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 whereas 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 19 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

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 the 1980s [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, it 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, it 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 dysfunctions 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 
functions [25,26,29-31].

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 
future implicated the role of the frontal lobe in selecting and 
initialing an organizational strategy to enhance the encoding of 
ew 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 are based 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 (CVLT) [51], the Hong 
Kong List Learning Test (HKLLT) [52,53], the Rey Auditory 
Verbal Learning Test [54,55], the Hopkins Verbal Learning Test - 
Revised (HVLT-R) [56] and the Children Auditory Verbal 
Learning Test [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 
the 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 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 worse 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 as the majority of 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 ASD 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 reported an intact verbal memory performance in ASD individuals because they have employed shorter task with stimuli restricted to simple common words [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).

**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.

### 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. | Normal (Adult)                  | 25          | 26.8        | Age, FSIQ, VIQ, & PIQ                | N-Back Letter Task                                              | No                                   |
| [67]               | Normal (Children)               | 44          | 12.4        | Wechsler Memory Scale                |                                                                  |                                      |
|                    | Hi–AUT (Adult)                  | 31          | 26.6        |                                      | - Letter Number                                                 | No                                   |
|                    | Hi–AUT (Children)               | 24          | 11.8        | WRAML                                |                                                                  |                                      |
| Bowler DM et al.   | Normal High–AUT                 | 21          | 16          | Age, VIQ, Mother Language            | RAVLT                                                           | No                                   |
| [69]               | 21                              | 19          |             |                                      |                                                                  |                                      |
| Whitehouse AJO et  | Normal ASD                      | 20          | 8.3         | Verbal Mental Age & Reading Ability  | Recall Task with Print Word Stimuli                             | No                                   |
| al. [70]           | 20                              | 10.9        |             |                                      |                                                                  |                                      |
| Tyson K et al.     | Normal Optimal–AUT              | 34          | 13.9        | Age, Gender, &N-VIQ                  | CVLT-2nd Edition II/#CVLT–Children’s Version                    | Yes                                  |
| [71]               | High–AUT                       | 34          | 12.8        |                                      |                                                                  |                                      |
|                    | 44                              | 13.9        |             |                                      |                                                                  |                                      |
| Andersen PM et al. | Normal ADHD                     | 50          | 11.6        | Age & VIQ                            | WISC- IV                                                        | Yes                                  |
| [72]               | High–AUT                       | 79          | 11.6        |                                      | - Letter Number Sequencing Test                                 |                                      |
|                    | - with ADHD                     | 16          | 12.2        | HVLT-R                               |                                                                  |                                      |
|                    | - without ADHD                  | 22          | 11.9        | - Acquisition                        |                                                                  |                                      |
|                    |                                  |             |             | - Recall                             |                                                                  |                                      |
|                    |                                  |             |             |                                     |                                                                  |                                      |
| Geurts HM & Vissers | Normal High–AUT                | 23          | 63.7        | Age, Gender, &DART-IQ                | RAVLT                                                           | No                                   |
| ME [73]            | 23                              | 63.6        |             |                                      |                                                                  |                                      |
| Williams, DL et al.| Normal High – AUT               | 38          | 12.2        | Age, VIQ, PIQ, FSIQ, & SES           | WISC-III                                                        | No                                   |
| [74]               | 38                              | 11.7        |             |                                      | - Digit Span                                                    |                                      |
|                    |                                  |             |             |                                      | WRAML                                                            | No                                   |
|                    |                                  |             |             | - Number/ Letter                     |                                                                  |                                      |
|                    |                                  |             |             | - Sentence memory                    |                                                                  |                                      |
|                    |                                  |             |             | - Story recall                        |                                                                  |                                      |
|                    |                                  |             |             | Verbal learning                      |                                                                  | No                                   |
| Jones CRG et al.   | Normal ASD                      | 55          | 15.5        | Age, VIQ, PIQ, & FSIQ                | Children’s Auditory Verbal Learning Test -2 (CAVLT – 2)        | Yes                                  |
| [59]               | 94                              | 15.5        |             |                                      | - Immediate Memory Span                                         | No                                   |
|                    |                                  |             |             |                                      | - Delayed Recall                                                 | No                                   |
|                    |                                  |             |             |                                      | - Recognition Accuracy                                           | No                                   |

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A Review of the Verbal Memory Profile of Individuals with Autism Spectrum Disorder

| Study | Normal | Hi–AUT | Lo–AUT | ASD | Non-affected Siblings | Age-matched | Gender | Verbal Learning Task | Immediate Recall | 10-mins Delay Recall | 30-mins Delay Recall | Recognition Test | Note: for children with an age of 17 or below. |
|-------|--------|--------|--------|-----|-----------------------|-------------|--------|----------------------|------------------|-------------------|-------------------|-----------------|---------------------------------------------|
| Sumiyoshi C et al. [48] | Normal | 15 | 29.7 | | | | | | The Hong Kong List Learning Test | Yes | Yes | Yes | Yes | Yes | CVLT–Children’s Version | No |
| Cheung MC, et al. [63] | Normal | 22 | 10.0 | | | | Age, Gender, & Hand- edness | | | | | | | | |
| | Hi-AUT | 22 | 10.5 | | | | | | | | | | | |
| | Lo-AUT | 16 | 10.3 | | | | | | | | | | | |
| Phelan HL et al. [61] | Normal | 15 | 12.4 | | | | Age, FSMIQ, VIQ & PIQ | | | | | | | | |
| | Hi-AUT | 15 | 13.0 | | | | | | | | | | | |
| Lind SE & Bowler DM [60] | Normal | 50 | 9.1 | | | | Age, Verbal Ability | | | | | | | | |
| | ASD | 53 | 9.3 | | | | | | | | | | | |
| Gabig CS [46] | Normal | 10 | 6.7 | | | | Age | | | | | | | | |
| | Hi-AUT | 15 | 6.5 | | | | | | | | | | | |
| Whitehouse AJO et al. [66] | Normal | 20 | 8.3 | | | | Age, FSMIQ, VIQ & PIQ | | | | | | | | |
| | Age Comparison | 20 | 10.9 | | | | | | | | | | | |
| | Ability Comparison | 20 | 10.9 | | | | | | | | | | | |
| Toichi M & Kamio Y [49] | Normal | 24 | 20.8 | | | | Age, FSMIQ, VIQ & PIQ | | | | | | | | |
| | ASD | 24 | 20.4 | | | | | | | | | | | |
| Toichi M & Kamio Y [50] | Normal | 25 | 20.2 | | | | Age, FSMIQ, VIQ & PIQ | | | | | | | | |
| | ASD | 25 | 20.3 | | | | | | | | | | | |
| Bennetto L et al. [58] | Clinical Control | 19 | 16.0 | | | | Age, Gender, Hand- edness, SES, FSMIQ, VIQ, & PIQ | | | | | | | | |
| | Hi–AUT | 19 | 15.2 | | | | | | | | | | | |
| Bowler DM et al. [65] | Normal | 16 | 33.3 | | | | Age & VIQ | | | | | | | | |
| | AS | 16 | 31.2 | | | | | | | | | | | |
| Minshew NJ [45] | Normal | 33 | 21.0 | | | | Age, Gender, Race, SES &FSIQ | | | | | | | | |
| | High–AUT | 21 | 20.7 | | | | | | | | | | | |

Note:
- 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

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 study 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

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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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