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A Comparison of Implicit Memory Performance in Mild Cognitive Impairment and Alzheimer Type Dementia Patients

Asena AKDEMİR, Banu TAVAT CANGÖZ, Sibel ÖRSEL, Kaynak SELEKLER

Abstract

Objective: *Implicit memory, defined as the recollection of knowledge unconsciously, automatically, and without being aware of it, is different than explicit memory, in which knowledge is recollected consciously, while being aware of it. In the present study, the implicit memory performance of patients with mild cognitive impairment (MCI) and Alzheimer's type dementia (ATD) (different stages) were compared to healthy controls.*

Method: *The study included 19 MCI patients and 23 ATD patients (11 mild-moderate and 12 severe stage ATD). Control subjects were matched to the patient groups according to age, gender, education, and hand preference. DSM-IV and NINCDS-ADRA diagnostic criteria were used for clinical assessment.*

Results: *The 4 × 3 ANOVA revealed a significant main effect of the level of processing, and group and level of processing interaction effect was also significant. Group main effect was not significant.*

Conclusion: *MCI and ATD groups performed similarly on the implicit memory task. Implicit memory performance was intact in patients with MCI and ATD; however, implicit memory performance of the patient groups differed according to the level of processing manipulation. For that reason, implicit memory tasks should be used for clinical diagnosis in ATD.*

Key Words: *Mild Cognitive Impairment, Alzheimer's Type Dementia, implicit memory*

INTRODUCTION

Alzheimer's disease is the most common type of dementia, compromising 50%-70% of all dementia types, and is a serious health problem. The prevalence of the disease is 6%-10% among those older than 65 years and 30%-70% among those older than 85 years (Selekler, 2003). There are no known laboratory tests for the diagnosis of Alzheimer's type dementia (ATD) (Öktem, 2003; Weintraub, 2004). In this regard, the assessment and diagnosis of mild cognitive impairment (MCI), a cognitive disorder due to aging that is considered a transition period for ATD, is also important (Crowell et al., 2002; Morris et al., 2001). This fact increases the importance of neuropsychological assessments that are required for detecting impairments in cognitive functions, which are seminal features of ATD (Crowell et al., 2002; Weintraub, 2004).

Several studies have reported that in ATD impairment occurs in memory functions (Braak and Braak, 1991; Spaan et al., 2003) or in attention (Christensen and Birrell, 1991). difficulties with numbers, impairment in unprompted speech, difficulty in finding words and in framing sentences (Öktem, 2003; Selekler, 2003). Implicit memory is a concept that is related to various phenomena. Reaction conditioning, priming effect, and unconscious and social behavior are only a few of these. Nonetheless, the majority of experimental studies on implicit memory have focused on priming (Blaxton, 1989; Challis, 1996). Priming is defined as the difference between test performance when the relevant information has been recently presented and performance when the relevant information has not been recently presented (Challis, 1996; Roediger, 1990). Past events can be retrieved in 2 ways, consciously and unconsciously. Implicit memory is defined as the hypothetical type of memory that is responsible for unconscious recollection of past events (Roediger, 1990; Schacter, 1987).

Asena Akdemir MD., e-mail: *asenaak@yahoo.com*

The Neuropsychological Background of Implicit Memory

The existence of implicit memory was first demonstrated in studies conducted with amnesic patients (Graf et al., 1985; Squire et al., 1987). Impairment in retrieving past events or in acquired knowledge is the differentiating characteristic of amnesic syndrome. This characteristic is measured by traditional explicit memory tests (recognition, remembering, learning, etc.). However, in the last 20 years, it was found that amnesic disorder causes memory impairment that is selective and neuropsychologically critical. In related studies, amnesic patients with impaired medial-temporal or diencephalic brain regions failed in explicit memory tests, such as remembering and recognition, but performed similarly to healthy age-matched controls on implicit memory tests, such as world stem completion (WSC), lexical decision-making, and implicit remembering of spatial information (Keels et al., 2005; Squire et al., 1987). Studies also exist showing that as in amnesia, in multiple sclerosis implicit memory is not impaired, whereas explicit memory functions, excluding recognition, are impaired (Scarrabelotti and Carroll, 1999). In other words, it has been suggested that medial-temporal and connected neocortical structures are responsible for explicit memory functions. On the other hand, priming, which is the basis of implicit memory, functions independently of the limbic system. According to this, as the neuronal basis of implicit memory might be neocortical structures, the cerebellum or basal ganglions (Markowitch, 2004). In their brain imaging studies of healthy individuals, Yasuno et al. (2000) showed that extra-striatal regions of the occipital lobe are responsible for perceptual implicit memory functions and anterior regions of the temporal-parietal lobe are responsible for conceptual implicit memory functions.

Implicit Memory Tasks and Alzheimer's Type Dementia

Experimental studies conducted with healthy individuals showed that implicit memory tasks can be categorized into 2 groups, perceptual and conceptual. Differences between these 2 types of implicit memory are as follows: a) While perceptual implicit memory tasks are sensitive to changes in the physical characteristics of the stimuli (modality of presentation, letter font, generating from a phonetic cue), conceptual implicit memory tasks are sensitive to the changes in the semantic characteristics of the stimuli (pleasantness/unpleasantness, anonymity/synonymy, producing from semantically related cues); b) While performance in perceptual implicit memory tasks is not affected by attention level changing cues, such as, pay attention/do not pay attention, performance in conceptual implicit memory tasks is (Cangöz, 2002; Cangöz and Ateşkan, 2003; Challis, 1996; Roediger, 1990).

The most frequently used implicit memory task in experimental studies on implicit memory functioning in ATD is WSC (Blaxton, 1989). This task is a perceptual implicit memory test with conceptual components (Gabrielli et al., 1994; Nebes, 1989). The majority of studies found that WSC performance is impaired in ATD (Carlesimo et al., 1995; Heindel et al., 1989; Keane et al., 1991; Spaan et al., 2003; Spaan et al., 2005). Nonetheless, there are other studies showing that WSC performance is not impaired in ATD. (Balota and Duchek, 1991; Dicket al., 1989; Golby et al., 2005; Keane et al., 1994; Kessels et al., 2005; Russo and Spinler, 1994). Some authors think that impairment in WSC performance is due to the conceptual components of the test (Gabrielli et al., 1994; Nebes, 1989). In fact, ATD patients perform comparably to normal controls in implicit memory tests that are mainly composed of perceptual components, such as perceptual recognition. These perceptual implicit memory tests are sensitive to the physical/perceptual characteristics of stimuli and/or stimuli that have dominant physical components (Blaxton et al., 1999; Nebes, 1989).

Failure on conceptual implicit memory tests is a determinant of impairment in semantic coding because conceptual implicit memory tests are sensitive to the semantic characteristics of stimuli (McCauley et al., 1996; Monti et al., 1996). However, impairment in semantic information processing or coding may vary according to the degree of ATD (mild, moderate, of severe). For example, a patient has the ability to accomplish semantic coding in mild or moderate level ATD, whereas he cannot do this spontaneously (Braak and Braak, 1991; Craik, 1984). In this regard, while the WSC task that shows implicit memory experimentally activates semantic coding (information processing at the semantic level) in normal controls due to conceptual components, it may not demonstrate the same effect in severe or extreme ATD patients. In fact, there are many studies showing that ATD patients fail in WSC tasks after completing semantic processing tasks (Carlesimo et al., 1995). Yet, it is not proven that ATD patients are unable to perform semantic coding. In contrast, there are various studies showing that patients with ATD preserve their WSC performance after performing tasks that require producing target words (Keane et al., 1994). A successful semantic coding (information processing in semantic level) occurs

Table I. Demographic characteristics of the participants.

n=80	MCI (n=19)	Mild-Moderate ATD (n=11)	Severe ATD (n=12)	Control (n=38)	F	P<
Age	65.0 (8.18)	68.4 (2.73)	70.5 (4.38)	67.79 (3.40)	2.29	.086
Education level (years)	10.7 (4.28)	7.8 (4.17)	10.1 (3.12)	10.1 (4.02)	1.28	.288
Sex (F/M)	10/9	3/8	9/3	18/20		
Dominant hand (right/left)	18/0	11/0	12/0	36/0		

with correct word production, and semantic representations are protected in the implicit memory test.

Many studies have used various implicit memory tasks in researching ATD, mostly WSC, and it has been shown that there is a selectivity regarding implicit memory, as the conceptual components are impaired (Gabrielli et al., 1994; Vaidya et al.1999; Spaan and ark. 2005) and the perceptual components are protected (Balota and Duchek, 1991; Golby et al., 2005; Keane et al. 1994, Kessels et al., 2005).

Conversely, there is inconclusive information about WSC performance in ATD. These controversial findings may be due to: a) using mixed patient groups that are not homogenous; b) using different neuropsychological assessment tools for the diagnosis of ATD; c) using different experimental designs (inter subject and/or between subjects); d) different criteria used in selecting the verbal material (words) in the WSC task.

Evidence gathered from functional screening tests in ATD patients and neuropsychological assessments of behavior support each other. In fact, the most commonly affected structures in ATD after the medial-temporal structure of the hippocampal cortex are the parietal and temporal connection regions. Due to increasing damage in these domains, verbal abilities, attention, visual-spatial functions, executive skills, and verbal implicit memory functions are reported to be impaired (Christensen and Birrell 1991). In this regard, it was stressed that impairment in language (verbal abilities) and visual-spatial functions are a reflection of ongoing damage in the neo-cortical neurons and their connections (Braak and Braak, 1991; Weintraub, 2004). In another study of early phase ATD patients using MRI, it was shown that implicit memory performance is impaired, which is related to the medial-temporal lobe, whereas implicit memory function is not impaired, which is related to the occipital cortex (Golby et al., 2005).

To the best of our knowledge, there no published studies regarding implicit memory in MCI. In recent years a number of studies have stated that implicit memory tests (especially with conceptual components) are more powerful than the mini mental examination (MME), especially in the determination of early phase ATD (Busse et al., 2003; Spaan et al., 2003; Spaan et al., 2005).

The aim of this research was to determine if there are differences in WSC scores (implicit memory performance) of ATD patients (various stages), MCI patients, and a control group. The second aim was to determine whether there are differences in WSC scores of the aforementioned groups when stimuli are coded in different information processing levels (visualization, consonant counting, and control).

METHOD

Sample

Participants in the MCI group (n:19) were selected from patients that presented to psychiatry and/or neurology clinics (Dışkapı Ankara Training and Research Hospital, Psychiatry Clinic and Hacettepe University, Medical Faculty, Neurology Clinic) with subjective memory problems, whose psychiatric and neurological assessments were in the normal range, who scored ≥ 24 on the standardized mini mental state test (SMME) (Güngen et al., 2002), scored 0.5 on the clinical dementia rating scale (CDRS) (Berg, 1988), and scored 1.5 points below the standard deviation of the mean score of the visual-auditory digit span, adult form (VADS-A) (Karakaş and Yalın, 1993; Karakaş et al., 1996).

For dementia diagnoses, DSM-IV (American Psychiatric Association, 1994) criteria and National Institute of Neurological, Communicative Disorders, and Stroke-Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) criteria were used. For the clinical assessment of ATD and possible Alzheimer's disease, the Alzheimer's Disease Assessment Scale-Cognitive subtest (ADAS-cognitive) (Örsel et al., 2004), the Behavioral

Table II. Means and standard deviations of the participants screening instruments scores.

	MCI	Mild-Moderate ATD	Severe ATD	Control	F	p<
SMME	26.52	16.63	12.17	28.74	441.95	.001
Score	(1.39)	(1.43)	(3.01)	(0.92)	155.82	.001
ADAS-cognitive	9.36	50.63	60.33	5.71	79.58	.001
Score	(2.88)	(15.40)	(15.76)	(5.40)	179.89	.001
Behave-AD	0.47	17.00	24.42	0.63	58.81	.001
Score	(069)	(9.63)	(10.75)	(1.05)	77.14	.001
CDRS	050	4.82	14.00	0.21		
Score	(000)	(4.74)	(4.33)	(0.74)		
HIS	126	5.73	10.25	0.61		
Score	(124)	(2.96)	(3.39)	(2.23)		
VADS-B	1795	15.36	11.75	21.71		
Score	(207)	(2.11)	(2.30)	(2.12)		

Pathology in Alzheimer's Disease Rating Scale (Behave-AD) (Sclan et al., 1996), and the Clinical Dementia Rating Scale (CDRS) (Berg, 1988) were used. ATD patients were classified as mild, moderate, and severe phase with CDRS. According to this, 19 (10 women, 9 men) of the patients were diagnosed with ATD, 11 of which were in the mild-moderate phase (3 women, 8 men) (mild and moderate phases were combined due to the low number of subjects) and 12 were in the severe phase (9 women, 3 men). Demographic characteristics of the participants are presented in Table I.

The age and education level of all participants were equivalent and there were no statistical differences in terms of age [$F(3.76) = 2.29$, $P < 0.086$] and duration of education [$F(3.76) = 1.28$, $P < 0.288$] among the groups. Participants did not have any psychiatric or neurological disorders, their mother tongues were Turkish, and all participants were right handed. The dominant hand was determined according to the participants' verbal reports on which hands they used with certain items, such as scissors and brush.

Normal controls were chosen among volunteers from the patients who presented to the psychiatry clinic of Dışkapı Training and Research Hospital and Neurology Department of Hacettepe University. All tests and scales that were administered to the patient groups were also administered to the control group. Mean standard deviations and scores of the participants are presented in Table II. Written informed consent was given by all participants.

Exclusion criteria

Patients scoring ≤ 14 on the Hamilton Depression Inventory (HDI) (Akdemir et al., 2001), patients with symptoms or signs of focal brain damage, which might be the cause of cognitive impairment, patients with focal lesions in neuro-radiological tests (CCT or MRI), patients with head trauma, patients with a psychiatric disorder, patients who had used any medication in the last 3 days that can influence the test performance, and patients who scored ≤ 4 on the Hachinski Ischemia Scale (HIS) (Hachinski et al., 1975) (vascular dementia is excluded with this criteria) were excluded from the study. In all, 2 schizophrenic, 2 depression, 4 hearing impaired, and 2 vascular dementia patients were excluded from the study.

Data Collection Tools

1) The Alzheimer's Disease Assessment Scale-Cognitive (ADAS-cognitive)

ADAS-cognitive, which measures cognitive functioning, has 11 subtests; word retention, naming objects, naming fingers, constructional praxis, ideational praxis, orientation, word recognition, command retention, language, word finding, and comprehension. –Test-retest reliability is 0.84, the inter-rater reliability coefficient is 0.97, and the correlation coefficient with CDRS is 0.57 (Örsel et al., 2004).

2) National Institute of Neurological, Communicative Disorders, and Stroke-Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA).

Alzheimer's disease diagnostic criteria published by NINCDS-ADRDA and DSM-IV criteria were used in this study (McKhann et al., 1984).

Table III. Means and standard deviations of implicit memory scores in different conditions.

n=80	MCI	Mild-Moderate ATD	Severe ATD	Control
Visualization	7.26	6.09	5.76	7.33
(Deep coding)	(0.79)	(1.14)	(1.11)	(1.58)
Consonant counting	5.26	5.09	5.08	5.37
(Shallow coding)	(0.87)	(1.22)	(1.00)	(9.62)
Control	2.37	2.64	2.35	2.82
(No coding)	(1.01)	(1.29)	(1.22)	(1.39)

Level of information processing (LIP) main effect: $F = 206.69$, $P < 0.001$; Group (G) main effect: $F = 1.21$, $P < 0.312$; (LIP) x (G) common effect: $F = 3.59$, $P < 0.017$

3) The Behavioral Pathology in Alzheimer's Disease Rating Scale (Behave-AD)

Behave-AD is used in evaluating behavioral problems in dementia. The 25 items cover paranoid and delusional ideation, hallucinations, activity disturbances, aggression, diurnal variation, mood, anxieties, and phobias, all which are rated on a 4-point scale of severity. The inter-rater reliability was reported to be high (0.65-0.91) (Sclan et al., 1996).

4) Clinical Dementia Rating Scale (CDRS)

CDRS evaluates the degree of dementia in patients with ATD. CDRS classifies dementia in 4 levels (0: none; 0.5: ambiguous; 1: mild; 2: moderate; 3: severe). Clinicians evaluate 6 cognitive domains (memory, orientation, judgment and problem-solving, community affairs, home and hobbies, and personal care) with a semi-structured interview. The inter-rater reliability was reported to be high (tau B = 0.91; kappa = 0.74) (Berg, 1988).

5) Hachinski Ischemic Score (HIS)

HIS is designed to evaluate dementia patients in terms of ischemic etiology. Those who score 4-7 points are considered at risk for vascular dementia. A score ≥ 7 points is indicative of possible vascular dementia. (Hachinski et al., 1975).

6) Standardized Mini Mental State Examination (SMME)

SMME was adapted to the Turkish population by Güngen et al. (2002). The sensitivity of the Turkish version is 0.91, its specificity is 0.95, and its positive and negative predictive values are 0.90 and 0.95, respectively. In addition, inter-rater reliability analysis revealed high correlations (r = 0.99) and kappa values (0.92). It is a screening test for general cognitive functions. The test evaluates 5 main domains: orientation, registration, attention and calculation, recall and language. The lowest score is zero and the highest score is 30.

7) Visual Aural Digit Span Test–B Form (VADS-B)

VADS-B is a forward digital span test with 4 subtests measuring attention and concentration. Each of the 4 subscales is composed of 8 digit spans, from 2 digits to 9 digits. The 4 subtests are: aural-verbal, visual-verbal, aural-written, and visual-written. VADS-B total score is equal to the arithmetic total of scores achieved (longest digit span remembered) in each subtest. Accordingly, the lowest score is zero and the highest score is 36. Test retest reliability is 0.84, the correlation coefficient calculated with WAIS forward digit span test is 0.69, and with WAIS backwards-digital span the correlation coefficient is 0.67 (Karakaş and Yalın, 1993).

8) World stem completion Test (WSC)

WSC is a verbal material set composed of 45 words. All the words used are concrete and frequently used in Turkish (Cangöz, 1997). In addition, the criteria included having at least 3 words starting with the first 3 letters of the 45 words used in the Turkish dictionary published by the Turkish Language Association (1980). This criterion was important in terms of demonstrating that word completion is not accomplished by chance. Of the 45 words, 15 (List A) were used in the control condition, 15 (List B) in the imagery condition, and 15 (List C) were used in the consonant counting condition. The mean number of letters in the words in List A, List B, and List C was 5.24 (range: 4-8) and the mean number of syllables was 2.2, (range: 2-3). Participants in the testing

Table 4. Comparison of the groups according to implicit memory scores in different information processing conditions.

Group	I-CC	I-C	CC-C
Control	+ (p<0.01)	+ (p<0.01)	+ (p<0.01)
MCI	+ (p<0.01)	+ (p<0.01)	+ (p<0.01)
Mild-Moderate ATD	– (p<0.33)	+ (p<0.01)	– (p<0.25)
Severe ATD	– (p<0.42)	+ (p<0.01)	+ (p<0.01)

Level of information processing: (I) visualization, (CC) consonant counting, (K) control.
Comparisons among information processing levels were made with t-tests.
When the difference between groups was significant, it is shown with (+), if the difference was not significant, it is shown with (-)

phase underwent the WSC task as a measure of implicit memory. The WSC task included 45 words (total of the words in Lists A, B, and C).

Cue words in the study and test phases were presented in a booklet containing 21 × 15-cm cards with test items and words written on them using uppercase letters. Accordingly, 3 booklets with cue words (Lists A, B, and C) and one booklet containing the test items (WSC) were used in the study. WSC is defined as an implicit memory task with dominant conceptual components and is widely used, as reported in the literature (Blaxton, 1989).

Procedure

Experimental Design

Participants were randomly assigned to the experimental conditions. The 45 words used in the study were divided into Lists A, B, and C. In the study phase, each of these lists was used in a different experimental condition (visualization, consonant counting, and control: basic level). Participants in the control group did not go through any procedures. In the study phase, participants were given a WISC task with 45 words. Words used for the control group were different from the ones used for the test groups and aimed to determine the basic level. The different word lists were presented using a counterbalancing technique. Counterbalancing is an experimental control method used to determine which list to present under different coding conditions.

Experimental application

Participants were privately tested in a silent room. Participants were informed that they would participate in a study related to word perception in order to avoid their awareness of memory measurement. During the study, each cue of the words was presented to the participants for 6 sec. In the visualization condition, participants were asked to visualize the words in a place that is appropriate for the word (house, school, park, supermarket, hospital, etc.) and say the name of this place out loud. In this condition, participants coded the cue words in a deep and/or semantic level by doing a cognitive task related to the meanings of the words. In the consonant counting condition, participants were asked to find the number of consonants in the presented word and say it out loud. In this condition, participants coded the cue words in a shallow and/or physical level by doing a cognitive task related to the physical characteristics of the presented words. Participants in the control group did not take any tests. After the study phase, participants were included in a 5 min distraction phase in which they were asked to say the names and surnames of Turkish film actors, as many as they could remember. The distraction phase was not scored. After the distraction phase, participants were taken into the test phase. In the test phase participants were given a WSC task in which they were asked to complete a word stem composed of the first 3 words with the first word that came in to their minds. Answers were recorded on a form by the experimenters.

Following the test phase, participants were asked 2 open-ended questions related to whether they had used any strategies that helped them to remember the words (mnemonics) and/or completed the words by realizing that the words were selected from the words in the study phase (explicit memory) (manipulation control). Participants who reported using any strategies or explicit memory were excluded.

Conversely, participants who reported that they had realized the words were selected from the study phase, but did not complete the words according to their memories were included in the implicit memory analysis.

This manipulation control is a frequently used method in studies using an implicit memory paradigm (Mulligan et al., 1999, Watkins et al., 2000). This technique aims to control the possible bias of explicit memory performance on implicit memory performance. As a result of this technique, the scores of 8 participants (3 from the MCI group and 5 from the control group) were excluded from the analysis.

Statistical Procedure

A 4 (MCI, mild-moderate ATD, severe ATD, and normal-control) × 3 (information processing level: visualization, consonant counting, and control) factor with a repeated measure in the last factor study design was applied. The group variable was converted by between groups and the level of information processing variable was converted by within group. The SPSS 10.0 package program was used for the analysis of the data.

FINDINGS

The one-way ANOVA findings of the participants' scores on the diagnostic tests (SMME, ADAS-cognitive, Behave-AD, CDRS, HIS, and VADS-B) are presented in Table II.

Participants' scores that were achieved under the different experimental conditions are presented in Table III. The main effect of the level of processing variable was statistically significant in the result of 4 × 3 repeated measures ANOVA [F (2.76) = 156.83, P < 0.001]. According to this, different information processing levels (coding) affected WSC scores.

In other words, there was a difference in implicit memory scores, in terms of information processing; however, this difference was not due to the difference between the control condition, and visualization and consonant counting conditions (visualization > control, consonant counting > control). The main effect of the group variable was not significant [F (3.76) = 1.21, P < 0.312]. Based on this, there were no differences in terms of WSC scores between the patient groups and the control group. In other words, the patient groups and the control group displayed similar implicit memory performance. In addition, the common effect of the group and level of information processing variables were significant [F (3.76) = 3.59, P < 0.017]. Performances of all groups in different information processing levels were analyzed using t-test and the results are presented in Table IV. According to the t-test analyses, there was a difference in terms of WSC scores in MCI patients in the visualization condition and consonant counting condition (t= 5.05, P < 0.01). Similarly, in MCI patients, the difference between the visualization condition and control condition (t= –6.65, P < 0.01), and the difference between the consonant counting condition and control condition in the same group (t= 6.13, P < 0.01) was statistically significant.

In mild-moderate ATD patients, the difference between the visualization and consonant counting conditions was not statistically significant. On the other hand, the difference between the visualization and control conditions in mild-moderate ATD patients was statistically significant (t= 5.49, P < 0.01).

In severe ATD patients, the difference between the visualization and consonant counting conditions was not statistically significant. Nevertheless, among severe ATD patients, the difference between the visualization condition and control condition (t= 6.07, P < 0.01), and the difference between the consonant counting condition and control condition was statistically significant (t= 2.29, P < 0.01).

In the normal control group, the difference between the visualization and consonant counting conditions was statistically significant (t= 5.02, P < 0.01). Similarly, in the normal control group the difference between the visualization and control conditions (t= 11.09, P < 0.01), and the difference between the consonant counting and control conditions in the same group was statistically significant (t= 12.48, P < 0.01).

In the comparisons made among the patient groups, the difference between MCI patients and severe ATD patients were statistically significant only in the consonant counting condition (t= 2.28, P < 0.05).

In summary, the MCI and ATD groups performed similarly on implicit memory tasks. In contrast, implicit memory performance of the patient groups differed according to the level of processing manipulation. However, when the basis of this effect was examined, it was observed that the main effect resulted form the differences between the visualization and consonant counting conditions in the mild-moderate and severe ATD patient groups.

In the MCI patient and normal control groups, the same main effect resulted from the differences between the visualization and consonant counting conditions, and differences in these conditions and the control condition. The difference between the 2 information processing conditions (visualization and consonant

counting) and the control condition being significant is a determinant in demonstrating implicit memory experimentally. Lastly, the common effects of group and information processing levels were also significant. According to this, in all groups implicit memory performance in the visualization and consonant counting conditions was higher than in the control condition. While the implicit memory score in the MCI and normal control groups was higher in the visualization condition than in the consonant counting condition, this difference was not evident between the mild-moderate ATD and severe ATD groups.

DISCUSSION

The term implicit memory is used to define a dimension of memory other than its traditional functions. As such, implicit memory is the unconscious and automatic remembering of past knowledge, and is reached through implicit memory tasks experimentally. The main aim of this research was to compare implicit memory performance in MCI patients, different stage ATD patients, and a control group.

When the findings were evaluated, the main effect of group on implicit memory performance was not significant. Based on this, when the level of information processing was constant, there were no differences between the MCI, mild-moderate and severe ATD patient groups, and the normal control group in terms of implicit memory scores. This finding is evidence for intact of the implicit memory function shown by the WSC task in the above-mentioned patient groups. The findings of this research support other related study findings in the literature that show implicit memory is not affected by MCI, or mild-moderate and severe phase ATD when the information processing variable is held constant (Balota and Duchek, 1991; Dicket al., 1989; Golby et al., 2005; Keane et al., 1994; Kessels et al., 2005; Russo and Spinler, 1994).

On the contrary, the finding that severe phase ATD patients failed in the shallow/physical coding condition in comparison to the MCI group suggested that implicit memory performance impairment occurs in severe stages of the disease. These findings partially support Spaan et al. (2005) and Golby et al. (2005), who reported that impairment in implicit memory performance could be an indicator of early phase ATD. The present study also showed that implicit memory was impaired in the deep/semantic coding condition in the early phase of ATD. This finding is identical to the findings of the 2 studies mentioned above (Spaan et al., 2005; Golby et al., 2005); however, implicit memory performance was impaired in the severe phase ATD group in the shallow/physical coding phase. Although there was a relative impairment in early phase ATD in the shallow/physical coding condition, it was not statistically significant.

To the best of our knowledge, there are no published studies on implicit memory in MCI. In this regard, the finding regarding the protection of implicit memory in MCI is another specific finding of this research. Our findings show that memory function was protected in 2 patient groups characterized by memory disturbance (MCI and ATD), and implicit memory was intact, which is a different dimension of memory. This can be interpreted as the existence of different cortical structures responsible for explicit and implicit memory functions; however, this interpretation should be clarified with further studies supported with brain imaging techniques. Therefore, models can be developed regarding the cognitive and neural basis of implicit memory in patients with MCI and ATD.

The most valuable finding gained through comparisons was t only the difference between MCI patients in the visualization (deep/semantic) condition and severe ATD patients in the same condition was significant . Accordingly, although implicit memory performance was similar in different ATD phases, it was different in the deep/semantic coding condition in MCI and severe ATD patients. In other words, semantic coding was impaired in the severe phase of ATD, whereas physical coding was not impaired. This finding supports other findings that show in ATD, verbal abilities, attention, spatial-visual functions, and executive functions, and in advanced phases of the disease, verbal implicit memory functions can be impaired due to increasing damage in the parietal and temporal connection regions of the hippocampal cortex, which are the most affected parts after medial-temporal structures (Carlesimo et al., 1995; Christensen and Birrell, 1991; Yasuno et al., 2000).

The present study's findings are important for the clinical assessment and understanding of MCI and ATD. Although the main effect of the level of information processing variable on implicit memory scores was significant, this difference, in general, was due to the differences of the means of the control condition and the 2 experimental conditions. When considered in terms of binary comparisons (Table IV), in the mild-moderate and severe ATD patient groups, there were no differences between the 2 experimental conditions, visualization

and consonant counting (except the difference between the control condition).

In other words, when the control condition is excluded, the 2 tasks that represent different information processing levels, visualization (deep/semantic coding) and consonant counting (shallow/physical coding), resulted in similar implicit memory performances in the mild-moderate and severe ATD patient groups. That is to say, the mild-moderate ATD and severe ATD patient groups were not affected by deep or shallow coding of the information. These findings obtained from the mild-moderate ATD and severe ATD patient groups are similar to research findings that show implicit memory is not affected by coding types (Blaxton, 1989; Java and Gardiner, 1991; Keane et al., 1994; McCauley et al., 1996).

In contrast, the MCI and normal control groups were affected by shallow or deep coding of the information. It is a widely accepted understanding that the information processing level is a variable that affects explicit memory performance, both in healthy individuals, and MCI and ATD patients (Nebes, 1989). However, in this research the finding that the same variable had affected implicit memory performance in the MCI and control groups might have been due to WSC being an implicit memory task with dominant conceptual components. Differing from other research studies, this study showed that the level of information processing created a difference in the implicit memory performance of MCI patients, which shows that semantic coding ability is not impaired in MCI patients, and even in implicit memory tasks they benefited more from semantic coding in comparison to physical coding.

As mentioned in the introduction, some researchers suggest that implicit memory tests (especially with conceptual components) are more powerful in the clinical assessment of early phase ATD than the commonly used MME (Busse et al., 2003; Spaan et al., 2003; Spaan et al., 2005). When the presented findings were evaluated in this regard, it was observed that results could change due to the stage of examination or the information that will be retrieved implicitly. In other words, if the information was coded in the deep/semantic level, this could differentiate early ATD, but if the information was coded in the shallow/physical level, it could only be differential in severe ATD.

Therefore, we think it is premature to conclude that implicit memory tests are more sensitive than the MME. Such a conclusion can only be reached if supported with further research findings. However, the authors agree with the above-mentioned studies that implicit memory tests should be included in neuropsychological tests used for the clinical evaluation of ATD.

The small number of participants in the patient groups and the fact that we subsequently combined mild and moderate phase ATD patients into one subgroup is the main limitation of this research. WSC, which is frequently used in implicit memory studies, was used in this study. This test is a perceptual implicit memory task that involves conceptual components. It is thought that future research studies using different tasks that represent different dimensions of implicit memory (for example, relatively more perceptual or more conceptual than WSC) will reveal interesting findings.

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