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WMS-III Logical Memory Performance after a Two-Week Delay in Temporal Lobe Epilepsy and Control Groups

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Abstract

Conventional memory assessment may fail to identify memory dysfunction that is characterized by intact recall for a relatively brief period but rapid forgetting thereafter. This study assessed immediate memory and retention after 30-minute and two-week delays in a control group ($n = 25$) and a group of individuals with temporal lobe epilepsy (TLE, $n = 25$). For raw free recall, thematic unit, and recognition memory scores from the Wechsler Memory Scale-3rd ed. (WMS-III) Logical Memory (LM) subtest, there were no group X trial interactions and the TLE group performed significantly worse than the controls on all trials. At the individual level, none of the patients (0%) demonstrated isolated free recall impairment at the two-week delay when raw scores were analyzed, and one patient (4%) but also five controls (20%) did so when percent retention scores were examined. In summary, TLE patients did not demonstrate disproportionate forgetting over two weeks on a widely used story memory test.

INTRODUCTION

Standardized neuropsychological memory tests typically measure immediate memory and then retention of the information after a 20-minute to 30-minute delay (Lezak, 1995). However, a few case studies have reported that some individuals with temporal lobe epilepsy (TLE) demonstrate intact auditory memory after such relatively brief delays, but subsequent unusually rapid memory loss or accelerated forgetting (Holdstock, Mayes, Isaac, Gong, & Roberts, 2002; Kapur et al., 1997; O'Connor, Sieggreen, Ahern, Schomer, & Mesulam, 1997). In addition, two studies reported such a pattern of forgetting at the group level in TLE patients versus controls between a 30-minute delay and either a 24-hour (Martin et al., 1991) or an 8-week delay (Blake, Wroe, Breen, & McCarthy, 2000). None of the individual cases described had typical mesial TLE, because the patients had either cancer and a very high seizure frequency (O'Connor et al., 1997), severe traumatic brain injury with extensive bilateral lateral temporal lobe atrophy (Holdstock et al., 2002), or a very late seizure onset (Kapur et al., 1997). In the group studies, the memory testing was atypical (Jones-Gotman, Smith, & Zatorre, 1993; Rabin, Barr, & Burton, 2005) in the sense that there were numerous presentations of the test stimuli when necessary to insure that each participant met a learning criterion (up to 12 repetitions of a 12-word list or 10 repetitions of a single story).

A recent study of auditory and visual selective reminding test performance, with a maximum of six learning trials, revealed that TLE patients, especially a group with left TLE, generally demonstrated poorer memory ability than controls but did not differ from the controls in rate of information loss across 30-minute and 24-hour delays (Bell, Fine, Dow, Seidenberg, & Hermann, 2005). In addition, there was no evidence that forgetting over the extended delay was more common in TLE patients compared to controls at the individual level. To determine

whether a delay longer than 24 hours might reveal reduced retention of information to be characteristic of TLE versus controls, we expanded the Wechsler Memory Scale - Third Edition (WMS-III, Wechsler, 1997a) assessment procedure by adding a two-week delay trial to the Logical Memory (LM) subtest for TLE patients and healthy controls.

METHODS

Research Participants

The 25 individuals with TLE were recruited after their medical records were reviewed by a board certified neurologist with expertise in epilepsy. This review included information pertaining to seizure semiology, previous EEGs and neuroimaging when available, and clinical history and course. Each patient then was classified as having seizures of definite, probable, or possible temporal lobe origin. Definite TLE was defined by continuous video/EEG monitoring demonstrating temporal lobe seizure onset. Probable TLE was defined by clinical semiology reported to reliably identify complex partial seizures of temporal lobe origin, in conjunction with interictal EEGs, neuroimaging findings, and/or developmental and clinical history. Only those patients meeting criteria for definite or probable TLE were recruited for study participation. Patients were recruited for the study whether or not they were considered potential candidates for unilateral anterior temporal lobectomy (ATL).

None of the members of the TLE group had foreign tissue lesions on head MRI. Six of the participants in the TLE group had undergone a left anterior temporal lobectomy at the time of this study. TLE seizure laterality was determined by interictal EEG or ictal video-EEG. The EEG results for the ATL cases were acquired presurgery. Twenty-four percent of the patient group had right TLE (3 interictal, 3 ictal), 44% left TLE (3 interictal, 8 ictal), and 8% bilateral TLE (1 interictal, 1 ictal). In 24% of the patients, TLE laterality was uncertain. During the year prior to this evaluation, 44% of the patients had seizures on a daily, weekly or monthly basis and the remaining patients had approximately yearly seizures or were seizure free. Five of the six individuals who had undergone a left ATL were seizure free. Twenty-three of the patients were taking at least one anti-epilepsy medication. Two patients who were experiencing simple partial seizures only, including one who had undergone a left ATL, were not taking an anti-epilepsy medication at the time of this study.

The majority of the 25 controls were friends, relatives or spouses of individuals with TLE. They met WMS III criteria for healthy controls (Psychological Corporation, 2002, Table 2.1, p. 21). All participants were between the ages of 18 and 63 and had a Wechsler Adult Intelligence Scale-Third Edition (WAIS-III, Wechsler, 1997b) short form full scale IQ ≥ 70 and ≤ 119 . In determining the full scale IQ, the verbal IQ was prorated on the basis of five subtests and the performance IQ was estimated on the basis of three subtests (Pilgrim, Meyers, Bayless, & Whetstone 2000; Psychological Corporation, 2002). See Table 1 for characteristics of the TLE and control groups.

Memory Assessment

All participants were administered the four original core subtests of the WMS-III (Faces, Family Pictures, Verbal Paired Associates, LM) plus a two-week delay trial for the WMS-III LM subtest. The WMS-III was administered as part of a neuropsychological battery selected for a longitudinal study of the neurobehavioral consequences of TLE at the University of Wisconsin Hospital in Madison, WI. All of the participants had been administered the test battery, with the exception of the LM two-week delay trial, approximately four years earlier. Neither group showed a significant gain in LM immediate or 30-minute delayed memory raw scores across the two evaluations (control group LM immediate: $t = -.57$, $df = 24$, $p = .58$, LM

delayed: $t = -.18$, $df = 24$, $p = .86$; TLE group LM immediate: $t = -.41$, $df = 24$, $p = .69$, LM delayed: $t = -.50$, $df = 24$, $p = .62$).

The WMS-III LM subtest immediate and 30-minute delay trials were administered according to test manual guidelines (Wechsler, 1997a). Briefly, story A is read once to the examinee, who then orally provides any information recalled. Story B is read twice to the examinee, with any recalled information provided after each reading. The examiner records the number of free recall units and thematic units, which represent more general information, that are provided by the examinee. The examinee is instructed to try to remember the stories because he or she will be asked to tell them again later. Following 30 minutes of other testing, the examinee is asked to provide any information recalled from Story A and then Story B. A standard cue is provided if the examinee has no memory of a story. The recall and thematic unit scores are again recorded. Fifteen yes/no recognition memory questions are then asked about each story and the recognition memory scores are recorded.

Participants in this study provided written consent to undergo neuropsychological testing and to receive a follow-up phone call that would be made approximately 14 days after completing the research test battery. They were not informed that the phone call would involve additional memory testing. Patients and controls who were from the same family were tested simultaneously for the standard WMS-III evaluation. In the rare cases when two family members were both assessed on LM two weeks later, we confirmed with the participants that the examinee was out of ear shot of his or her co-participant when the telephone testing was being conducted.

It was not possible to communicate by telephone with every participant exactly 14 days after administration of the WMS-III, but an attempt was made to complete the phone call as close as possible to 14 days later (see Results section). After introducing himself at the time of the telephone call, the examiner stated, "Do you remember the two stories that were read to you two weeks ago? I want you to tell me the stories again. Tell me everything that you remember about the first story. Start at the beginning." After the first story, the examiner stated, "Now tell me everything that you can remember about the second story." If a participant had no recall of a story, the standard WMS-III LM cue was provided. For the purposes of this study, we tallied the total number of intrusion errors (reported details that were not part of either story) that were provided during free recall at the two-week delay trial. Recognition memory again was tested. Finally, members of the TLE group were asked to estimate how many seizures they had experienced since completing the neuropsychological research battery about two weeks earlier.

LM raw scores were used in the statistical analyses; savings or percent retention scores also were used for analyses at the individual level. The percent retention scores represent the number of story units recalled on the immediate memory trial (story A plus second trial of story B) divided by the number of units recalled after the 30-minute and two-week delays, respectively (maximum = 100%).

In order to determine the number of participants in each group with an impaired score on each LM variable, memory impairment was defined as a score ≤ -1.0 standard deviation (SD) below the mean of the control group. The one SD cut-off has been used to define scores as abnormal on standardized tests of memory and cognition (Heaton, Grant, and Matthews, 1991; Heaton, Taylor, and Manly, 2003). Impairment on the LM subtest corresponded to raw scores ≤ 28 for immediate memory and ≤ 24 and 13 for the 30-minute and two-week delays, respectively.

RESULTS

Group Analyses

Length of Extended Delay, Intrusions and Cueing

There was no difference between the two groups in the mean length in days of the extended delay: control group = 15.9 (3.6) and TLE group = 15.5 (2.6), $t = .46$, $df = 48$, $p = .65$. The groups also did not differ with regard to number of intrusions produced at the two-week delay trial: control group = 1.2 (1.4) and TLE group = 1.0 (1.2), Mann-Whitney $U = 289.0$, $p = .63$.

There was no difference between the groups in the percentage of individuals who required cueing for at least one story at the two-week delay trial, but there was a trend toward a greater frequency of cueing within the TLE group after this extended delay (control group $n = 7$ [28%], TLE group $n = 13$ [52%], $z = 1.73$, $p = .08$). Cueing data at the 30-minute delay trial was available for only a subset of the participants (control $n = 18$; 1 [6%] cued; TLE $n = 15$; 7 [47%] cued). Thus, a direct comparison cannot be made of the frequency of cueing at the 30-minute and two-week delays. The apparent increase in need for cueing in the control group at the two-week delay is consistent with the finding that some controls had poor retention of information over the extended delay (see Individual Analyses section below). Among those for whom 30-minute delay cueing data was available, cueing was more often required within the TLE group compared to the control group. This finding is consistent with the fact that the patients had significantly poorer memory at all trials compared to the controls. In summary, it does not appear that the need for cueing grew disproportionately among the TLE patients versus controls between the 30-minute and two-week delay trials.

Free Recall

A 2 X 3 (Group X Trial) univariate analysis of variance (ANOVA) for LM free recall revealed main effects of group [$F(1, 144) = 29.3$, $p < .01$] and trial [$F(1, 144) = 42.5$, $p < .01$], but no significant group X trial interaction effect [$F(1, 144) = .91$, $p = .41$]. T tests revealed that the control group differed significantly from the TLE group on the immediate ($t = 3.2$, $df = 48$, $p < .01$, effect size = .88), 30-minute delay ($t = 3.7$, $df = 37$ [corrected for inequality of variance], $p < .01$, effect size = 1.02), and two-week delay ($t = 2.4$, $df = 48$, $p < .05$, effect size = .45) trials. The findings did not change when the analyses excluded the patients who had undergone left ATL or those with unknown seizure laterality.

Because the 11 left TLE and left ATL patients could be considered most likely to demonstrate forgetting of verbal information over time, we also analyzed the results for this subgroup of patients versus controls. Once again, there were main effects of group and trial, but no significant group X trial interaction effect ($p = .19$). Although the interaction effect tends toward significance for this analysis, the results did not reveal a tendency toward disproportionate forgetting during the two-week delay in the patient group. Retention after the 30-minute delay was slightly worse in these patients (20.0/25.0, 80%) versus controls (29.7/33.4, 89%), whereas retention of the initially learned information after the two-week delay was slightly better in these patients (15.3/25.0, 61%) versus controls (18.6/33.4, 56%).

Because LM Story A is presented to examinees just once, whereas there are two learning trials for Story B, we also conducted separate analyses for each story for the entire sample of participants. For both Story A and B, there were main effects of group and trial, but no significant group X trial interaction effect (p values for interaction effect: Story A = .35, Story B = .63). T tests revealed that the control group differed significantly from the TLE group on the immediate, 30-minute delay, and two-week delay trials for both stories.

Thematic

A 2 X 3 (Group X Trial) univariate analysis of variance (ANOVA) for LM thematic (story gist) scores revealed main effects of group [$F(1, 141) = 21.7, p < .01$] and trial [$F(1, 141) = 7.9, p < .01$], but no significant group X trial interaction effect [$F(1, 141) = .60, p = .55$]. *T* tests revealed that the control group differed significantly from the TLE group on the immediate ($t = 3.2, df = 48, p < .01$, effect size = .66), 30-minute delay ($t = 3.7, df = 37$ [corrected for inequality of variance], $p < .01$; effect size = .77), and two-week delay ($t = 2.4, df = 48, p < .05$, effect size = .71) trials.

Recognition

A 2 X 2 (Group X Trial) univariate analysis of variance (ANOVA) for LM recognition scores revealed main effects of group [$F(1, 96) = 18.76, p < .01$] and trial [$F(1, 96) = 34.5, p < .01$], but no significant group X trial interaction effect [$F(1, 96) = .37, p = .55$]. There are only two trials in this analysis because recognition memory is not tested after the immediate free recall trial. *T* tests revealed that the control group differed significantly from the TLE group at the 30-minute delay trial ($t = 3.4, df = 38$ [corrected for inequality of variance], $p < .01$; effect size = .95), and two-week delay trial ($t = 2.7, df = 48, p < .05$, effect size = .76).

Individual Analyses

Free Recall Raw Scores

Figure 2 shows the percentage of participants who had an impaired raw score (≤ -1.0 SD from control mean) on each of the LM memory variables: immediate, 30-minute delay, and two-week delay. The TLE group had a significantly higher percentage of individuals with impairment at the immediate ($z = 2.89, p < .01$) and 30-minute delay trials ($z = 3.14, p < .01$), but not at the two-week delay ($z = 1.32, p > .05$). In addition, it is notable that none of the TLE patients versus three controls (12%) showed memory impairment solely at the two-week trial ($z = 1.79, p > .05$).

Free Recall Percent Retention Scores

Thirteen (52%) of the TLE group demonstrated an impaired percent retention score at the 30-minute delay compared to four (16%) of the control group ($z = 2.69, p < .01$). For the two-week delay, seven (28%) of the TLE group and five (20%) of the controls demonstrated impairment ($z = .66, p > .05$). Only one (4%) of the patients versus five (20%) of the controls showed isolated memory impairment at the two-week delay when percent retention scores for the 30-minute and two-week trials were analyzed ($z = 1.74, p > .05$).

Correlation between LM scores and seizures

A total of 10 TLE patients (40%) reported experiencing at least one seizure during the two-week delay. One of these TLE patients reported a total of 25 seizures during this extended delay, but all of these were said to have been simple partial seizures. The number of seizures experienced by the remaining 9 patients during the two-week delay ranged from 1 to 3. There was no significant correlation between presence/absence of a seizure and the LM two-week delayed memory raw score ($r_s = -.24, p = .27$) or percent retention score ($r_s = -.07, p = .74$).

DISCUSSION

In this study, we examined WMS-III LM subtest performance in healthy controls and individuals with TLE. The standard LM data for the TLE group in this study are quite similar to those from another recent report concerning patients with TLE (Dulay, Schefft, Fargo, Privitera, & Yeh, 2004), which suggests that the TLE group in the current study is not atypical.

We added a two-week delayed memory trial to the conventional LM immediate memory and 30-minute delayed memory trials in order to determine whether the TLE group or a subset of this group would show rapid forgetting over the extended interval. There were significant effects of group and trial for LM free recall, thematic unit, and recognition memory raw scores, but there were no group X trial interactions. The TLE group consistently differed significantly from the controls at all three trials. The findings did not change when the analyses included only patients with a history of left TLE or excluded the patients who had undergone left ATL or those with unknown seizure laterality. These results indicate that, at the group level, the TLE patients did not lose more information over the two-week delay compared to controls.

In addition, analyses at the individual level showed no evidence of disproportionate forgetting in the individuals with TLE compared to the controls. Analysis of raw scores revealed that none of the participants with TLE showed isolated memory impairment at the two-week trial, and only one (4%) of the patients showed isolated impairment at that trial when percent retention scores for the 30-minute and two-week delay trials were analyzed.

Our results are consistent with a previous study of auditory and visual selective reminding test (SRT) performance in controls and individuals with TLE (Bell et al., 2005), in which 56% of both the controls and TLE patients in the present study were included. In the SRT study, which utilized immediate, 30-minute delay, and 24-hour delay trials, a left TLE group ($n = 22$) performed significantly worse than controls ($n = 49$) on all three trials of both SRT measures. The right TLE group ($n = 20$) differed from the controls on all three visual SRT trials and on learning for the auditory SRT. There were no between group differences in rate of information lost at the 30-minute versus the 24-hour delay. At the individual level of analysis in the SRT study, there was no difference in the percentage of patients versus controls who demonstrated isolated memory impairment at the 24-hour delay.

The current results also are consistent with another study of visual SRT performance in left and right TLE patients and controls (Giovagnoli, Casazza, & Avanzini, 1995). In that study, the right TLE group demonstrated impaired immediate memory compared to the other two groups, but there were no differences among the groups in percentage of information retained across delay trials extending from one hour to 13 days.

In conclusion, disproportionate forgetting over an extended delay in patients with epilepsy has been demonstrated mainly in individual cases with severe brain injury or illness or at the group level after overlearning of information across numerous, consecutive learning trials. The results of this investigation of WMS-III LM performance after 30-minute and two-week delays provide evidence that the conventional 30-minute delay typically is sufficient for measuring memory functioning in individuals with TLE. This hypothesis could be tested further in larger subsets of TLE patients with clearly lateralized seizures by studying performance on other standardized memory tests (Wood, Saling, O'Shea, Berkovic, & Jackson, 2000) or memory for everyday events after a delay of weeks. Functional neuroimaging studies of learning and memory after an extended delay in patients with TLE and controls might help identify the neuroanatomic structures that contribute to long term retention and whether there are any anatomic activation differences in these groups. Additional study of recall after extended delays in patients with other neurological disorders that affect memory also would help determine the adequacy of conventional memory assessment procedures.

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Note. The immediate memory component of the percent retention scores was based on recall of story A and recall on the second trial of story B.

Figure 1.
WMS-III Logical Memory Percent Retention by Group and Delay Trial.

Figure 2.
Percentage of the TLE and Control Groups with Impaired Logical Memory Raw Scores by Trial.

Table 1

Demographic and Seizure History Data

	Group	
	Control	TLE
N	25	25
Age	35 (11)	39 (10)
Education	14.0 (2.1)	13.3 (1.7)
WAIS-III short form FSIQ *	104 (10)	94 (12)
% Female	68	60
Right handed	92	84
Age of onset (yrs)		11 (8)
Number of AEDs		1.5 (1)
Number of pts with any seizure type during two-week delay		10

*
p < .01.

AED = anti-epilepsy drug.

Table 2
WMS-III General Memory Index (GMI) and Logical Memory (LM) Subtest Data by Group

Variable	Control	Group	TLE
WMS-III GMI **	113 (13)		93 (18)
LM standard scores			
Free recall			
Immediate **	12.0 (2.3)		9.4 (3.5)
30-min delay **	12.0 (2.1)		9.1 (3.8)
30-min percent retention **	11.8 (1.8)		9.4 (4.0)
Thematic			
Immediate *	11.8 (2.9)		9.8 (2.7)
30-min delay **	11.5 (2.5)		9.2 (3.4)
LM raw scores			
Free recall			
Immediate – all trials ^{a**}	47.7 (8.1)		38.4 (12.1)
Immediate – 2 trials ^{b**}	33.4 (5.9)		26.8 (8.6)
30-min delay **	29.7 (5.8)		20.8 (10.7)
Two-week delay *	18.6 (5.1)		13.8 (8.4)
Thematic			
Immediate – all trials ^a	18.5 (3.5)		16.8 (2.9)
Immediate – 2 trials ^{b*}	12.7 (1.9)		11.2 (2.5)
30-min delay **	12.1 (2.2)		9.8 (3.5)
Two-week delay *	10.8 (2.3)		8.3 (4.3)
Recognition			
30-min delay **	27.3 (2.1)		24.4 (3.7)
Two-week delay *	23.4 (2.7)		21.2 (3.0)

*
p < .05.

**
p < .01.

^a Scores represent recall for story A plus recall for both trials of story B.

^b Scores represent recall for story A plus recall for second trial of story B. These data were used in the statistical analyses.