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Different Verbal Learning Strategies in Autism Spectrum Disorder: 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 unrelated words over 5 trials, was administered to 21 high-functioning adolescents and adults with autism spectrum disorder (ASD) and 21 matched typical individuals. The groups showed similar overall levels of free recall, rates of learning over trials and subjective organisation of their recall. However, the primacy portion of the serial position curve of the ASD participants showed slower growth over trials than that of the typical participants. The implications of this finding for our understanding of memory in ASD are discussed.

Keywords High-functioning ASD · Verbal learning · Free recall · Serial position effects · Memory

Introduction

The memory capabilities of individuals with autism spectrum disorder and average intelligence (ASD), 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 et al. 1997; Minshew and Goldstein 1993, 2001), recognition (Bowler et al. 2000a, b, 2004, 2007), cued recall (Bowler et al. 1997), recognition of source (Bowler et al. 2004), perceptual priming (Bowler et al. 1997) and conceptual priming (Gardiner et al. 2003). There is, however, a difficulty with free recall when semantic relations among the studied words are available to aid recall (Boucher and Warrington 1976a, b; Bowler et al. 1997, 2000b; Smith et al. 2007; Tager-Flusberg 1991 but see also Leekam and Lopez 2003) as well as on the later trials of multi-trial, free recall learning paradigms (Bowler et al. 2008; Minshew and Goldstein 1993). There is also some evidence that even when overall free recall performance is undiminished, the differential patterning of recall across the positions of items in the study lists (serial position effects) are not the same in lower-functioning individuals with ASD (Renner et al. 2000) who were found to have diminished primacy (recall of early list items) and enhanced recency (recall of last list items) effects.

The interpretation of this pattern of serial position effects depends on the theoretical perspective taken on why such effects occur in free recall. The classic two-store or modal model of memory (Atkinson and 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 the distinctiveness of studied items, with more recently studied items being 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 (Tan and Ward (2000). Atypical serial position effects in ASD, therefore, suggest that material is rehearsed differently by such individuals.

Different processing of remembered material by individuals with ASD in paradigms involving multiple free

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recall trials is supported by the findings of Bowler et al. (2008). They employed a procedure developed by Tulving (1962) which involved presenting participants 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, the subjective organisation of individual participants tended to converge over trials, suggesting that shared semantic categories were used to constrain recall in the non-autistic sample. By contrast, individuals with ASD 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 ASD 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 ASD. 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 orbitofrontal lesions. Although much of the literature on frontal lobe involvement in ASD has implicated orbitofrontal and ventromedial areas (Dawson et al. 1998, 2002), there is also some evidence of dorsolateral involvement, especially on tasks with a working memory component (Minshew et al. 1999). Recent work by Loveland et al. (2008) has also shown diminished performance by individuals with ASD on tasks that measure dorsolateral prefrontal—hippocampal connectivity.

In view of the well-documented executive function difficulties seen in ASD (see Hill 2004 for review) we predicted that individuals with ASD would show similar patterns of serial position effects on the RAVLT as were found for frontal patients by Eslinger and Grattan (1994). Finding support for this prediction would also allow us to make inferences about underlying memory processes in ASD, particularly in the context of a task that is more complex than those typically employed with this population. To test the 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 (HRDP) 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 or main psychiatric conditions in first degree relatives were recruited from a panel of typical participants maintained by the same institution. All participants were given a consent form (approved by the Institutional Review Board of HRDP) to sign (a parent or legal guardian signed for participants under 18 years of age; participants and a parent (or legal guardian) both signed if participant was between age 14–18 and participants alone signed if over 18 years of age). ASD and comparison participants were group matched on verbal ability, 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, $df = 40$, all p's $> .2$. All participants had French as their first language.

Procedure

Participants were administered the French version of the RAVLT (Rey 1964: see Lezak 1983 for the English version). This consists of a list of 15 words that are presented

Table 1 Chronological Ages and IQ scores for the ASD and Comparison group

	ASD ($N = 21$)			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

on five consecutive trials. 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 were recorded. This procedure was repeated on four further trials.

All participants were tested by the same and the order of testing of ASD and comparison participants was random.

Results

Mean numbers of repetitions (ASD Mean = 1.00 (SD = 1.94), Comparison Mean = 0.62 (SD = 1.36)) (t 0.31, $df = 40$, NS) or extra-list intrusions (ASD Mean = 2.76 (SD = 2.59), Comparison Mean (2.52 (SD = 2.44)) ($t = 0.74$, $df = 40$, NS) did not differ between groups. Mean recall rates for the first, middle and last 5 serial positions on trials 1–5 are summarised in Table 2. Analysis of these data using a 2 (Group) by 3 (Early, Middle, Late Serial Position) × 5 (Trial) mixed repeated measures ANOVA yielded significant main effects for Serial Position ($F = 30.73$, $df = 2{,}39$, $p < .001$) and Trial ($F = 95.99$, $df = 2{,}39$, $p < .001$) and the Group × Serial Position by Trial interaction ($F = 2.48$, $df = 2{,}39$, $p < .035$). 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 Fig. 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 ASD than the comparison participants and on Trial 5, both groups show similar performance on the recency and middle serial positions but the ASD group show a diminished primacy effect. Separate analyses of the serial position data (aggregating the first, middle and last 5

Table 2 Mean numbers of items recalled in early, middle and late serial positions over trials (Max = 5)

Trial		1			2			3			4			5		
Group		Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
ASD	Mean	2.86	1.76	2.43	3.62	2.38	3.29	3.48	3.48	3.57	4.24	3.57	3.95	4.14	3.81	4.43
	(SD)	(1.28)	(1.14)	(1.03)	(1.32)	(1.16)	(1.31)	(1.25)	(1.08)	(1.16)	(0.94)	(1.33)	(1.12)	(1.06)	(0.87)	(0.93)
Comp	Mean	2.7	1.38	2.19	3.48	3.00	2.67	4.33	3.00	3.43	4.48	3.62	4.00	4. 52	3.71	4.43
	(SD)	(1.08)	(1.07)	(1.40)	(0.81)	(1.26)	(1.20)	(0.66)	(1.18)	(1.08)	(0.60)	(1.07)	(1.10)	(0.81)	(1.01)	(0.89)
Total	Mean	2.71	1.57	2.31	3.55	2.69	2.98	3.90	3.24	3.50	4.36	3.60	3.98	4.33	3.76	4.33
	(SD)	(1.18)	(1.10)	(1.21)	(1.07)	(1.10)	(1.25)	(0.95)	(1.13)	(1.12)	(0.77)	(1.20)	(1.11)	(0.94)	(0.94)	(0.91)

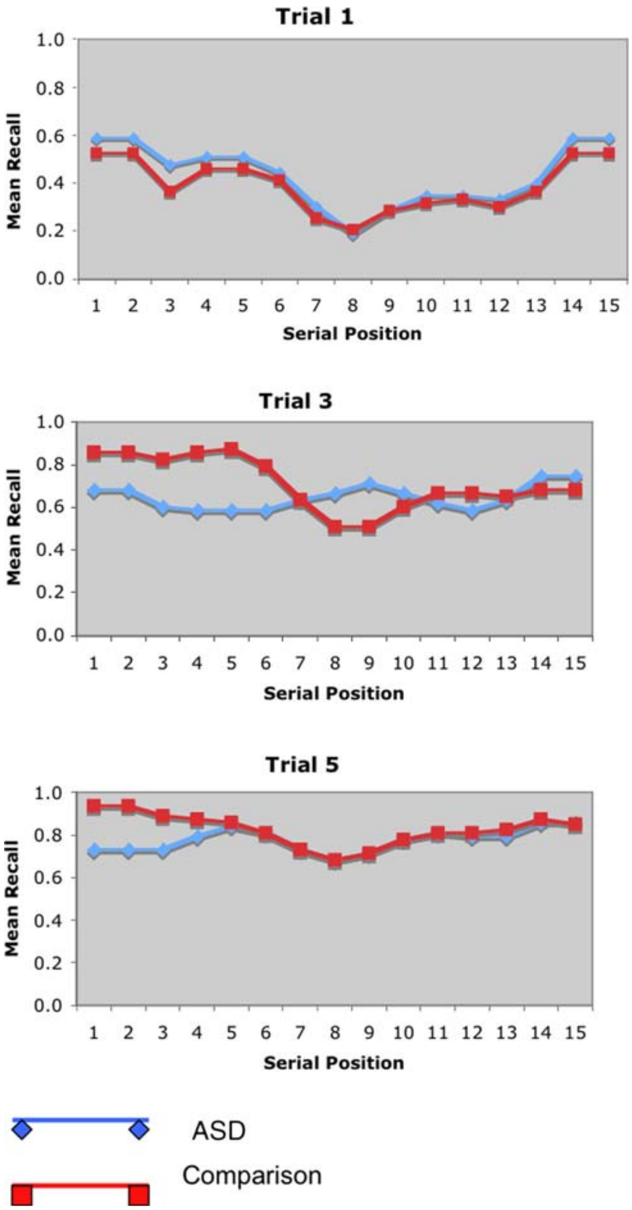

Fig. 1 Serial position curves for both groups on Trials 1, 3 and 5

positions) for Trials 1, 3 and 5 for the ASD and comparison groups yielded the following results. On Trial 1, the ASD group showed a significant serial position effect ($F = 5.71$, $df = 2, 19$, $p < .02$) and a significant quadratic trend ($F = 10.20$, $df = 1, 20$, $p < .01$). The comparison group also showed a significant serial position effect ($F = 5.07$, $df = 2, 19$, $p < .02$) and quadratic trend ($F = 9.03$, $df = 1, 20$, $p < .01$). On trial 3, the ASD 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 ($F = 9.20$, $df = 2, 19$, $p < .001$) and quadratic trend ($F = 15.94$, $df = 1, 20$, $p < .002$). On Trial 5, the ASD participants showed no significant serial position effect ($F = 2.77$, $df = 2, 19$, NS) but a significant quadratic trend ($F = 3.18$, $df = 1, 20$, $p < .04$) whilst the comparison participants showed both a significant serial position effect ($F = 4.53$, $df = 2, 19$, $p < .03$) and quadratic trend ($F = 8.06$, $df = 1, 20$, $p < .02$). 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 ASD group showing a flattening of the serial position curve and a slower evolution of the primacy effect over trials.

Because of the potential impact of age and IQ on memory performance, correlations were calculated between these variables for the overall sample. Only the correlation with IQ was found to be significant ($r = .47$, $N = 42$, $p < .01$). In view of this association, the ANOVAs reported in the previous paragraph were repeated using IQ as a covariate, which resulted in the disappearance of all but one of the significant effects (largest $F = 2.67$, smallest $p = .12$). The only effect to survive covarying IQ was the 3-way Group × Serial Position × Trial effect ($F = 2.45$, $df = 8{,}32$, $p < .04$, $\omega^2 = .02$) illustrated in Fig. 1. This analysis shows that although learning and serial position effects are IQ-dependent to a similar extent in both participant groups, the different patterning of the evolution of the primacy effect in the ASD group, although small, is robust and independent of IQ.

Finally, 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 (ASD Mean = .29 (SD = .12), Comparison Mean = .29 (SD = .11) ($t = 0.02$, $df = 40$, NS).

Discussion

The findings of the present investigation confirm and extend existing work on free recall learning in individuals with ASD. They also show some similarities in the patterning of free recall over multiple trials in individuals with ASD and those with frontal lobe damage. Earlier work has shown undiminished free recall by people with ASD on single trials for unrelated items in this population (Bowler et al. (2008); Minshew and Goldstein 2001; Renner et al. 2000) and the present findings show that such comparable performance extends to a five-trial paradigm. Although this observation appears to contradict the findings of the only other investigation of free recall learning in people with ASD (Bowler et al. 2008), which reported moderately diminished recall in free recall learning, the method employed in that study differed from the one used here in two respects. First, there were fewer trials in the present study (5 vs. 16),and differences in recall did not emerge until after the fifth trial in the Bowler et al. study. Second, Bowler et al. (2008) presented words in a different order on each trial, thereby making greater demands on memory processing and rendering plausible the argument that the 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 ASD 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 tested here are comparable to those reported by Bowler et al. (2008) and suggest that the ASD 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 analysis of covariance reveals that the between-group difference in patterning of serial position effects over trials is robust and holds even when the effects of IQ are controlled. The serial position patterns of the ASD group echo to a limited extent those of Eslinger and Grattan (1994), and thus suggest some dorsolateral prefrontal involvement in memory in individuals with ASD. Second, in contrast to earlier findings such as those of Renner et al. (2000), the ASD group tested here did not show a diminished primacy effect on the early learning trials. However, on later trials they showed clear evidence of a reduction in primacy effects. This flattening of the serial position curve over trials suggests that individuals with ASD process material differently during learning. All we can say at present is that their learning appears to be an extension of the recency effect, whereby on successive trials they appear to ‘work backwards’ from the last-presented item rather than processing the material in a way that promotes preferential learning of the latest- and earliest-list items at the expense of those in the middle of the list. It may be the case that individuals with ASD do not engage in the semantic re-coding that the modal model (Atkinson and Shiffrin 1968) posits as necessary for transfer of information to longer-term store, and that they rely instead on more perceptual aspects of the studied material. Alternatively, following the distinctiveness model (Crowder 1976), 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 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 favours the modal account of diminished primacy effects. Alternatively, the differential primacy effects observed here may result from the tendency of people with autism to concentrate on processing individual elements in a memory task (item-specific processing, Hunt and Seta 1984). In the context of memory in typical individuals, Zimmer et al. (2000) argue that the diminished primacy and enhanced recency effects seen in recall of sequences of tasks performed by the participant results from 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 et al. (2008) has shown diminished relational processing (i.e. a the capacity to process separate items in terms of meaningful and associative relations among them) and enhanced item-specific processing (i.e. the capacity to process items in isolation, without reference to inter-item relations) 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 configurations, without the mandatory activation of the words’ relational, semantic content. This would allow focusing on their distinctiveness, but would also have the kinds of consequences reported in the present study on the patterning of their serial position curves. Such an account is also compatible with the enhanced perceptual functioning theory of Mottron et al. (2006).

The findings of the current study show a different pattern of change in serial position effects in a multi-trial free recall paradigm in individuals with ASD. They are consistent with a growing body of evidence showing that individuals with ASD process material in memory in a more item-specific manner rather than evaluating and using relations among items to enhance recall. The implications of such an account are that instructional materials and strategies designed for this population should take account of this differential imbalance between these two information-processing strategies. The next question for scientific investigation is to establish whether diminished relational processing reflects a genuine deficit in this population or is merely a consequence of a preference for processing individual items.

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