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A review of the verbal memory profile of individuals with autism spectrum disorder

Abstract

Behavioral studies concerning the memory of individuals with Autism Spectrum Disorder (ASD) have yielded inconsistent results over the past few decades. Some have found impairment where as others have reported an intact memory profile in ASD. Therefore, in the present review, we will examine the verbal memory profile of ASD. A systematic search has located 18 articles for review and analysis. It is suggested that ASDs mainly have an intact verbal recognition performance but impaired verbal recall ability. The conflicting memory performance found in ASD may probably be due to confounding factors, including differences in the experimental designs of research studies, the intellectual functioning levels of ASD and their developmental trajectories. In general, the memory processing of ASD is implicated by the frontal lobe function, and the memory problem is primarily caused by the poor utilization of organizational strategies during information encoding. A failure to encode the information properly will directly hinder their later retrieval performance. Finally, priorities for future research in the memory functions of ASD are suggested, and the need for more rigorous research paradigms is highlighted. With a more comprehensive understanding of the underlying mechanism of the memory functions of those with ASD, it is believed that better intervention programs can be developed to aid their memory deficits and to improve their daily-life performances.

Keywords: autism spectrum disorder, verbal memory, recall and recognition, task complexity, chronological age, functioning level

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Introduction

ASD is a neuro-developmental disorder characterized by disturbance in communication and social interaction, restricted interests, and stereotyped behaviors.[1] Previous findings have attributed the cause of ASD both to genetic contribution and environmental influences.[2,3] Yet, with the advancement in neuro-imaging techniques, there is now an even greater insight into the neurobiology perspective and more evidence of the involvement of the neuro-developmental component in ASD.[4,5] The prevalence of ASD has been increasing during the past decades. A study has found that the number of diagnosed cases of ASD in the 2000s is double that of the prevalence rate as reported in the1980s.[6] Apart from the genuine rise in the number of children with ASD, greater awareness and changes in the diagnostic criteria have contributed to an increase in the cases reported.[7,8] The current estimation of the rate of individuals with ASD has increased to 110 per 10,000.[9]

Autism Spectrum Disorder as a Frontal Disorder

Higher cortical functions have been reported to be impaired in the ASD population, yet their severity has varied. Whereas some individuals with ASD show severe impairments in general, others show isolated cognitive dysfunctions.[10,11] In recent years, three key common theories have been explored in an attempt to explain the brains and the behaviors of those with ASD. First, is the theory of mind deficit.[12] Neuro-physiological studies and neuro-imaging have confirmed that children with ASD develop their theory of mind much more slowly than normal developing children and show less activation of the brain regions corresponding to their theory of mind.[13–16] Second, is the theory of weak central coherence? This theory suggests that individuals with ASD have a special information processing style rather than a deficit.[10,17,18] However, further investigations of the brain basis of central coherence are required to confirm this idea. Although these two theories together have explained many deficits and characteristics of ASD, the executive dysfunction theory might be the best one to account for ASD on its own. It has been suggested that ASD is a frontal disorder of the executive dysfunctions.[19] There are similarities in cognitive and behavioral presentations between individuals with ASD and individuals with frontal lesions. The abnormalities found in individuals with ASD, such as the lack of motivation to communicate, poor social interaction, and repetitive behaviors, are suggested to be related to the atypical functioning of the frontal lobe[20–22] for review.

Memory and Frontal Lobe

The frontal lobe is located in the anterior part of each cerebral hemisphere of the brain. It is the largest structure in the brain and it constitutes about one–third of the whole brain volume. The frontal lobe is thought to play a central role in the executive control of the higher cortical functions such as memory, planning, and organization capability.[23–25] In 1935, it was first suggested that the frontal cortex was involved in memory. A study on frontal-lobe–lesioned monkeys found that they perform well on immediate response but that they fail when delayed [26] and for human beings with frontal injuries, they perform normally on classic memory tests.[27–28] but on examination with extend neuropsychological memory assessments, the results show that there is a close relation between the frontal lobe and memory.[29–31,25,26]

It has been suggested that the frontal cortex plays a central role in organizing memory.[32–34] This is crucial in facilitating memory encoding and retrieval, especially when there is a large amount of information to remember. The behavioral data of patients with frontal lobe dysfunctions or lesions have further implicated the role of the frontal lobe in selecting and initialing an organizational strategy to enhance the encoding of new information and retrieval.[35–38] In addition, in Positron Emission Tomography (PET) studies, the encoding and

retrieval of verbal information have led to prefrontal activation in which encoding has been more dependent on the left prefrontal cortex.[39,40] The regional cerebral blood flow in the frontal regions was found to be correlated with the rate of encoding.[41] The faster the rate of encoding, the larger the amount of blood flows to the frontal regions when it consumes more energy. One study has also suggested that when the encoding materials require self-organization, the activation of the dorsal–lateral prefrontal cortex would even be greater.[42] In other words, when the materials are presented in a random order, the effort to rearrange them into categories based on their semantic relations requires the involvement of the prefrontal cortex. When individuals lose the ability to self-organize the presented materials, it may result in poor memory performance. Some studies have found that memory encoding deficits would lead to retrieval deficits.[43,44] If the information is not learnt in an effective way, there will be greater interference and memory loss during the process.

Role of Frontal Lobe Function Implicated in Memory Processing of ASD

There is increasing evidence of the involvement of the frontal lobe in the memory processing of ASD. The results of neuropsychological testing on individuals with ASD are suggestive with regard to the frontal-lobe-related memory deficits. Individuals with ASD are reported to adopt less effective strategies to facilitate memory encoding and retrieval than normal developing individuals. There is evidence to support that ASD individuals have reduced neural connectivity and information processing deficits when utilizing cognitive strategies for the efficient encoding of information.[45] With a failure to initiate organizing strategies, ASD individuals would learn new materials inefficiently and show a greater impairment when the complexity of the materials increases.[46,47] They cannot use category information to aid their recall.[48] Various studies have also shown that ASD individuals utilize a different organization and processing of memory from normal developing individuals.[49,50] These memory performances found in individuals with ASD are parallel to individuals with dysfunctional or damaged frontal lobes.

Memory in Autism

Memories being commonly known as the ability to store retain and recall information and experience, is related to everything in our lives. We are constantly making decisions and basing our actions on them. Over the past few decades, the memory performance of ASD individuals has been widely investigated. However, the results are inconsistent across different studies. Verbal memory is a broad term which commonly refers to the memory of language in its various forms. It is typically assessed by neuropsychological tests that measure the memory of a list of words, sentences or even a comprehensive story. To mention a few, the California Verbal Learning Test,[51] the Hong Kong List Learning Test (HKLLT),[52,53] the Rey Auditory Verbal Learning Test[54,55] and the Verbal Intelligence Scale (VIQ) from the Wechsler Adult Intelligence Scale – Revised (WAIS) – R[56,57] are widely used verbal memory tests. There have been numerous studies which investigate the verbal memory functions of individuals with autism over the past years, but the results have been inconclusive. It may therefore be beneficial to review the previous articles to enhance our understanding of verbal memory functions in ASD individuals. With a closer examination of each of the studies, it may be possible to ascertain the reasons which lead to the different results and hence provide more clues for further studies. Interventions and special services may develop accordingly to assist them to perform better in their daily lives.

Method

The articles for examination were identified through a comprehensive literature search from various academic search engines, namely, PsycINFO, MEDLINE, and Embase. Six-hundred-and-twenty-seven articles resulted from this search 174 from PsycINFO;277 from MEDLINE; and 176 from Embase. These articles were identified by key words searches by combining terms of verbal memory, verbal recall, verbal learning, verbal recognition, autism, autistic, and Asperger syndrome. Studies on individuals with comorbid ASDs and other developmental disorders were excluded from the analysis. Only empirical studies with measures of verbal memory performance of ASD were selected. In addition, studies are required to include age and verbal ability matched control as reference to ensure a fair comparison with the verbal-performance ASD. Finally, 19 studies were chosen and included for analysis (Figure 1).

Discussion

Performance on Verbal Recognition

The performance on verbal recognition is considered to be more consistent. Most of the reviewed studies have reported that verbal recognition of ASD is intact.[58–61] When ASD individuals were provided with a new list of words to recognize and then asked whether the items have been previously presented or not, their performance on correct identification was comparable with normal developing individuals. ASD individuals were able to achieve a performance comparable to that of normal developing individuals even in a delayed recognition condition.[45,58,60] It is suggested that ASD individuals were able to consolidate and store the information which is mediated by the temporal lobes.[62] In addition, there also is evidence which shows that ASD individuals commit similar levels of conservative response bias when compared with normal developing individuals in verbal recognition tasks. This indicates that both normal developing individuals and ASDs have a tendency to favor "no" responses and this suggests that both groups are using similar decision criteria on verbal recognition. In other words, they use similar verbal recognition strategies.[60] However, ASDs have also been reported to commit more false alarm errors, and this indicates that they are more susceptible to interference from irrelevant information.[63]

Performance on Verbal Recall

Regarding the performance of ASDs on verbal recall, previous literatures have reported inconsistent results. Nevertheless, it is believed that there are some degrees of impairments in general. A number of reviewed studies have reported that ASD individuals were impaired in verbal recall tasks.[45–46,48,58-60,63–65] ASDs showed poorer performance on free recall, and the severity of impairment increased from single word recall to sentence recall and then to story recall. However, there were no differences between the performance of immediate free recall and long-delayed recall.[45,61] It is suggested that individuals with ASD were able to maintain the information stored once they have encoded it accordingly. On the other hand, individuals with ASD, but not the normal developing individuals, have shown improvement from free to cued recall. When they were provided with external support during the retrieval of information, they were able to achieve better performances.[58,61] It gives concrete evidence to support the Task Support Hypothesis (TSH).[65]

Problems of Encoding and Retrieval

Verbal memory deficits in ASDs may be caused by the impairments in encoding and retrieval of information this is asthe majority of

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studies have suggested. They have given evidence to support that there is reduced neural connectivity and information processing deficits in utilizing cognitive strategies for the efficient encoding of information in autistic individuals.[45] With a failure to initiate proper organizing strategies, ASD would not be able to learn new materials efficiently and hence show a greater impairment when the complexity of materials increased.[46,47] It seems that ASDs fail to categorize the information to aid their recall.[48] Studies have also shown that ASDs utilize an organization and processing of memory which is different from normal developing individuals.[49,50] Therefore, more studies will have to be done to achieve a deeper understanding of its underlying mechanism.

In addition to encoding problems, ASDs suffer from difficulty in retrieving information. Several studies have shown that ASDs who were impaired in the free recall of words or stories were able to perform as well as normal developing individuals when given cues or recognition choices.[45,58] This provided concrete evidence that ASD individuals have difficulties in retrieving information. Research with a more vigorous paradigm design will provide more concrete evidence for these claims.

Confounding Factors

The inconsistent findings in verbal memory functions of an individual with ASD may also be attributed to the following confounding factors.

Experimental Design: Task complexity would greatly affect the results obtained in different research studies. For example, simple tasks, such as digit span and letter or word recall, would not impair the performance of ASDs.[58,66,67] These studies may not therefore be able to find impairment on verbal memory in individuals with ASD when compared with normal developing individuals. In addition, some studies have employed fewer verbal materials and they have also been restricted to simple common words moreover, these studies have also reported intact verbal performance in ASD individuals.[49] However, these studies may have overestimated the verbal memory ability of ASDs.

Developmental Trajectories: The chronological age of the ASDs is another factor which contributes to the inconsistent findings on their verbal memory performance. Evidence has shown that the verbal memory impairment is more severe in the younger ASD population. Simple tasks, such as letter or number recall, have been reported to show impairment in ASDs with a mean age of 6.5[46] whereas it has been reported as intact in teenage and adult samples.[58,67] A study which included both adults with ASD and children/adolescents with ASD also reported that children/adolescents with ASD react more slowly when they give the correct responses in different tasks which examine verbal memory performance.[67] It is suggested that this may be due to the plasticity of the developing brain in children/adolescents with ASD when they adjust to and accommodate their inborn memory deficits. Therefore, children/adolescents with ASD may have a profounder impairment in verbal memory functions than their adult counterparts.

Level of Functioning: Various studies have found that low-functioning ASD individuals Lo–AUT perform worse than high-functioning ASD individuals (Hi–AUT) in verbal memory performance.[63] Most of the studies did not classify their ASDs into Hi–AUT and Lo–AUT, and therefore they blurred the real situation. There should be an association between the level of functioning and the verbal memory functions, i.e., the higher the intelligent quotient of the ASD, the better the verbal memory performance. In addition, two studies administered the same test; the group of children with ASD achieving a lower Verbal IQ showed impairment whereas the other one showed intact verbal memory performance [58,61]. Therefore, it is suggested that the level of functioning would also be a possible confounding factor in the inconsistent results on verbal memory performance of ASDs (Table 1).

Table 1 Selected research articles for review

Reference	Groups	Sample Size	Age (Years)	Matched Criteria	Measures of Verbal Memory	Impairments found in Autistic Sample
Williams DL et al.[67]	Normal (Adult)	25	26.8	Age, FSIQ,VIQ,& PIQ	N – Back Letter Task	
	Normal (Children)	44	12.4		Wechsler Memory Scale	No
	Hi–AUT (Adult)	31	26.6		- Letter Number	
	Hi–AUT (Children)	24	11.8		WRAML	No
					- Number/Letter	No
Bowler DM et al.[69]	Normal	21	16	Age,VIQ, Mother Language	RAVLT	No
	High–AUT	21	19			
Whitehouse AJO et al.[70]	Normal	20	8.3	Verbal Mental Age & Reading Ability	Recall Task with Print Word Stimuli	No
	ASD	20	10.9			
Tyson K et al.[71]	Normal	34	13.9	Age, Gender, &N-VIQ	CVLT-2nd Edition II/#CVLT–Children's Version	Yes
	Optimal–AUT	34	12.8			
	High–AUT	44	13.9			

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Table Continued...

Reference	Groups	Sample Size	Age (Years)	Matched Criteria	Measures of Verbal Memory	Impairments found in Autistic Sample
Andersen PM et al.[72]	Normal	50	11.6	Age & VIQ	WISC- IV	
	ADHD	79	11.6		Letter Number Sequencing Test	Yes
	High–AUT					
	with ADHD	16	12.2		HVLT-R	
	without ADHD	22	11.9			Yes
					Acquisition	Yes
					Recall	
Geurts HM & Vissers ME[73]	Normal	23	63.7	Age, Gender, &DART-IQ	RAVLT	No
	High–AUT	23	63.6			
Williams, DL et al. [74]	Normal	38	12.2	Age, VIQ, PIQ, FSIQ, & SES	WISC-III	No
	High – AUT	38	11.7			
					Digit Span	No
					WRAML	Yes
						Yes
					Number/ Letter	No
					Sentence memory	
					Story recall	
					Verbal learning	
Jones CRG et al.[59]	Normal	55	15.5	Age, VIQ, PIQ,& FSIQ	Children's Auditory Verbal Learning Test -2 (CAVLT – 2)	
	ASD	94	15.5			
					Immediate Memory Span	Yes
					Delayed Recall	No
					Recognition Accuracy	No
Sumiyoshi C et al.[48]	Normal(Age-matched)	15	29.7	Gender	Verbal Learning Task	Yes
	Non-affected Siblings	14	24.5			
	ASD	22	26.5			
Cheung MC, et al.[63]	Normal	22	10	Age, Gender, &Handedness	The Hong Kong List Learning Test	
	Hi–AUT	22	10.5			Yes
	Lo–AUT	16	10.3		Immediate Recall	Yes
					10-mins Delay Recall	Yes
					30-mins Delay Recall	Yes
					Recognition Test	
Phelan HL et al.[61]	Normal	15	12.4	Age, FSIQ, VIQ,& PIQ	CVLT–Children's Version	No
	Hi–AUT	15	13			
Lind SE & Bowler DM[60]	Normal	50	9.1	Age, Verbal Ability	Expressive One Word Vocabulary Scale	
	ASD	53	9.3			
					Recognition	No
					Source Memory (Recall)	Yes

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Table Continued...

Reference	Groups	Sample Size	Age (Years)	Matched Criteria	Measures of Verbal Memory	Impairments found in Autistic Sample
Gabig CS[46]	Normal	10	6.7	Age	Non-word Repetition	Yes
	Hi–AUT	15	6.5		Digit Span	Yes
					Sentence Imitation	Yes
					Story Recall (Index of propositions recalled & longest utterance length)	Yes
Whitehouse AJO et al.[66]	Normal	20	8.3	Verbal Mental Age, Non-verbal Mental Age, Reading Ability		No
		20	10.9		Explicit Verbal Recall Task	
	Age Comparison					
	Ability Comparison	20	10.9			
	Hi–AUT					
Toichi M & Kamio Y49	Normal	24	20.8	Age, VIQ, & PIQ, & Non-verbal Reasoning Ability	Free Recall	No
	ASD	24	20.4			
Toichi M & Kamio Y[50]	Normal	25	20.2	Age, VIQ,&PIQ, & Non-verbal Reasoning Ability	Word Completion Task	No
	ASD	25	20.3		with Indirect Priming	
Bennetto L et al.[58]	Clinical Comparison	19	16	Age, Gender, Handedness, SES, FSIQ, VIQ, & PIQ	Temporal Order Memory (Words)	Yes
	Group				Recognition Memory (Words)	
	Hi – AUT	19	15.2			No
					CVLT-Children Version	
					Learning ability	No
					Retention	No
					Immediate/Delayed Recall	Yes
					Immediate/Delayed Cued Recall	No
					Delayed Recognition	No
					Sentence Span & Counting Span	Yes
					Digit Span	No
Bowler DM et al.[65]	Normal	16	33.3	Age & VIQ	Word Recall Task	Yes
	AS	16	31.2		Cued Recall	No
					Word Stem Completion	No
Minshew NJ[45]	Normal	33	21	Age, Gender, Race, SES,&FSIQ	CVLT	Yes
	High–AUT	21	20.7			

Note: #for children with an age of 17 or below.

High-AUT: High-functioning Autism; Low-AUT: Low-functioning Autism; AS: Asperger Syndrome; ASD: Autism Spectrum Disorder; ADHD: Attention Deficit Hyperactive Disorder; DART-IQ: Dutch adult reading test IQ; VIQ: Verbal IQ; N-VIQ: Non-verbal IQ; PIQ: Performance IQ; FSIQ: Full scale IQ; SES: Socio-economic status ; CVLT: California Verbal Learning Test; HVLT-R: Hopkins Verbal Learning Test – Revised; RAVLT: Rey Auditory Verbal Learning Test; WRAML: Wide Range Assessment of Memory and Learning; WISC: Wechsler Intelligence Scale for Children

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Conclusion

In the present article, we discovered that previous research studies have focused on Hi–AUT in which Lo-AUT individuals were rare. Several studies have combined Hi–AUT and Lo–AUT for analysis but there were no comparisons between them. Although some studies have preliminarily shown uneven memory abilities across the spectrum,[58,61,63] there is still an urgent need to implement more studies on Lo–AUT and to compare their performance with Hi–AUT in order to have a more comprehensive understanding of the verbal memory profile across the spectrum. Ideally, studies including both neuropsychological assessments and brain measures would potentially be able to identify the underlying mechanism leading to the memory deficit in ASDs. Added to that, most of the studies presented used either teenage or adult samples; more studies need to be done on children to keep track of the developmental changes in ASDs. Longitudinal studies of memory functions in ASDs would shed light on the developmental factors that may contribute to the impaired verbal memory performance in ASD. Memory development in normal individuals follows a well-documented trajectory[68] and ASD as a neuro-developmental disorder, it is suggested the delayed or abnormal memory development of ASDs in their early years may have cumulative consequences as they are growing up. More evidence is therefore required before a valid conclusion can be drawn. Finally, it has been suggested that ASD individuals are less efficient in initialing cognitive strategies to organize information. One study has reported an increase in performance from a recall of random word list to a categorized word list for ASDs. However, their performance nevertheless remained worse than that of normal developing individuals.[48] Further research with more vigorous experimental designs is required to support the claim, and we intend to devise interventions and measures to overcome the incapability of ASD individuals to initiate organization strategies. This will advance our theoretical understanding as well as yield practical value in enhancing the memory functioning of individuals with ASD and in improving their learning and academic performance.

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Conflicts of interest

Author declares there are no conflicts of interest.

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