



## Verbal memory deficits in relation to organization strategy in high- and low-functioning autistic children

Mei-chun Cheung<sup>a</sup>, Agnes S. Chan<sup>b,c,\*</sup>, Sophia L. Sze<sup>b,c</sup>, Winnie W. Leung<sup>b</sup>, Cho Yee To<sup>d</sup>

<sup>a</sup> Institute of Textiles and Clothing, The Hong Kong Polytechnic University, Hong Kong

<sup>b</sup> Neuropsychology Laboratory, Department of Psychology, The Chinese University of Hong Kong, Hong Kong

<sup>c</sup> Integrative Neuropsychological Rehabilitation Center, The Chinese University of Hong Kong, Hong Kong

<sup>d</sup> School of Education, University of Michigan, Ann Arbor, USA

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### ABSTRACT

The present study examined the verbal memory profile and its relation to organizational strategies in high-functioning (Hi-AUT) and low-functioning (Lo-AUT) children with autism. Twenty-two Hi-AUT and 16 Lo-AUT, and 22 age-, gender- and handedness-matched normal children (NC) were required to remember a list of semantically related words for immediate and delayed recall and recognition. All autistic children showed impaired free recall, a reduced discrimination score and an elevated false alarm rate at recognition. While Hi-AUT children showed encoding and retrieval deficit, Lo-AUT children demonstrated more severe encoding problem and an additional retention difficulty. Lo-AUT, but not the Hi-AUT, children showed impaired semantic clustering. The recall performance in autistic children was not as strongly correlated with semantic clustering as in NC. The dual deficits of encoding and retrieval in autistic children, regardless of functioning level, implicate a frontal-lobe problem commonly observed in autism. The additional retention difficulty shown by low-functioning autistic children may be suggestive of pathological temporal-lobe involvement. The present findings may provide insights into future exploration of memory intervention for autistic children.

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### 1. Introduction

Autism is a neurodevelopmental disorder characterized by impairments in communication and social interaction, and restricted/stereotyped behaviors or interests (American Psychiatric Association, 2000). Variability in the degree of impairment was found in higher cortical functions such as memory. While some autistic individuals show severely impaired memory, some fall into the other extreme with 'savant' memory (O'Connor & Hermelin, 1989). One hypothesis suggests that autistic individuals with mental retardation (low-functioning) tended to have more severe memory impairment than those with normal intelligence (high-functioning) (see Shalom, 2003 for a review). Nevertheless, the exact memory profile and the underlying basis of memory processing in autism are uncertain.

According to the information processing model, memory processing comprises three stages: encoding (information acquired at learning trials), retention (storage of information over a delayed interval), and retrieval (recalling information from memory storage). Verbal memory deficits in different processing stages were documented in high- and low-functioning individuals with autism in previous studies (e.g., Bennetto, Pennington, & Rogers, 1996; Shalom, 2003; Williams,

\* Corresponding author at: Department of Psychology, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong. Tel.: +852 2609 6654; fax: +852 2603 5019.

E-mail address: [aschan@psy.cuhk.edu.hk](mailto:aschan@psy.cuhk.edu.hk) (A.S. Chan).

Goldstein, & Minshew, 2006). Some consistent findings were on the relatively intact retention ability of high-functioning autistic individuals, showing that they were capable of retaining as much acquired information as normal individuals at delayed recall (e.g., Bennetto et al., 1996; Minshew & Goldstein, 1993). However, studies on low-functioning autistic individuals have been rare, and initial experimental data (Boucher & Warrington, 1976) indicated that these individuals were impaired in recall at brief delays. Note, however, that their sample included autistic individuals with normal nonverbal intelligence.

Memory retrieval can be assessed by the difference in performance between free recall and recognition or by cued recall. Several studies showed that high-functioning autistic individuals who were impaired in free recall of word lists or stories were able to perform up to normal level when provided with recognition choices (Bennetto et al., 1996; Minshew & Goldstein, 1993) or semantic cues (Boucher & Warrington, 1976), suggesting that these individuals were not incapable of learning new verbal materials, but had difficulty in retrieving them from memory. In contrast, other studies reported intact free recall performance in high-functioning autistic individuals, which ran counter to the notion of retrieval deficit (Minshew, Goldstein, & Siegel, 1997; Toichi & Kamio, 2002, 2003). Furthermore, the finding that high-functioning autistic individuals demonstrated limited improvement in memory recall even when semantic cues or recognition choices were provided (Minshew & Goldstein, 2001; Williams et al., 2006) suggested that their memory problem may involve difficulties in encoding. Boucher and Warrington (1976) and Boucher (1981) showed that the memory profile of low-functioning autistic individuals was similar to that found in patients with temporal-lobe related amnesic syndrome which was characterized by impaired free recall and recognition. This suggests that the memory deficit of low-functioning individuals with autism was not simply a retrieval problem, but possibly involved a deficiency in learning and consolidating new information into long term memory. Unfortunately, their findings were not replicable in later studies. It was postulated that the poor recall and recognition performance might be the result of mental deficiency but not autism (Barth, Fein, & Waterhouse, 1995).

One possible reason for the inconsistent findings could be the different age of participants. The majority of the studies included autistic individuals with age-range spanning from teenage to adulthood (e.g., aged from 12 to 40 in Minshew & Goldstein, 1993, 2001; Minshew et al., 1997), or included only adult subjects (Bowler, Matthews, & Gardiner, 1997). The profile for autistic children may be different from autistic adults due to neural plasticity, that is, the adaptability of the developing autistic brain to accommodate inborn memory deficiency. Thus, the memory deficits of autism at a younger age may manifest as more severe than in adulthood.

Some researchers proposed that the verbal memory deficit in autistic individuals is secondary to these individuals' deficiency in utilizing effective strategies to monitor, organize and maintain the to-be-learned materials. The impairment is more prominent when learning materials are meaningful, semantically related and in vast amount (Minshew & Goldstein, 1993, 2001; Minshew et al., 1997). This executive control of memory processing was found to be mediated by the frontal-lobe, which matures up to early adulthood (Sowell, Thompson, Holmes, Jernigan, & Toga, 1999). An increasing number of neuropsychological, neuroimaging and neuro-electrophysiological studies have reported abnormal frontal-lobe structure and functioning in autistic children and adolescents (Brocki & Bohlin, 2004; Chan, Sze, & Cheung, 2007; Courchesne & Pierce, 2005a, 2005b; Joseph, McGrath, & Tager-Flusberg, 2005; Kawasaki, Yokota, Shinomiya, Shimizu, & Niwa, 1997; Kleinmans, Akshoomoff, & Delis, 2005; O'Shea, Fein, Cillessen, Klin, & Schultz, 2005; Ohnishi et al., 2000). Given the postulations of frontal-lobe related memory deficit and pathological frontal development associated with autism, the memory profile of autistic individuals may vary across the life span as a function of frontal-lobe function. In addition, the immature frontal-lobe functioning in normal children may have reduced the discrepancy in memory ability from that of autistic children.

To the authors' knowledge, only two studies focused on verbal memory of autistic children (aged from 7 to 16) with intact intellectual functioning. While a recent study (Williams et al., 2006) supported an encoding deficit, an earlier study (Boucher & Warrington, 1976) supported a retrieval deficit given the autistic children's enhanced recall performance when prompted with semantic cues. However, the verbal materials used in the two studies were not directly comparable as Williams et al. (2006) used sentences and stories whereas Boucher and Warrington (1976) used word lists. Not only are the verbal memory profile of autistic children inconclusive, little is known about the underlying nature of the deficits.

The present study therefore aimed at investigating the verbal memory profile of high- and low-functioning children with autism using the information processing model. It was anticipated that high-functioning children with autism would exhibit encoding and/or retrieval deficits but intact retention, whereas low-functioning children would show either a similar deficit pattern at a more severe degree, or have additional difficulty in retention. The second aim was to explore the memory processes of autistic individuals in terms of strategies in organizing and storing to-be-learned materials. The memory problem of autistic children was anticipated to be associated with their ineffective semantic clustering strategy, regardless of functioning level. Findings from the present study may help shed light on the memory processing of autistic children as a function of the general intelligence level and memory strategy which may hopefully bring insights into future directions of research and clinical trials on possible effective memory intervention for autistic children.

## 2. Materials and methods

### 2.1. Participants

Twenty-two high-functioning (Hi-AUT) and 16 low-functioning (Lo-AUT) children with autism and 22 children with normal development (NC) participated voluntarily in the study with informed consent from their parents. The study was

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