusing on their distinctiveness, but would also have consequences on the patterning of their serial position effects.

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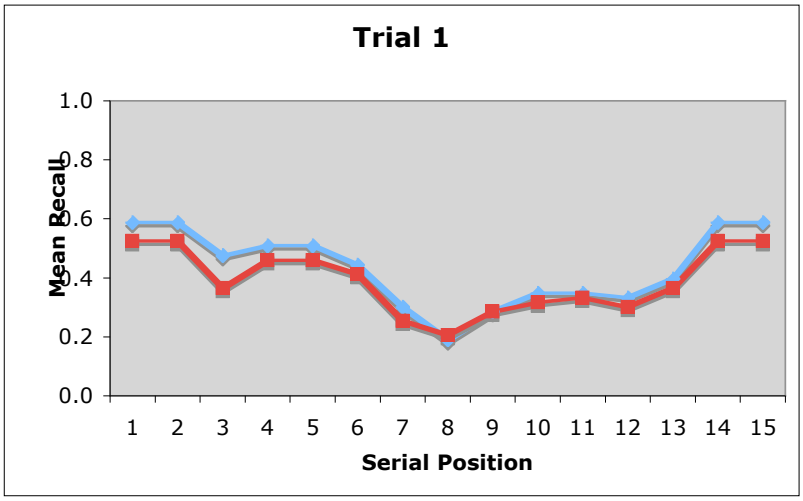
Table 1: Chronological Ages and IQ scores for the PDD and Comparison group.

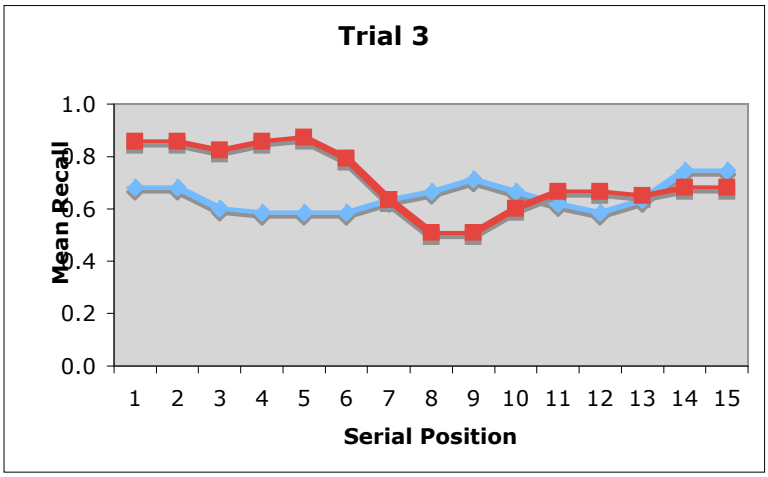
	PDD (N=21)			Comparison (N=21)		
	Mean	SD	Range	Mean	SD	Range
Age (years)	19	8.69	9-39	16	3.74	11-25
VIQ[a]	106	16.0	93-144	110	10.2	94-127
PIQ[b]	111	12.8	66-141	108	10.7	94-147
FIQ[c]	109	11.9	91-139	110	9.1	89-125

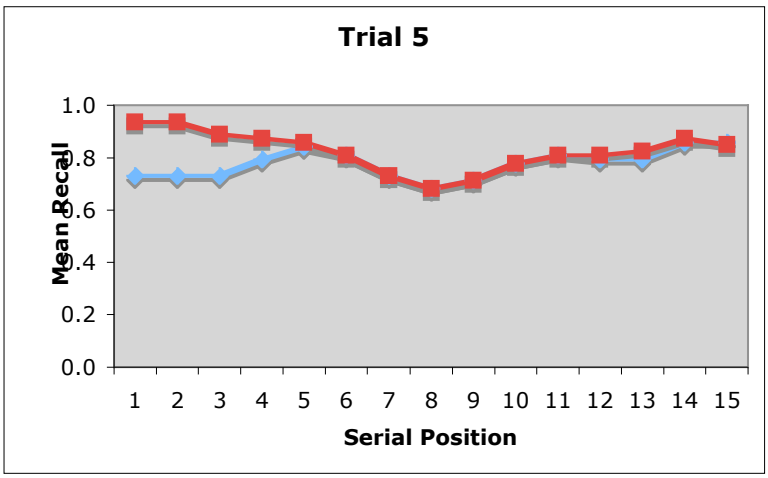
[a] Verbal IQ

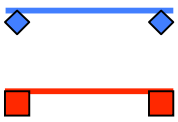
[b] Performance IQ

[c] Full-Scale IQ


Trial 1
Mean Recall
1.0
0.8
0.6
0.4
0.2
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Serial Position


Trial 3
Mean Recall
1.0
0.8
0.6
0.4
0.2
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Serial Position


Trial 5
Mean Recall
1.0
0.8
0.6
0.4
0.2
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Serial Position


PDD
Comparison