Journal of the International Neuropsychological Society (2003), **9**, 363–375.

DOI: 10.1017/S1355617703930025

Verbal learning in Alzheimer's dementia

ALMA AU,[1] AGNES S. CHAN,[2] AND HELEN CHIU[3]

[1]Department of Clinical Psychology, Queen Elizabeth Hospital, Hong Kong, China
[2]Department of Psychology, The Chinese University of Hong Kong, Hong Kong, China
[3]Department of Psychiatry, The Chinese University of Hong Kong, Hong Kong, China

(RECEIVED March 12, 2001; REVISED April 4, 2002; ACCEPTED April 4, 2002)

Abstract

Many recent findings in Western countries suggest that episodic recall is the most sensitive discriminator between patients with mild Alzheimer disease (AD) and the normal elderly, while semantic memory tends best to differentiate between moderate and severe AD patients. The present study is the first to examine in detail the episodic memory of Chinese AD patients in Hong Kong with a locally developed list learning test, comparing procedures that do or do not encourage the use of semantic organization. The performance of 28 AD patients was compared to that of 30 normal controls. AD patients did significantly worse in terms of acquisition and retention and also benefited significantly less from external organization cues. In the discriminant function analysis, the rate of forgetting in the random condition and the total retention score in the blocked condition were found to be the best predictors for differentiating between AD patients and controls. On the other hand, in the differentiation between mild and moderate AD, semantic clustering in the blocked condition was found to be the best predictor. Results of the present study were discussed in the light of the previous findings reported in the Western countries and the neuropathological changes of AD patients. (*JINS*, 2003, *9*, 363–375.)

Keywords: Verbal learning, Episodic memory, Semantic memory, Alzheimer's disease

INTRODUCTION

Tests of episodic memory have been regarded as the most useful early detectors of Alzheimer's disease (AD), while measures of lexical–semantic functions are among the best discriminator between mild and moderate to severe AD patients (Christensen et al., 1991; Welsh et al., 1991). This interpretation is consistent with the findings on the neuropathological changes of AD suggesting that the hippocampus and entorhinal cortex are involved in the earliest stage and that the frontal, temporal and parietal association cortices become increasingly involved as the disease progresses (Braak & Braak, 1991; DeLacoste & White, 1993). The episodic memory deficit of AD is characterized by ineffective consolidation or storage of new information, a rapid rate of forgetting and a failure to benefit from organization and category cues (Butters et al., 1990; Delis et al., 1991). In terms of ineffective consolidation, AD patients exhibited little improvement in acquiring information over repeated learning trials and that they were more likely to recall the most recently presented information in free-recall tasks (Delis, 1991). However, the main characteristic associated with memory impairment of AD is the rapid forgetting of information over time as compared to the normal elderly (Hart et al., 1988; Welsh et al., 1991;).

In a cross-sectional study from the Consortium to Establish a Registry for AD, the utility of measures of forgetting was demonstrated by Welsh et al. (1991) who compared AD patients with normal elderly on several verbal memory measures derived from a list-learning task. They reported that the highest accuracy in differentiating the two groups was achieved with delayed free recall with a 10-minute delay. This measure was significantly more effective than measures of learning, naming and verbal fluency. However, Welsh et al. (1991) also argued that because of the floor effects, delayed recall (i.e., forgetting) was not useful for discriminating between the moderately and severely demented. The rate of forgetting and the saving score have also been found to be very sensitive in the early and differential diagnosis of AD. Hart et al. (1988a) reported on faster than normal rates of forgetting in AD patients between 90 s and 10 min. Larrabee et al. (1993) also found accelerated

Reprint requests to: Alma Au, Department of Clinical Psychology, Queen Elizabeth Hospital, 30 Gascoigne Road, Kowloon, Hong Kong, China. E-mail: auml@ha.org.hk

forgetting within the 1st hr, even when AD and controls were matched on the rate of acquisition. The rate of forgetting was also found to be relatively unaffected by age and level of education (Ivnik et al., 1991; Trahan 1992).

In studies comparing the effectiveness of external organization cues to facilitate learning and memory, AD patients as compared to age-matched controls were found to benefit less from category cues that had been explicitly associated to the targets during the study phase (Baeckman & Herlitz, 1996; Carlesimo & Oscar-Berman, 1992). Furthermore, Weingartner et al. (1981) reported that both depressed and demented patients recalled significantly fewer words than normal subjects did when the words were presented randomly. However, when the lists of words were presented in clusters, depressed patients recalled significantly more words approaching the performance of normal individuals. In contrast, the number of items recalled by the demented patients in the clustered condition did not significantly differ from that in random condition.

To conclude, numerous studies in the West have shown that measures of the ability to learn new information and to retain it over time as well as to benefit from external organization cues can differentiate AD patients from normal older adults. The main purpose of the present study was to explore the learning and memory profile of AD patients in Hong Kong. Another purpose was to examine the effects on memory performance of the increasing cognitive impairment associated with the severity of AD. The present study is the first to examine in detail the quantitative and qualitative aspects of the verbal memory deficit in Chinese patients with AD, comparing procedures that do or do not encourage the use of semantic organization.

METHODS

Research Participants

Twenty-eight patients meeting the DSM–IV criteria for AD was recruited from the United Christian Hospital and the Prince of Wales Hospital. These patients were also diagnosed as having probable AD as defined by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer Disease and Related Disorders Association work group (NINCDS-ADRDA; McKhann et al., 1984). First, a preliminary diagnosis was made after discussion with the Geriatrician who had examined the patients and reviewed their social and family history. Only cases with presenting history of at least nine months of persisting memory problems were chosen. Second, a formal diagnostic assessment made by psychiatrists of the psychogeriatric teams at the two hospitals together with the administration of the Chinese Cantonese version of the Mini-Mental State Examination (MMSE; Chiu et al., 1994). Third, each patient was also rated according to the Reisberg Global Deterioration Scale (GDS: Reisberg, 1982) in order to gauge the clinical phase or stage of dementia. Fourth, the functional ability of each patient was assessed with a Cantonese translation of Basic and Instrumental Activities of Daily Living Scales (ADL; Lawton, 1983; Linn & Linn, 1983). Fifth, the Cantonese version of Hamilton Depression Rating Scale (HAM–D; Hamilton, 1967) was administered to rule out cases with severe depression. Finally, when seen by the psychologist, these patients were given the Dementia Rating Scale (DRS; Mattis, 1973) translated into Chinese by Chan et al. (2001). The formal diagnosis was confirmed in a multidisciplinary case conference chaired by the psychiatrist with all the information collected using the procedures described (i.e., GDS, MMSE, DRS, ADL).

Thirty normal elderly controls living independently were recruited on a voluntary basis from two Elderly Social Centers in the East Kowloon Region. Based on the comprehensive (including medical) records of the centers, individuals with a history of alcoholism, drug abuse, learning disabilities and serious neurological or psychiatric illness were excluded from the control group. The Chinese DRS was also administered to rule out possible cognitive impairment and the mean was found to be well above the cut-off score of 112 for the local Chinese population (Chan et al., 2001). The demographic characteristics and the DRS scores together with the *t* tests results of AD patient and control groups are summarized in Table 1.

To further establish the effect of the severity of dementia, the patients group was divided into mild AD and moderate AD subgroups, using the Reisberg Global Deterioration Scale (GDS). Patients classified at Stages 4 and 5 on the Scale were allocated to the mild AD group while patients at Stage 6 were allocated to the moderate AD group. Based on this classification, 15 patients were allocated to the mild AD group and 13 to the moderate AD group. Significant differences on *t* tests ($p < .001$) were found between the scores obtained for the mild AD and moderate AD group for GDS, MMSE, DRS, ADL (Table 2). However, owing to difficulties in recruiting male moderate AD patients, the moderate AD group contained only female patients.

Materials

The Hong Kong List Learning Test (HKLTT) consists of two-16-word lists of Chinese words, and all of which are two-character nouns. The first list contains four groups of items from each of the following categories: *family member*, *country*, *furniture*, and *vegetable*. The words in this list are randomly organized so that no two items of the same category are presented consecutively. Items of the second list are from four other categories: *clothing*, *flower*, *music*, and *occupation*. In the second list, words are organized in clusters in which the items of the same category are presented in sequence. In each of the two lists, two categories are construed to be more abstract while the other two categories are construed to be concrete. In the first list, *family member* and *country* are more abstract than *furniture* and *vegetable*. In the second list, *music* and *occupation* are more abstract than *clothing* and *flower*.

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

Table 1. Baseline participant characteristics

Variable	Controls *M* (*SD*)	AD patients *M* (*SD*)	*T*-value between controls and AD patients
Number	30	28	
Sex (% female)	79	60	
Age	73.13 (5.42)	74.96 (7.98)	1.02
Years of education	4.16 (2.83)	4.89 (5.04)	0.67
DRS			
Attention	36.49 (0.65)	32.72 (4.74)	−4.17**
Initiation	31.97 (4.18)	17.07 (6.78)	−9.99**
Construction	4.87 (1.25)	2.82 (2.25)	−4.24**
Conceptualization	31.97 (2.80)	26.71 (5.09)	−4.82**
Memory	22.78 (3.29)	9.68 (4.99)	−11.72**
Total	128.07 (8.98)	89.11 (18.24)	−10.21**

**$p < .001$.

An attempt has been made to match the level of typicality, frequency and difficulty of two word lists. All items were within the frequency rank of 10 to 35 in the norms provided by Jeng et al. (1973), suggesting that the items were of mid-level frequency in the category. In a pilot study, the two lists were presented orally, one at a time, to 10 college students. Results suggested that the two lists were matched in terms of their level of difficulty for comprehension and learning as the number of items they recalled from the two lists did not differ significantly.

Procedure

Written consent was obtained from each participant or carer prior to the testing. Each list of the two conditions was presented three times. In the *random* condition of the Verbal Learning Test, instructions for the first trial were as follows: "I am going to read a list of words. After I finish, you will tell me as many words as you can remember, in any order that you like." After making sure that the subject understood the instructions, the list of words was read aloud by the examiner at the rate of 1 word/s. The subject was asked to recall the words aloud and the examiner without offering any feedback recorded his/her responses. The instructions for the second and third trials were as follows: "I am going to read the same list of words again and you should try to remember them. After I finish, you will tell me as many words as you can remember, in any order you like. Remember, you should tell me all the words you can remember, including those you have just told me. Any ques-

Table 2. Baseline characteristics of the mild AD and moderate AD groups

Variable	Mild AD patients *M* (*SD*)	Mild AD patients (females only) *M* (*SD*)	Moderate AD patients *M* (*SD*)	*T*-value between mild AD and moderate AD
Number	15	9	13	
Sex (% female)	60	100	100	
Age	74.67 (9.94)	75.11 (8.92)	75.31 (5.27)	−0.22
Years of education	6.60 (5.24)	4.67 (2.00)	3.08 (4.72)	1.86
GDS	4.60 (0.51)	4.89 (0.33)	6.00 (0.00)	−10.69**
MMSE	19.73 (4.30)	17.44 (2.88)	10.00 (2.48)	7.45**
ADL	20.80 (6.94)	24.11 (6.31)	41.00 (3.46)	−9.93**
HAM–D	7.00 (2.83)	7.78 (3.03)	8.62 (1.26)	−1.99
DRS				
Attention	35.23 (0.72)	35.08 (0.61)	29.80 (5.73)	3.39**
Initiation	21.33 (5.82)	17.89 (2.26)	12.15 (3.89)	4.97**
Construction	4.20 (1.82)	4.33 (1.32)	1.23 (1.54)	4.68**
Conceptualization	29.00 (4.00)	28.22 (3.23)	24.08 (5.05)	2.83**
Memory	12.93 (3.97)	11.22 (1.48)	5.92 (3.02)	5.29**
Total	102.73 (10.90)	96.76 (6.25)	73.39 (10.51)	7.24**

**$p < .001$.

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

tions?" Without notification in advance, the subject was required to recall the list of words again after 10 min and then after another 20 min (i.e., a 30-min delayed recall). Immediately after the 30-min delayed recall condition, the recognition task was presented. The recognition task involving a yes/no format consisted of 32 items, 16 from the target list and 16 foils.

The *blocked* condition always followed the random condition so that the spontaneous use of semantic organization could be examined in the random condition. Otherwise, the random condition would be contaminated if it were preceded by the blocked condition. In the blocked condition, the procedure followed that in the random condition except that before the first learning trial the subject was informed about the number of items, the four categories and the order of presentation as in the following: "I am going to read 16 words from four categories. The four categories are clothing, flower, music, and occupation. I will first read four kinds of clothing and then four types of flowers. After that, four types of music and then four names of occupation. When I finish, you will tell me as many words as you can remember in any order you like." In addition, the cued recalls were added after the third recall trial of the blocked condition, the 10-min and 30-min recall trials. The instructions were as follows: "Please tell me the words related to clothing and accessories," "Please tell me the words related to music," "Please tell me the words related to flowers," and "Please tell me the words related to occupations."

ANALYSIS OF RESULTS

Scoring was based on Chan and Kwok (1998). Thirty AD patients were firstly compared with the 28 controls. Then, subdividing the patient group, 15 moderate AD patients were compared with 13 mild AD patients. To rule out gender effects, a subanalysis was done to compare the 9 female mild AD patients with the all-female moderate AD patients. Education was used as the covariate throughout the analysis of variance as there was considerable variability in the education level as evidenced by the large standard deviations. In view of the many statistical comparisons carried out, the Bonferroni correction would yield a very conservative alpha level. Instead, in order to reduce Type 1 error, the significance level was set at a reasonably conservative level of .01.

Comparing AD Patients With Normal Controls

Acquisition

The total learning score was obtained by adding the number of items recalled on Trials 1 to 3 (Table 3). With education as the covariate, a Group (AD patient, control) × Condition (blocked, random) ANCOVA was then used to examine the total learning score. The Group × Condition interaction effect was significant [$F(1,55) = 41.92$, $p < .001$]. The simple effect of group was analyzed by the one-way ANCOVA. The AD patient group was found to have significantly less total learning than the control group for both random [$F(1,55) = 27.86$, $p < .001$] and blocked conditions [$F(1,55) = 36.17$, $p < .001$]. The simple effect of condition was analyzed using the paired-sample t tests. The control group learned significantly more words in the blocked than in the random condition [$t(27) = 2.90$, $p < .01$]. However, for the AD patient group, no significant difference in

Table 3. Results on the list learning test for control and patient groups

	Random condition		Blocked condition	
Score	Controls ($N = 30$) M (SD)	AD patients ($N = 28$) M (SD)	Controls ($N = 30$) M (SD)	AD patients ($N = 28$) M (SD)
Trial 1	4.43 (1.79)	1.78 (1.44)	5.13 (2.66)	1.60 (1.52)
Trial 2	6.57 (1.98)	3.29 (2.29)	8.00 (3.33)	2.96 (2.67)
Trial 3	8.37 (2.28)	3.68 (2.52)	9.53 (2.85)	3.71 (2.24)
Trial 4 (10 min)	6.00 (2.97)	0.78 (2.33)	7.97 (3.75)	1.39 (1.93)
Trial 5 (30 min)	6.00 (2.86)	0.64 (2.13)	7.73 (3.86)	0.54 (1.77)
Cued Recall 1			9.50 (2.40)	1.82 (2.45)
Cued Recall 2			8.83 (2.88)	0.96 (2.15)
Cued Recall 3			8.75 (3.10)	0.67 (1.95)
Total Learning	19.07 (4.83)	8.75 (5.91)	22.53 (7.86)	8.25 (5.53)
Total Retention	12.00 (5.72)	1.43 (4.45)	15.70 (7.30)	1.93 (3.55)
Forgetting Rate (10 min)	−29.85 (28.45)	−89.85 (25.10)	−17.41 (32.31)	−68.77 (34.12)
Correct Hits	13.47 (2.76)	6.54 (4.69)	14.28 (1.31)	7.17 (5.49)
False Alarm	1.73 (1.87)	3.27 (4.21)	2.07 (2.55)	3.79 (4.32)
Discrimination Score	73.33 (19.76)	20.43 (25.16)	76.29 (18.17)	21.09 (30.77)
Semantic Clustering	1.67 (1.18)	0.71 (0.71)	5.30 (2.79)	1.71 (1.33)
Recency Effect	27.61 (12.33)	54.24 (34.25)	34.90 (10.47)	53.73 (37.11)

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

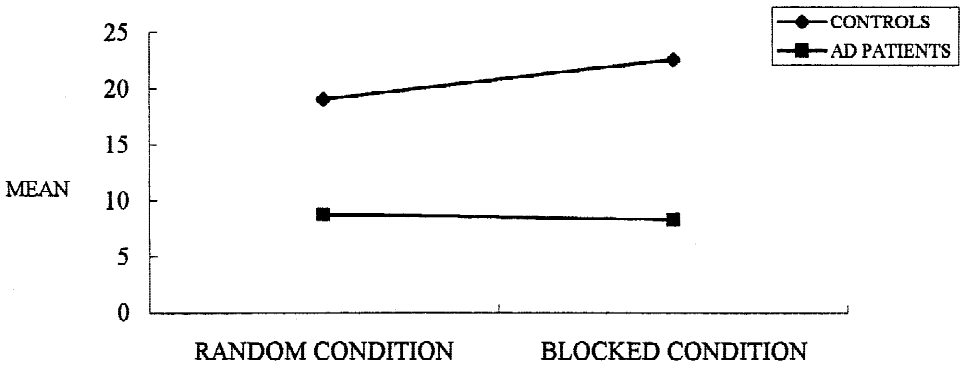

Fig. 1. Total learning for random and blocked conditions, AD patients *versus* controls. (Error bars are omitted but standard deviations may be found in Table 3.)

total learning was found between the random and blocked condition (Figure 1).

To explore whether the most recently presented material was more likely to be recalled, the recency effect was calculated by dividing the number of last four items of the list recalled in Trial 3 by the number of total number of words recalled in Trial 3 and then multiplied by 100. A Group (AD patient, control) × Condition (blocked, random) ANCOVA was used to examine the recency effect. Results indicated that the group effect was significant as AD patients had a larger recency effect for both conditions [$F(1,55) = 13.87$, $p < .001$]. The effects of condition and Group × Condition were not significant.

Retention

The total retention score was obtained by adding the number of items recalled on 10-min and 30-min delayed recall (Table 3). With education as the covariate, a Group (AD patient, control) × Condition (Blocked, Random) ANCOVA was then used to examine the total retention score. Results indicated that the Group × Condition interaction effect was significant [$F(1,55) = 7.77$, $p < .01$]. The simple effect of group was then analyzed by the one-way ANCOVA. The AD patient group was found to have significantly less total retention than the control group for both random [$F(1,55) = 65.20$, $p < .001$] and blocked conditions [$F(1,55) = 83.43$, $p < .001$]. The simple effect of condition was analyzed using the paired-sample *t* tests. Results indicated that the control group retained significantly more words in the blocked than in the random condition [$t(27) = 3.59$, $p < .01$]. However, for the AD patient group, no significant difference in total retention was found between the random and blocked condition (Figure 2).

The rate of forgetting in the first 10 min was calculated by the following formula: (10-min delayed recall − Trial 3)/Trial 3 × 100%. Using a Group × Condition ANCOVA, the interaction between Group × Condition leaned towards significance [$F(1,55) = 6.63$, $p < .05$]. The simple effect of group was analyzed by the one-way ANCOVA. The AD patient group was found to have a significantly higher rate of forgetting than the control group for both random [$F(1,55) = 34.63$, $p < .001$] and blocked conditions [$F(1,55) = 16.44$, $p < .001$]. The simple effect of condition was analyzed using the paired-sample *t* tests. The AD patient group had a slower rate of forgetting in the blocked

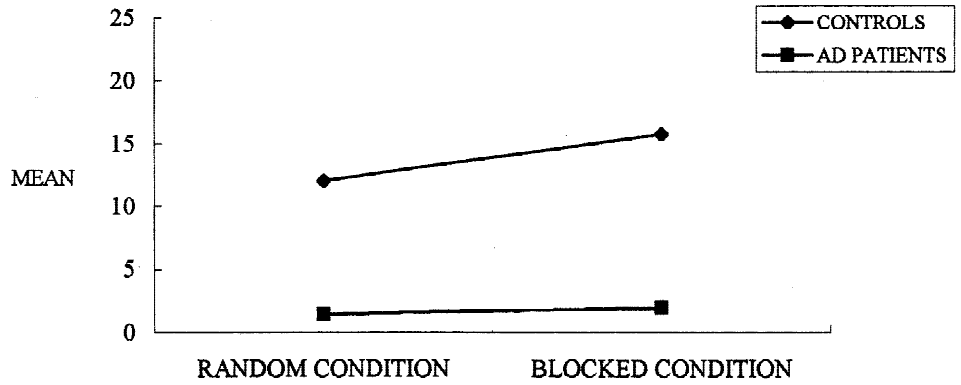

Fig. 2. Total retention for random and blocked conditions, AD patients *versus* controls. (Error bars are omitted but standard deviations may be found in Table 3.)

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

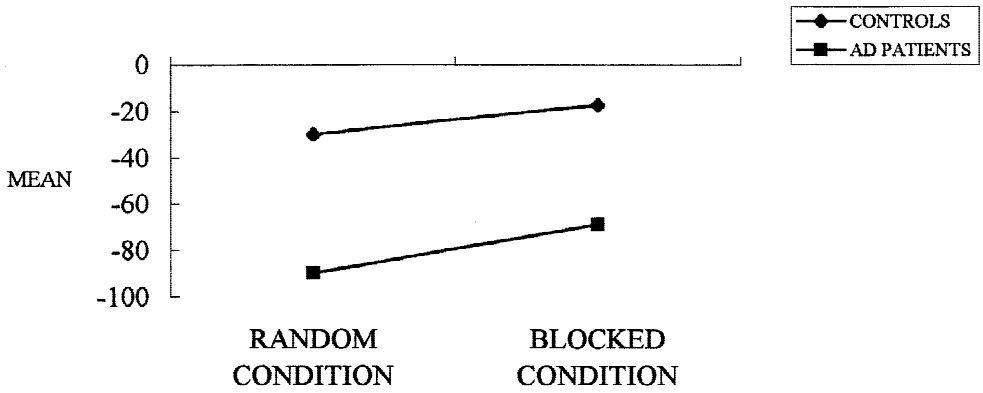

Fig. 3. Rate of forgetting in the 1st 10 min for random and blocked conditions, AD patients *versus* controls. (Error bars are omitted but standard deviations may be found in Table 3.)

than in the random condition [$t(27) = 3.16$, $p < .01$]. However, for the control group, no significant difference in rate of forgetting was found between the random and blocked condition (Figure 3).

Recognition

In addition to the number of correct responses, a response was classified as a false alarm when the response was incorrectly identified as a target item (Table 3). The number of correct hits in the recognition task may over-estimate the participant's ability to discriminate target and foil items if too many false alarm errors were committed. Thus, a discrimination score was obtained to correct this possible bias by the following formula: (Correct Hits − False Alarm)/16 × 100%. A Group × Condition ANCOVA was used to analyze the discrimination scores obtained. The group effect was significant as the AD patient group obtained a lower discrimination score [$F(1,55) = 82.17$, $p < .001$]. However, the effects of condition and Group × Condition were not significant (Figure 4).

Semantic clustering

To examine the subject's ability to spontaneously utilize semantic knowledge in organizing new information, a score of semantic clustering was calculated for each subject (Table 3). The score was obtained by counting the number of times two items that belong to the same category were recalled consecutively in Trial 3 of both Random and Blocked conditions. A Group × Condition ANCOVA was used to examine the semantic clustering score. The interaction effect of Group × Condition was significant [$F(1,56) = 17.68$, $p < .001$]. The simple effect of group was analyzed by the one-way ANCOVA. The AD patient group was found to have significantly less semantic clustering for both random [$F(1,55) = 14.17$, $p < .001$] and blocked conditions [$F(1,55) = 41.28$, $p < .001$]. The simple effect of condition was analyzed using the paired-sample t tests. More semantic clustering was found in the blocked than in the random condition for both the control [$t(29) = 6.43$, $p < .01$] and the AD patient groups [$t(27) = 3.88$, $p < .01$]. However, more importantly, as the Group ×

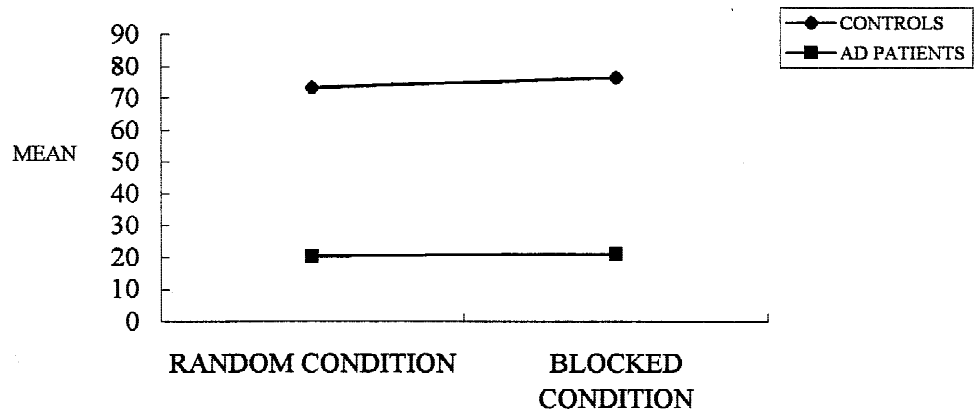

Fig. 4. Discrimination score for random and blocked conditions, AD patients *versus* controls. (Error bars are omitted but standard deviations may be found in Table 3.)

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

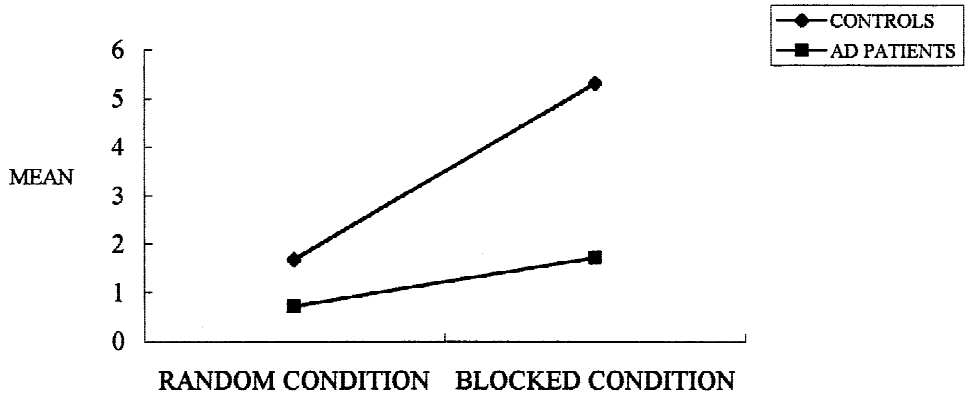

Fig. 5. Semantic clustering for random and blocked conditions, AD patients *versus* controls. (Error bars are omitted but standard deviations may be found in Table 3.)

Condition interaction was significant, the increase of semantic clustering from the random to the blocked condition was significantly less in the AD patient group than the normal control group (Figure 5).

Discriminant function analysis

A discriminant function analysis was performed using the variables analyzed in the preceding sections as predictors of membership of the two groups: AD patients and controls. The predictors of the random and blocked conditions were as follows: total learning and retention, recency effect, the rate of forgetting in the first 10 min, the discrimination score and semantic clustering scores. Fifty-eight cases were processed. To explore the clinical utility of the different conditions, separate discriminant function analyses were conducted for each condition. For the random condition, the rate of forgetting in the first 10 min was identified as the best predictor. The discriminant function calculated had a chi-square of 44.04 ($df = 1$, $p < .001$). The eigenvalue was 1.28 and the canonical correlation was .75. The standardized canonical discriminant function coefficient was 1.00. With the jackknife classification procedure, the overall percentage of cases correctly classified was 82.8%. Twenty-three out of 28 AD patients and 25/30 controls were correctly classified.

For the blocked condition, the total retention was identified as the best predictor. The discriminant function calculated had a chi-square of 49.87 ($df = 1$, $p < .001$). The eigenvalue was 1.46 and the canonical correlation was .77. The standardized canonical discriminant function coefficient was 1.00. With the jackknife classification procedure, the overall percentage of cases correctly classified was 91.4% which was marginally higher than the percentage of cases correctly classified by the rate of forgetting (random condition). Twenty-seven out of 28 AD patients and 26/30 controls were correctly classified. To further explore the ability of the HKLTT in distinguishing AD patients from normal controls, the classification rate of the total retention (blocked condition) was compared with that of the more commonly

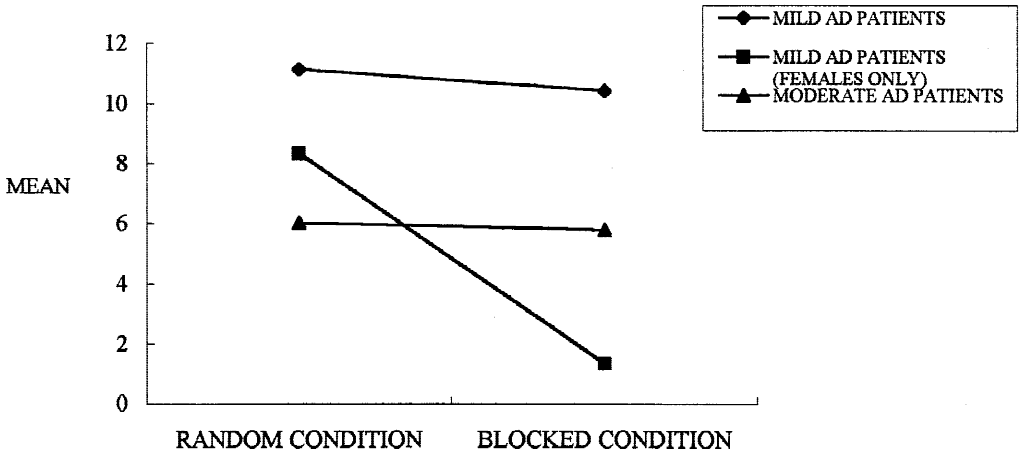

Fig. 6. Total learning for random and blocked conditions, mild *versus* moderate AD patients. (Error bars are omitted but standard deviations may be found in Table 4.)

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

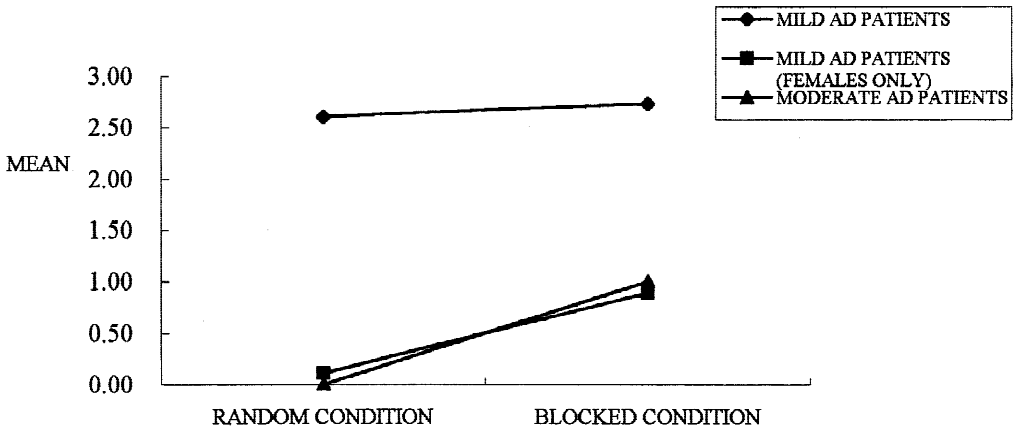

Fig. 7. Total retention for random and blocked conditions, mild *versus* moderate AD patients. (Error bars are omitted but standard deviations may be found in Table 4.)

used DRS memory test score. With the jackknife classification procedure, the overall percentage of cases correctly classified with the DRS memory score was 89.7%. Two of 28 AD patients and 26/30 controls were correctly classified. Thus, the classification rate of the total retention (blocked condition) was compatible with that of the DRS memory test score.

Comparing Mild With Moderate AD Patients

Acquisition

With education as the covariate, a Group (mild AD, moderate AD) × Condition (blocked, random) ANCOVA was then used to examine the total learning score. For total learning in acquisition (Table 4), the main effect of condition [$F(1,25) = 30.65$, $p < .01$] was significant but the effects of group and Group × Condition were not. Both groups were found to have more total learning in the random than the blocked condition. A similar picture was obtained for the all-female comparison as only the main effect of condition was significant [$F(1,19) = 22.48$, $p < .001$]. No significant difference was observed for recency effect (Figure 6).

Retention

With education as the covariate, a Group (mild AD, moderate AD) × Condition (blocked, random) ANCOVA was then used to examine the total retention score. The effects of Group × Condition, group, condition were all nonsignificant. The rate of forgetting tended to be lower in the blocked than the random condition [$F(1,25) = 4.48$, $p = .05$] but the effects of group and Group × Condition were not significant (Figures 7 and 8).

Recognition

The mild AD patient group was found to have a higher discrimination score [$F(1,25) = 9.03$, $p < .01$]. The effects of condition and the Group × Condition interaction were not significant. A similar group tendency was obtained for the all-female comparison [$F(1,19) = 54.4$, $p = .05$] (Figure 9).

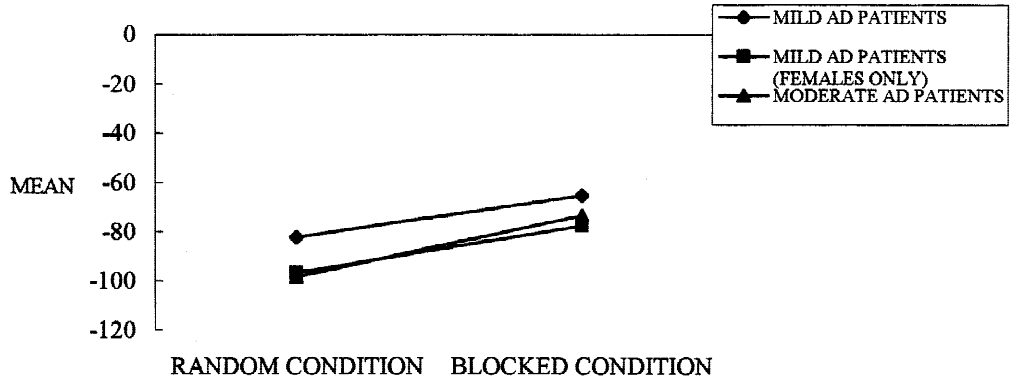

Fig. 8. Rate of forgetting in the 1st 10 min for random and blocked conditions, mild *versus* moderate AD patients. (Error bars are omitted but standard deviations may be found in Table 4.)

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

Table 4. Results on the list learning test for mild AD and moderate AD groups

	Random condition			Blocked condition		
Score	Mild AD patients ($N = 15$) M (SD)	Mild AD patients (females only) ($N = 9$) M (SD)	Moderate AD patients ($N = 13$) M (SD)	Mild AD patients ($N=15$) M (SD)	Mild AD patients (females only) ($N = 9$) M (SD)	Moderate AD patients ($N = 13$) M (SD)
Trial 1	2.33 (1.50)	1.56 (1.13)	1.15 (1.14)	2.13 (1.73)	1.67 (1.41)	1.00 (1.00)
Trial 2	4.27 (2.52)	3.44 (2.24)	2.15 (1.34)	3.60 (2.61)	2.67 (1.58)	2.23 (1.59)
Trial 3	4.53 (2.87)	3.33 (2.18)	2.69 (1.65)	4.73 (2.21)	3.67 (1.12)	2.54 (1.66)
Trial 4 (10 min)	1.20 (3.08)	0.11 (0.33)	0.08 (0.28)	1.80 (2.31)	0.78 (0.83)	0.92 (1.32)
Trial 5 (30 min)	1.20 (2.83)	0.00 (0.00)	0.00 (0.00)	0.93 (2.37)	0.11 (0.33)	0.07 (0.28)
Cued Recall 1				2.87 (2.80)	1.67 (1.66)	0.62 (1.19)
Cued Recall 2				1.60 (2.72)	0.56 (0.88)	0.23 (0.83)
Cued Recall 3				1.20 (2.57)	0.44 (0.88)	0.08 (0.28)
Total Learning	11.13 (6.45)	8.33 (5.12)	6.00 (3.85)	10.40 (6.06)	1.33 (1.66)	5.77 (1.02)
Total Retention	2.60 (5.91)	0.11 (0.33)	0.00 (0.28)	2.73 (4.58)	0.89 (1.05)	1.00 (1.48)
Forgetting Rate (10 min)	−82.34 (32.57)	−96.88(8.84)	−98.61 (4.81)	−65.31 (32.84)	−77.78 (24.65)	−73.49 (36.86)
Correct Hits	8.47 (3.96)	8.44(3.91)	3.91 (4.46)	8.43 (5.00)	7.50 (5.18)	5.40 (5.91)
False Alarm	3.80 (4.72)	4.11(5.67)	2.55 (3.47)	2.86 (2.80)	2.88 (2.95)	5.10 (5.76)
Discrimination Score	29.17 (25.30)	27.08 (24.61)	8.52 (20.40)	34.82 (23.73)	28.91 (22.89)	1.88 (30.05)
Semantic Clustering	0.80 (0.77)	0.78(0.67)	0.62 (0.65)	2.33 (1.18)	1.77 (1.10)	1.00 (1.15)
Recency Effect	46.44 (31.95)	50.52(34.96)	63.33 (35.95)	53.36 (37.50)	28.91(22.89)	54.24 (38.38)

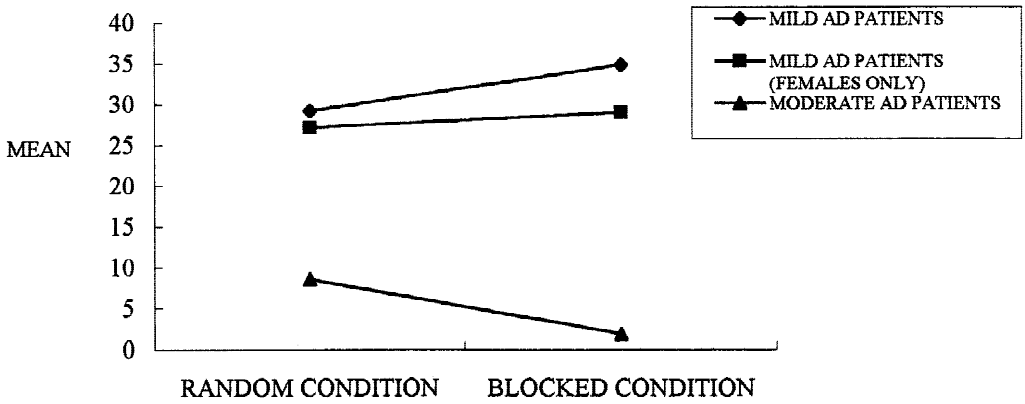

Fig. 9. Discrimination score for random and blocked conditions, mild *versus* moderate AD patients. (Error bars are omitted but standard deviations may be found in Table 4.)

Semantic clustering

Though failing to reach the level of significance, there was some suggestion of Group × Condition interaction [$F(1,25) = 3.64$, $p = .06$]. As compared to the moderate AD patient group, the mild AD patient group tended to have more semantic clustering for the blocked condition [$F(1,25) = 5.29$, $p = .05$] though not in the random condition. Comparing the female mild AD patients with the all-female moderate AD patients, the female mild AD patients also had the tendency toward more semantic clustering in the blocked condition [$F(1,25) = 3.96$, $p = .06$]. The simple effect of condition was analyzed using the paired-sample *t* tests. More semantic clustering was found in the blocked than in the random condition for the mild AD patients [$t(14) = 3.94$, $p < .01$]. A similar trend was found for the female mild AD patients [$t(8) = 2.00$, $p = .08$]. However, the effect of condition was not found to be significant for moderate AD patients (Figure 10).

Discriminant function analysis

A discriminant function analysis was performed on exploratory basis using the variables analyzed in the preceding sections as predictors of membership of the two groups: mild AD and moderate AD patients. The following variables of *both* random and blocked conditions were parsimoniously selected as predictors: total learning and retention, recency effect, the rate of forgetting in the first 10 min, the discrimination score and semantic clustering scores. Twenty-eight cases were processed .The discriminant function had a chi-square of 18.45 ($df = 1$, $p < .001$). The eigenvalue was 1.46 and the canonical correlation was .77. In the stepwise analysis, semantic clustering (blocked condition) was identified as the predictor variable. The standardized canonical discriminant function coefficient was .91. With the jackknife procedure, the overall percentage of cases correctly classified was 78.6%. Thirteen out of 15 mild AD patients and 9/13 moderate AD patients were correctly classified. To further explore the ability of the HKLTT in distinguishing moderate from mild AD patients, the classification rate of the semantic clustering (blocked condition) was compared with that of the commonly used DRS supermarket fluency test. With the jackknife classification procedure, the overall percentage of cases correctly classified with the DRS supermarket fluency test was 82.1%. Thirteen out of 15 mild AD patients and 10 of 13 moderate AD patients

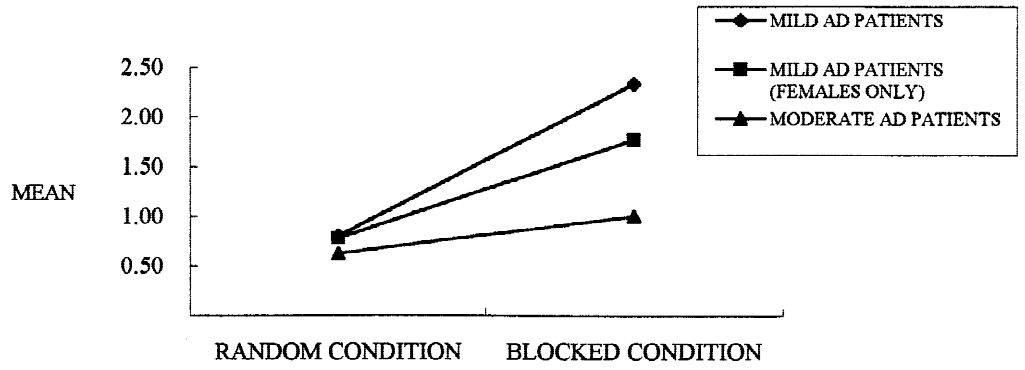

Fig. 10. Semantic clustering for random and blocked conditions, mild *versus* moderate AD patients. (Error bars are omitted but standard deviations may be found in Table 4.)

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

were correctly classified. Thus, the classification rate of the semantic clustering score was compatible with that of the supermarket fluency test.

DISCUSSION

The study is one of the first to examine in detail the quantitative and qualitative aspects of the memory deficits of Chinese patients with AD. It is also perhaps the only study on a Chinese verbal learning test comparing test procedures that do and do not encourage the use of semantic organization. In terms of encoding and acquisition, findings of the present study suggested that the Chinese AD patients learned fewer words than the controls on the total of three learning trials of both random and blocked conditions. Furthermore, they were more likely to recall the most recently presented material. In terms of retention, the Chinese AD patients in the present study demonstrated marked impairment in total delayed recall. In particular, as compared to the normal controls, AD patients were found to have a significantly higher rate of forgetting in the first 10 min. These findings were consistent with a number of previous studies that highlighted the prominent encoding or acquisition deficit of Western AD patients characterized by impaired total learning across three learning trials (Butters et al., 1990; Delis et al., 1991). The finding on the rapid rate of forgetting is consistent with previous findings in the Western literature (Welsh et al., 1991). AD patients were also found to have a relatively poorer performance than the controls in recognition. The observation that AD patients did poorly on both delayed recall and recognition is consistent with the hypothesis that memory problems of AD patients are primarily related to encoding and not retrieval.

It was also observed that AD patients failed to benefit from external organization cues in terms of both total learning and retention. Furthermore, AD patients were found to have less semantic clustering in both the random and blocked conditions. Consistent with previous findings, these results suggest that Chinese AD patients utilized less semantic organization in the learning of new information (Baeckman & Herlitz, 1996; Weingartner et al., 1981). The total retention score in the blocked condition was also found to be highly effective in differentiating between AD patients and controls. Though the classification rate of the total retention (blocked condition) is slightly higher than that of the rate of forgetting (random condition), the administration of both conditions rather than just the blocked condition can provide clinically useful information contrasting the learning with and without semantic organization cues.

Another purpose of the study was to examine the effects on memory test performance of increasing cognitive impairment associated with the severity of AD. In terms of acquisition as measured by learning across trials, mild AD patients were shown to perform better than moderate AD patients. However, in terms of retention, no significant differences were found between mild and moderate AD patients in total delayed recall and the rate of forgetting. However, the mild AD patients were found to have more semantic clustering than the moderate AD patients in the blocked condition. Furthermore, the presence of external organization cues increased semantic clustering for the mild but not the moderate AD patients. In the discriminant function analysis of the present study, semantic clustering was identified as the best predictor for differentiating between mild and moderate AD patients. This finding was consistent with previous observation that delayed recall was not useful for discriminating between the mildly and the more severely demented but that measures of semantic memory could serve this purpose better (Christensen et al., 1991).

The failure of external organization cues to increase semantic clustering in moderate AD may reflect on the increasing disruption of semantic network with the severity of dementia (Salmon & Chan, 1994). This interpretation is consistent with the findings on the neuropathological changes of AD suggesting that the hippocampus and entorhinal cortex are involved in the earliest stage and that the frontal, temporal, and parietal association cortices become increasingly involved as the disease progresses (Braak & Braak, 1991).

Finally, there are three major suggestions for future investigations. Firstly, the sample size was small and therefore did not permit the simultaneous examining of the effects of different levels of demographic characteristics such as education and age range. Secondly, there were particular difficulties in matching the sex and education level of the AD patients. As there were difficulties recruiting male patients in the moderate AD group, a separate analysis was done to compare the females of the mild AD group with the all-female moderate AD group on the various measures. The possibility of gender differences raised questions that were beyond the scope of the present study. Recent literature debated about the hypothesis that females tended to live longer with dementia and therefore were more likely to exhibit severe cognitive deterioration (Gambassi et al., 1999; Swanwick et al., 1999). On the other hand, some findings reported on the positive effect of endogenous estrogens on cognitive performance among women with AD (Buckwalter et al., 1997). Other possible intervening factors include education level and cultural issues. It also appeared that the mild AD patient group in the present study was more educated than the moderate AD patient group. Thus, the comparison between the mild and moderate AD patients in general might still be affected by differences in education.

The third issue was related to the level of functioning of the mild AD patients in the study. It was noted the average MMSE score of the mild AD patients in the study was around 20. This score was slightly lower than the scores quoted in Western studies on early stages of AD. For instance, the very mildly demented AD patients in the study by Welsh et al. (1991) on the differentiating power of delayed recall had MMSE scores above 24/30. The possibility that the present study had not recruited the very mildly demented can have at least two implications for the interpretations of the results. The first implication concerns the relative effec-

https://doi.org/10.1017/S1355617703930025 Published online by Cambridge University Press

tiveness of episodic and semantic measure in differentiating AD patients and controls. Perhaps, with the very mildly demented, the rate of forgetting would emerge more clearly as the best predictor of membership between patients and controls. The rapid forgetting of AD patients can have potentially important clinical implications. Most of the commonly used memory tests typically include a 20-min to 30-min delayed recall (Delis et al., 1987; Wechsler, 1987). In the light of the present findings, the 10-min delayed recall could generate useful information for differentiating between AD patients and normal controls.

Furthermore, the low MMSE scores of the mild AD patients may imply that nearly any neuropsychological test would yield significant differences between these patients and normal controls. In the present study, the simpler DRS measures were found to yield classification rates comparable to those of the HKLTT measures. Thus, it would seem that for distinguishing the mild AD patients on the low side from the normal controls, the simpler DRS measure is sufficient. However, if a comprehensive and detailed description of the patients' verbal learning and memory abilities is desired, the use of the HKLTT can be justified. In future, it would be interesting to explore whether the comparability of the DRS and HKLTT rates will hold if the very mildly demented patients are recruited.

To conclude, the present study is the first to examine in detail the episodic memory of the Chinese AD patients in Hong Kong with a locally developed list learning test, comparing procedures that do or do not encourage the use of semantic organization. The Chinese AD patients did significantly worse in terms of acquisition and retention and also benefited significantly less from external organization cues. Furthermore, the rate of forgetting in the random condition and the total retention score in the blocked condition were found to be the best predictors for differentiating between AD patients and controls. These recall measures were not found to differentiate well between mild and moderate AD. Instead, semantic clustering in the blocked condition was identified as a useful discriminating variable for this purpose. Results of the present study are consistent with those reported in Western countries and are consistent with the findings on the neuropathological changes of AD patients.

ACKNOWLEDGMENTS

This research was supported by Grant 212916 from the Health Service Research Committee to Alma Au and Agnes Chan. The authors would like to express gratitude to Dr. David Salmon, Dr. Catherine Tang and Dr. Chan Wai for helpful comments. We would also like to thank Dr. Pan Pey Chyou, Chen Quin Lin, Maria Tsang and Maggie Ng for subject recruitment and data collection.

REFERENCES

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorder* (4th ed.). Washington, DC: Author.

Baeckman, L. & Herlitz, A. (1996). Knowledge and memory in Alzheimer Disease: A relationship that exists. In R.G. Morris (Ed.), *The cognitive neuropsychology of Alzheimer-type dementia* (pp. 89–104). Oxford, UK: Oxford University Press.

Braak, H. & Braak, E. (1991). Neuropathological staging of Alzheimer-related changes. *Acta Neuropsychologica*, *82*, 239–259.

Buckwalter, J., Schneider, L.S., Wilshire, T.W., & Dunn, M.E. (1997). Body weight, estrogen and cognitive functioning in Alzheimer disease: An analysis of the Tacrine Study Group data. *Archives of Gerontology and Geriatrics*, *24*, 260–267.

Butters, N., Salmon, D.P., & Heindel, W.C. (1990). Process underlying the memory impairment of demented patients. In E. Goldberg (Ed.), *Contemporary neuropsychology and the legacy of Luria* (pp. 99–126). Hillsdale, NJ: Erlbaum.

Carlesimo, G.A. & Oscar-Berman, M. (1992). Memory deficits in Alzheimer's patients: *A Comprehensive Review*, *3*, 119–169.

Chan, A. & Kwok, I. (1998). *Hong Kong List Learning Test (HKLTT): Manual and Preliminary norms*. Hong Kong: Department of Psychology, The Chinese University of Hong Kong.

Chan, A., Choi, A., & Salmon, D.P. (2001). The effects of age, education, gender on the Mattis Dementia Rating Scale performance of elderly Chinese and American individuals. *Journal of Gerontology: Psychological Sciences*, *56*, 356–363.

Chiu, H.F.K., Lee, H.C., Chung, W.S., & Kwong, P.K. (1994). Reliability and validity of the Cantonese Version of the Mini-Mental State Examination: A preliminary study. *Journal of Hong Kong College of Psychiatrists*, *4* (Suppl. 2), 25–28.

Christensen, H., Hadzi-Pavlovic, D., & Jacomb, P. (1991). The psychometric differentiation of dementia from normal aging: A meta-analysis. *Journal of Consulting and Clinical Psychology*, *3*, 147–155.

Cummings, J.L. (1990). *Subcortical dementia*. New York: Oxford University Press.

De Lacoste, M. & White, C.L. (1993). The role of cortical connectivity in Alzheimer disease pathogenesis: A review and model system. *Neurobiology of Aging*, *14*, 1–16.

Delis, D.C., Massman, P.J., Butters, N., Salmon, D.P., Cermak, L.S., & Kramer, J.H. (1991). Profiles of demented and amnesic patients on the California Verbal Learning Test: Implications for the assessment of memory disorder. *Psychological Assessment*, *3*, 19–26.

Delis, D.C., Kramer, J.H., Kaplan, E., & Ober, B.A. (1987). *The California Verbal Learning Test*. New York: The Psychological Corporation.

Gambassi, G., Lapane, K.L., Landi, F., Sgadari, A., Mor, V., & Bernabei, R. (1999). Gender differences in the relation between comorbidity and mortality of patients with Alzheimer disease. *Neurology*, *53*, 508–516.

Hamilton, M. (1967). Development of a rating scale for primary depressive illness. *British Journal of Social and Clinical Psychology*, *6*, 278–296.

Hart, R.P., Kwentus, J.A., Harkins, S.W., & Taylor, J.R. (1988a). Rate of forgetting in mild Alzheimer type dementia. *Brain and Cognition*, *7*, 31–38.

Ivnik, R.J., Malec, J.F., Tangalos, E.G., Peterson, R.C., Kokmen, E., & Kurland, L.T. (1990). The Auditory Verbal Learning Test (AVLT): Norms for ages 55 years and older. *Psychological Assessment*, *2*, 304–312.

Jeng, C.I., Lai, M.W., & Liu, I.M. (1973). Category norms in Chinese and English from bilingual subjects. *Acta Psycologica Taiwan*, *15*, 81–153.

La Rue, A. (1992). *Aging and neuropsychological assessment*. New York: Plenum.

Lawton, M.P. (1983). Assessment of behaviors required to maintain residence in the community. In T. Crook, S. Ferris, & R. Bartus (Eds.), *Assessment in geriatric psychopharmacology* (pp. 118–135). New Canaan, CT: Mark Powley Associates, Inc.

Linn, M.W. & Linn, B.S. (1983). Assessing activities of daily living in institutional settings. In T. Crook, S. Ferris, & R. Bartus (Eds.), *Assessment in geriatric psychopharmacology*. (pp. 97–109). New Canaan, CT: Mark Powley Associates, Inc.

Larrabee G.J., Youngjohn, J.R., Sudilovsky, A. & Crook, T.H. (1993). Accelerated forgetting in Alzheimer-type dementia. *Journal of Clinical Experimental and Neuropsychology*, *14*, 701–712.

Mattis, S. (1973). *Dementia Rating Scale Professional manual*. Odessa, FL: Psychological Assessment Resources.

McKhann, G., Drachman, D., Folstein, M., Katzman, R., Price. D., & Stadlin, E.M. (1984). Clinical diagnosis of Alzheimer's auspices of the Department of Health and Human Services Task Force on Alzheimer's disease. *Neurology*, *34*, 939–944.

Reisberg, B., Ferris, S.H., De Leon, M.J., & Crook, T. (1982). The Global Deterioration Scale for Assessment of Primary Degenerative Dementia. *American Journal of Psychiatry*, *139*, 1136–1139.

Rey, A. (1964). *The clinical examination in psychology*. Paris: Press Universitaire de France.

Salmon, D.P. & Chan, A. (1994). Semantic memory deficits associated with Alzheimer's disease. In L.S. Cermak (Ed.), *Neuropsychological explorations of memory and cognition: Essays in honor of Nelson Butters* (pp. 61–76). New York: Plenum Press.

Swanwick, G. & Lawlor, B.A. (1999). Is female gender a risk factor for Alzheimer disease? *International Psychogeriatrics*, *11*, 219–222.

Trahan, D.E. (1992). Analysis of learning and rate of forgetting in age-associated memory differences. *Clinical Neuropsychologist*, *6*, 241–246.

Wechsler, D. (1987). *Wechsler Memory Scale–Revised*. New York: The Psychological Corporation.

Weingartner, H., Kaye, W., Smallberg, S.A., Ebert, M.H., Gillin, J.C., & Sitaram, N. (1981). Memory failures in progressive idiopathic dementia. *Journal of Abnormal Psychology*, *90*, 187–196.

Welsh, K.A., Butters, N., Hughes, J.P., Mohs, R.C., & Heyman, A. (1991). Detection and staging of Alzheimer's disease: use of neuropsychology measures developed for CERAD. *Archives of Neurology*, *49*, 448–452.