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Autobiographical Memory and Mood: Effects of Electroconvulsive Therapy

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An Autobiographical Memory Interview (AMI) was administered to 75 depressed inpatients and 16 nondepressed controls. Patients were randomized to 1 of 4 forms of electroconvulsive therapy (ECT) that varied in electrode placement and stimulus intensity. Short-term retrograde amnesia was assessed during the week following the randomized phase. Bilateral ECT produced more marked deficits than right unilateral ECT. At a 2-month follow-up, persistent amnesic deficits were related to having received a second ECT course and, to a lesser extent, bilateral ECT during the randomized phase. The magnitude of clinical improvement was not associated with amnesia scores at either time point. There were no differential amnesic effects as a function of the affective valence of memories. It appears that retrograde amnesia for autobiographical information after ECT and mood congruence effects on recall are independent phenomena. The magnitude and persistence of retrograde amnesia is related to how ECT is performed and not to changes in clinical state or the affective valence of memories.

Electroconvulsive therapy (ECT) has well-documented neuropsychological effects. Shortly after an ECT course, patients typically manifest retention deficits for newly learned information (*anterograde amnesia*) against a background of improved performance on tests of attention, immediate learning, and intelligence (Sackeim et al., 1992, 1993; Steif, Sackeim, Portnoy, Decina, & Malitz, 1986). ECT also results in retrograde amnesia (Weiner, Rogers, Davidson, & Squire, 1986), the severity of which is thought to be temporally graded (Squire, 1986; Squire, Slater, & Chace, 1975; Squire, Slater, & Miller, 1981).

Amnesia for autobiographical events may be an especially robust, iatrogenic effect (Weiner, 1984). Squire and Slater (1983) found that 3 years after treatment patients reported gaps in memory for events that occurred on average 6 months before and 2 months after bilateral (BL) ECT. Research with objective measures has also demonstrated persistent impairment of autobiographical memory after ECT. Squire et al. (1981) documented amnesia for events that occurred in close proximity to BL ECT when patients were assessed 7 months after the treatment course. Weiner et al. (1986) compared depressed patients treated with medications with patients randomized to ECT conditions that differed in electrical waveform and electrode placement. At 6-month follow-up, patients treated with BL ECT showed persistent impairment in recalling autobiographical information, whereas patients treated with right unilateral (RUL) ECT did not differ from non-ECT controls. To date, retrograde amnesia for autobiographical memories is the one domain in which there is evidence that ECT may produce persistent deficits.

ECT is a highly effective antidepressant treatment (American Psychiatric Association, 1990; Janicak et al., 1985; National Institutes of Health, 1985). After receiving ECT, many patients experience profound alteration in affective state. The relationship between the amnesic and therapeutic effects has long been a source of controversy. One class of theories has suggested that patients appear to be clinically improved after ECT because they have a global amnesic syndrome and other cognitive side effects (Breggin, 1979; Friedberg, 1977; Miller, 1967). For instance, it has been claimed that manifestation of a "punch drunk," acute confusional state makes patients appear less depressed. To test this view, a large number of studies

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sought correlations between the cognitive and therapeutic effects. In general, when significant associations were obtained they were in the opposite direction, indicating that improved performance on measures of attention and immediate learning after ECT was associated with superior clinical outcome (e.g., Calev et al., 1991; see Sackeim, 1992, for a review). Similarly, several recent studies have shown that when compared with pre-ECT scores, patients' subjective evaluations of memory function improve shortly after ECT and that the magnitude of this change covaries with the extent of symptomatic improvement (Coleman et al., in press; Pettinati & Rosenberg, 1984; Weiner et al., 1986). On the other hand, significant associations between objective anterograde or retrograde amnesic deficits and clinical change have not been observed (Frith et al., 1983, 1987; Sackeim et al., 1993; Weeks, Freeman, & Kendell, 1980; Weiner et al., 1986). However, there have been few attempts to examine such relationships specifically with measures of retrograde amnesia for autobiographical information.

Janis (1948, 1950a, 1950b; Janis & Astrachan, 1951) was the first to study changes in autobiographical memory after ECT. Using open-ended questioning about personal events, he reported persistent amnesia for at least 1 month after ECT in schizophrenic patients. Janis suggested that retrograde amnesia for affectively charged, personally disturbing events was particularly likely. Indeed, offering a psychodynamic account, he claimed that amnesia for this type of information was at least partly responsible for ECT's efficacy.

A class of theories emphasizing mood congruency effects would also suggest that there should be prominent relationships between amnesia for negatively charged personal memories and therapeutic response. There is evidence that the retrieval of personal memories is dependent on affective state, with negatively charged information more readily recalled in depressed than neutral or elated mood states (Blaney, 1986; Bower, 1981; Singer & Salovey, 1988; Watkins, Mathews, Williamson, & Fuller, 1992). Accordingly, given the marked change in clinical state in patients who respond to ECT, this subgroup should manifest greater difficulty in recalling the details of negative personal events when compared with patients who remain depressed.

Both the theory advanced by Janis (1950a) and the phenomenon of mood congruence suggest that negatively valenced affective memories are particularly susceptible to amnesia after ECT. In contrast, depth of encoding and self-schema theories might give the opposite impression (Bower, 1992). Compared with affectively neutral personal information, emotionally laden memories may be subject to better learning, more extensive elaboration, and more frequent retrieval. This may increase resistance to amnesia. Indeed, there is substantial evidence that the memorability of an event is often associated with its affective intensity (Brewer, 1988; Chriastianson & Loftus, 1987; Dutta & Kanungo, 1975). However, susceptibility to retrograde amnesia as a function of the affectivity of memories has never been tested empirically.

The change in the affective state after ECT might also account for another aspect of retrograde amnesia. There is evidence that the retrograde amnesia is temporally graded for both impersonal and personal information, with events most proximal to ECT most vulnerable to loss (Squire et al., 1975; Squire & Cohen, 1979; Squire et al., 1981). This evidence has been influential in supporting the view that long-term memories undergo an extended period of consolidation. However, Kinsbourne and Wood (1982) suggested that the marked change in the clinical state of depressed patients after ECT accounts for the temporal gradient. Drawing on the notion of mood state dependence in learning and memory (Blaney, 1986; Eich, Macaulay, & Ryan, 1994; Singer & Salovey, 1988), they argued that recent events most likely occurred during the depressive episode, whereas remote events more likely occurred when patients were euthymic. This view stipulates that the temporal gradient is observed because recovered patients are tested after ECT in the same affective state as when they experienced remote events, but in a different state relative to more recent events. Therefore, this account predicts that patients who respond to ECT show a steeper temporal gradient than nonresponders. This view has also never been tested.

This study examined autobiographical memory in a sample of depressed patients and matched normal controls. Patients were tested before, during the week after, and 2 months after ECT. The patients were randomized to the RUL or BL electrode placements and low- and high-electrical dosage, allowing for determination of the effects of treatment parameters on retrograde amnesia. Patients who did not respond to the randomized condition received a second crossover course of high-dosage BL ECT. The autobiographical memory assessment sampled affectively charged (*positive* and *negative*) and neutral events, as well as recent (past year) and more remote memories. The comparison of the baseline performance of depressed patients and normal controls allowed for determining the extent to which the depressed state had an impact on the accessibility of autobiographical memories. After ECT, there was considerable variation among the patients in symptomatic improvement. This allowed for determining the extent to which the overall magnitude of retrograde amnesia was related to clinical state change and specifically as a function of the recency and affective valence of autobiographical events.

Because of results of previous studies, we expected that patients treated with BL ECT and/or who crossed over to a second course of ECT would have the most severe and persistent retrograde amnesia (Weiner et al., 1986) and that this amnesia would be more marked for recent than remote autobiographical events (Squire et al., 1981). Studies of anterograde amnesia and of retrograde amnesia for public information suggest that the amnesic and therapeutic effects of ECT are independent (Sackeim, 1992). In contrast, the view that the therapeutic effects are contingent on the development of an organic amnesic syndrome predicts more severe retrograde amnesia among ECT responders (Breggin, 1979). Mood congruence (Singer & Salovey, 1988) and psychodynamic (Janis, 1950b) theories predict that among patients who respond to ECT retrograde amnesia would be more marked for negatively than positively charged autobiographical events. Mood state dependence theory (Kinsbourne & Wood, 1982) predicts that the temporal gradient in retrograde amnesia would be steeper among ECT responders. We tested each of these alternative predictions.

Method

Participants

The sample contained 75 depressed patients and 16 normal controls. The patients met the Research Diagnostic Criteria (RDC; Spitzer, Endicott, & Robins, 1978) for major depressive disorder on the basis of interviews including the Schedule for Affective Disorders and Schizophrenia (SADS; Endicott & Spitzer, 1978). At pre-ECT baseline, patients had scores on the Hamilton Rating Scale for Depression (HRSD; Hamilton, 1967) of at least 18. History of schizophrenia, schizoaffective disorder, other functional psychosis, rapid-cycling bipolar disorder, neurological insult or illness, substance dependence, recent substance abuse, ECT within the past 6 months, or a current serious medical illness were exclusion criteria. Controls had negative lifetime history of all RDC disorders on the basis of SADS interviews and had scores on the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961) no greater than 9. They met the same exclusion criteria as the patients. Controls had been free of medication for at least 4 weeks. With the exception of lorazepam (up to 3.0 mg per day as needed), patients were withdrawn from all psychotropic medications for at least 5 days before neuropsychological evaluation and ECT. With an upper limit of 30 days on average, the depressed sample had been free of psychotropics 13.3 days ($SD = 8.6$) before the baseline assessment of autobiographical memory and 16.9 days ($SD = 7.7$) before the start of ECT.

Table 1 presents descriptive information on the patients and control samples. There were 45 women (60%) in the depressed group and 11 women (69%) in the normal comparison group, with no difference in the distributions, $\chi^2(1, N = 91) = 0.43, p > .50$. Analyses of variance (ANOVAs) were conducted on the demographic variables listed in Table 1 with diagnostic group (depressed vs. normal) and gender as between-subjects terms. There were no significant effects involving diagnostic group ($ps > .10$). Table 1 also presents clinical features of the depressed sample; 25 patients (33%) met the RDC for bipolar disorder; 34 (45%) had psychotic depression; and 30 (40%) had a history of previous ECT.

Table 1
Demographic and Clinical Characteristics of Depressed and Control Groups

Variable	Depressed (n = 75) *M*	Depressed (n = 75) *SD*	Control (n = 16) *M*	Control (n = 16) *SD*
Age (years)	54.0	13.9	59.6	9.1
Education (years)	13.3	3.2	14.6	2.3
WAIS–R Verbal IQ (score)	103.6	16.2	104.6	10.5
Socioeconomic status[a]	2.4	1.1	2.1	0.9
Length of current episode (weeks)	44.0	33.6		
No. previous affective episodes	3.5	3.3		
No. previous psychiatric hospitalizations	2.3	2.9		
Pretreatment HRSD (score)	33.2	8.1		
Age at onset (years)	37.6	17.3		
Lorazepam dosage at baseline (mg/day)	1.1	0.9		

Note. A maximum of 104 weeks was imposed on length of current episode. A maximum of 10 was imposed on number of previous episodes and on number of previous hospitalizations. WAIS–R = Wechsler Adult Intelligence Scale—Revised; HRSD = Hamilton Rating Scale for Depression.
[a]Determined according to the Hollingshead Four-Factor Index.

Materials

The autobiographical memory interview (AMI) was part of a larger assessment battery used to assess the acute, short-term, and long-term cognitive effects of ECT (Sackeim et al., 1993). The AMI was adapted from an earlier version developed by Weiner et al. (1986) and was administered in a structured interview format. The classes of events included illnesses and hospitalizations, work history, places of residence, travel and entertainment activities, and significant, as well as everyday events in the lives of the interviewees, their families, and friends. The interview involved inquiries about 281 personal events or event details (see Table 2). Of these inquiries, 185 items required a response that described an individual, location, or an event (*descriptive questions;* e.g., "On what street was the building where you last worked?"); 20 items required a numerical response (e.g., "At the time you entered the hospital what was [name of friend's] age?"); 31 items required the interviewee to supply a date including the month and year of a singular event (e.g., "Prior to your hospitalization, in what month and year did you last take a trip out of the tristate area?"); 6 items required a date including the month and day of a recurring event (e.g., "Can you tell me the month and day of your friend's birthday?"); 16 items required a dichotomous yes or no response (e.g., "During the year prior to your present hospitalization, did you consult a physician about a physical complaint or illness?"); and 14 items required a list of names (e.g., "Who went with you on this trip?").

Within the set of 185 descriptive questions, there were 28 inquiries about events that took place within the year prior to hospital admission and 40 inquiries about events that took place at least 1 year before admission. Nineteen of the recent (past year) and 19 remote questions were matched for content, eliciting the same type of descriptive details about the same type of event. For example, participants were asked to describe the worst thing that happened to them both in the past year and lifetime, not including the past year. To elicit autobiographical information about affectively charged material, the interviewer included questions about the worst and best events that the participant had ever experienced. Examples of these items included inquiries about the best and worst New Year's Eve and the best and worst general events in the past year and lifetime. After specific events were identified, details about the events were elicited. For example, after the identification of a worst New Year's Eve, participants were asked what they did on that occasion, who they were with, where the event took place, and what about the event made it emotionally significant. A total of 67 descriptive questions (from the larger set of 185) focused on negatively charged events and 34 descriptive questions concerned positively charged events. In addition, 31 items about negatively or positively charged events were matched for content. For example, the same detailed inquiries were made about both the best or worst trip the participant had ever taken.[1]

The AMI took between 1 and 3.5 hr to administer. For 52 patients, the AMI was also administered to a family member or close friend. Corroborators were asked to respond to the items as they thought the participant would. When corroborators indicated uncertainty, they were informed of the patient's pretreatment response and asked for verification.

The AMI was administered once to the controls without family member corroboration. The interview was identical to that given to patients, except that questions using the present hospitalization as a

[1] As shown in Table 2, of the 185 descriptive questions, 68 explicitly referred to a recent or remote event. All but 3 descriptive questions could be classified in terms of affectivity (neutral, positive, or negative). These 3 questions concerned the day of hospital admission. The items that were matched in content were subsets of the unmatched items.

Table 2
Autobiographical Memory Interview Variables and Scoring Categories at Retesting

Variable	Number of items	Scoring category
Descriptive questions	185	Consistency
Total recall or recognition	185	Consistency
Total recall	185	Consistency
Recall or recognition of events	43	Consistency
Recall of events	43	Consistency
Recall of event details	142	Consistency
Total	185	Number of "don't know" responses
Yes–no questions	16	Consistency
Month/year questions	31	Number of responses
Month/year questions	31	Directional discrepancy with baseline
Month/year questions	31	Absolute discrepancy with baseline
Month/day questions	6	Number of responses
Month/day questions	6	Directional discrepancy with baseline
Month/day questions	6	Absolute discrepancy with baseline
List questions	14	List elements consistent with baseline (%)
List questions	14	List elements inconsistent (novel) with baseline (%)
Descriptive questions[a]		
Temporal categorization		
Recent–unmatched	28	Consistency
Remote–unmatched	40	Consistency
Recent–matched	19	Consistency
Remote–matched	19	Consistency
		Ratio of consistent responses to matched recent relative to matched remote items (temporal gradient)
Affective categorization		
Neutral–unmatched	81	Consistency
Positive–unmatched	34	Consistency
Negative–unmatched	67	Consistency
Positive–matched	31	Consistency
Negative–matched	31	Consistency
		Ratio of consistent responses to matched positive relative to matched negative items (affective valence)

[a]The temporal and affective categorizations were based only on descriptive questions.

time reference were reworded, substituting the controls' participation in a screening session for the research project. The screening session took place approximately 2 weeks earlier. In addition, three AMI items concerned details about the patient's current hospitalization and were not administered to the control.[2] At all time points, participants were strongly encouraged to guess when uncertain.

Procedure

Electroconvulsive therapy. The patients were randomly assigned to one of four ECT treatment conditions (Sackeim et al., 1993). These conditions crossed the variables of electrode placement (RUL vs. BL) and stimulus intensity (low vs. high electrical dosage). Treatments were administered three times per week. Anesthetic medications included atropine (0.4 mg, IV), methohexital (0.75 mg/kg), and succinylcholine (0.5 mg/kg). Patients were oxygenated (100% O_2) from anesthetic administration until the resumption of spontaneous respiration. A custom-modified MECTA SR-1 (Mecta Corp., Lake Oswego, OR) device delivered a constant current, brief pulse electrical stimulus. Seizure duration was monitored both for motor manifestations and EEG expression. Other physiological monitoring included continuous assessment of EKG, pulse oximetry, and vital signs.

The standard bifrontotemporal electrode placement was used for BL ECT and the d'Elia placement (d'Elia, 1970) for RUL ECT. A titration procedure involving an ascending method of limits was performed at the first treatment to quantify the minimal electrical intensity that produced an adequate generalized seizure (Sackeim, Decina, Prohovnik, & Malitz, 1987). Dosage titration was repeated at the last treatment. Patients assigned to the low-dosage conditions received an electrical intensity that was just above seizure threshold at all treatments. At all but the first and last treatments, patients assigned to the high-dosage conditions received an electrical intensity (in units of charge) that was 2.5 times the seizure threshold determined in the first session.

Clinical evaluation. The patients and a clinical evaluation team composed of a research psychiatrist and a social worker were unaware of the randomized assignments. The team completed HRSD ratings twice a week during the ECT course and also determined the number of treatments. No minimum or maximum treatment number was imposed on patients who showed clinical improvement. ECT was stopped when patients became asymptomatic or had not shown continued improvement over at least 2 treatments. At least 10 treatments were required before classifying patients as nonresponders.

[2] These three items were omitted from the baseline comparisons of the patient and normal control groups but were included in the analyses of the amnesic effects in patients.

This criterion was reduced to 8 treatments for patients who showed no improvement during the ECT course. The evaluation team also completed HRSD ratings within 2 days and again 1 week following the end of ECT. At all time points, intraclass correlation coefficients for HRSD scores between the raters were 0.98 or higher. Mean scores across the two raters were used.

The a priori criteria for classification as a responder required a decrease of at least 60% in HRSD scores immediately following ECT compared with the pre-ECT baseline, a maximal post-ECT HRSD score of 16, and maintenance of these gains for at least 1 week following ECT while free of psychotropic medication. Nonresponders to the randomized assignment were eligible for an open crossover phase with high-dosage BL ECT. Of the 75 patients in this study, 41 were eligible for crossover, and 32 completed this treatment phase. The ECT and evaluation procedures in the open phase were identical to those in the randomized phase.

Testing intervals. Of the 75 patients who completed the AMI at baseline, 72 were retested during the week after the end of the randomized treatment condition. These patients averaged 9.6 treatments ($SD = 2.4$) during the randomized phase. In addition, 45 of these patients were readministered the AMI 8 weeks after the completion of all ECT (randomized or crossover phase).

At each retest occasion, patients were administered only those AMI items for which they gave a definite reply at baseline. Inquiries were not made if patients had indicated at baseline that they did not know the answer to a question or that the item did not apply to them. Furthermore, 43 items could be subject to recognition testing at retesting (see Table 2). These items described a specific event (e.g., a trip to Florida) that led to questioning about its details. If at retesting, the patient did not spontaneously report any event or gave a inconsistent response (e.g., a trip to California), they were reminded of the original description. When patients indicated that they recognized the event reported at baseline, subsequent inquiries about details concerned the event described at baseline. When patients did not recognize the original event, a recognition error was noted, and there was no detailed questioning about this event.

AMI scoring. At all time points, interviewers were unaware of the randomized treatment assignment. An audio recording was made of each AMI interview, and each recording was reviewed to check the accuracy of the written records. Table 2 provides a summary of the AMI measures scored at baseline and retesting. This study focused on the extent to which the responses of patients at retesting were consistent with their responses at earlier assessment. Responses at the 1-week post-ECT interview were scored as consistent or inconsistent with the baseline reports. At the 2-month follow-up, two sets of consistency scores were derived. Like at the 1-week post-ECT time point, patients were credited with consistency if the response matched the baseline response (Measure A). A more liberal criterion was also used, crediting consistency if the follow-up response matched either the baseline or the 1-week post-ECT response (Measure B). At each retest occasion, the number of consistent responses was computed for all the items requiring a descriptive response and for the subgroupings of these items as a function of whether they identified the occurrence of an event (and were subject to recognition testing) or inquired about the details of the event. Consistency scores were also derived for subgroupings of the descriptive items that were classified in terms of recency (recent and remote) and affectivity (positive, negative, and neutral). For each category of items examined in the statistical analyses of the retest data, the number of consistent responses was the dependent measure, and the number of responses produced at baseline was a covariate. For simpler presentation, descriptive statistics are reported in terms of the percentage of consistent responses

$$\left[\frac{\text{Number consistent at retest}}{\text{Number produced at baseline}} \times 100\right].$$

Three scores were derived for the date questions (month/year or month/day). These were the total number of items for which a date was given (regardless of consistency), the average discrepancy in the number of days between the dates reported at retest and baseline [Retest − Baseline], and the average absolute discrepancy [|Retest − Baseline|]. To achieve normal distributions, we applied logarithmic transformations to the average discrepancy scores. For the items requiring that the participant produce a list, the total size of the lists produced at baseline was calculated, as well as the number of list elements at retesting that either overlapped or were novel relative to the baseline lists. Items that required a numerical response (e.g., age of a friend) were not included in the analyses. To examine temporal gradients, we computed the ratio of responses to descriptive questions about recent relative to remote events. To examine the effects of affective valence, we computed the ratio of responses to descriptive questions about positively charged relative to negatively charged events. Both ratio scores were based only on items matched for content. Finally, for the patient group baseline responses were also scored as corroborated or not by the family member or friend.

Results

Comparison of Depressed and Normal Groups at Baseline

Table 3 presents descriptive statistics for the baseline AMI scores of the depressed and normal comparison groups. Analyses of covariance (ANCOVAs) were conducted on these scores, with group (depressed vs. normal) and gender as between-subjects variables and age and education as covariates.[3] The significance levels from these ANCOVAs for the main effect of diagnostic group and for the covariate age are also presented in Table 3.

Depressed patients produced significantly fewer total responses across all item types, averaging 11.5% fewer total responses than normal controls. Within the item categories, the depressed group had significantly fewer responses requiring a descriptive answer and produced fewer responses requiring that events be dated by month and year (*singular events*). The groups did not differ in number of responses given to yes–no, month/day (*recurring events*), or list questions. The two groups were also equivalent in the total size of the lists they produced.

Depressed patients produced fewer responses for all categories of descriptive questions classified as recent (past year) or remote (see Table 3). There were no effects of diagnostic group in the ANCOVA on the ratio of response rates to matched recent compared with matched remote items. Table 3 also presents the response rates as a function of affective categorization. Despite the large number of neutral questions, the depressed and normal groups were equivalent in response rates ($p > .20$), whereas there were pronounced differences for all categories of affectively charged items ($ps \leq .01$). An ANCOVA on the ratio of responses to positively and negatively charged matched questions yielded no effects of diagnostic group (depressed: $M = 1.16$, $SD = 0.54$; control: $M = 1.10$, $SD = 0.18$). Although depressed patients produced fewer

[3] Age and education were used as covariates after preliminary analyses across the two samples and within the depressed group indicated that verbal IQ and socioeconomic status did not account for additional variance in AMI scores.

Table 3
Baseline Scores and ANCOVA Results on the Autobiographical Memory Interview for Depressed Patients and Controls

Variable	Depressed (n = 75) *M*	Depressed (n = 75) *SD*	Control (n = 16) *M*	Control (n = 16) *SD*	*p* Depressed vs. control	*p* Age
Total responses	157.1	36.1	177.6	19.0	.02	.003
to descriptive questions	113.7	25.9	129.4	14.7	.01	.005
to yes–no questions	11.9	3.1	12.9	1.6	*ns*	.05
to month/year questions	21.1	6.5	24.3	3.9	.04	.004
to month/day questions	3.0	1.2	3.1	1.1	*ns*	.003
to list questions	7.5	2.7	7.9	2.6	*ns*	.05
Total quantity reported for list questions	13.9	7.5	12.4	4.4	*ns*	.002
Recent vs. remote memory						
Past year–unmatched	15.3	5.4	19.7	3.8	.001	.02
Remote–unmatched	22.6	9.4	30.4	8.2	.0007	.001
Past year–matched	12.3	4.0	15.4	2.8	.001	.01
Remote–matched	12.0	4.2	15.6	3.0	.002	.048
Positive vs. negative affective questions						
Positive–unmatched	22.1	8.0	29.4	5.1	.0006	.01
Negative–unmatched	31.7	9.9	37.3	6.4	.01	.002
Neutral–unmatched	59.0	10.5	62.7	6.5	*ns*	.04
Positive–matched	20.0	7.5	27.3	5.0	.0004	.01
Negative–matched	18.8	7.8	25.2	4.9	.0001	.0001

Note. ANCOVA = analysis of covariance.

responses than normal controls to the affective questions, this effect was not contingent on emotional valence.

Across all the ANCOVAs, none of the main effects or interactions involving gender approached significance. As shown in Table 3, in each analysis there were effects involving age. Older participants produced fewer responses in every item category and had smaller total list size. There were significant effects of education for the number of month/year responses (p = .03) and for the number of responses to matched recent items ($p < .05$), as well as a trend for total number of responses (p = .09). In each case, less educated participants produced fewer responses.

Clinical Correlates of Baseline Responses

Within the patient sample, three simultaneous regression analyses were conducted predicting the total number of descriptive responses, the ratio of responses to recent compared with remote matched events, and the ratio of responses to affectively positive compared with affectively negative matched events. The independent variables were age, gender, education, history of past ECT, HRSD score, subtype of unipolar–bipolar depression, subtype of psychotic–nonpsychotic depression, and length of current episode. Across these three analyses, the only significant effect was the relationship between patient age and the total number of descriptive responses, $F(1, 64) = 4.04, p < .05$. Examination of zero-order correlations confirmed that there were no associations between symptomatic severity as assessed by the HRSD and these three dependent variables ($ps > .17$).[4]

Short-Term Effects of ECT Treatment Conditions

For the 72 patients who completed the AMI during the week after the randomized ECT course, ANOVAs were conducted with electrode placement (RUL vs. BL) and dosage condition (low vs. high) as between-subjects variables on the continuous demographic and clinical variables listed in Table 1 and on the number of ECT treatments administered and daily lorazepam dosage during the ECT course. There were no significant effects ($ps > .10$). Log-linear analyses indicated that the treatment groups were also equivalent in the distributions of gender, history of past ECT, unipolar–bipolar depression, and psychotic–nonpsychotic depression ($ps > .28$).

Table 4 presents descriptive statistics for each of the four treatment groups of the extent to which responses following treatment were consistent with baseline responses. ANCOVAs were conducted on the raw posttreatment scores for these variables, with electrode placement and dosage condition as between-subjects variables and age, number of ECT treatments, and the respective baseline scores as covariates. Table 4 also presents the significance levels from these ANCOVAs for the main effects of electrode placement and for the covariate age.

For descriptive responses, the RUL and BL ECT groups differed in the consistency of recall of the events about which

[4] Zero-order correlations were also computed between the patients' daily dosage of lorazepam in the 48 hr preceding the baseline AMI assessment and the three dependent measures. None of the correlations was significant ($ps > .12$).

Table 4
Consistency of 1-Week Posttreatment Autobiographical Memory Interview Scores With Baseline and ANCOVA Results

	Unilateral				Bilateral				*p*	
	Low dose (*n* = 16)		High dose (*n* = 18)		Low dose (*n* = 18)		High dose (*n* = 20)			
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Electrode placement	Age
Descriptive questions										
Total recall or recognition	72.8	13.6	77.1	11.7	60.3	10.9	68.4	14.1	.0007	*ns*
Total recall	68.8	12.5	73.7	11.6	55.0	10.4	62.9	14.3	.002	.06
Recall or recognition of events	72.8	20.8	80.9	14.6	67.0	15.1	77.4	16.0	*ns*	*ns*
Recall of events	57.2	16.1	67.8	14.4	46.8	13.6	56.1	17.8	.001	*ns*
Recall of event details	72.8	13.1	75.8	12.1	58.0	11.8	65.4	14.5	.0001	*ns*
Yes–no responses	74.2	19.5	79.6	13.4	57.2	23.0	73.9	19.0	.03	*ns*
Month/year responses[a]	76.5	17.4	80.6	12.8	55.3	24.8	69.9	15.7	.0009	*ns*
Month/day responses[a]	94.1	11.1	95.4	11.2	83.8	21.5	82.0	23.2	.005	.06
List items										
Consistent[b]	67.1	29.9	79.4	18.1	59.1	25.8	64.9	19.2	.006	*ns*
Inconsistent[b]	16.0	25.1	11.7	9.3	24.2	25.3	23.6	15.9	.01	*ns*
Recent vs. remote memory										
Past year–unmatched	61.7	19.5	64.7	16.4	33.6	14.2	42.7	23.0	.0001	.08
Remote–unmatched	49.4	28.7	59.6	14.9	29.6	20.1	44.6	24.1	.0004	*ns*
Past year–matched	53.4	21.5	62.6	25.1	36.0	23.8	40.5	29.1	.0004	.06
Remote–matched	50.9	27.2	60.2	17.9	35.7	21.4	48.6	24.2	.003	.07
Positive vs. negative affective questions										
Positive–unmatched	54.1	23.8	62.9	18.5	41.0	16.6	51.7	23.5	.02	*ns*
Negative–unmatched	58.2	19.5	64.5	14.3	36.0	15.5	51.3	16.9	.0001	*ns*
Neutral–unmatched	78.5	9.2	82.0	9.8	69.1	9.8	73.0	12.1	.0004	*ns*
Positive–matched	52.6	24.3	62.8	19.5	42.4	19.0	51.1	24.3	.03	*ns*
Negative–matched	51.1	29.3	57.6	13.8	37.1	25.8	46.2	20.9	.03	*ns*

Note. Except where indicated, scores represent the percentage of responses at retest that were identical to baseline responses, relative to the number of baseline responses. ANCOVA = analysis of covariance.
[a]Number of responses at retest relative to baseline, regardless of consistency. [b]Percentage of list items at retest either consistent or inconsistent (novel) with baseline list items.

follow-up detailed inquiries were made (recall of events). However, the ANCOVA on the consistency of events either recalled or recognized yielded no effects involving treatment conditions, indicating that the treatment groups were equivalent at posttreatment in the number of events subjected to further inquiry about details. Compared with RUL ECT, BL ECT resulted in significantly greater inconsistency in every other scoring category for descriptive questions, including the temporal and affective classifications. An ANCOVA was also conducted on the number of descriptive questions for which patients had provided a definite response at baseline and at posttreatment explicitly stated that they did not know the answer. This analysis yielded only a main effect of electrode placement, $F(1, 65) = 4.72, p = .03$. Patients treated with BL ECT ($M = 22.6$, $SD = 15.8$) gave more "don't know" responses than patients treated with RUL ECT ($M = 16.3$,

$SD = 10.6$). Therefore, the greater inconsistency of patients treated with BL ECT was due in part to a higher rate of pure memory failure.

Relative to RUL ECT, BL ECT also resulted in fewer consistent responses to yes–no items (see Table 4). For list questions, the BL ECT group both recalled fewer list elements that were identical to those reported at baseline, and they reported more novel list elements. Regardless of consistency with baseline, the BL ECT group reported fewer dates, whether of the month/year (singular event) or month/day (recurring event) variety.

Across the sample, the month/year dates following ECT occurred earlier in time than the dates given at baseline ($M = -222.3$ days, $SD = 790.5$), $t(71) = 3.06, p = .003$. None of the effects in an ANCOVA on the month/year directional discrepancy values (electrode placement by stimulus intensity with age and number of treatments as covariates) approached significance. A similar ANCOVA was performed on the absolute discrepancy values. Although patients who received BL ECT had considerably larger absolute discrepancy scores, there was marked variability in these values, and the main effect of electrode placement was not significant, $F(1, 65) = 2.56, p = .11$. For the month/day items, there was no tendency in the total sample for dates to move forward or backward in time and no effect approached significance in the ANCOVA on the directional values. In the ANCOVA on the absolute discrepancy scores, there was a trend for a main effect of electrode placement, $F(1, 65) = 3.18, p = .08$. Patients treated with BL ECT ($M = 9.2$ days, $SD = 26.9$) tended to have larger discrepancies than patients treated with RUL ECT ($M = 1.0$ days, $SD = 2.7$).

Across the sample, the ratio of consistent responses to recent relative to remote matched items ($M = 0.99, SD = 0.54$) was unchanged compared with the similar ratio at baseline ($M = 1.05, SD = 0.28$), $t(71) = 0.85, p > .40$. The ANCOVA on these post-ECT ratio scores yielded a strong effect of electrode placement, $F(1, 65) = 8.55, p < .005$. Patients treated with RUL ECT were unchanged in their ratio scores, paired $t(33) = -1.32, p > .19$, whereas patients treated with BL ECT had reduced ratios following ECT, paired $t(37) = 2.11, p = .04$. BL ECT produced greater inconsistency in the recall of recent relative to remote matched events.

Across the sample, there was no change in the ratio of consistent responses to the positive affective items relative to negative affective items when compared with the similar ratios at baseline. The ANCOVA on the post-ECT ratio scores did not yield any effects of treatment conditions. Thus, there was no indication that the amnesic effects of the ECT conditions were contingent on the affective valence of items.

Across all the analyses of the impact of the treatment conditions on post-ECT AMI scores, there were few indications that stimulus dosage was consequential.[5] The interaction between electrode placement and dosage condition did not approach significance in any analysis. Similarly, the number of treatments administered, which was used as a covariate in every analysis, showed no relationships with post-ECT AMI scores. As shown in Table 4, patient age showed significant or marginal relationships with several AMI variables. After ECT, older patients tended to have lower total recall scores for descriptive items and give fewer consistent responses to unmatched recent items and matched recent and remote items. They tended to give fewer month/year responses, and when they did provide such dates, older patients had larger absolute discrepancies compared with responses at baseline. The covariate baseline scores had strong associations with posttreatment scores in every analysis ($ps < .0001$).

Effects of Short-Term Clinical Outcome

In the larger parent study, the treatment groups differed in the extent of short-term clinical improvement (Sackeim et al., 1993). Low-dosage RUL ECT lacked efficacy, high-dosage RUL ECT was intermediate, and both forms of BL ECT were equivalent and superior to either form of RUL ECT. A similar pattern held in the subsample included here. A log-linear analysis on response rates yielded a significant effect of electrode placement, $\chi^2(1, N = 72) = 6.14, p = .01$, and a trend for an interaction between electrode placement and stimulus intensity, $\chi^2(1, N = 72) = 2.77, p = .096$. The response rates were 18.5%, 44.4%, 66.7%, and 55.6% for the low- and high-dose RUL and the low- and high-dose BL ECT groups, respectively. Across the sample, the average HRSD score 1 week after ECT was 5.7 ($SD = 3.3$) among responders and 25.1 ($SD = 10.2$) among nonresponders.

Three sets of analyses examined the relationships of change in clinical state to post-ECT AMI scores. First, a series of ANCOVAs were conducted with electrode placement and response classification as between-subjects variables and age and baseline scores as covariates. These analyses repeated those conducted on the effects of the treatment conditions on AMI scores, substituting response classification for the between-subjects variable of dosage condition and dropping the covariate number of treatments. Across these analyses, the significant main effects of electrode placement were maintained throughout. There were no effects involving response classification.

The second set of analyses treated the change in clinical state as a continuous variable. ANCOVAs were conducted with electrode placement and dosage condition as between-subjects variables and percentage of change in HRSD scores over the ECT course and baseline AMI scores as covariates. The interaction between electrode placement and percentage change in HRSD scores was also included as a covariate term. Across these analyses, only one effect involved symptomatic change. There was an interaction between electrode placement and the extent of clinical improvement on the number of post-ECT "don't know" responses. Regression analyses were conducted separately for the RUL and BL groups, predicting the number of these responses based on the percentage change in HRSD scores and the total number of descriptive responses produced at baseline. With RUL ECT, greater clinical improve-

[5] The ANCOVA on the number of consistent yes–no responses yielded a main effect of dosage condition, $F(1, 65) = 5.21, p = .02$, as did the ANCOVA on the number of month/year responses given at posttreatment, $F(1, 65) = 4.82, p = .03$. Low-intensity stimulation was associated with fewer consistent yes–no responses and fewer month/year responses.

ment was associated with fewer "don't know" responses ($p < .03$), but there was no relationship for BL ECT ($p = .13$).

Third, zero-order correlations were computed across the sample between the change in HRSD scores and post-ECT AMI percentage consistency scores (arc sine transformed) and the ratio scores based on the temporal and affective categorizations. There were no significant correlations.

These analyses indicated that the effects of the treatment conditions on post-ECT AMI scores were independent of clinical state change. Despite the fact that BL ECT was clearly associated both with greater inconsistency in recall for a host of AMI measures and with superior clinical outcome, there was sufficient variability in these effects so that no evidence emerged that the overall degree of retrograde amnesia was related to clinical outcome or that clinical outcome was associated with recall scores as a function of the temporal or affective categorization of items.

Corroborated Personal Memories: Short-Term Effects

For 3 patients, corroborators verified less than 10% of the patients' baseline descriptive responses. In the remaining 49 patients, the average rate of corroboration was 75.7% ($SD = 13.5$, range = 42.2% to 95.6%). The 3 patients were dropped from the analyses of corroborated data. With the measure of total recall for descriptive items, there was a strong association between the extent of consistency in responses shortly after ECT for material that had or had not been corroborated, $r(47) = 0.67, p < .0001$. However, in 48 of the 49 patients, the consistency of recall was higher when the baseline reports had been corroborated ($M = 72.9\%$, $SD = 13.7$) compared with unverified reports (44.6%, $SD = 19.7$), paired $t(48) = 14.1$, $p < .0001$. This suggested that corroborated material was more resistant to retrograde amnesia.

The ANCOVAs examining the short-term effects of the treatment conditions were repeated, restricting the data set to the corroborated material. As before, the analysis of the consistency score for the number of events either recalled or recognized yielded no effects involving treatment conditions. In contrast, there was a significant main effect of electrode placement for all other categories of descriptive response ($ps \leq .03$). In general, the effect sizes for these contrasts of the electrode placements exceeded those obtained in the previous analyses that combined corroborated and noncorroborated material. For instance, relative to the number of corroborated baseline responses, the consistency of total recall averaged 79.8% ($SD = 10.7$) with RUL ECT ($n = 23$) and 66.9% ($SD = 13.4$) with BL ECT ($n = 26$), $F(1, 42) = 13.0, p = .0008$. The ANCOVA on the number of "don't know" responses yielded main effects of electrode placement, $F(1, 42) = 9.3$, $p = .004$, age, $F(1, 42) = 5.5$, $p = .02$, and the number of corroborated baseline responses, $F(1, 42) = 17.6, p < .0001$. Patients treated with BL ECT ($M = 11.8$, $SD = 9.1$) averaged more than twice as many "don't know" responses as patients treated with RUL ECT ($M = 5.9$, $SD = 6.1$). Across these analyses of the consistency scores, which included the temporal and affective classifications of items, there were no significant effects involving stimulus dosage condition. As in analyses of the total material, comparisons with baseline indicated that there were no changes in the ratio scores as a function of temporal or affective classifications. ANCOVAs also did not yield effects of the treatment conditions on the ratio scores based on either temporal or affective classifications.

This set of ANCOVAs was repeated, substituting response status for the between-subjects variable of dosage condition. There were no effects involving clinical response status, and the significant effects of electrode placement were maintained through out. Zero-order correlations were also computed between the percentage change in HRSD scores over the ECT course and AMI scores for corroborated material (percentage consistency relative to baseline and change in ratio scores). There were no significant associations.

Two-Month Follow-Up: Comparison to the 1-Week Post-ECT Time Point

The foregoing analyses indicated that electrode placement had a profound impact on AMI scores during the week after the randomized phase. After this phase, 18 of the 45 patients who completed the AMI at all three time points were administered an average of 9.3 additional crossover treatments ($SD = 3.3$) with high dosage BL ECT. Therefore, the analyses of the 2-month follow-up AMI scores focused on whether patients had been administered RUL or BL ECT during the randomized phase and whether patients had received one (randomized phase) or two (randomized and crossover phases) courses of ECT.

The first set of analyses examined change in AMI scores between the evaluations conducted following the randomized phase and at 2-month follow-up. Repeated measures ANCOVAs were conducted with electrode placement during the randomized phase and crossover status as between-subjects variables, age and the baseline AMI score as covariates, and time point (1-week vs. 2-month follow-up) as the repeated measures variable. The dependent variables were total recall scores for descriptive questions, the ratio of consistent responses for recent and remote matched events, and the ratio of consistent responses for positively and negatively charged matched events. These analyses were conducted twice, scoring the 2-month follow-up responses as consistent if they matched the baseline reports (Measure A) and scoring such responses as consistent if they matched either the baseline or the 1-week post-ECT reports (Measure B).

Figure 1 illustrates the consistency of total recall for the treatment groups at each time point. The ANCOVA on the consistency of total recall (Measure A) yielded main effects of electrode placement, $F(1, 39) = 6.34, p < .02$, age, $F(1, 39) = 4.80, p = .03$, and the baseline score, $F(1, 39) = 60.76, p < .0001$. There was also a significant interaction between crossover status and time point, $F(1, 39) = 6.80, p = .01$. Patients originally randomized to BL ECT had fewer consistent descriptive responses across time points. Older patients also manifested greater inconsistency. Patients who received one course of ECT had significantly improved total recall consistency scores at the 2-month follow-up relative to the 1-week time point, paired $t(26) = -2.39, p = .02$, but patients who received two ECT courses had decreased scores, paired $t(17) = 2.06$, $p = .05$.

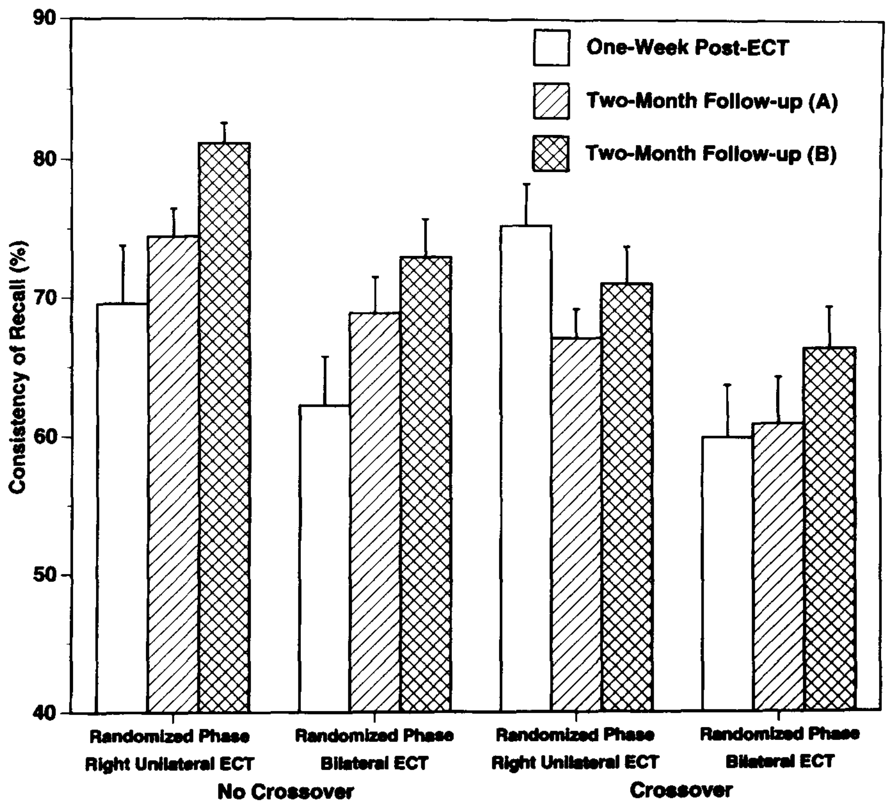

Figure 1. Percentage of consistency of recall for all descriptive questions at 1 week and 2 months after electroconvulsive therapy (ECT), as a function of treatment conditions. Measure A scored responses as consistent only if they matched baseline reports, whereas Measure B scored responses as consistent if matched either the baseline or 1-week post-ECT reports.

This pattern was maintained in the repeated measures ANCOVA with the second method (Measure B) for scoring consistency at the 2-month follow-up. There were main effects of electrode placement, $F(1, 39) = 6.77$, $p = .01$, age, $F(1, 39) = 7.05$, $p = .01$, and the baseline score, $F(1, 39) = 60.66$, $p < .0001$, and an interaction between crossover status and time point, $F(1, 39) = 7.45$, $p < .01$. As illustrated in Figure 1, with this more liberal scoring method, patients who received only one ECT course had markedly improved total recall consistency scores at the 2-month follow-up compared with the 1-week time point, paired $t(26) = -4.25$, $p < .0002$. In contrast, patients who received two ECT courses were unchanged, paired $t(17) = 0.24$, $p > .81$. These analyses indicated that patients originally randomized to the BL electrode placement had lower consistency across time points in total recall scores for descriptive questions. Furthermore, receiving a second course of high dosage BL ECT had a deleterious effect on the consistency of recall at the 2-month follow-up. In contrast, patients who completed ECT after the randomized phase had improved consistency scores at 2-month follow-up relative to 1-week post-ECT.

The repeated measures ANCOVAs on the ratio score based on the temporal categorization of events yielded a trend for recall consistency to be poorer for recent events relative to remote events at 2-month follow-up (Measure A), $F(1, 39) = 3.92$, $p = .05$. This suggested that across the sample amnesia at 2-month follow-up was greater for recent relative to remote events. The only other effects in the repeated measures ANCOVAs on the ratio scores (both temporal and affective classifications of items) concerned the covariate baseline scores ($ps < .0001$). These analyses indicated that there was no change across the posttreatment time points in the relative consistency of recall as a function of the affective valence of events.

Two-Month Follow-Up: Effects of the Treatment Conditions

To more carefully examine the persistent effects of the treatment conditions, a series of ANCOVAs were conducted on the 2-month follow-up responses with electrode placement (randomized phase) and crossover status as between-subjects variables and age and baseline scores as covariates. These ANCOVAs were conducted with the scoring technique requiring a match with the baseline response (Measure A) and the more liberal scoring method (Measure B). The major findings were identical regardless of scoring method, and results are presented only for Measure A. Table 5 presents descriptive statistics for the between-groups variables and the significance levels for the main effects of electrode placement, crossover status, and the covariate age from these univariate ANCOVAs.

Table 5
Consistency of 2-Month Follow-Up Autobiographical Memory Interview Scores With Baseline and ANCOVA Results

	Unilateral ECT				Bilateral ECT						
	No crossover (n = 8)		Crossover (n = 12)		No crossover (n = 19)		Crossover (n = 6)		*p*		
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	Electrode placement	Crossover status	Age
Descriptive questions											
Total recall or recognition	79.3	5.5	71.8	7.3	72.8	12.5	68.1	3.8	*ns*	*ns*	*ns*
Total recall	74.5	5.7	67.1	7.3	68.9	11.3	60.9	8.3	.09	<.05	*ns*
Recall or recognition of events	83.3	9.7	77.3	13.6	80.0	17.1	78.8	13.4	*ns*	*ns*	*ns*
Recall of events	64.1	7.6	59.1	10.9	65.3	13.4	52.6	15.6	*ns*	.09	*ns*
Recall of event details	78.1	6.8	69.8	8.4	70.4	12.1	64.1	8.2	.07	.07	*ns*
Yes–no responses	85.2	11.5	78.1	16.2	80.6	18.6	46.7	24.8	.07	.005	.05
Month/year responses[a]	87.5	7.5	76.1	18.4	72.8	19.8	65.4	25.2	*ns*	.04	*ns*
Month/day responses[a]	100.0	0.0	84.2	16.3	84.2	23.3	87.5	14.7	*ns*	*ns*	*ns*
List items											
Consistent[b]	81.3	12.9	62.7	23.8	75.4	20.6	81.2	13.3	*ns*	*ns*	*ns*
Inconsistent[b]	12.3	7.7	26.3	24.6	12.9	11.1	10.0	13.5	*ns*	*ns*	*ns*
Recent vs. remote memory											
Past year–unmatched	55.0	13.2	42.9	12.0	41.5	15.1	30.8	15.8	.03	<.05	*ns*
Remote–unmatched	65.8	11.6	48.2	25.3	49.9	21.5	47.1	12.3	*ns*	.09	*ns*
Past year–matched	47.2	16.5	37.6	15.3	37.9	13.7	32.6	15.4	.08	*ns*	*ns*
Remote–matched	64.8	13.0	49.7	23.6	49.4	19.4	55.9	9.7	*ns*	*ns*	*ns*
Positive vs. negative affective questions											
Positive–unmatched	63.5	13.5	57.2	19.2	52.8	16.8	54.1	12.2	*ns*	*ns*	*ns*
Negative–unmatched	67.5	10.9	52.6	12.3	62.6	15.6	49.5	17.3	*ns*	.01	*ns*
Neutral–unmatched	82.6	3.3	78.2	5.2	77.5	10.8	69.9	7.8	.01	*ns*	*ns*
Positive–matched	62.1	13.6	58.0	21.3	50.8	16.4	53.5	11.8	*ns*	*ns*	.07
Negative–matched	63.2	14.6	39.7	22.0	60.0	23.8	51.7	15.5	*ns*	.02	*ns*

Note. Except where indicated, scores represent the percentage of responses at retest that were identical to baseline responses, relative to the number of baseline responses. ANCOVA = analysis of covariance. ECT = electroconvulsive therapy.
[a]Number of responses at retest relative to baseline, regardless of consistency. [b]Percentage of list items at retest either consistent or inconsistent (novel) with baseline list items.

As shown in Table 5, administration of crossover treatment had a pronounced effect on several AMI variables. Patients who received crossover treatment were significantly less consistent in their baseline responses for the measures of total recall for descriptive responses, yes–no responses, unmatched recent events, and unmatched and matched negatively charged events. These patients also produced fewer month/year responses and tended to have lower consistency scores for the recall of events, event details, and unmatched remote events. To a lesser extent, having received BL ECT during the randomized phase was also associated with reduced consistency scores at the 2-month follow-up. Such patients had significantly lower scores for unmatched recent events and neutral events. They tended to be less consistent in recall of event details, in yes–no responses, and for recent matched events. Across these ANCOVAs, the only interaction between electrode placement and crossover status to approach significance concerned the consistency of yes–no responses, $F(1, 39) = 3.98, p = .05$. Post hoc comparisons indicated that patients who had received both BL ECT in the randomized phase and crossover treatment produced fewer consistent yes–no responses than each of the other groups ($ps < .03$). As shown in Table 5, patient age displayed few relationships with follow-up AMI scores. The trends for yes–no responses and matched positive events were due to lower consistency scores in older patients.

The ANCOVA conducted on the number of "don't know" responses yielded a marginal main effect of crossover status, $F(1, 39) = 3.83$, $p = .06$. Patients who received two ECT courses more frequently indicated pure memory failure ($M = 22.1$, $SD = 11.3$) compared with patients who received only one course ($M = 13.5$, $SD = 12.4$). In the ANCOVAs on directional and absolute discrepancy for the items requiring a date, there was a trend for a main effect of crossover status on the directional discrepancy in month/day responses, $F(1, 39) = 4.05$, $p = .05$. Patients who received crossover treatment tended to provide dates that were earlier in time than they did at pretreatment ($M = -3.2$ days, $SD = 9.3$), whereas there was no such effect in patients who received one ECT course ($M = 0.3$ days, $SD = 2.8$). The ANCOVAs on the ratio scores (temporal and affective classification of events) did not yield any effects involving treatment condition or age. In all of the analyses, there were significant effects of the covariate baseline score ($ps < .0002$).

Two-Month Follow-Up: Associations With Clinical State

The average HRSD score at 2-month follow-up was 8.6 ($SD = 6.6$), reflecting an average improvement of 72.2% ($SD = 23.1$) relative to baseline. An ANOVA (randomized electrode placement by crossover status) yielded no effects on

2-month follow-up HRSD scores. The ANCOVAs examining the effects of the treatment conditions at 2-month follow-up were repeated, including the percentage change in HRSD scores as an additional covariate. No associations with clinical state change emerged. Similarly, zero-order correlations between 2-month follow-up HRSD scores and consistency scores for total recall for descriptive questions and ratio scores as function of temporal and affective valence did not yield significant relations.[6]

Discussion

Summary of Findings

At baseline, the depressed group had a modest deficit in the number of autobiographical memories they produced. There was no evidence that this deficit was contingent on the temporal categorization of items as sampling recent or remote events. The depressed and normal control groups were equivalent in the number of memories they produced for neutral items, but the depressed group reported fewer memories of affectively laden events. This pattern may have been due to intrinsic differences in the content of the neutral and affective questions. Many neutral items inquired about overlearned or frequently recalled material, such as home addresses or the names of friends and family members, whereas the affectively laden questions focused exclusively on discrete events. For this reason, in this study we explicitly compared responses to positively and negatively charged items, addressing the role of affective valence. We could not address broader issues pertaining to distinction between affectively laden and affectively neutral autobiographical memories. Contrary to the notion of mood congruency (Blaney, 1986; Bowers, 1992; Singer & Salovey, 1988), the affective valence of events (positive vs. negative) did not have differential impact on the number of memories recalled by the depressed and normal groups.

Technical parameters in the administration of ECT had pronounced effects on the consistency of recall of autobiographical memories at both the short-term and long-term time points. During the week after the randomized phase, patients who were treated with BL ECT showed considerably greater inconsistency when compared with patients treated with RUL ECT. At this time point, the BL ECT group also produced more "don't know" responses, indicating pure memory failure. At the 2-month follow-up, patients who received only one course of ECT showed substantial improvement in their consistency scores compared with the assessment conducted shortly following the randomized phase. In contrast, patients who received a second crossover course of treatment with high-dosage BL ECT had decreased consistency scores at the 2-month follow-up. Similarly, at this assessment interval, patients who had received two courses of ECT gave a greater number of "don't know" responses. There were indications that the electrode placement used during the randomized phase was also associated with the magnitude of persistent deficits. For several AMI variables, patients originally randomized to BL ECT had poorer consistency scores at 2-month follow-up, compared with patients randomized to RUL ECT. In general, the effects of treatment parameters on the magnitude of retrograde amnesia were strongly maintained when the analyses were restricted to only those personal memories that had been corroborated by a family member or friend.

There was no evidence that the overall magnitude of retrograde amnesia was related to the extent of clinical improvement. Notably, retrograde amnesia was considerably greater following BL ECT as compared with RUL ECT. In general, patients treated with BL ECT also displayed a superior short-term antidepressant response. Nonetheless, both across the sample and when controlling for the contributions of treatment conditions, there were no relationships between clinical improvement and AMI scores. There was also no evidence that change in clinical state was related to a temporal gradient in retrograde amnesia or to a differential effect on memory for positively vs. negatively charged affective events. Before considering the theoretical implications of these findings, the validity of the methods used to quantify retrograde amnesia should be addressed.

Validity of the AMI

There is some evidence that relative to normal controls depressed patients have more conservative response biases or thresholds in the recall or recognition of previously presented material (Corwin, Peselow, Feenan, Rotrosen, & Fieve, 1990). ECT may also result in a lack of the sense of familiarity for previously learned material (Squire et al., 1981; Zubin, 1948). To mitigate these effects, participants were always encouraged to answer each question, regardless of their certainty. Consequently, the principal method for quantifying retrograde amnesia focused on consistency in the recall of personal memories across time points. However, a fundamental problem in assessing autobiographical memory is the lack of absolute indices of the accuracy of recall. Individuals may give consistent responses over time that are persistently inaccurate recollections. Inconsistency could also be due to inaccurate recall at baseline followed by correct recollection. Nonetheless, several considerations support the approach we took to this problem.

At the retest occasions, patients were free to report different events than they had at baseline. However, when this occurred, an attempt was made to ascertain whether patients recognized the original event. All inquiries about event details concerned only those events originally reported at baseline. When accounting for recognition, there were no effects of the treatment conditions or clinical state on the number of events subject to detailed inquiry. Nonetheless, there were marked and predictable effects of the treatment conditions on the consistency of recall of event details. Although a variety of factors might determine whether an individual recalls the same out-of-town trip on two occasions, inconsistency in recalling the details of a specific trip is particularly likely to reflect an amnesic effect.

Second, the differences among the treatment groups in the

[6] Only 35 patients had corroboration of their baseline responses and also participated in the 2-month follow-up. The small sample size of treatment condition subgroups (randomized electrode placement by crossover status) precluded analyses of the follow-up data restricted to corroborated material.

measures of recall consistency were mirrored in the more restrictive measure of "don't know" responses. At the short-term time point, BL ECT resulted in greater recall inconsistency and more responses indicating pure memory failure. The same pattern held for crossover ECT patients at the 2-month follow-up. It is noteworthy, however, that the measures of recall consistency were often more sensitive to treatment group differences than the more extreme measure of "don't know" responses.

Third, a large proportion of the baseline reports of a subgroup of patients were corroborated by a family member or friend. Overall, at the short-term time point, consistency scores were markedly higher for corroborated than for noncorroborated memories. Nonetheless, the analyses restricted to the corroborated memories demonstrated the same pattern of treatment condition effects, and lack of associations with clinical outcome, as was observed more generally.

Fourth, two scoring methods were used for the 2-month follow-up. One method required that a follow-up response match the baseline response to be considered consistent. The other method credited consistency when there was a match with either the baseline response or the 1-week post-ECT response. Both scoring methods yielded the same pattern of effects. This suggests that instances of inconsistency because of inaccurate recall during the depressed state at baseline and accurate recall shortly following ECT did not have a major influence.

Finally and perhaps most critically at the 2-month follow-up patients who had received only one ECT course showed significantly enhanced consistency with their baseline reports when compared with themselves during the week after ECT. This improvement in the consistency of recall despite the passage of time must reflect a diminishing retrograde amnesia. Thus, it seems reasonable to conclude that determining the consistency of recall of personal memories before and after ECT provides a valid method for assessing retrograde amnesia for autobiographical information. The procedures exemplified here should be of value in quantifying the extent of retrograde amnesia for autobiographical information after neurosurgical interventions, because in that context it is also possible to conduct baseline evaluations.

Limitations of the Study

The relatively small size of the normal control group and the absence of retesting of this group were important limitations. Without normative information on the extent of inconsistency in recall over time, it is impossible to determine whether the treatment groups that showed the least retrograde amnesia after ECT, nonetheless, had short- or long-term deficits. Rather, the demonstration of differences among the treatment conditions can only be interpreted as indicating relative (as opposed to absolute) differences in the magnitude of retrograde amnesia. However, the fact that the treatment conditions differed at the 2-month follow-up does indicate that, at least for some patients, ECT resulted in persistent retrograde amnesia.

Other limitations of the study concern the temporal and affective categorization of items. Almost all the objective evidence that ECT results in a temporally graded retrograde amnesia comes from studies of memory for impersonal, public events (Squire et al., 1975, 1981). Squire et al. (1981) conducted the only recent study to test for a temporal gradient in amnesia for autobiographical information after ECT. Participants reported as many details as possible about 10 autobiographical events. Shortly after treatment with high intensity BL ECT, patients had a general decrement in the recall scores compared with a small group of non-ECT controls. This deficit appeared most marked for recent events. At 7-month follow-up, the two groups were equivalent in total recall measures, indicating no overall deficit. However, at this time point, an item analysis showed that the ECT group recalled and recognized fewer details about the day of their hospital admission, an event that on average occurred 11 days before the start of ECT. This study provided the only objective evidence of a temporal gradient in the amnesia for autobiographical information following ECT. Therefore, given this limited literature, there is uncertainty about the time frame of recent personal events that are most susceptible to persistent loss, as well as the possibility that manifestation of a temporal gradient fluctuates as a function of the interval since treatment.

The AMI was structured to sample both events that occurred during the year previous to hospital admission and more remote events. In this study, evidence of a temporal gradient was somewhat inconsistent. At the short-term time point, across the sample, the dates (month/year) that patients gave for singular (nonrecurring) events moved backward in time relative to the dates reported at baseline. Furthermore, at the short-term assessment, BL ECT was clearly associated with the most robust amnesic effects. Patients who received BL ECT also showed reduced consistency for recent relative to remote events. At the 2-month follow-up, the total sample showed reduced consistency scores for recent relative to remote events. However, at the long-term time point, the differences among the treatment conditions in retrograde amnesia were not associated with the temporal categorization of events. Consequently, it is possible that the relative deficit in the recall of recent events observed in the total sample at this time point was due to normal forgetting and not a consequence of ECT. Future research should include retesting of a normal or patient comparison group to resolve this issue, as well as consider alternative cutoffs to categorize events as recent or remote.

There was no indication in this study that the affective valence of memories differentially contributed to the recall deficit of patients at baseline or to patterns of post-ECT amnesia. The need to generate a large pool of personal memories and to sample the same classes of event across participants led to the approach of asking participants to report details about their "best" and "worst" events. The extent to which this procedure truly elicited emotionally significant memories was not assessed, leaving a source of uncertainty. It is possible that some reported events may have had only minor emotional significance at the time of occurrence or that some events no longer carried the affective meaning they originally engendered. This concern is somewhat mitigated by our informal observations that participants often displayed marked emotional reactions during the interviews.

Nonetheless in the future, researchers should have participants evaluate the emotional significance of the events (Clark & Teasdale, 1982; Eich et al., 1994).

One of the most critical areas of uncertainty pertains to the possibility that the consistency scores at the retest occasions were influenced by the act of recollecting at previous AMI sessions (i.e., carryover effects). Rather than assessing memory only for the original events, the retest scores may have been contaminated by explicit memory of responses given at the earlier interviews or by implicit priming effects. Were this the case, the differences observed among the treatment conditions after ECT in the retest AMI consistency scores would still be interpreted as reflecting differences in the extent of retrograde amnesia but with the important caveat that the retrograde amnesia pertained to the positive effects of the baseline testing session on subsequent event recall, and not necessarily to earlier representations of the autobiographical events. However, we are doubtful that differential carryover effects strongly contributed to the results. The differences among the treatment conditions in recall consistency at retesting were mirrored in the rates of "don't know" responses. Although the treatment groups were equivalent in recalling and/or recognizing that events had taken place, they differed both in the consistency of their report of the details about these events and in reporting that they had no memory of these details. The failure to remember event details that were in fact recalled during the depressed baseline state should reflect amnesia for the original memory of the event and not simply for memory of the previous interview. Nonetheless, the role of carryover effects needs to be examined. Obtaining normative data on retest effects would only partially address this issue because the learning impairments associated the depressed state could be a source of confound (Sackeim & Steif, 1988), as well as ECT alterations of the magnitude of practice effects. An alternative approach would be to assess memory accessibility for a set of novel autobiographical items presented at retesting (precluding a carryover influence) and establish relationships between these response production scores for novel items and consistency scores (same items at baseline and retest).

Implications: Mood and Memory

No support was obtained for any of the theories that posit a relationship between the therapeutic and amnesic effects of ECT. Historically, both some critics and proponents of ECT have offered the argument that retrograde amnesia is intimately associated with clinical response (see Sackeim, 1994, for a review). Indeed, some have suggested that if profound amnesia were produced by extraordinarily intensive forms of treatment, new behavior patterns could be established, or old, temporally remote, and less pathologic behavior patterns would predominate (Cameron, 1960; Lambourn, 1981). The production of retrograde amnesia for therapeutic purposes provided the rationale for "regressive ECT" (Cameron, 1960; Kennedy & Anchel, 1948), in which multiple-seizure inductions were administered on a daily basis. Contrary to these views, at both the short- and long-term time points, we found that the magnitude of clinical improvement was unrelated to the overall extent of retrograde amnesia. These negative findings were obtained even though the data set was skewed toward observing such a relation: BL ECT was associated both with greater retrograde amnesia and superior clinical outcome. These findings are particularly important because retrograde amnesia for autobiographical information was rarely examined in the previous studies that suggested that the therapeutic and amnesic effects of ECT are independent (e.g., Calev et al., 1991; Cronholm & Ottosson, 1963; Frith et al., 1983; Weeks et al., 1980).

At baseline, depressed patients and normal controls did not differ in the relative accessibility of affectively positive and negative personal memories. Within the patient group, baseline symptom severity was not associated with differential recall. Across the sample and as a function of clinical outcome, there was no evidence that the affective valence of memories was related to the magnitude of retrograde amnesia after ECT. Consequently, there was no evidence of mood congruence effects on the accessibility of autobiographical memories at baseline or on the pattern of retrograde amnesia after ECT.

Mood congruence effects have been most frequently studied using experimental mood inductions with normal participants (Blaney, 1986; Singer & Salovey, 1988). Even in such controlled circumstances, the evidence for mood congruency is mixed. It appears that mood congruence effects are more robust in studies focusing on encoding, as opposed to recall. Encoding studies have demonstrated that material that is congruent with mood at the time of presentation is better learned (e.g., Bower, Gilligan & Monteiro, 1981; Gilligan & Bower, 1984). Such studies have shown mood congruence effects on the learning of affectively intoned word lists, sentences, or stories, but there is no evidence that such effects extend to the encoding of autobiographical events. There is also little evidence that effects of mood congruence on encoding occurs with natural variation in mood in normal or clinical samples (Hasher, Rose, Zacks, Sanft, & Doren, 1985; Silberman, Weingartner, Laraia, Byrnes, & Post, 1983).

The findings of this study are particularly relevant to the study of mood congruence effects in recall. There is inconsistent evidence for preferential recall of learned or autobiographical material as a function of congruence with current mood (see Singer & Salovey, 1988 for a review). Often times, such effects are asymmetric, with positive mood states influencing recall to a larger extent than depressed states and positively valenced material subject to larger congruence effects than negatively valenced material (e.g., Teasdale & Fogarty, 1979). Consequently, the absence of mood congruence effects in this study may be partly due to the absence of an "elated" or positive mood state, as the comparisons of depressed and normal controls at baseline and those of patients to themselves in depressed and euthymic states may be more akin to comparisons of depressed and neutral mood conditions.

Three other considerations may also account for our failure to observe mood congruence effects. First, in clinical samples, such effects have been mostly observed for memory of experimenter presented material (e.g., Breslow, Kocsis, & Belkin, 1981) and when effects have been obtained with autobiographical memory they have often pertained to the latency of recall (e.g., Lloyd & Lishman, 1975) or to the extent of detail in the reported memories (Brittlebank, Scott, Williams, & Ferrier, 1993). Second, there is evidence that mood congruence and mood-state dependence effects are most readily obtained when the recall of autobiographical memories is unstructured (Eich et al., 1994). Typical procedures involve presentation of cue words as free association stimuli for recalling autobiographical events. In contrast, our procedures required deliberate memory search for specific classes of events. It may be that mood congruence influences the speed of recall and biases the content of memories retrieved under unstructured conditions (Clark & Teasdale, 1982). Our findings suggest that mood congruence has minimal impact on the capacity to retrieve autobiographical memories. In particular, this study provided the first test of the extent to which mood congruence is manifested in retrograde amnesia. It appears that the amnesia for autobiographical information induced by ECT and preferential retrieval of mood-congruent memories are distinct phenomena.

This study provided only an indirect test of the influence of mood state dependence on amnesia. Kinsbourne and Wood (1982) suggested that depressed patients were particularly likely to experience remote events during a euthymic mood state and recent events during a depressed state. They hypothesized that the evidence for a temporal gradient in retrograde amnesia after ECT is due to the mismatch between encoding in either the euthymic or depressed states and post-ECT testing during the euthymic state. This suggests that compared with responders, patients who do not respond to ECT have a flatter temporal gradient, because of better recall of recent events. We did not observe such a pattern, but, as noted, the evidence in this study of a temporal gradient in amnesia was mixed. In general, studies of mood-state dependent effects on autobiographical memory have reported even less consistent results than studies of mood congruent effects (Bower, 1992; Eich et al., 1994; Singer & Salovey, 1988). Demonstration of mood state dependence may also require the use of unstructured tasks and the contrast of opposing mood states (i.e., depression and euphoria). Furthermore, a recent study documenting a robust mood-state dependent effect in normal participants, observed this phenomenon only when the interval between changes in mood state was 2 days and no effect with a 7-day interval (Eich et al., 1994). In contrast, mood-state dependent effects would have to persist for a far longer duration to modulate the retrograde amnesia produced by ECT.

Implications: ECT and Retrograde Amnesia

The magnitude and persistence of cognitive deficits following ECT are a function of how the treatment is performed. There is substantial evidence that in the acute period immediately after seizure induction, the extent of disorientation and of anterograde and retrograde amnesia is related to electrode placement, stimulus dosage, and stimulus waveform (Sackeim, 1992). Several days after completion of an ECT course, the effects of stimulus dosage on anterograde amnesia appear to wane, but effects of electrode placement are still prominent (Sackeim et al., 1993). Similarly, in this study, during the week after the randomized phase, BL ECT produced considerably greater retrograde amnesia than RUL ECT, but there were few effects of stimulus dosage conditions. At the long-term time point, having received a second, high-dosage course of ECT with the BL placement and to a lesser extent having been originally randomized to BL ECT were the factors associated with persistent amnesia. These findings were consistent with those reported by Weiner et al. (1986). In a relatively small sample, they found that at 6-month follow-up retrograde amnesia in autobiographical memory was most marked in patients randomized to BL ECT.

Parallels have often been raised between the amnesic effects of ECT and those that arise from injury to medial temporal structures (e.g., Squire, 1986). However, there is no credible evidence that ECT results in tissue necrosis (Devanand, Dwork, Hutchinson, Bolwig, & Sackeim, 1994; Weiner, 1984), and there has yet to be in vivo imaging studies investigating the relationships between alterations in the activity of functional neural systems and the magnitude or persistence of retrograde amnesia after ECT. It is also uncertain whether the advantage of right unilateral ECT is due to the relative sparing of left hemisphere language functions that may be critical in the retrieval of autobiographical memories or whether bilateral alteration of patterns of functional activity is a prerequisite for more profound retrograde amnesia. Our findings that the magnitude of retrograde amnesia at the 2-month follow-up decreased in patients who received only one ECT course and was increased in patients who received two courses is compatible with the view that remote personal memories undergo an extended period of consolidation that may be disrupted by ECT (Sackeim, 1992; Squire, 1986). Recovery from this disruption is time dependent. However, follow-up further out in time and comparison to non-ECT controls will be necessary to determine the extent to which the persistent deficits observed in this study reflect slower recovery or permanent memory loss.

Practically, the findings clearly indicate that use of the right unilateral electrode placement can substantially reduce the magnitude of short-term retrograde amnesia for autobiographical information. Similarly, minimization of exposure to prolonged courses of high-intensity bilateral treatment may reduce persistent effects. Finally, the independence of the therapeutic and amnesic effects of the treatment implies a dissociation in either the anatomic loci or the type of neurobiological processes that subserve efficacy and cognitive side effects. Therefore, it is conceptually possible for modifications of ECT to be devised that retain its therapeutic properties without its untoward effects.

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