DICHOTIC PERCEPTION AND MEMORY CAPABILITY AFTER ELECTROCONVULSIVE THERAPY

by

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ABSTRACT

To investigate whether electroconvulsive therapy (ECT) is associated with deficits in cognitive functioning, accuracy of dichotic perception and memory was tested in 11 depressed patients before and after treatment with ECT. The performance of these patients was compared with that of remitted and depressed patients who had been treated with ECT at least 6 months previously (N=15), depressed patients who were currently being treated with medication and who had never received ECT (N=15), remitted depressives who had never received ECT (N=17), and normal individuals without history of affective disorder (N=20).

Prior to treatment, the patients who were to receive ECT had impaired levels of performance on a test of verbal memory (Logical Memory) and on a test of visuospatial memory (Benton Visual Retention Test). These deficits in performance were apparently attributable to the high level of depression present among those patients. Two weeks after treatment, and despite clinical remission, the ECT patients continued to exhibit diminished levels of performance on the test of verbal memory and also showed significant impairment in the ability to recall autobiographical material. No deficits in performance were detected among the patients who had received ECT at least 6 months previously, and no other differences among groups reached statistical significance.

With regard to dichotic perceptual ability, no differences among groups were detected. However, subjects who were currently in treatment with ECT, as well as the depressed subjects overall, failed to demonstrate the degree of ear asymmetry that is normally found on tests of dichotic perception. Possible reasons for this lack of asymmetry are discussed. It is noted that the research evidence that has been accrued to date has tended to support the hypothesis that there is an asymmetry of cerebral hemispheric activation and dominance during certain states of psychopathology. In depression this hemispheric imbalance has usually been found to be one of relative dominance of the right cerebral hemisphere. The results of the present study are taken to provide support for the theory that there are abnormalities of hemispheric lateralization during states of depression. The results of the present study do not provide any evidence of long-term (that is, 6 months or more after treatment) deficits in cognitive functioning associated with ECT.

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Since its introduction in 1938, electroconvulsive therapy (ECT) has been the subject of considerable debate. ECT is a clinical procedure, usually employed in the treatment of severe depression, in which an alternating current of 70-120 volts is applied to the brain. As such, ECT research has focused upon the effectiveness and safety of ECT. With regard to the former, the methodological deficiencies of work in this area (e.g., absence of placebo-ECT control groups, heterogeneous patient samples, lack of double-blind procedures, and vague outcome criteria) have led some researchers to conclude that ECT has yet to be demonstrated effective (e.g., Costello, 1976; Lambourn & Gill, 1978), whereas others have concluded that ECT is indeed effective in the treatment of some psychiatric disorders (e.g., Avery & Winokur, 1977; Turek & Hanlon, 1977). Overall, the consensus of opinion appears to be that ECT is effective therapeutically when used in limited quantity (between 5 and 15 treatment sessions) with selected patients. Depressed patients for whom medication has proven to be ineffective may be particularly good candidates for ECT. In their review of the outcome literature Scovern and Kilmann (1980) concluded that the fast action of ECT warrants its use in situations of acute suicide potential but that patients other than endogenous depressives tend to be poor candidates for ECT. They also noted that ECT has not been found to reduce relapse.

The mortality rates associated directly with ECT have generally been found to be quite low, and appear to be acceptable in light of the mortality risks associated with suicide attempts. A survey by Beresford (1971) indicated that between the years 1964 and 1968 the sudden death rate with ECT was less than 0.01 percent of all treated cases, although earlier reports (presumably written before the use of more advanced, safer techniques such as the mandatory presence of an anesthetist during treatment) placed the mortality rate somewhere in the range of 0.1 percent (Kalinowski, 1959) to 0.3 percent (Friedman, 1949).

Unfortunately, methodological inadequacies have also been characteristic of much of the work that has investigated the more subtle aspects of safety during ECT -- specifically, the work that has investigated the effects of ECT upon cognitive functioning. The result has been that some workers have denounced ECT as being a contributor to brain damage (e.g., Friedberg, 1977), whereas others have concluded that there is no evidence that ECT produces long-term deficits in brain functioning (e.g., Taylor, Tompkins, Demers, & Anderson, 1982). The evidence regarding the effects of ECT on cognitive functioning are reviewed in the present paper. (The papers included in this review are summarized in Table 1.) Following this review, a study is described in which the long-term effects of ECT were examined with a technique that differs substantially from the methods employed in previous ECT research.

Research Into the Effects of ECT Upon Cognitive Functioning

As indicated above, there exists substantial variability in the quality and methodology (and thus outcome) of studies that have been undertaken to examine cognitive changes following ECT. This variability makes it difficult to conceptualize the results of such work and provide definitive statements regarding the existence of deleterious ECT effects. Almost all of the work in this area has focused upon the effects of ECT upon short- and long-term

Table 1

Summary of ECT Literature Reviewed

Authors	Follow-up Interval	Prolonged Deficits	Short-term Deficits
Zubin & Barrera (1941)	Immediate	?	Yes
Levy et al. (1942)	6 months	Yes	Yes
Smith et al. (1943)	12 months	No	Yes
Brody (1944)	1-2 years	Yes	Yes
Perlson (1945)	3 months	No	?
Norman & Shea (1946)	?	Yes	Yes
Stone (1947)	2-3 weeks	No	Yes
Tyler & Lowenbach (1947)	1-5 years	No	?
Funkhouser (1948)	?	No	?
Huston & Strother (1948)	1-19 months	No	Yes
Luborsky (1948)	6 months	No	Mixed
Medlicott (1948)	6 months	Yes	Yes
Rabin (1948)	?	?	?
Janis (1950)	4 months	Yes	Yes
Stone (1950)	2 months 3 years	No	?
Worchel & Narcisco (1950)	9 days	No	Yes
Janis & Astrachan (1951)	4 weeks	Yes	Yes
Pascal & Zeaman (1951)	7 months	No	No
Stieper et al. (1951)	3 weeks	Yes	Yes
Michael (1954)	6 weeks	No	Yes
Hetherington (1956)	10 days	No	Yes
Korin et al. (1956)	3 weeks	No	Yes

Table 1, continued

Authors	Follow-up Interval	Prolonged Deficits	Short-term Deficits
Miura et al. (1960)	?	Yes	Yes
Cronholm & Ottosson (1961)	1 week	?	Yes
Cronholm & Ottosson (1963)	1 week	?	Mixed
Bilikiewicz & Krzyzowski (1964)	?	?	Yes
Cronholm & Molander (1964)	2 months	No	?
Gottlieb & Wilson (1965)	Immediate	?	Yes
Martin et al. (1965)	Immediate	?	Yes BL[a] No UL[b]
Zamora & Kaelbing (1965)	Immediate	?	Yes
Schwartzman & Termansen (1967)	?	No	Yes
Cannicott & Waggoner (1967)	Immediate	?	Yes BL No UL
Halliday et al. (1968)	3 months	Yes	Yes
Strain et al. (1968)	36 hours 10 days	No	Yes
Sutherland et al. (1968)	36 hours 4 days 3 weeks	Memory: no EEG: yes	No
Valentine et al. (1968)	Immediate EEG: 10 days	Memory: no EEG: yes	Yes
Zinkin & Birtchnell (1968)	Immediate	?	Yes
Bidder et al. (1970)	30 days/1 year	Yes	Yes
Costello et al. (1970)	2 days	?	Yes
Cronin et al. (1970)	1 month	Yes	Yes
Miller (1970)	3-14 days	?	No

Table 1, continued

Authors	Follow-up Interval	Prolonged Deficits	Short-term Deficits
Brunschwig et al. (1971)	10 days 1 year	No	Yes
Abrams et al. (1972)	Immediate	?	Yes
Goldman et al. (1972)	10-15 years	Yes	Yes
Templer et al. (1973)	>7 years	Yes	Yes
Small (1974)	5 years	No	Yes
Regenstein et al. (1975)	11 months	Yes	Yes
Squire & Miller (1974)	24 hours	?	Yes
Squire (1975)	24 hours	?	Yes
Squire & Chace (1975)	6-9 months	No	?
Squire et al. (1975)	1-2 weeks	No	Yes
Squire et al. (1976)	25 days	Yes	Yes
Ashton & Hess (1976)	Immediate	?	Yes
d'Elia (1976)	Immediate	?	Yes
d'Elia et al. (1976)	Immediate	?	Yes
Squire & Slater (1978)	16-19 hours	?	Yes
Jackson (1978)	10 days	No	Yes
Patterson et al. (1978)	8 hours	?	Yes
Robertson & Inglis (1978)	Immediate	?	Yes
Squire et al. (1979)	6 months	?	?
Freeman & Kendell (1980)	1 year 6 years	?	?
Freeman et al. (1980)	9 months- 30 years	Yes	?

Table 1, continued

Authors	Follow-up Interval	Prolonged Deficits	Short-term Deficits
Weeks et al. (1980)	1 week 4-7 months	No	Yes
Squire et al. (1981)	1 week 7 months	No	Yes
Daniel et al. (1982)	24 hours	?	Yes
Daniel et al. (1983)	24 hours	?	Yes
Daniel et al. (1985)	24 hours	?	Yes
Shellenberger et al. (1981)	12-58 months	No (Complaints only assessed)	?
Squire & Slater (1983)	7 months (UL) 3 years (BL)	Yes (Complaints only assessed)	?

[a]UL = Unilateral ECT
[b]BL = Bilateral ECT

memory. Unfortunately, these studies suffer various deficiencies, including: (a) diagnostic and other forms of heterogeneity among patients; (b) a tendency to confound learning with retention; (c) extreme variability in time of testing, so that immediate post-ECT confusion has been mistaken for a more stable problem with memory retrieval or consolidation; (d) tests of questionable reliability and validity; and (e) inadequate follow-up testing. Moreover, in later work that examined the differential effects of bilateral ECT (i.e., that in which the electrodes and shock are applied simultaneously, over the temporo-parietal regions, to both sides of the brain) and unilateral ECT (that in which the electrodes and shock are applied to only one side of the brain, over the temporo-parietal area) the situation was complicated further by the necessity to employ tests that assessed verbal and nonverbal memory independently.

ECT Research Conducted Between 1940 and 1960

Unilateral (UL) ECT was reported originally by Friedman and Wilcox (1942) but was not introduced in its present form until about 1958 (Lancaster, Steinert, & Frost, 1958). Researchers of the 1940's and the 1950's therefore did not need to concern themselves with the differential effects of lateralized ECT on left and right hemispheric functioning. Unfortunately, a majority of these workers also failed to concern themselves with methodological rigor in the design and implementation of their research. For example, none of the 13 studies from the 1940's that were reviewed by this author (Brody, 1944; Funkhouser, 1948; Huston & Strother, 1948; Levy, Serota, & Grinker, 1942; Luborsky, 1948; Medlicott, 1948; Norman & Shea, 1946; Perlson, 1945; Rabin, 1948; Smith, Hastings, & Hughes, 1943; Stone, 1947; Tyler & Lowenbach, 1947; Zubin & Barrera, 1941) incorporates procedures designed to keep the experimenters blind to the treatments patients received and most include information (e.g., descriptions of patient diagnoses and tests employed) that is at best incomplete and at worst anecdotal. The usual conclusion of these reports was that some impairment in recall begins shortly after a few ECT treatments have been rendered. Moreover, four studies (Brody, 1944; Levy et al., 1942; Medlicott, 1948; Norman & Shea, 1946) contain data that provide evidence of protracted deficits in cognitive functioning (i.e., approximately 6 months to 2 years after ECT). Eight studies do not contain such evidence (Funkhouser, 1948; Huston & Strother, 1948; Luborsky, 1948; Perlson, 1945; Smith et al., 1943; Stone, 1947; Tyler & Lowenbach, 1947; Zubin & Barrera, 1941) and one paper contains mixed results (Rabin, 1948). Although a majority of the reports from the 1940's provide support for the conclusion that there are no identifiable prolonged deficits following ECT, it is noteworthy that only one study (Huston & Strother, 1948) with negative results contained adequate control and follow-up measures whereby patients were tested before and after ECT. It should also be noted that a return to pre-ECT levels of functioning -- as occurred among subjects in the Huston & Strother study -- does not in itself signal the absence of deleterious ECT effects. Because pre-ECT depression levels are usually higher than post-ECT depression levels, and the alleviation of depression can in itself be expected to result in some improvement in cognitive functioning, it is possible that a post-ECT memory test score could equal the pre-ECT score merely because the alleviation of depression had offset the memory impairment introduced by ECT.

The studies reviewed from the 1950's appear generally to be of a design superior to that of their predecessors. All, however, were completely open studies (i.e., not blind) in which the experimenters were aware of the kind of treatment patients had received. In this decade it was again observed that ECT administration usually resulted in some impairment in memory shortly after treatment commenced. Of nine studies reviewed, three contain evidence in support of the existence of prolonged ECT deficits (Janis, 1950; Janis & Astrachan, 1951; Stieper, Williams, & Duncan, 1951), whereas the remaining six studies do not contain such evidence (Hetherington, 1956; Korin, Fink, & Kwalwasser, 1956; Michael, 1954; Pascal & Zeaman, 1951; Stone, 1950; Worchel & Narcisco, 1950). However, three of these studies did not contain a control group (Pascal & Zeaman, 1951; Stone, 1950; Worchel & Narcisco, 1950). Reports from the 1950's incorporated a description of the test measures utilized, and it is therefore possible to examine more closely the kinds of cognitive functions that were under investigation. A majority of this research employed tests of recall of objective information (e.g., Wechsler Memory Scale) in addition to a variety of other tests such as the Army Alpha and the Rorschach. Tests of recall of personal information were also employed, and it is intriguing to observe that all of the studies that noted residual deficits following ECT used tests of recall of autobiographical material. It is unfortunate, however, that in only one of the three studies with positive results -- that is, those in which evidence of protracted cognitive dysfunction was described -- (Janis, 1950) were patients followed for more than one month after treatment. Taken together, the studies from the 1950's do provide some evidence of retrograde amnesia for personal information up to 3 months after ECT, but do not indicate that after ECT there exists anterograde amnesia for objective information. The methodological inadequacies of the studies from this era preclude definitive statements regarding the overall long-term effects of ECT.

ECT Research Conducted During the 1960's

The research that was conducted into ECT during the 1960's was significant for a number of reasons. Of particular interest from a methodological perspective were: (a) the introduction of blind and double-blind techniques (in which the experimenter and, in the latter, the patient were unaware of the precise form of treatment administered); (b) the utilization of batteries of test measures, with some attention paid to the selection of tests with suitable psychometric properties; and (c) the increased use of control groups and random assignment to groups. This decade also witnessed the awakening of interest in the differential effects on brain functioning of UL ECT and BL ECT. Four of the studies from the 1960's were concerned with the long-term differential effects of UL and BL ECT, and five studies were concerned only with the overall residual effects of ECT. In the latter group of studies, two had negative results (Cronholm & Molander, 1964; Schwartzman & Termansen, 1967), one had positive results indicative of residual impairment after ECT (Miura, Okada, & Masao, 1960) and two papers (Cronholm & Ottosson, 1961; 1963) reported a follow-up period of a duration insufficient to provide data on the long-term effects of ECT. It should also be noted that the Miura et al. paper was a case report in which the researchers relied upon the subjective complaints of a single patient to reach their conclusion that a trial of 11 ECT sessions produced memory deficits for some (undisclosed) time after treatment.

As noted above, four studies conducted during the 1960's had as their focus the differential effects of electrode placement upon cognitive functions. The UL-BL investigations tended to be more complex than earlier research into the global effects of BL ECT, and these and later studies possessed methodological qualities that were generally superior to those of earlier reports. The result is that more credence can usually be given to the findings of such work. These studies will therefore be described in some detail. Halliday, Davison, Browne, and Kraeger (1968) performed a double-blind study in which 52 endogenous depressives (i.e., those with a particular cluster of symptoms -- such as early morning awakening, diurnal variation in severity of mood disturbance, and loss of pleasure in most activities -- that has been found to be associated with a good response to somatic forms of therapy such as those that employ medication or ECT) were assigned randomly to three ECT groups: BL, right UL, and left UL. Retention of verbal and nonverbal material was tested before and after a series of four ECT sessions and also at the end of the series of treatments. Forty-four of the patients were retested 3 months after the termination of treatment. The right UL patients were found to have experienced impairment in nonverbal memory, whereas the left UL patients had verbal memory dysfunction. The BL patients experienced impairment in the recall of both verbal and nonverbal material. Although after three months there was improvement in all of the test scores, some residual deficits persisted.

In contrast to these results, Strain et al. (1968) found no significant deficits in, or differences between, patients treated with BL ECT and patients treated with nondominant UL ECT. Nondominant UL ECT is that in which shock is delivered to the hemisphere of the brain opposite to that in which the language functions are localized. In a right-handed person the hemisphere of choice is therefore usually the right hemisphere. Tests for recall of verbal and nonverbal material were administered 10 days after a series of treatments. However, like earlier researchers (Janis, 1950; Janis & Astrachan, 1951; Stieper et al., 1951), these workers did note some deficit in the ability of the patients to recall personal information from the recent past. Sutherland, Oliver, and Knight (1968) provided data that suggested an improvement on the Wechsler Memory Scale when given 36 hours after a course of BL, dominant UL, or nondominant UL ECT. The improvement was most marked in the nondominant UL group. In all groups, however, it would appear that this upward change could have been attributed to the clinical improvement in depression and the practice effects associated with repeated administration of the Wechsler test. Indeed, evidence that there was some residual alteration in brain functioning was provided by the finding of Sutherland et al. that electroencephalograms (EEG's), which were recorded before ECT and then at 4 days and at 3 weeks after ECT, showed detectable changes in a high percentage of the patients at both of the post-ECT examinations.

Electroencephalographic abnormalities after a course of ECT were detected also in a study conducted by Valentine, Keddie, and Dunne (1968). In this study a given patient was assigned randomly to one of four ECT groups: BL sinusoidal (sinusoidal ECT is a form of shock therapy that utilizes diphasic, sinusoidal current for a duration of about 1 second); BL pulse (the pulse ECT utilized by Valentine et al. consisted of brief pulses of current, with bidirectional spikes of very short duration, passed through the brain for 5 seconds); UL sinusoidal; or UL pulse. Retention of paired associates was tested when the patient regained orientation after the first, third and fifth ECT sessions, and EEG examinations were made before and about 10 days after the course of ECT. The data indicated that the pulse method of ECT resulted in a smaller amount of memory impairment than the sinusoidal method (although all groups showed some decrement in memory capability), such that the UL pulse group had the least amount of decrement, the BL pulse group had more, and the BL sinusoidal group had the most decrement. However, EEG changes, which took the form of increased temporal theta activity, were present in over 50 percent of the patients after ECT, spread across all of the groups.

Three years earlier, Martin and his colleagues (Martin, Ford, McDonald, & Towler, 1965) had also detected electroencephalographic changes in patients after ECT. Martin et al. found evidence of EEG slowing, restricted to the hemisphere over which the shock had been administered. The work of Martin and his associates, together with a number of other studies that were conducted during the 1960's, also indicated that right- and left-sided UL ECT and BL ECT have different effects upon the brain (Bilikiewicz & Krzyzowski, 1964; Cannicott & Waggoner, 1967; Gottlieb & Wilson, 1965; Martin et al., 1965; Zamora & Kaelbing, 1965; Zinkin & Birtchnell, 1968). The results of these studies and the studies discussed above indicate that the degree of confusion and memory impairment experienced immediately after UL ECT is less than that experienced following BL treatment. Moreover, the effects of the UL treatments can be differentiated on the basis of whether shock is applied to the dominant or to the nondominant hemisphere of the brain. Verbal memory impairment has been found to be more likely to follow dominant UL ECT, whereas nonverbal memory dysfunction has been found more frequently after nondominant UL ECT.

ECT Research From 1970 to 1974

Similar observations were made during the 1970's. In 1970, Bidder and his associates (Bidder, Strain, & Brunschwig, 1970) tested verbal and nonverbal memory, and memory for recent and remote personal information, in 96 depressed patients who were assigned randomly to either nondominant UL ECT or BL ECT. Results indicated that there was significantly less decline in memory in the UL group than there was in the BL group. At 30 days after treatment one quarter of the patients showed no memory impairment, and by 1 year after the last ECT session the average verbal memory performance of the patients had improved over pre-ECT levels. No significant differences among the UL and BL patients were found at the 1-year follow-up. The data indicate that there were residual deficits in nonverbal memory performance in both treatment groups, and it is unfortunate that no information was provided regarding the follow-up performance of the patients on the tests of recall of personal information.

Differences between UL and BL ECT patients were detected also in a study performed by Cronin et al. (1970). These workers observed that patients who received nondominant UL ECT had less memory disturbance than those patients who received dominant UL ECT or BL ECT. Nevertheless, all groups experienced some disturbance in memory functioning for as long as 1 month after treatment. Costello, Belton, Abra, and Dunn (1970) also found that patients treated with nondominant UL ECT suffered less verbal memory disturbance than patients treated with dominant UL ECT. The latter group experienced less memory impairment than a group of patients who received BL ECT. In this study, patients learned a list of paired words before treatment and were tested for recall, recognition, and relearning of this list after the fourth ECT and after completion of the course of ECT. However, Costello et al. examined only the short-term effects of ECT, approximately 2 days after treatment.

In contrast to the above results, Miller (1970) found no evidence of residual deficits in the verbal memory capability of a group of psychiatric patients (with unspecified diagnoses) who were tested 3 to 6 days and 7 to 14 days after a course of ECT. Comparison was made with a control group of psychiatric patients who did not receive ECT. Brunschwig, Strain, and Bidder (1971) also failed to uncover evidence of residual memory dysfunction when they tested 33 patients up to 1 year after BL ECT. The authors did find a decline in verbal memory test scores and personal memories 36 hours after a course of ECT, but verbal memory scores 30 days after treatment were better than those obtained before treatment. At follow-up 1 year later, additional significant improvement in verbal memory was found. It is unfortunate, however, that tests of recall of personal information were not readministered during the follow-up.

Goldman, Gomer, and Templer (1972) observed decreased retention of visual stimuli and signs of cerebral dysfunction in a group of 20 chronic schizophrenics tested 10 to 15 years after the patients had undergone an average of 70 ECT sessions. Comparison was made with a control group of chronic schizophrenics who had been matched for age, sex, race, and education and who had not received ECT. In an extension of this study, Templer, Ruff, and Armstrong (1973) noted deficits in Bender-Gestalt test performance in 22 chronic schizophrenics assessed at least 7 years after they had received an average of nearly 60 ECT sessions. The control group again consisted of matched chronic schizophrenics who had not undergone ECT. This study, unlike that of Goldman et al., contained both double-blind procedures and controls for the degree of psychosis in the experimental and control groups. In light of the probable heterogeneity of patient symptomatology (it is possible, for example, that the patients who were given ECT were more severely ill than the patients not so treated), the unquantified effects of long-term medication, and the large number of ECT sessions, neither of these studies provides compelling evidence regarding the effects on cognitive functions of moderate dosages of ECT. The same is true of a case report by Regenstein, Muroski, and Eagle (1975), in which evidence of residual deficit on the Wechsler Adult Intelligence Scale and a mental status examination in a depressed patient who had received approximately 145 ECT treatments is reported. Such work nevertheless warrants some consideration, if only as an incentive for further study.

Further comparison of the effects of nondominant UL ECT and BL ECT upon clinical status, memory, and electroencephalographic patterns was made by Abrams et al. (1972). Patients were examined with verbal and nonverbal memory tasks and were given an EEG examination before commencing ECT, 1 day after the fourth ECT session, and then after each subsequent ECT session. Abrams and his colleagues observed that: (a) the UL patients exhibited less post-ECT decrement than the BL patients in performance on two auditory verbal memory tasks, but that none of the BL or UL patients showed impaired post-ECT performance on a visual, nonverbal task; (b) the (right) UL ECT patients demonstrated post-ECT EEG slowing on the right side, whereas the BL patients demonstrated EEG slowing on the left side; and (c) the BL patients had a better therapeutic response than the UL patients. Because the report by Abrams et al. lacks certain information -- there are no specific details provided regarding memory scores, for example -- the precise ramifications of the study remain unclear. However, the report does demonstrate the differential effects of BL and UL ECT. The data also suggest that evidence of changes in cognitive functioning after ECT is dependent upon the nature of the tests employed to detect such changes. Small (1974) also examined the differential effects upon memory of various ECT techniques. In this prospective double-blind study 100 patients (a majority of whom were schizophrenic) were assigned randomly to treatment with flurothyl (Indoklon, a chemical substance which induces seizure activity) or treatment with BL ECT, right UL ECT, or left UL ECT. The subjects were compared on a number of occasions on the Wechsler Memory Scale and on a variety of other psychological tests for up to 5 years after treatment. Although at follow-up there were no significant differences among the groups on the Wechsler scale, patients who had received BL ECT yielded the lowest mean scores. Moreover, 50 percent of the BL patients complained of persistent memory defects, whereas few of the other patients had such complaints. This study, like work that employed tests of recollection of personal information (e.g., Janis, 1950) does suggest the presence of residual deficits in the ability to recall material of a subjective nature. Such deficits, should they exist reliably, appear to be revealed only sporadically on standardized memory tests.

ECT Research From 1975 to 1979

Commencing in the mid-1970's and continuing into the 1980's, L.R. Squire and his colleagues have examined the effects of ECT on memory. Generally, these studies have indicated that ECT results in both retrograde and anterograde amnesia, but that the amnesic effects dissipate during the several months after treatment. In an early study (Squire & Miller, 1974) 18 depressed patients undergoing BL ECT were exposed to visual stimuli 20 minutes, 50 minutes, and 180 minutes after their first four treatments. Recognition of the material was assessed at 30 minutes and at 24 hours after each learning session. Results indicated that there was an initial impairment in the ability of the patients to retain material, but that this impairment dissipated within the first 3 hours after treatment. However, although the results of the 30-minute delay recognition task did not change significantly as treatments progressed, the ability of the patients to retain material for a 24-hour period was significantly poorer, and improved more slowly, after the fourth treatment than after the first treatment. This finding indicates that there were cumulative effects of ECT on memory capability and suggests also that the 24-hour delay retention task was more sensitive to memory impairment than was the 30-minute delay retention task.

Squire (1975) tested memory for remote public events in 20 patients who were receiving BL ECT. Half of the patients were tested at 40 minutes and at 24 hours after the first session and half of the patients were tested at corresponding times after the fifth session. Results suggested that during the course of the first five ECT sessions, patients developed a marked impairment in remote memory that covered nearly the entire time period sampled (which was 1940 to 1969). This impairment was still present 24 hours after the fifth treatment. Electroconvulsive therapy was not found to affect performance on the verbal portion of the Wechsler Adult Intelligence Scale. No follow-up of the patients was implemented. Squire and Chace (1975) did attempt to determine the long-term effects of ECT in a retrospective study in which they examined 38 former patients who had received a course of BL ECT or right UL ECT, or had undergone hospitalization without ECT, 6 to 9 months previously. These individuals were compared with a group of 15 patients who were currently receiving BL ECT. Immediate and delayed retention tasks and tests of remote memory failed to distinguish among the three groups of former patients, whereas the hospitalized ECT group was worse on each test than any of the other groups. It was noted that patients who had received BL ECT were more likely to have subjective complaints of memory disturbance. However, patients who complained of such disturbance did not perform differently on the objective memory tests than patients who did not have such complaints.

Squire and Chace hypothesized that this situation may have been attributable to either the insensitivity of the tests or to a sensitizing effect of the memory impairment associated initially with BL ECT, so that BL patients became more alert to subsequent memory failures. What is apparent in this study is that although ECT did appear to result in memory dysfunction immediately after treatment, there was no evidence of impairment relative to control subjects 6 to 9 months after ECT.

Squire, Slater, and Chace (1975) utilized a novel approach to the testing of remote memory when they assessed the recall of television program titles for the years 1957 to 1972 in 16 patients undergoing a series of BL ECT. One form of the test was given before the first ECT and an alternate form of the test was administered 1 hour after the fifth ECT. After ECT, memory was found to be unaffected for programs broadcast 4 to 17 years before treatment, but there was substantial impairment in recall of programs broadcast up to 3 years prior to treatment. Further testing of the patients 1 to 2 weeks after treatment revealed recovery of memory to near pre-ECT levels. Moreover, when an additional group of 8 UL ECT patients received the same test measures, no significant differences were found between their pre- and post-treatment levels of performance. The results of this study therefore suggest that: (a) impairment after BL ECT was greater than that following UL ECT; (b) there was a temporal effect with regard to the retrograde amnesia, such that recent memories were impaired more than remote ones; and (c) no residual deficits were detected 2 weeks after ECT.

Squire and his associates (Squire, Slater, & Chace, 1976) employed a technique similar to the one described above when they evaluated the ability of 20 BL ECT patients to determine the temporal order in which television programs had been broadcast during the years 1962 to 1973. This test of temporal judgment was administered before the first ECT session, 1 hour after the fifth session, and 6 to 25 days after completion of treatment. A group of 30 hospital volunteers served as controls. The results of this study suggested an impairment in the ability of the patients to recall the order of the programs for the 5 to 7 years preceding ECT. This impairment, which was apparent after the fifth session and still present 1 to 3 weeks after completion of treatment, supports and extends the observations of Squire et al. (1975). The ECT-induced deficits in recall/temporal judgment revealed in the 1976 study covered a longer period (5 to 7 years) and persisted for a longer time after ECT (at least 3 weeks) than the deficits in simple recall uncovered in the 1975 study. This suggests that relatively subtle deficits in recall may persist after ECT but go undetected when conventional memory tests are used.

Such conventional tests were employed in three other studies that were undertaken in 1976. Ashton and Hess (1976) compared the performance of 7 nondominant UL ECT patients and 8 BL ECT patients in their ability to recognize shapes (which were assumed not to be codable semantically) that had been shown 1 hour before an (unspecified) ECT session. Testing occurred 2 hours after the same session. Although there was a marked trend, such that the BL patients exhibited lower recall performance than the UL patients, no significant differences emerged. However, the recall performance of both groups of patients was poorer after ECT than it was during a control testing session conducted later the same day. It is unfortunate that no follow-up was conducted and that the performance of the patients was not examined over the course of several ECT sessions.

In two studies d'Elia (d'Elia, 1976; d'Elia, Lorentzson, Raotma, & Widepalm, 1976) investigated the effects on memory of placement of electrodes during UL ECT. His results confirmed earlier findings (e.g., Halliday et al., 1968) of greater impairment in recall of nonverbal information following nondominant UL ECT and greater impairment in recall of verbal material after dominant UL ECT. The d'Elia studies incorporated a crossover design in which patients were switched from one electrode placement -- that is, dominant or nondominant -- to the other on the second and third ECT sessions. Testing occurred after each session and the order of electrode placements was determined randomly. Although the design of the studies precluded any assessment of prolonged impairment of memory after UL ECT, d'Elia's comment that the occupation of the patient should be considered when deciding whether to use dominant UL ECT or nondominant UL ECT appears to have some merit. An artist or an architect, for example, whose work relies heavily upon right hemispheric functioning, might not be a suitable candidate for right UL ECT. Squire and Slater (1978) also investigated the differential effects of location of electrodes when they compared nondominant UL ECT with BL ECT. These workers examined the verbal and nonverbal memory performance of patients by using tests with both immediate and delayed (16 to 19 hours after learning) recall requirements. In support of the previous observations of Squire (Squire &

Miller, 1974), the delayed-recall test was found to be more sensitive to memory impairment than was the immediate-recall test. Although no significant effects in performance on the immediate-recall tasks were detected, the BL ECT group experienced severe impairment on the delayed-recall verbal and nonverbal tasks. The UL ECT group was impaired on the delayed-recall nonverbal memory tasks, but not to the same extent as were the BL ECT patients.

Immediate- and delayed-recall tests were also employed in the research conducted by Robertson and Inglis (1978). These workers also observed that BL ECT resulted in greater memory impairment than did nondominant UL ECT. Robertson and Inglis compared the BL ECT and UL ECT groups with normal subjects and with non-ECT depressives on five verbal and nonverbal visual recognition tests given before the first ECT session and after the fourth ECT session (or at equivalent times in the non-ECT groups). The groups had similar levels of performance on the first test session, but the second testing revealed that the BL ECT group exhibited greater inter-session decrement than any of the other groups. The other groups did not differ from one another. The UL ECT group experienced some decline in performance in the recognition of nonverbal stimuli. Although this decrement was greater than that of the control groups -- whose scores on the nonverbal tests actually improved -- it was less than that experienced by the BL ECT group. Neither Robertson and Inglis nor Squire and Slater (1978) sought evidence concerning residual deficits after ECT. Jackson (1978) did conduct such a search but was unable to find evidence of protracted memory deficits. Jackson assigned randomly 34 male patients (diagnoses unspecified) to right UL ECT, left UL ECT, and BL ECT groups. Jackson then tested the recall of the patients for verbal and nonverbal material before ECT, 30 minutes after treatment, and again 10 days later. All of the ECT groups experienced a decline in performance from the pre-ECT session to the first post-ECT session, but all measures of the groups had returned to pre-ECT levels 10 days later. It should be noted, however, that Jackson did not use delayed-recall tasks, and it is possible that this omission may account for his inability to detect any deficits in the patients 10 days after ECT.

Two other studies from the late 1970's will be discussed briefly. One of these studies contained too few subjects to be able to demonstrate powerful effects (Patterson, Lawler, & Rochester, 1978) and one was concerned only with the subjective memory complaints of the patients after ECT (Squire, Wetzel, & Slater, 1979). Patterson et al. examined the ability of patients who had recently received their first nondominant UL ECT treatment to recognize verbal or pictorial material that had been presented prior to the ECT session. Testing was conducted on a number of occasions up to 8 hours after ECT. The authors uncovered evidence of ECT-induced retrograde amnesia, inasmuch as the performance of the ECT patients declined significantly after the treatment session, relative to the performance of a group of non-ECT depressed control subjects. However, amnesic effects 8 hours after treatment were found to be attenuated in comparison with the effects observed at an earlier time after treatment. In contrast to this finding of fairly rapid diminution of ECT-related memory deficits are the results of the study conducted by Squire et al. (1979), in which patient complaints of memory dysfunction were of concern. Squire and his colleagues utilized a self-rating instrument to assess memory complaints before BL ECT, 1 week after ECT, and 6 months after ECT. They observed a number of changes in the complaints after ECT and postulated that the changes may have been attributable to the different nature of depression-induced and ECT-induced deficits. One week after ECT, patients rated their memory as being worse than before ECT. Six months after ECT, the patients rated half of the memory complaint items more severely and half of the items less severely than before ECT. Overall, the results indicated that the patients' impressions of their memory were altered by the ECT and that these altered impressions persisted, in gradually diminishing form, for at least 6 months after treatment. These findings may be considered in conjunction with Squire's earlier observation (Squire & Chace, 1975) that patients who complained of memory deficits did not reveal such deficits on objective memory tests, but may have been sensitized to subsequent memory lapses by their ECT experience.

ECT Research During the 1980's

Freeman and his associates (Freeman & Kendell, 1980; Freeman, Weeks, & Kendell, 1980) continued the investigation into subjective memory complaints of patients following ECT. Freeman and Kendell interviewed 166 patients about the BL ECT experience of the patients either 1 year or 6 years after they had received such treatment. Although most of the patients felt that their therapy had helped them, and were not unduly upset or frightened by the procedure, 64 percent of the patients complained that they had experienced memory impairment after ECT and 30 percent of the patients felt that they suffered from residual memory dysfunction. In a continuation of this work, Freeman, Weeks, and Kendell (1980) solicited ECT-treated former patients who felt that they had been affected adversely by their treatment. These individuals were then compared with two groups of normal volunteers on a battery of memory tests. Although several significant differences between the ECT patients and the control subjects were found, most of these differences disappeared when an analysis of covariance was performed to control for the effects of medication, severity of depression, number of other symptoms, age, and social class. Nevertheless, deficits persisted on tests of verbal learning and face-name association. The authors noted that the results do not show definitively that ECT causes residual memory impairment, but that the results are compatible with such a possibility. Certainly, the subjects themselves associated their memory disabilities with their ECT.

A prospective study conducted by the same workers was designed to clarify this issue. Weeks, Freeman, and Kendell (1980) gave a battery of memory tests to UL ECT and BL ECT patients, non-ECT depressed patients, and normal control subjects before ECT, 1 week after treatment, and again 4 to 7 months later. Before treatment the ECT patients were significantly more impaired than the non-ECT control subjects on 9 of 19 cognitive tests, probably due to more severe depression in the ECT patients, but had improved significantly on five tests 1 week after treatment. Parenthetically, it should be noted that this improvement was attributable to increased scores by the UL ECT patients. The BL ECT patients continued to demonstrate overall cognitive impairment 1 week after ECT. Four months after therapy, the ECT patients were significantly worse than the non-ECT patients and the control subjects on three tasks and were better on one task. Three months later, the ECT and the non-ECT groups differed on only one test (the ECT group was better than the non-ECT group), although both patient groups were impaired slightly on a number of tests relative to normal control subjects. The results of this study were therefore interpreted by Weeks et al. as indicating that ECT does not cause lasting cognitive impairment.

However, the possibility that such impairment does exist, but is simply missed by conventional memory tests, was raised again in a study conducted by Squire, Slater, and Miller (1981). These authors tested 43 ECT patients for recall of public events information, television program information, and personal autobiographical material on three occasions: (a) before ECT, (b) 1 week after treatment, and (c) 7 months after treatment. Significant declines in the ability to recall public events and television program information were observed immediately after ECT, but 7 months later recall of this information had reverted to pre-ECT levels. The ability of the patients to recall personal information also declined after ECT. Although recall of remote personal events had normalized 7 months after treatment, residual deficits in the recall of recent personal events -- that is, those that occurred up to 1 or 2 years prior to treatment -- persisted. This finding indicates that protracted impairment in the capacity to recall personal information may exist even in the absence of residual deficits in the ability to recall more objective data.

A series of studies conducted by Daniel and his associates (Daniel, Crovitz, Weiner, & Rogers, 1982; Daniel, Weiner, & Crovitz, 1983; Daniel, Crovitz, Weiner, Swartzwelder, & Kahn, 1985), in which a form of autobiographical material was utilized, is therefore of interest. Of concern in these studies was the effect of various forms of ECT (BL, UL, sinusoidal, and brief-pulse) upon the ability of the patients to recall information of an autobiographical nature. It was confirmed in the first two of these studies (Daniel et al., 1982, 1983) that BL ECT resulted in greater impairment of recall than did UL ECT. Moreover, Daniel et al. (1982) noted that sinusoidal and brief-pulse forms of ECT stimulation did not exert different effects upon memory, whereas Daniel et al. (1983) detected more amnesic effects among patients who underwent sinusoidal ECT than among those patients who underwent brief-pulse ECT. It is unclear why these differences arose, but methodological problems may once again form a basis for such discrepancies. Daniel et al. (1982; 1983) tested recall of material only 24 hours after ECT, and thus provided no evidence concerning the long-term effects of treatment. Moreover, the tests of memory were at best rather cursory. No test was truly autobiographical in the sense that it required the recollection of meaningful personal data. The research performed by Daniel et al. (1982; 1983) is therefore useful primarily as an exemplification of the short-term differential effects upon memory of various forms of ECT. The conclusion appears to be that UL ECT, particularly brief-pulse UL ECT, is preferential inasmuch as it is associated with less severe cognitive impairment. This conclusion, it will be recalled, is similar to the one reached by Valentine et al. (1968). Daniel et al. (1985), in an extension of their earlier work, examined the relationship between postictal EEG suppression -- that is, the gross reduction in neural activity as reflected by the electroencephalogram -- following an ECT-induced seizure -- and the ability to recall autobiographical data. Daniel et al. (1985) observed a significant positive relationship between the presence of such suppression and the presence of ECT-induced amnesia. It is perhaps reasonable to conclude from this observation that the greater the impact of the artificially induced seizure upon the brain, the greater the disruption of cognitive functioning. In the absence of protracted follow-up and a more thorough analysis of post-ECT neuropsychological functioning, one can conclude little more.

The results of a retrospective study by Shellenberger, Miller, Small, Milstein, and Stout (1981), in which an adequate follow-up of patients was undertaken, did not suggest the presence of residual memory disturbance after ECT. In this study, 21 patients who had received right UL ECT 12 to 58 months previously and 18 normal control subjects were asked to assess subjectively their present memory capabilities. The results indicated that the ECT and control groups did not differ in terms of complaints of memory disturbance -- although, of course, it is possible that formal testing would have revealed deficits in the ability of the patients to recall personal material. The results of a recent study by Squire and Slater (1983) indicate that the difference in outcome of the Squire et al. (1981) and the Shellenberger et al. (1981) studies is attributable to the fact that in the former study BL ECT patients were tested, whereas in the latter study patients who had undergone UL ECT were examined. In the Squire and Slater (1983) research, patients who had received BL ECT up to 3 years previously and patients who had received right UL ECT or no ECT up to 7 months previously provided self-reports of memory problems. Whereas the depressed patients who had not received ECT did not complain of memory problems 7 months after hospitalization, and the UL ECT patients reported only mild memory complaints, 3 years after treatment about one-half of the BL ECT patients reported that they had poor memory. Notwithstanding this finding, examination of objective memory test results that were obtained 6 months after ECT revealed no difference in performance between patients who complained of memory dysfunction and patients who did not complain of such dysfunction. It will be recalled that a similar finding was obtained by Squire and Chace (1975).

A Summary of ECT Research Findings

A simple tally of the studies discussed above (the reader is referred again to Table 1) reveals that 25 of the investigations failed to detect evidence of residual memory impairment after ECT, whereas 17 investigations did detect evidence of residual deficits. Twenty-six studies contained mixed results or did not possess a follow-up interval of a duration that was sufficient to provide information regarding long-term effects. Of the six papers that included discussion of the memory complaints of patients following ECT, five noted that a majority of the patients surveyed had such complaints and one reported no difference between ECT patients and control subjects in frequency of memory complaints. Such a tally obviously ignores the qualitative differences among studies but does indicate that, despite a substantial number of investigations, there is still insufficient evidence upon which to base definitive conclusions regarding the long-term effects of ECT upon the brain. There are several reasons for the diversity in research outcome. As noted earlier, variability in the quality of research methodology accounts for some (and probably much) of the diversity. So too does the type of ECT rendered. For example, UL ECT -- in particular nondominant UL ECT -- has usually been found to result in less impairment than BL ECT. Another refinement in procedure, brief-pulse UL ECT, may result in even fewer side effects. The use of different tests and different test procedures is also likely to have produced some disparity in research outcome. In this regard, it is of interest to note that work that has utilized delayed-recall test procedures (e.g., Squire & Slater, 1978) -- in which there is a protracted retention period between learning and recall -- has indicated that such procedures may be more sensitive to memory deficits than are those procedures involving brief retention intervals. It is also of considerable interest to note that all of the studies of the effects of ECT upon ability to recall personal autobiographical material (e.g., Daniel et al., 1985; Janis, 1950; Squire et al., 1981; Strain et al., 1968) yielded provocative results. Such findings raise the possibility that subtle deficits in cognitive functioning may be present for a considerable period of time after ECT but go undetected by a majority of current test procedures.

The Role of Dichotic Perception Tasks in ECT Research

The research outlined above involved a search for evidence of neurological deficits after ECT by means of an examination of the intellectual functioning of ECT-treated patients. As such, it has provided a rather coarse estimate of the information processing efficiency of those patients. An alternative approach to the investigation of ECT-related deficits would be to examine intellectual processing capability directly, by means of procedures such as reaction time and dichotic listening tasks. Dichotic listening (DL), introduced by Broadbent (1956), occurs when different auditory stimuli are presented simultaneously to the left and right ears. Dichotic procedures have been used over the past 2 decades for a variety of purposes, including early research to provide information on hemispheric laterality. An examination of the literature, however, revealed that there is an absence of useful information regarding the DL performance of individuals who have been treated with ECT.

Of particular relevance to ECT are the investigations that have used DL performance as an index of brain -- and especially temporal lobe -- damage. This relevance is couched in the fact that although there is considerable variability in the actual placement of the electrodes during the ECT procedure, the usual clinical application results in a discharge of electricity over or near the temporo-parietal area of the brain. This site of electrical discharge appears to be the reason why the major side effects associated with ECT are those that are also commonly seen after traumatic disruption of temporal lobe activity. Inglis (1970) notes that the primary similarity between ECT and temporal lobe disruption is that each results in deficits in learning and discrimination, and that these deficits are specific to the side of the brain in which disruption occurs (i.e., verbal impairment following dominant -- usually left -- hemispheric disruption and nonverbal impairment following disruption of the nondominant hemisphere). A variety of research, to be discussed below, has indicated that DL tasks are sensitive to temporal lobe damage. As such, it is likely that such tasks can be used successfully to evaluate the effects of ECT upon temporal lobe activity.

Such an evaluation is described in the present paper. To provide background information on DL, and to demonstrate its relevance to ECT, the salient DL literature will first be discussed.

A Review of the Dichotic Perception Literature

Dichotic Perception in Normal Subjects

To comprehend the research that has been conducted to investigate the effects of brain damage on dichotic listening performance it is necessary to understand something about normal dichotic listening performance. A review of 14 papers concerning the performance of normal subjects on DL tasks (Broadbent & Gregory, 1964; Bryden, 1963; Geffen & Caudry, 1981; Curry, 1967; Efron & Yund, 1974; Efron, Dennis, & Yund, 1977; Geffen, Traub, & Stierman, 1978; Kimura, 1961a, 1964, 1967; Lowe, Cullen, Berlin, Thompson, & Willett, 1970; Satz, Achenbach, Pattishall, & Fennell, 1965; Shankweiler & Studdert-Kennedy, 1967; Warrington & Pratt, 1980) revealed the following relevant points:

1. The contralateral auditory pathways are dominant, so that stimuli presented to one ear are transmitted more readily to the auditory area of the opposite hemisphere (e.g., Kimura, 1961a, 1967). The salience of input from the ipsilateral ear is therefore relatively attenuated.

2. There is superior recognition of verbal material -- for example, syllables, words, and digits -- when such material is presented to the right ear. This right-ear superiority holds for nearly all right-handed, and many left-handed, individuals (e.g., Broadbent & Gregory, 1964; Kimura, 1961a).

The accepted reason for this right-ear superiority is that in a majority of people the left hemisphere has dominant language-processing functions. This dominance interacts with the superiority of the contralateral auditory pathways to produce right-ear dominance for the perception of verbal stimuli.

3. Nonverbal stimuli such as tones and melodies are recognized better when they are presented to the left ear (e.g., Kimura, 1964). The reason for this left-ear superiority is that in most individuals the right hemisphere is dominant in the processing of nonverbal material.

Thus, if a normal subject is given a DL task in which different words, syllables, or digits (the stimuli employed most commonly) are presented simultaneously to both ears, that subject will usually demonstrate superior recognition and recall of the material that was delivered to the right ear. Conversely, a DL task that uses tones or chords as stimuli will typically result in the superior recall of the material that was presented to the left ear. If the subject has a reversal of typical hemispheric lateralization, however, so that the language processing centers are lateralized to the right, rather than to the left hemisphere, a reversal in ear dominance may occur. It is for this reason that it is important to assess the probable lateralization of the subject prior to dichotic testing. On a practical level, it may be expedient to test only right-handed individuals, who generally follow the patterns of lateralization outlined above. (On the basis of clinical and laboratory studies of cerebral lateralization Levy, 1974 estimated that 99.67 percent of right-handed people have language functions represented in the left hemisphere.)

Dichotic Perception in Subjects with Brain Damage

With this knowledge of normal performance on DL tasks it becomes possible to examine critically the effects of brain damage on dichotic performance. Probably the first research to document the sensitivity of DL tasks to brain (specifically, temporal lobe) damage was conducted by Kimura (1961b). Kimura tested 71 patients who had undergone temporal or frontal lobectomy. Tests included a DL task in which different digits were presented simultaneously in pairs to the right and left ears and a task in which digits were presented alternately to the two ears. The task of the subject was to recall as many of the digits as possible after each series of digits. The important finding on the DL task was that unilateral temporal lobectomy on either side resulted in significant impairment in the recognition of material arriving at the ear contralateral to the surgical site. This effect was not observed after frontal lobectomy. Damage to the left (dominant) temporal lobe frequently impaired performance in both ears, although affecting them to different extents. For this reason, and because preoperative scores for the right ear were higher than those for the left ear, care had to be exercised in comparing pre- and post-surgery scores. Therefore, Kimura compared preoperative and postoperative differences between the ipsilateral and contralateral fields (i.e., ipsilateral minus contralateral scores were obtained before and after surgery) when she analyzed her data.

Similar effects were revealed in a slightly more complex study conducted by Schulhoff and Goodglass (1969). These workers tested three groups of 10 subjects: (a) neurologically intact control subjects; (b) patients who had experienced damage to the right hemisphere of the brain; and (c) patients who had experienced left-sided brain damage. Although the extent of brain damage is not well-described, the patients appeared to have generalized brain damage (restricted to the hemisphere specified), usually as a consequence of cerebral vascular accident. Subjects were presented dichotically with tonal sequences, digits, and clicks, the perception of which is assumed to be mediated by right, left, and non-lateralized hemispheric activity, respectively. The subjects were then requested to state the pattern of tones, the digits presented, and the number of clicks heard in each ear. In the normal subjects, as expected, click-counting capability was very similar for stimuli presented to the right and left ears. In these subjects the perception of digits was generally superior at the right ear and the perception of tones was superior at the left ear. The left-brain damaged patients showed substantial impairment in the ability to detect digits presented to either ear (a finding similar to that of Kimura), little or no impairment in tonal perception, and significant right-ear impairment in click detection. Patients with right-sided damage also showed the expected left-ear impairment for digits. However, contrary to expectation, no discernible effect upon the perception of tones was noted.

The Sparks-Geschwind Model

The observation by both Kimura (1961b) and Schulhoff and Goodglass (1969) that left hemispheric damage results in bilateral deficits in digit perception appears to be explicable in terms of language dominance. Presumably, left-sided lesions impair language processing abilities to such an extent that digit perception (which is mediated by the language processing centers of the brain) is impaired globally. However, Sparks and his colleagues (Sparks, Goodglass, & Nickel, 1970a, 1970b) went a step further when they observed that ipsilateral ear inferiority in the perception of words and digits was common among patients with damage to the left hemisphere. Conversely, and as expected, contralateral ear inferiority was almost invariably present among patients with right-sided damage. Sparks et al. explain their findings on the basis of a revision of the Sparks-Geschwind model, which was first proposed by Sparks and Geschwind (1968). In the revised model it is conjectured that the only significant inputs to each temporal lobe are from the contralateral ear, but that auditory stimuli are also shared transcallosally by fibres that run between the auditory association area of each hemisphere. Stimuli from each ear are therefore assumed to arrive in the primary auditory area of the contralateral temporal lobe, become elaborated in the adjacent auditory association area, and be transmitted transcallosally to the other hemisphere. The effects of lesions to the left temporal lobe would, according to this model, depend upon the extent of the lesions: Lesions that affect only the primary auditory and association areas would result in impairment in both ears, worse in the right, because they would degrade the right-ear signal but leave the left-ear (transcallosal) signal unaffected. Lesions that also affected the transcallosal pathway would impair input from the left as well as from the right ear and result in impairment in both ears. However, the degree of impairment would be greater in the left ear.

Zurif and Ramier (1972) obtained results that can be interpreted on the basis of the Sparks-Geschwind model. These authors gave left-brain damaged patients, right-brain damaged patients and neurologically intact control subjects a DL task in which digits and consonant-vowel syllables served as stimuli. Control subjects and right-brain damaged patients were observed to have a right-ear advantage for both digits and syllables (the advantage was greater in the patients than in the controls), whereas the left-brain damaged patients demonstrated impairment in both ears, slightly worse in the left. The somewhat greater decrement in the ipsilateral ear could be attributed to the fact that the left-sided lesions were likely to have been quite extensive in nature, having been due to tumor, trauma, or cerebro-vascular accident. If this were in fact the case, the Sparks-Geschwind model would be supported.

The results of a study conducted by Netley (1972), however, do not appear -- at least initially -- to be congruent with those that might be predicted by way of the Sparks-Geschwind model. Netley assessed dichotic listening performance in 12 hemispherectomized patients and 15 medical control subjects. He noted that in the hemispherectomized subjects the digits presented to the ear ipsilateral to the operational site were recalled better than those presented to the contralateral ear. Moreover, these subjects were not found to have experienced any significant impairment in the dominant ear, relative to the control subjects. On the basis of the Sparks-Geschwind model it might have been predicted that the radical lesion effects of left hemispherectomy would have resulted in bilateral impairment on the DL task, with greater impairment in the left (ipsilateral) ear. It should be noted, however, that the hemispherectomized patients either had congenital injuries or had sustained injury early in life. It could therefore be argued that the Sparks-Geschwind model is not directly applicable to these patients but is of more use to comprehend the effects of damage that occurs later in life when less recovery of function is possible. In support of such an argument, a comparison by Netley of the congenital-injury and the early-injury groups revealed that the contralateral-ear scores of the latter group were lower than those of the former group. That is, the patients who had sustained injury later in childhood exhibited patterns of dichotic listening performance that were more congruent with those suggested by the Sparks-Geschwind paradigm.

The results of two relatively recent studies are also of interest. Siegenthaler and Knellinger (1981) presented digits dichotically to 16 normal control subjects and to 16 patients who had experienced brain injury. Although the data indicated that perception of the digits was in all of the patients higher in the ear ipsilateral to the injury, they also suggested that there was impairment in both ears -- together with considerable variability in the side of relative ear dominance -- in the left-injured patients. These findings support the Sparks-Geschwind model. However, the results of a project by Efron and Crandall (1983) are more perplexing. These workers undertook a prospective study in which nine patients were tested dichotically before and after they had undergone unilateral anterior temporal lobectomy. Prior to surgery the patients exhibited variable ear dominance for dichotic perception of tones, in contrast to the left-ear advantage that is normally found, perhaps as a result of existing pathology: Two patients in the left-lobectomy group had right-ear dominance and two had left-ear dominance; four of the five patients in the right-lobectomy group had left-ear dominance and one patient had right-ear dominance. After surgery all of the patients displayed changes in magnitude or side of dominance in directions that were consistent with the expectation of the authors that a unilateral lobectomy decreases the perceptual salience of tones presented to the ear contralateral to the lesion. Thus, in the right-lobectomy group all of the left-dominant patients shifted toward right-dominance, whereas the solitary right-dominant patient became more strongly right-dominant. In the left-lobectomy group the patients who had been right-dominant prior to surgery exhibited a decrease in the strength of that dominance, whereas the patients who were preoperatively left-ear dominant increased their left-dominance after surgery.

The above findings are in accord with observations made previously with four other patients (Efron, Dennis, & Yund, 1977) and with work that has revealed contralateral ear impairment for the recognition of digits after unilateral lobectomy (Kimura, 1961b). However, they do not correspond well with other research that has indicated that the right hemisphere is dominant in the processing of tones (Kimura, 1964) or the work that has indicated little or no impairment in the perception of tones after lesions to either hemisphere (Schulhoff & Goodglass, 1969). They are also not readily explicable in terms of the Sparks-Geschwind model. The results do indicate, however, that factors such as the chronicity of pathology, the extent of lesioning (variable in the Schulhoff study and radical in the Efron work) and the precise nature of the stimuli (e.g., the recognition of tone sequences versus the recognition of tone pitch) affect dichotic perception and therefore warrant consideration.

A Summary of the Dichotic Literature

In summary, the literature pertaining to dichotic listening indicates that in dichotic perception tasks normal individuals usually exhibit right-ear superiority in the detection of verbal material and left-ear superiority in the detection of nonverbal material. Damage to the brain in the vicinity of the temporal lobe in the right hemisphere results in deficits in the perception of material presented to the left ear. This damage in turn exaggerates the relative superiority of the right ear in tasks that involve the dichotic perception of verbal material and diminishes the superiority of the left ear in the perception of nonverbal material. Lesions to the left hemisphere of the brain have a more variable effect upon dichotic perception. Left-sided damage results in bilateral impairment in the perception of verbal material, but the impairment may be greater in the left or the right ear. Sparks et al. (1970a, 1970b) suggest that the degree of lateral impairment is contingent upon the extent of the lesion, such that deeper lesions result in relatively more impairment in the left ear and less radical lesions result in relatively more impairment in the right ear. Left-sided damage has been found to have varied effects upon the dichotic perception of nonverbal material.

The Staggered Spondaic Word Test

A dichotic listening test that has been the focus of a considerable body of research is the Staggered Spondaic Word Test (SSW; Katz, 1962). The SSW Test is a dichotic word perception task in which the subject is presented with two spondaic words (e.g., upstairs, downtown), one to each ear. These words are partially overlapped in time so that the last syllable of the first word competes with the first syllable of the second word. The task of the subject is to repeat the words immediately after their presentation. The SSW Test was designed to assist in the evaluation of dysfunction in the central auditory nervous system (Katz, 1962) and has been employed with a variety of normal populations (e.g., Arnst, 1981; Brunt & Goetzinger, 1968) in addition to clinical populations such as alcoholics (Spitzer & Ventry, 1980), head trauma patients (Katz, Basil, & Smith, 1963), the learning disabled (Stubblefield & Young, 1975), stutterers (Hall & Jerger, 1980), and the autistic (Wetherby, Koegel, & Mendel, 1981). As such, it has been shown to be a sensitive instrument in the detection of central auditory nervous system dysfunction. Moreover, it is, in its brevity and simplicity -- it takes approximately 10 minutes to complete and involves only immediate memory -- particularly suitable for use with psychologically disturbed subjects. The SSW Test would therefore appear to be an appropriate device with which to investigate the dichotic perceptual ability of affectively disordered patients.

The Prior Use of Dichotic Tasks with ECT Patients

In view of the similarities between the deficits that may follow ECT and the deficits that follow temporal lobe damage, and the characteristic patterns of dichotic performance that tend to follow unilateral brain damage, the application of dichotic testing to ECT patients appears to be a logical progression in ECT-related research. Further evidence that dichotic testing may be useful in ECT research comes from two previous studies that have been conducted to examine the dichotic listening performance of ECT patients. In the first of these studies Altman, Balonov and Deglin (1979) employed a dichotic stimulation task in which clicks were presented binaurally to patients before and after the patients received treatment with UL ECT. The task of the patient was to indicate whereabouts in his/her head the sound seemed to be localized. In such a task the clicks are perceived as being at one specific location in the head. Precisely where the stimuli appear to be located is contingent upon the simultaneity of binaural stimulation. For example, with completely simultaneous presentation of the clicks the stimuli are normally perceived to be at the midline of the skull. Altman et al. noted that, for up to 10 minutes after right UL ECT, the patients experienced gross distortions of sound localization and lateralization, such that in all cases there was a shift to the right of between 60 and 90 degrees. That is, after ECT the patients perceived the clicks to be significantly further to the right side of their head than they had perceived those stimuli to be during a pre-ECT control condition. However, no such distortion of sound localization was detected in a group of patients who received left UL ECT. Altman and his colleagues concluded that their findings provide evidence that there is an inner spatial coordination system localized in the right hemisphere, and that this system was disrupted by the administration of right UL ECT. Although these observations are applicable only to the immediate post-ECT period, and cannot be used to support a hypothesis of long-term changes after ECT, they do emphasize the disruptive effect of ECT. Of particular significance to the present study, they also accentuate the sensitivity and applicability of dichotic stimulation tasks to ECT research.

In a more recent study, Moscovitch, Strauss, and Olds (1981) gave a DL task to seven depressed ECT patients and to an equal number of depressed patients who were receiving drug therapy. All patients were right-handed women. The DL task, which used verbal stimuli, was given to the ECT patients 1 day prior to ECT, 4 hours after the second treatment session, and 3 to 4 months after completion of ECT. In the medicated (non-ECT) patients, to whom the DL task was given 2 days apart, a right-ear advantage was noted. In the ECT patients, only a slight average right-ear advantage was present before ECT. A substantial right-ear advantage was observed after the second ECT session, however, and this advantage was maintained for at least 3 to 4 months after ECT. The data indicate that after ECT the patients experienced a decline in left-ear performance and an increase in right-ear performance -- patterns that are consistent with the effects of right-sided brain damage.

Nevertheless, Moscovitch et al. did not interpret their results as indicating that ECT had produced cognitive abnormalities. Rather, they noted that the changes in lateral dominance corresponded with alleviation of depression, and they suggested that the changes in dichotic perceptual performance reflected normalization of hemispheric activity. Unfortunately, methodological problems in this study render such conclusions untenable. One major problem with the study is that the control group was comprised only of depressed patients who received treatment with antidepressants and who were tested dichotically 2 days apart. Therefore, there was no comparison of the dichotic performance of the medicated patients before and after clinical remission and no comparison was made between ECT patients and normal individuals. Another shortcoming of the study is that only seven patients were tested originally, and only five of these individuals were retested 3 or 4 months later. Notwithstanding these difficulties, the results of this study are most provocative.

The hypothesis, discussed by Moscovitch et al., that changes in hemispheric activity are associated with psychopathology has been investigated previously by a number of workers (e.g., Lerner, Nachson, & Carmon, 1977; Yozawitz et al., 1979). Although the outcome of such research has been varied, the results of several studies (e.g., Bruder, Sutton, Berger-Gross, Quitkin, & Davies, 1981; Lishman, Toone, Colbourne, McMeekan, & Mance, 1978; Wexler & Heninger, 1979; Yozawitz et al., 1979) have suggested that abnormal levels of cerebral asymmetry are present during states of affective disorder. In brief, these reports have indicated that there tends to be a lack of hemispheric among depressed patients. It will be recalled that in normal individuals there is typically a right-ear advantage in the perception of verbal dichotic stimuli and a left-ear advantage in the perception of non-verbal dichotic stimuli. As noted above, the findings of Moscovitch et al. were interpreted as being in support of such work.

<u>Rationale for the Present Study</u>

The present study was conducted because of the need for an investigation of the neuropsychological and dichotic perceptual performance of a sufficiently large group of individuals who had received ECT at least several months previously. In this study, patients who had previously received ECT had their memory and DL performance compared with groups of: (a) normal controls; (b) depressed patients currently undergoing ECT; (c) remitted, non-ECT depressives; and (d) depressed, non-ECT patients. It was envisaged that a study of this nature would make it possible to determine whether long-term changes in memory and DL performance are present in ECT patients, and if so whether these changes reflect normalization of hemispheric activity or, conversely, a departure from normalcy. On the basis of prior research, it was expected that normal subjects would exhibit right-ear superiority for the perception of dichotically presented verbal stimuli. What was of considerable interest with regard to ECT was whether patients who had undergone ECT demonstrated DL performance that differed significantly from that of normal control subjects and that of remitted and unremitted non-ECT depressives. It was anticipated that if ECT does result in protracted abnormalities in brain functioning, then right UL ECT patients should exhibit exaggerated right-ear dominance for the dichotic perception of verbal stimuli relative to normal subjects. It was anticipated further that the patterns of responding in the remitted former ECT patients relative to those of the depressed former ECT patients, depressed non-ECT patients, and patients currently undergoing ECT would permit evaluation of the possibility (noted by Moscovitch et al., 1981) that the hemispheric activation of depressives differs initially from that of normal individuals but reverts to normal after ECT.

Hypotheses

Specifically, it was hypothesized that normal subjects would exhibit no deficits on the dichotic perception or memory tests and that they would display a right-ear advantage for dichotic perception. It was hypothesized further that remitted, non-ECT depressives would exhibit patterns of memory and DL performance similar to those of normal individuals. With regard to the depressed, non-ECT patients, it was anticipated that these subjects would display no significant deficits or deviations on the DL task, but that they might -- because of the effects of their depression -- exhibit somewhat reduced memory task performance. Note that, according to Moscovitch et al., these patients would not be expected to display the significant right-ear advantage on the DL task that is characteristic of normal subjects. The pattern of response of the patients currently undergoing a series of ECT was expected to vary as a function of their ECT status. It was hypothesized that prior to the commencement of the ECT series these individuals would exhibit patterns of DL and memory task performance similar to those of the depressed, non-ECT patients. However, it was anticipated that after completion of the ECT series these patients would exhibit little change or slight improvement in memory functioning -- due to the alleviation of depression, offset by the memory impairment induced by ECT -- but would exhibit enhanced right-ear superiority on the DL task. Examination of the DL performance of these patients prior to ECT and evaluation of the DL performance of the depressed, non-ECT patients was expected to reveal whether this change in dichotic perception could be attributed to right-hemispheric damage or to the normalization of hemispheric functioning following the alleviation of depression.

The individuals who had received ECT at least several months prior to testing were expected to display patterns of DL performance similar to those of the patients who had just completed their course of ECT. The interpretation of such an outcome would be governed in part by the clinical status of the patients who had completed ECT several months previously and in part by the patterns of DL performance of the depressed patients in the other groups. It was anticipated that the memory capability of the patients who had received ECT many months prior to testing would vary according to clinical status. Those patients who were depressed at the time of testing were expected to display patterns of neuropsychological performance that were poorer than those of normal subjects and remitted depressives, due to the direct effect of depression. However, evidence of memory impairment in the remitted ECT past-treated depressives would be consistent with an interpretation of residual memory dysfunction due to ECT.

In light of the fact that the present study was one of the few bodies of research in which a relatively sophisticated and reliable index of dichotic perception (the SSW test) was utilized, it was also of interest to obtain more general information concerning the DL performance of all subjects. Specifically, it was of interest to determine whether groups differed in terms of performance on specific subscores of the SSW test. For example, it was expected that the dichotic perceptual performance of depressed subjects -- and in particular ECT patients -- might differ from that of non-depressed subjects and that such differences would tend to be reflected by lower levels of functioning on certain SSW Test measures.

Method

Subjects

A total of 78 right-handed males (N=24) and females (N=54) were tested at Shaughnessy Hospital in Vancouver. On the basis of their psychiatric history and current diagnosis, these individuals were assigned to one of the following categories of subjects:

1. Normal control subjects without features or history of psychiatric problems, clinical depression, or ECT (N=20).
2. Clinically depressed patients who had never received, and were not currently receiving, ECT (N=15).
3. Remitted depressives who had never received ECT (N=17).
4. Depressed patients who were currently receiving a course of right UL ECT (Current ECT group; N=11).
5. Depressives who had received a course of right UL ECT not less than 6 months prior to testing (Past ECT group; N=15). The mean elapsed time since ECT was 9.75 years, with a range of 6 months to 25 years.

The normal control subjects were recruited at local offices of the Unemployment Insurance Commission and were paid for their participation in the study. These individuals were matched to the patient groups on the basis of age, sex, and education, and were screened to eliminate those with past or current psychological/psychiatric problems. This screening was accomplished by administration of a modified version of the Diagnostic Interview Schedule (National Institute of Mental Health, 1981; Appendix A.01) and the Beck Depression Inventory (Beck, 1972; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Appendix A.02). The mean age of the 7 male and 13 female control subjects was 48.28 years and 38.00 years, respectively. Standard deviations were 10.32 and 13.08 years, respectively.

All patients, whether remitted or currently depressed, had received a primary diagnosis of Major Affective Disorder with depression according to the criteria specified in the third edition of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 1980). Overall, 39 of the patients had received a diagnosis of Major Depression (Unipolar) and 19 of the patients had been diagnosed as suffering from a Bipolar Disorder with depressive features. That is, those patients with a disturbance in mood who had not, and who had, respectively, experienced a lifetime episode of mania and whose affective syndrome was not attributable to any other physical or mental disorder. Diagnosis was made initially by the Director (a senior psychiatric consultant), Affective Disorders Clinic, Department of Psychiatry, Shaughnessy Hospital. This diagnosis was then corroborated by the structured interview given at the time of clinical testing for the present study. Forty-six of the patients were receiving antidepressant medication or lithium carbonate when tested and 12 of the patients had not received medication for at least 1 month prior to testing. The mean age of the 17 male depressives was 48.94 years, with a standard deviation of 11.06 years. The mean age of the 41 female depressives was 46.61 years, with a standard deviation of 13.54 years. The characteristics of the participants in the study are summarized in Tables 2 and 3.

Table 2

Demographic Characteristics of Subjects

Group	Number of Subjects		Age		Education (Yrs)
	Female	Male			
Normal	13	7	M	41.60	13.50
			SD	12.93	3.32
Depressed, Non-ECT	11	4	M	40.80	12.53
			SD	13.00	2.72
Remitted, Non-ECT	14	3	M	46.24	14.06
			SD	11.17	2.56
Current ECT	7	4	M	56.82	12.18
			SD	11.51	1.66
Past ECT	9	6	M	48.27	12.47
			SD	12.03	2.72

Table 3

Clinical Characteristics of Subjects

Group	Medication Status		Diagnosis		Scores on Clinical Scales		
	Medicated	Free	UP	BP		Hamilton	Beck
Normal	0	20	0	0	M	--	4.45
					SD	--	4.58
Depressed, Non-ECT	12	3	10	5	M	17.62	29.20
					SD	6.74	6.20
Remitted, Non-ECT	11	6	12	5	M	8.92	7.47
					SD	6.64	6.50
Current ECT (Pre-treatment)	10	1	8	3	M	26.80	29.64
					SD	6.42	10.93
Current ECT (Post-treatment)	11	0	8	3	M	10.00	12.20
					SD	1.00	11.46
Past ECT	13	2	9	6	M	11.64	8.00
					SD	7.93	10.18

Note. Hamilton = Hamilton Rating Scale for Depression.
Beck = Beck Depression Inventory. The lowest score possible on the versions of the Hamilton and Beck used in this study was zero. The highest scores possible on the versions of the Hamilton and Beck used in this study were 61 and 62, respectively.
UP = Unipolar affective disorder (DSM-III criteria)
BP = Bipolar affective disorder (DSM-III criteria)

Dichotic Perception

The ability of a subject to perceive stimuli that were presented dichotically was assessed by means of the Staggered Spondaic Word Test (SSW). In the present section a number of audiological and SSW Test terms are introduced. To assist the reader in the comprehension of this material a glossary of audiological and SSW Test terminology is provided in Appendix A.07. As noted in the introductory section of the present paper, the SSW Test is a dichotic listening task that involves two spondee words partially overlapped in time (a spondee is a metrical foot consisting of two long syllables). In this test, the right and left ears received two different words (e.g., "upstairs", "downtown") at approximately the same time. A total of 40 words were presented. The task of the subject was to repeat each pair of words as it was presented. The partial overlapping of the spondee words was intended to attenuate somewhat the right-ear advantage typically found in dichotic stimulation tasks. The first spondee was presented to one ear and the second spondee was presented to the other ear after a slight delay. The word-pair sequences alternated between beginning at the right ear (right-ear-first condition) and at the left ear (left-ear-first condition). Consequently, competing and non-competing items were introduced to both the right and left ears.

Administration of the SSW Test was standardized and followed the procedures outlined by Arnst (1982). To ensure correct administration of the SSW Test, an audiometric examination of the subject was first undertaken. This examination was conducted following standardized audiological procedures (e.g., Hughson & Westlake, 1944) and was performed to obtain the following information for each subject: (a) pure-tone threshold, (b) three-frequency pure-tone average, (c) speech reception threshold, and (d) speech discrimination score. To establish the pure-tone threshold of the subject, the Method of Limits was employed: Pure-tone stimuli (i.e., those of a single frequency, with simple sinusoidal acoustical properties) were presented, by way of audiometer and headphones, to each ear of the subject, one ear at a time. These stimuli had a rise/decay time of 0.04 seconds and duration of between 1.5 and 2.0 seconds. The stimuli were presented initially to the subject at minimum intensity, with a gradual increase in intensity until the subject acknowledged (usually by the pre-arranged signal of raising a hand) that a tone had been heard. The intensity levels at which the stimuli were conveyed to the subject were then decreased in 10-decibel (dB) steps until the subject no longer responded, increased in 5-dB steps until the subject responded again, decreased in 10-dB steps until no subject response was elicited, and finally increased in 5-dB steps until the subject responded again to the stimuli. The pure tone threshold was defined as the lowest intensity at which the subject responded to the stimuli 50 percent of the time. The three-frequency pure-tone average was defined as the mean intensity threshold for tones that were presented to the subject at frequencies of 500, 1,000, and 2,000 hertz. To determine the speech reception threshold of the subject, spondees (e.g., cowboy, baseball) were read to the subject by the audiologist. These spondaic words were taken from lists normally employed in audiological tests and were chosen for their properties of familiarity to speakers of North American English and their overall linguistic redundancy (i.e., they were easy words). They were conveyed to the subject, via microphone, audiometer and headphones, at levels of intensity that were varied in the manner described above. The speech reception threshold was defined as the lowest intensity at which 50 percent of the spondees were repeated correctly. Finally, on the basis of the speech reception threshold it was possible to determine the speech discrimination score of the subject. This score, expressed as percent error, was predicated upon the accuracy with which the subject repeated a series of words read to him/her at a level of intensity that was 30-dB above the speech reception threshold of the subject.

The data obtained from the audiological examination were then utilized in the administration of the SSW Test. The SSW Test was given immediately after the audiological evaluation and was presented to the subject at a level of intensity that was 50-dB above the three-frequency pure-tone average threshold of the subject. The SSW Test protocol was pre-recorded by the test developer and commercial distributor (c Jack Katz/Auditec, St. Louis, Missouri) and, as such, was presented to each subject in a standardized manner. In summary, the audiologist would test the auditory acuity of each ear of the subject, adjust the presentation levels so that the ears received the same relative level of stimulation, start the SSW Test tape, and then tally the verbal responses of the subject manually on the standardized SSW Test Response Form (c Jack Katz, 1970, 1977).

Evaluation of the performance of the subject was made by examination of the errors committed in each of the listening conditions. These conditions were: (a) the right non-competing (RNC) -- that is, the first syllable of the first spondee is presented to the right ear while the left ear receives no stimulation; (b) right competing (RC) -- the second syllable of the first spondee is presented to the right ear while the left ear is presented with the first syllable of the second spondee; (c) left competing (LC); and (d) left non-competing (LNC). Errors were tallied for each of the listening conditions for both the right-ear-first and the left-ear-first presentations and a right-ear (RE) and left-ear (LE) score derived from the means of the RC, RNC, and LC, LNC scores, respectively. There were a total of 20 trials for each of the conditions. Additionally, an evaluation of SSW Test performance was made by examination of the number of rearrangements, or reversals, of word sequences reported by the subject. Subjects were told to repeat the words in the order in which they were presented. For example, such a rearrangement would occur when the actual order of presentation of the spondees was "upstairs, downtown" but the subject reported having heard "downtown, upstairs" or "uptown, downstairs".

The SSW Test scores were summarized initially by calculation of a raw score. This score represented the percentage of error in each of the listening conditions (RNC, RC, LC, LNC) and was dichotomized into a right-ear raw SSW score and a left-ear raw SSW score by averaging the two right-ear conditions and the two left-ear conditions, respectively. From this raw score corrected SSW scores could be calculated. These C-SSW scores were computed to account for any peripheral distortion (i.e., cochlear hearing loss) that was determined from the preliminary audiological examination. The corrected scores for each ear were obtained by subtracting the Speech Discrimination Scores (described above) from the raw SSW scores. That is, C-SSW = (%Error R-SSW)-(%Error SDS). A total C-SSW score could also be derived, simply by averaging the right-ear C-SSW and the left-ear C-SSW scores. The specific C-SSW scores that were utilized as dependent measures were therefore the SSW Total, SSW Right-Ear error, SSW Left-Ear error, and SSW Reversals. In addition, the SSW Condition score was recorded. The Condition score was the maximum percentage of error present in any of the four listening conditions. The decision to use the RE and LE scores -- which were collapsed from the RC, RNC, and LC, LNC scores, respectively -- in the data analyses was taken because of the fact that in the SSW Test the subject responded at each trial by repetition of two complete spondaic words (e.g., backdoor, playground). Only half of each word was overlapped. As such, the analysis of overlapped syllables in isolation would have provided spurious information because of the interaction between perception of one of the syllables and perception of the complete word.

Audiometric Equipment

All subjects were tested audiometrically at Shaughnessy Hospital in a Tracoustics RS257DS double-walled sound booth. Stimuli were conveyed to the subject by means of Telephonics TDH-39 headphones in circumaural cushions. Audiometric readings of frequency and level of intensity of stimuli were made on a Madsen OB77 audiometer. The SSW Test instructions and stimuli were pre-recorded on cassette tape by Auditec of St. Louis, Missouri (c Jack Katz, 1970, 1977). This tape was played on an Akai GX-M10 stereo cassette deck.

Neuropsychological Performance

Neuropsychological performance was evaluated by means of a battery of memory tests given immediately before the audiological examination. This battery of tests, which was administered by the experimenter, consisted of the following measures:

1. Recurring Figures Test (Kimura, 1963). This is a test of the ability to recognize stimuli that are presented in a visual modality. The stimuli employed, and the technique of administration, make it particularly sensitive to dysfunction in the right temporal lobe area of the brain (Kimura, 1963; Rixecker & Hartje, 1980). In this test, the subject was shown a series of 20 cards, on each of which was a line drawing of either a geometric figure or an irregular nonsense figure. Each card was exposed to the subject for approximately 3 seconds. The subject was then shown, in fairly rapid succession, 100 other cards. On each of these cards was a line drawing that was similar, or identical, to those drawn on the 20 cards shown initially. The task of the subject was to indicate which of the cards shown in the latter series had been shown previously in the initial series of cards. (In all, 20 geometric and 20 irregular figures recurred in the second series.) The final score on this test was obtained by calculating the total number of correct identifications --that is, the recurring figures identified correctly as having been seen before -- and subtracting from this total the number of false positives (i.e., the non-recurring figures identified incorrectly as having been seen before).

2. Digit Span. The Digit Span subtest of the Wechsler Scales (Wechsler Memory Scale, Wechsler, 1945; Wechsler Adult Intelligence Scale, Wechsler, 1955, 1981) is considered to be a test of short-term memory or immediate auditory memory. Additionally, it measures concentration and attention as well as the ability to shift thought patterns (from Digits Forward to Digits Backward). The task of the subject was to recall immediately, and repeat in proper sequence, series of digits that were presented orally (Digits Forward) and to recall and repeat in the correct reverse sequence similar series of digits (Digits Backward). A maximum of eight digits were presented in the Digits Forward portion of the subtest and a maximum of seven digits were presented in the Digits Backward portion of the subtest. Up to two trials (with different digits) were allowed for a given number of digits and Digits Forward or Digits Backward was discontinued if both trials were failed. The scores for Digits Forward and Digits Backward were calculated independently and each score consisted of the number of digits in the longest series repeated correctly. (Appendix B.01.)

3. Benton Visual Retention Test (Benton, 1974). This is a test of the ability to recall and reproduce from memory stimuli that are presented visually. It consists of a series of 10 cards. On each card is a drawing comprised of from 1 to 3 geometric figures. For each card the subject was required to examine the drawing for a period of 10 seconds, retain for 15 seconds the stimuli that were perceived, and then draw the figure or figures that had been exposed during that trial. To reproduce the stimuli, the subject was given a pencil with eraser and, at the end of the 15-second

retention interval, a piece of unlined paper that was of a size identical to that of the card on which the target stimuli were drawn (i.e., 5.5 X 8.5 inches). Form D, Administration D (10 seconds of exposure followed by 15 seconds of delay) of the test was employed for all subjects. In the case of the patients in the Current ECT group, each of whom was tested twice, Form E, Administration D was utilized in the second examination. The system of scoring followed the one described by Benton (1974) and consisted of evaluation of the number of correct reproductions. In this evaluation each design was judged to be correct or incorrect on the basis of its similarity to the samples of correct and incorrect reproductions given by Benton. A design that was reproduced correctly was given a score of one, whereas an incorrect reproduction received a score of zero. The maximum total score possible was therefore 10 and the minimum total score possible was zero.

4. Logical Memory. The logical memory subtest of the Wechsler Memory Scale (Wechsler, 1945) is considered to be a test of the ability to recall logical material that is presented orally. With delayed recall, this test becomes one of delayed recall of verbal material. In this subtest the subject was informed that he or she was to be read a very short story and that she/he would be asked to recall as many details of the story as possible after a delay of a few minutes. The first passage of material was then read to the subject, followed by a retention interval of 5 minutes. During this interval the subject completed a handedness questionnaire and the Beck Depression Inventory and commenced the Personal Data Questionnaire, all of which are described below. At the conclusion of the

5-minute interval the subject was asked to recall the material presented in the first passage and was then read a second passage of material. The presentation of this material was followed by a retention interval of 3 minutes, during which the subject continued work on the Personal Data Questionnaire. At the completion of the 3-minute interval the subject was requested to recall details of the material that had been presented in the second passage. The score for a subject consisted of the mean number of ideas recalled correctly on both passages. All subjects were given Form I of the Logical Memory subtest. In the case of the Current ECT patients, Form II of the subtest was administered at retest to minimize possible test-retest effects. (Appendix B.02.)

5. Personal Data. The 32-item Personal Data Questionnaire utilized was designed specifically for the present research. It was patterned after a similar scale used by Squire (Squire et al., 1981) and was intended to assess the ability of the subject to recall material of an autobiographical nature. This questionnaire required the subject to recall both objective and subjective information from the distant and recent past. (Appendix B.03.)

<u>Depression</u>

The level of depression of the subject was assessed by means of the Beck Depression Inventory (BDI), a 21-item self-report inventory intended to evaluate current levels dysphoria. According to the BDI norms reported by Burns and Beck (1978), moderate levels of depression are indicated by scores of between 21 and 30, whereas severe and very severe depressions are suggested by scores of between 31 and 40 and 41 and 63, respectively. For the purposes of group classification in the present study, a score of 21 or above was therefore taken to indicate the presence of depression of clinical severity.

In addition to the completion of the BDI, an objective evaluation of the level of depression in the patients was conducted by the referring psychiatrist. This evaluation was communicated by the completion by the psychiatrist of the Hamilton Rating Scale for Depression (Hamilton, 1960; Appendix A.03) at the time at which the patient was referred for testing. Because the Hamilton scale was completed at the time of referral there was frequently a period of 1 to 3 weeks between such completion and the participation of the patient in the study. Accordingly, the Hamilton scale was used to corroborate the presence and extent of depression, rather than as the principal means of mood evaluation.

Cerebral Organization

An evaluation of the relative handedness -- and thus probable hemispheric laterality -- of each subject was made with the Edinburgh Checklist Criteria (Appendix A.04). This self-report inventory lists 10 activities and asks the respondent to rank each activity on a five-point scale, where 1 = left hand only employed in the task and 5 = right hand only. To be considered right-handed -- and therefore suitable for inclusion in the present study -- a subject was required to obtain a minimum score of 35, out of a maximum of 50, on the Edinburgh Checklist.

Organicity

Because it was important to control for the effects of brain pathology due to organic deteriorative factors other than the (relatively subtle) ones that may be induced by ECT, subjects who possessed or were suspected of having gross signs of organic brain deterioration were excluded from the study. In the case of the patients, pre-test screening for organicity was predicated upon the diagnostic impressions of the referring psychiatrist.

Procedure

Subjects were tested between March, 1985 and March, 1986. Patients were approached initially for participation in the study by the psychiatrist who was Director of the Psychiatric Outpatients Department and the Affective Disorders Clinic at Shaughnessy Hospital. After explaining the project to the patient (see Appendix A.05 for the information handout given initially to the patients), and after establishing the willingness of the patient to take part in the research, the psychiatrist rated the patient on the Hamilton Rating Scale for Depression. He then referred the patient to the experimenter for audiological and neuropsychological evaluation. Usually, there was little or no delay -- at most 1 day -- between diagnostic interview, completion of the Hamilton scale, and referral to the experimenter. The experimenter then immediately contacted the patient to establish an appointment for testing. At this point, due to the time constraints of the audiologist at Shaughnessy Hospital, there was an average waiting period of approximately 1 week before patients were given the audiological and neuropsychological test batteries. In some instances, such as in the case of acutely depressed individuals and/or those about to receive ECT, the waiting period was reduced to between 1 and 2 days. As noted above, the normal control subjects were solicited by advertisements placed at offices of the Unemployment Insurance Commission. The control subjects were tested, on an ongoing basis, in the same time period as the patients. These subjects were screened initially at the time of their telephone contact in response to the advertisement. If deemed suitable for testing, an appointment for testing was established. This appointment was usually for a date no later than 2 to 3 weeks after the time of intial contact.

The procedure for testing was uniform for all subjects. After being given a brief description of the purpose and procedure of the study, the subject was asked to read and sign a consent form giving informed consent for participation in the research project (Appendix A.06). After such consent was given, neuropsychological testing commenced. The sequence of testing was as follows:

1. Digit Span.
2. Recurring Figures Test.
3. Logical Memory, Paragraph A presentation.
4. Beck Depression Inventory.
5. Edinburgh Handedness Checklist.
6. Logical Memory, Paragraph A recall.
7. Logical Memory, Paragraph B presentation.
8. Personal Data Questionnaire.
9. Logical Memory, Paragraph B recall.

10. Benton Visual Retention Test.

11. Structured diagnostic interview.

Following the completion of this battery of tests, the subject was escorted to the Ear, Nose And Throat Clinic, where pure-tone audiometric assessment and the SSW Test were conducted. All subjects, with the exception of those in the Current ECT group, were tested once. In the case of the Current ECT group, subjects were tested upon two occasions: Once a few days prior to commencement of electroconvulsive therapy and once approximately 2 weeks after completion of ECT. It should be noted that although eleven of these patients were tested before treatment, only ten of the patients were available for re-test due to the severe relapse and re-hospitalization of one individual.

Results

The performance of the subjects on the tests of neuropsychological and dichotic functioning is depicted in Figures 1 to 13. Performance on the SSW Test may be compared with the criteria for normal and abnormal SSW Test scores reported by Arnst (1982) and shown in Table 4. As shown in Table 4, it is possible to obtain a negative error score for each of the dependent measures on the SSW Test. Such negative scores are possible because in the calculation of C-SSW scores the Speech Discrimination Scores are subtracted from the raw SSW scores. For the sake of clarity, and because negative "overcorrected" scores are not believed to reflect cerebral abnormality, SSW scores on the Figures have been collapsed at the lower end of the ordinate so that the negative values are grouped in a single category, designated as < 0.

Group Differences

Age and Level of Education

To obtain overall descriptive information concerning the status of the subjects, means and standard deviations were calculated for the performance of each of the groups. The performance means and standard deviations are shown in Table 5. Although normal subjects had been matched with patients on the basis of age, sex, and education, it had not been possible to match closely each of the patient groups on these variables. To establish whether groups differed significantly in terms of age and education, two one-way analyses of variance were performed. There were no significant differences among groups on the basis of education, $F(4, 73)$

FIGURE 1. AUTOBIOGRAPHICAL MEMORIES

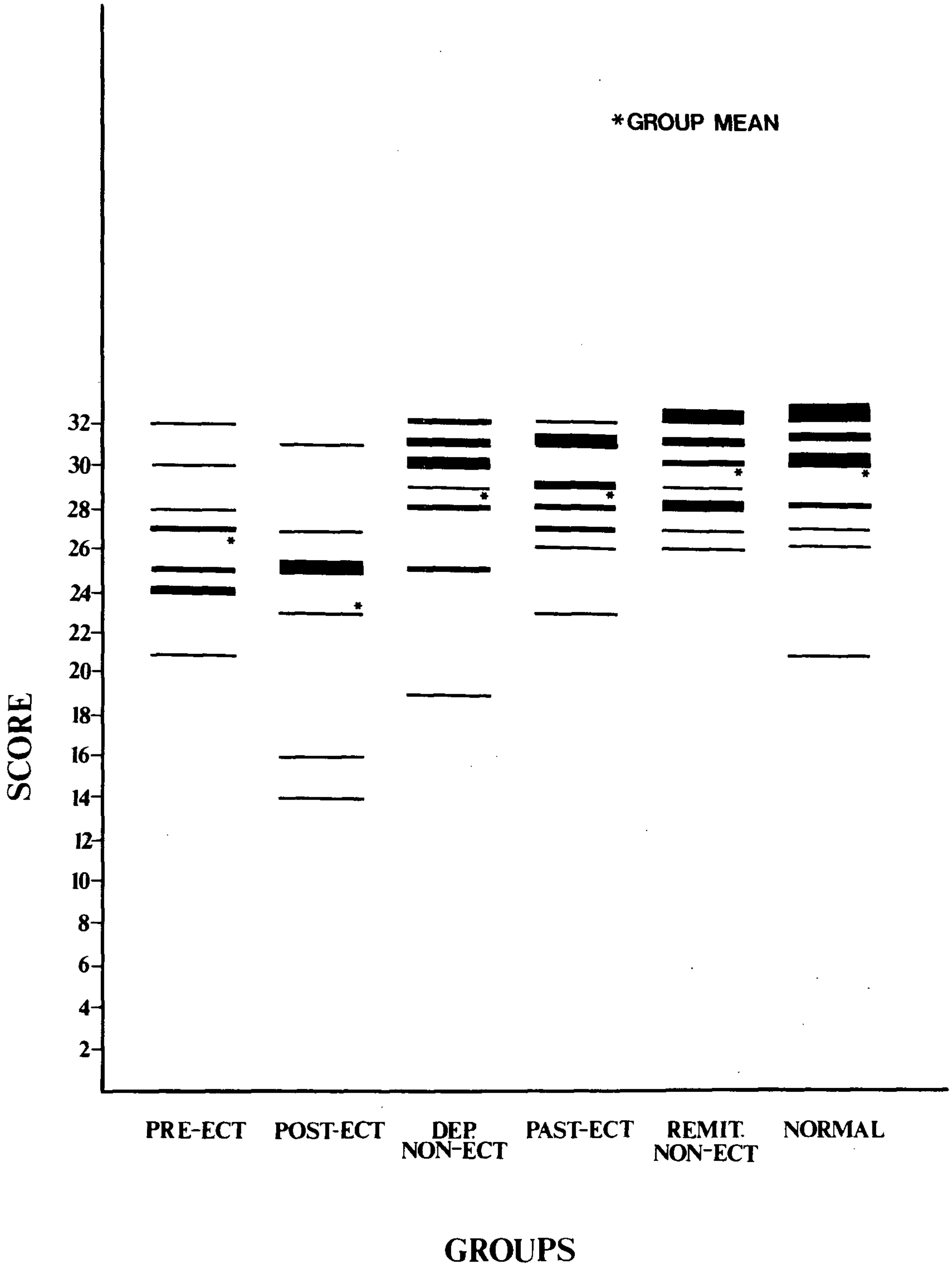


FIGURE 2. LOGICAL MEMORY

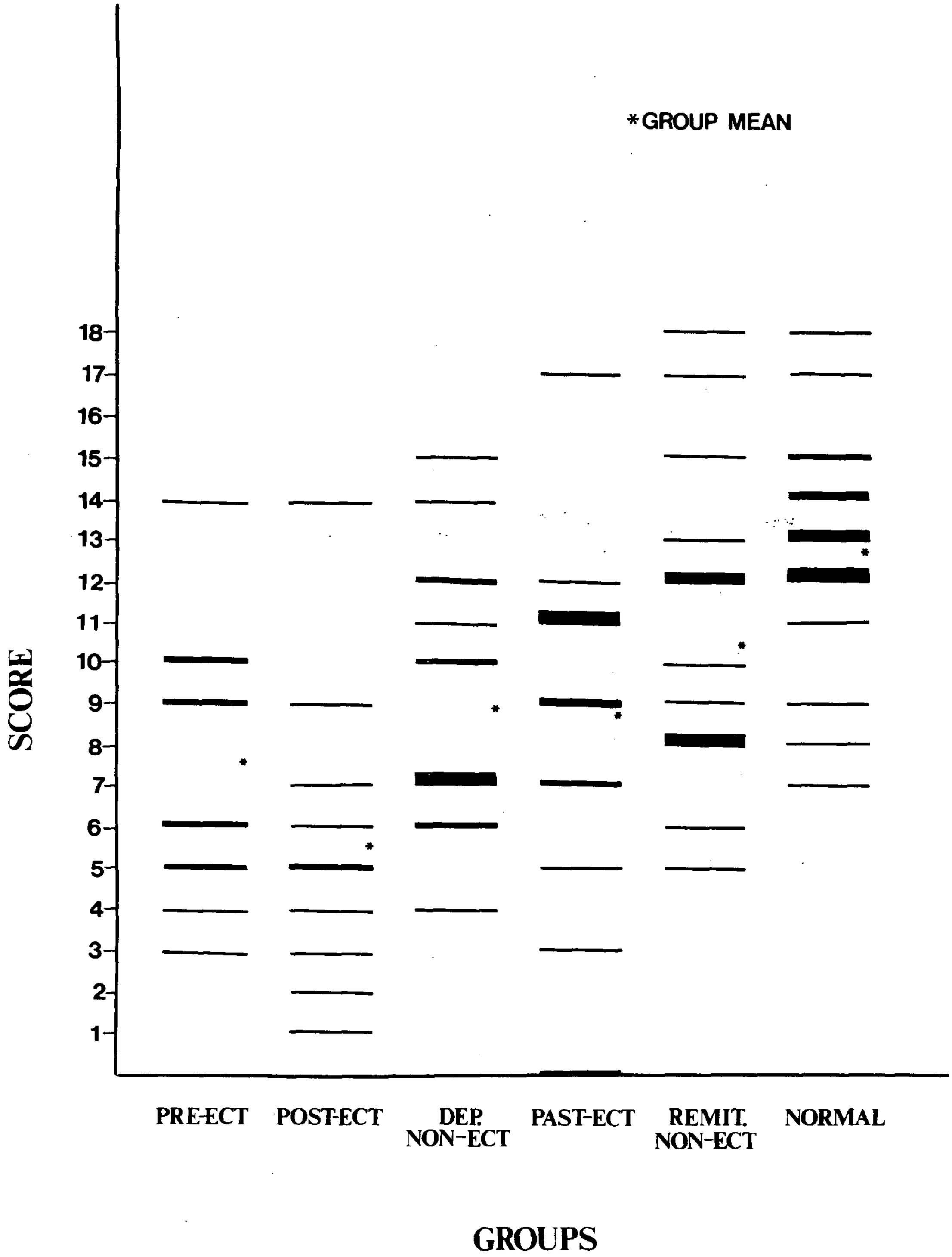


FIGURE 3. RECURRING FIGURES

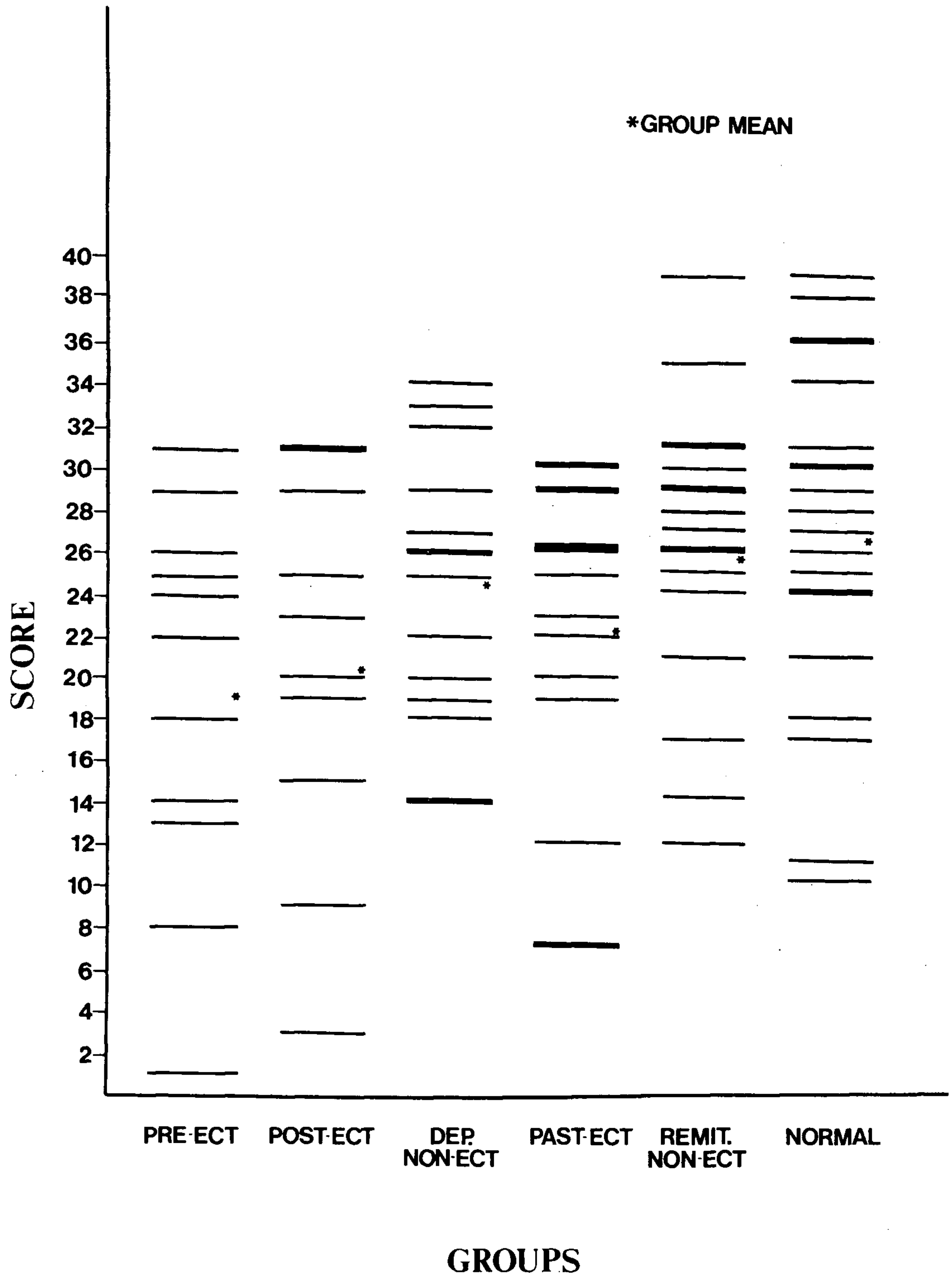


FIGURE 4. DIGITS FORWARD

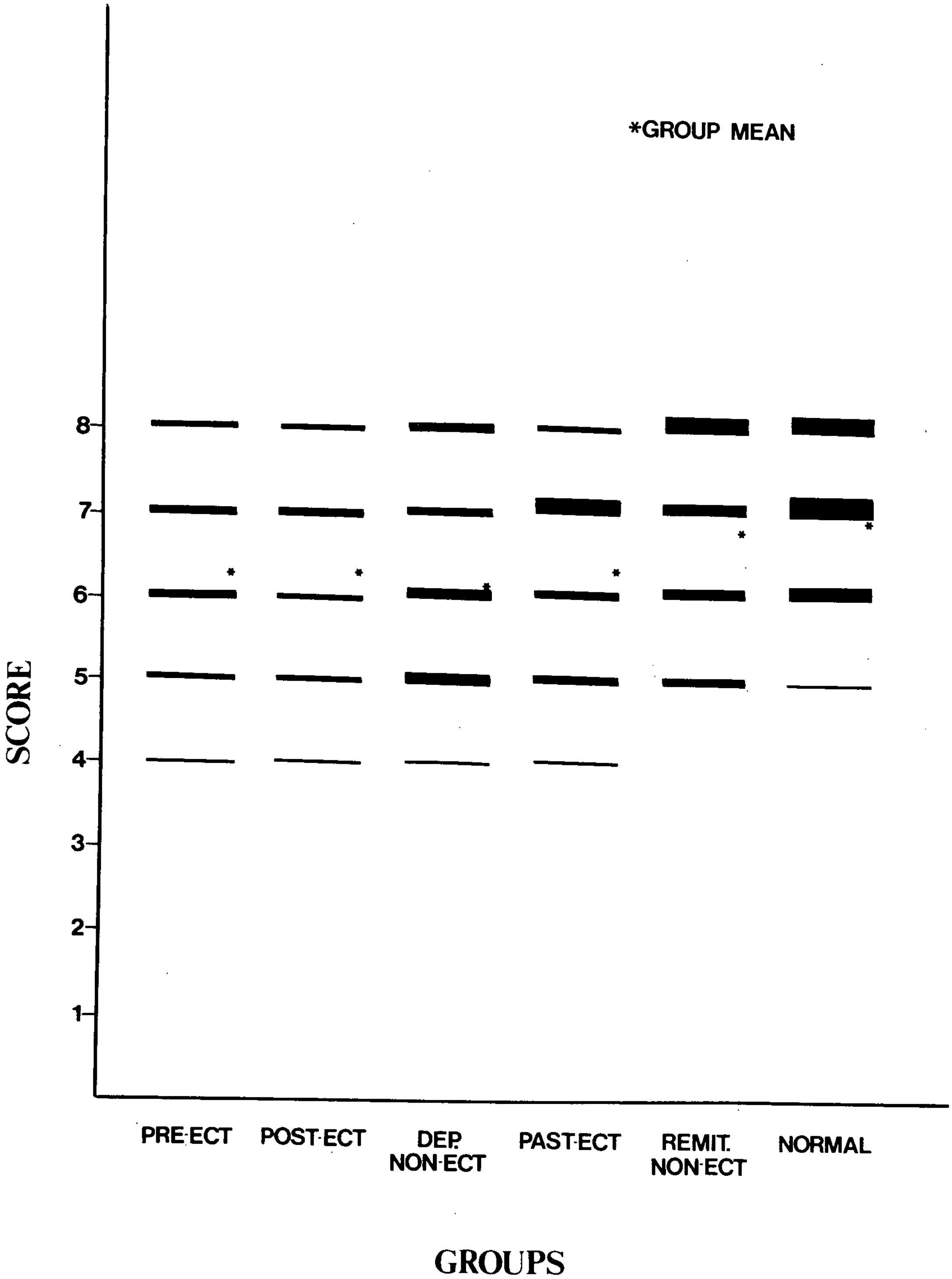


FIGURE 5. DIGITS BACKWARD

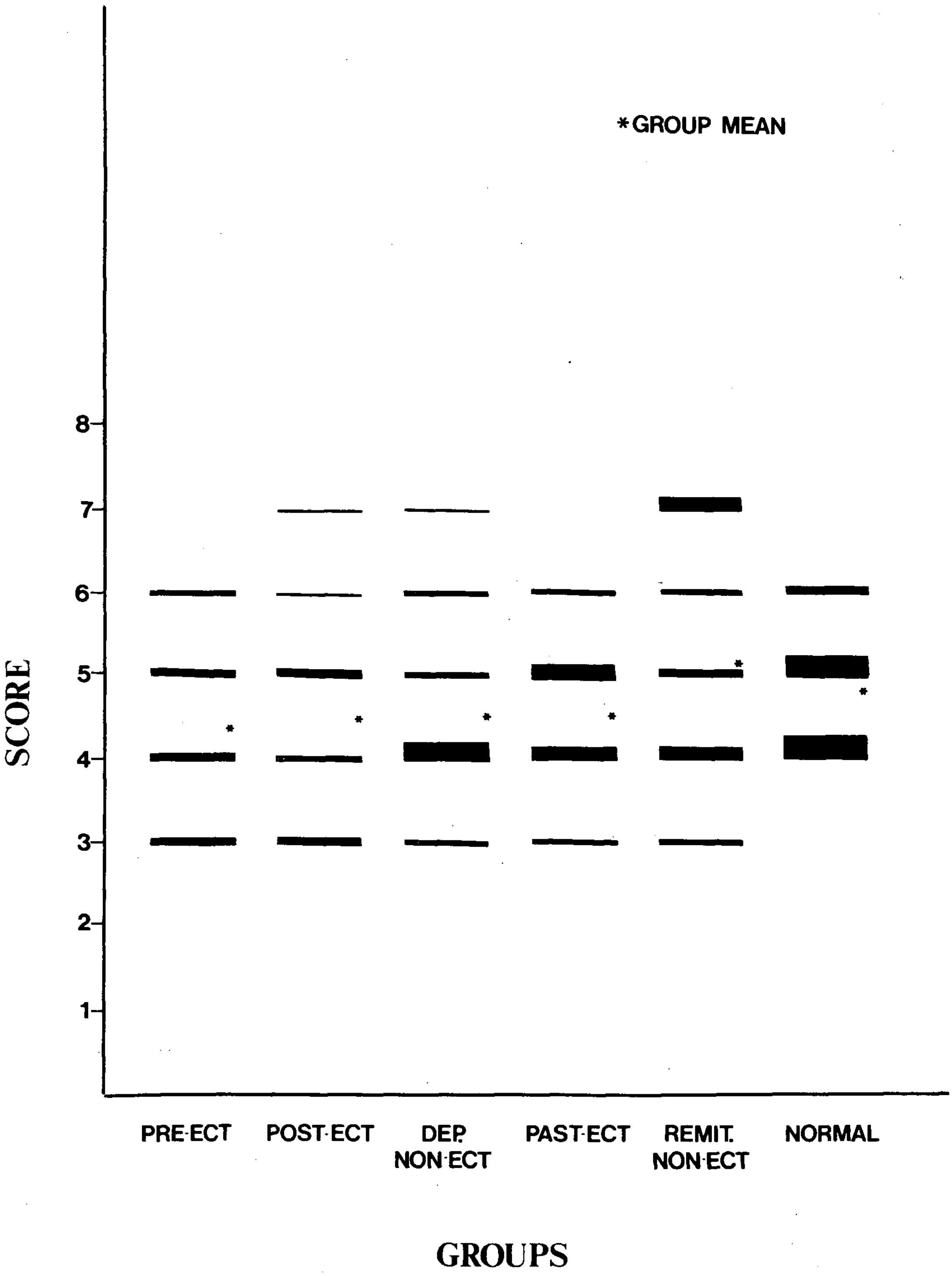


FIGURE 6. BENTON

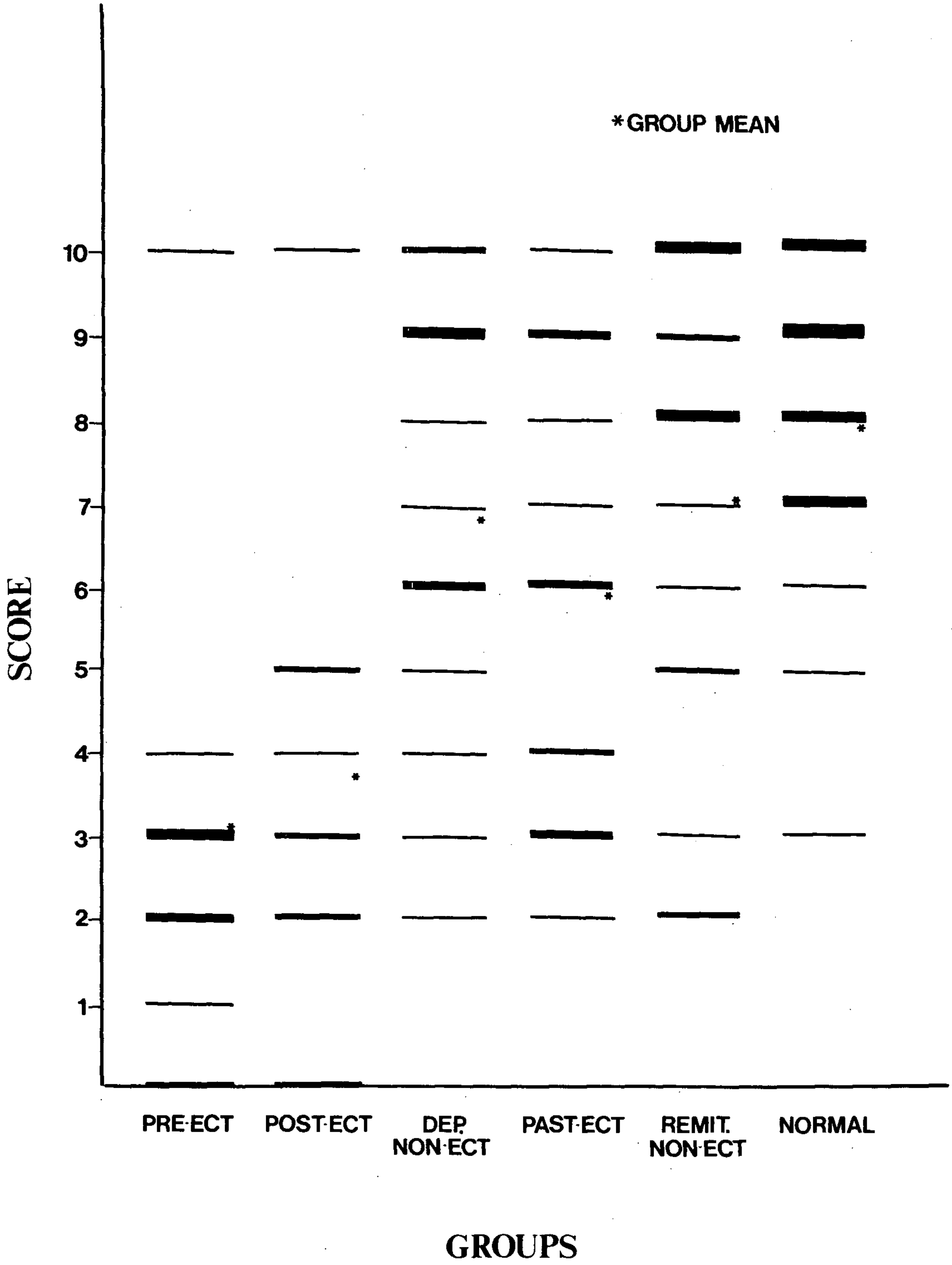


FIGURE 7. SSW TOTAL ERROR

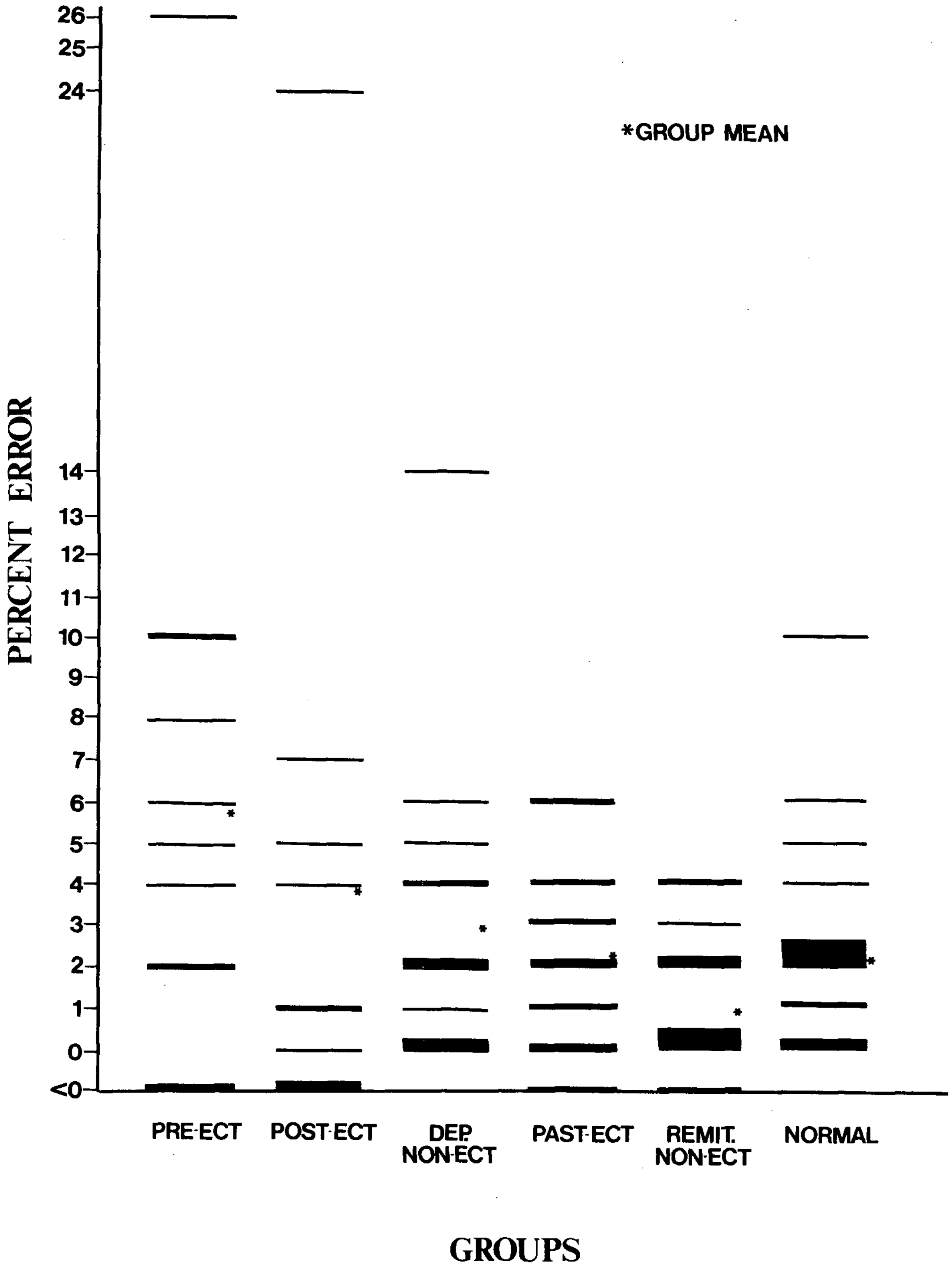


FIGURE 8. SSW RIGHT EAR ERROR

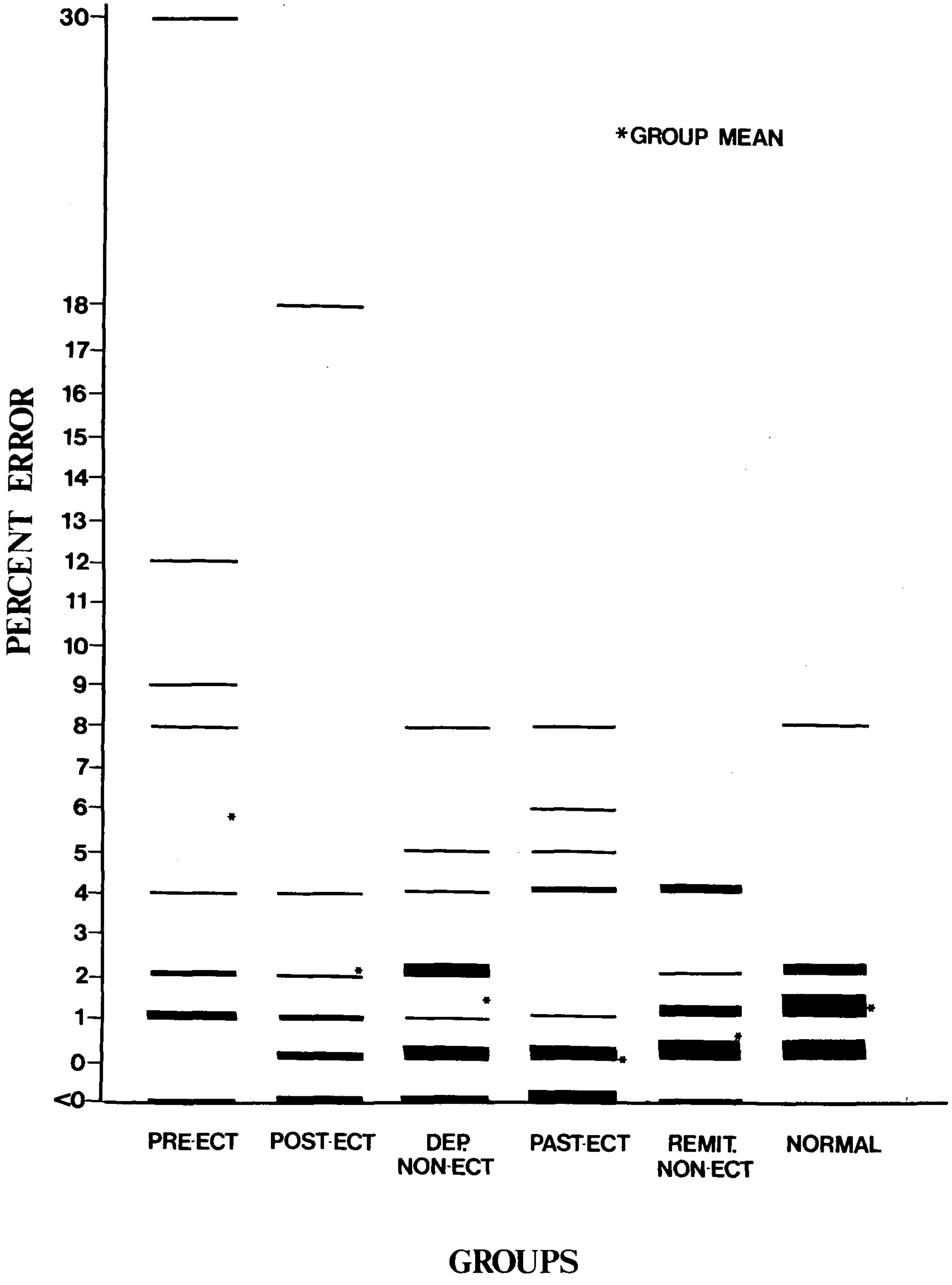


FIGURE 9. SSW LEFT EAR ERROR

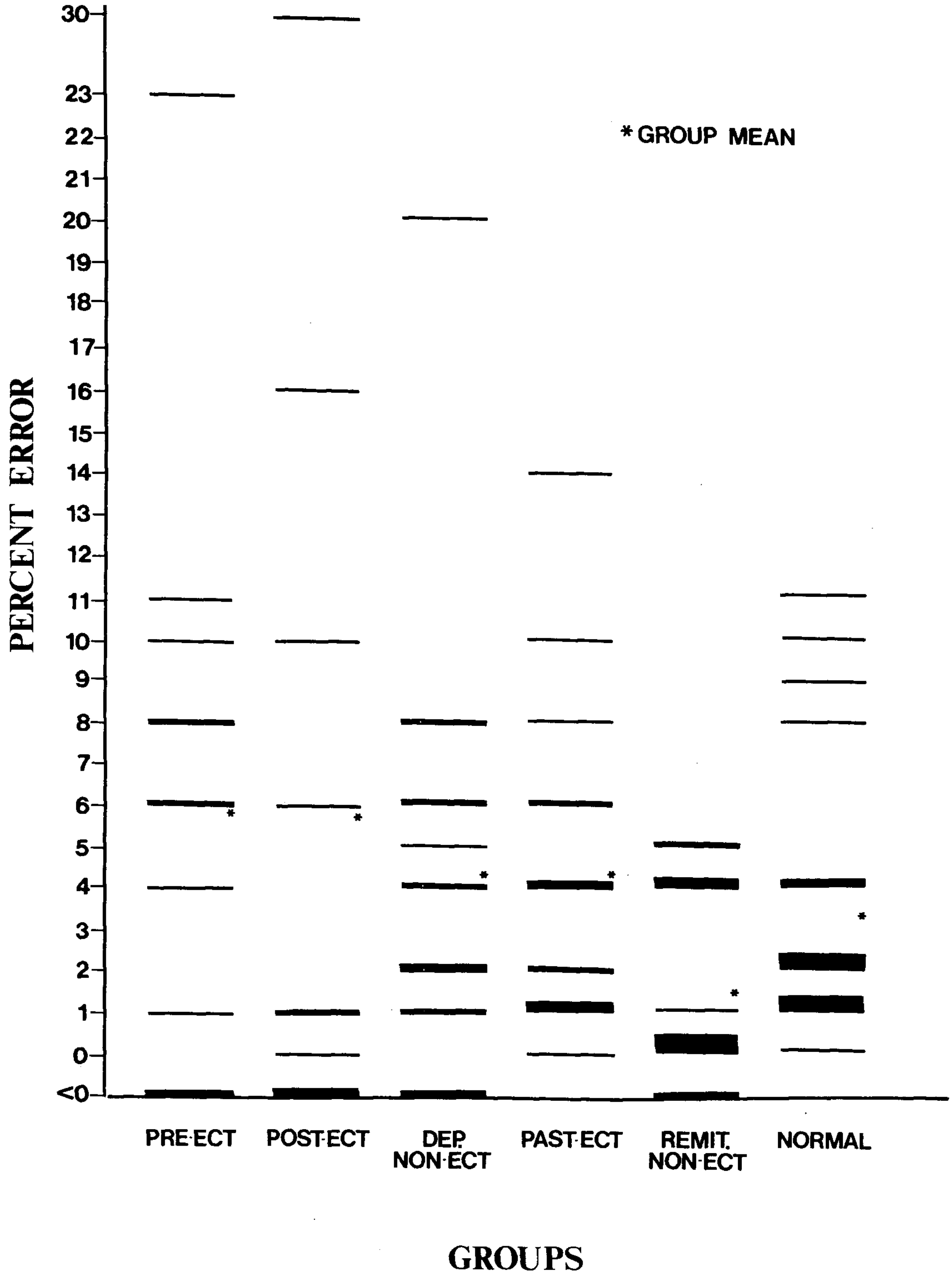


FIGURE 10. SSW REVERSALS

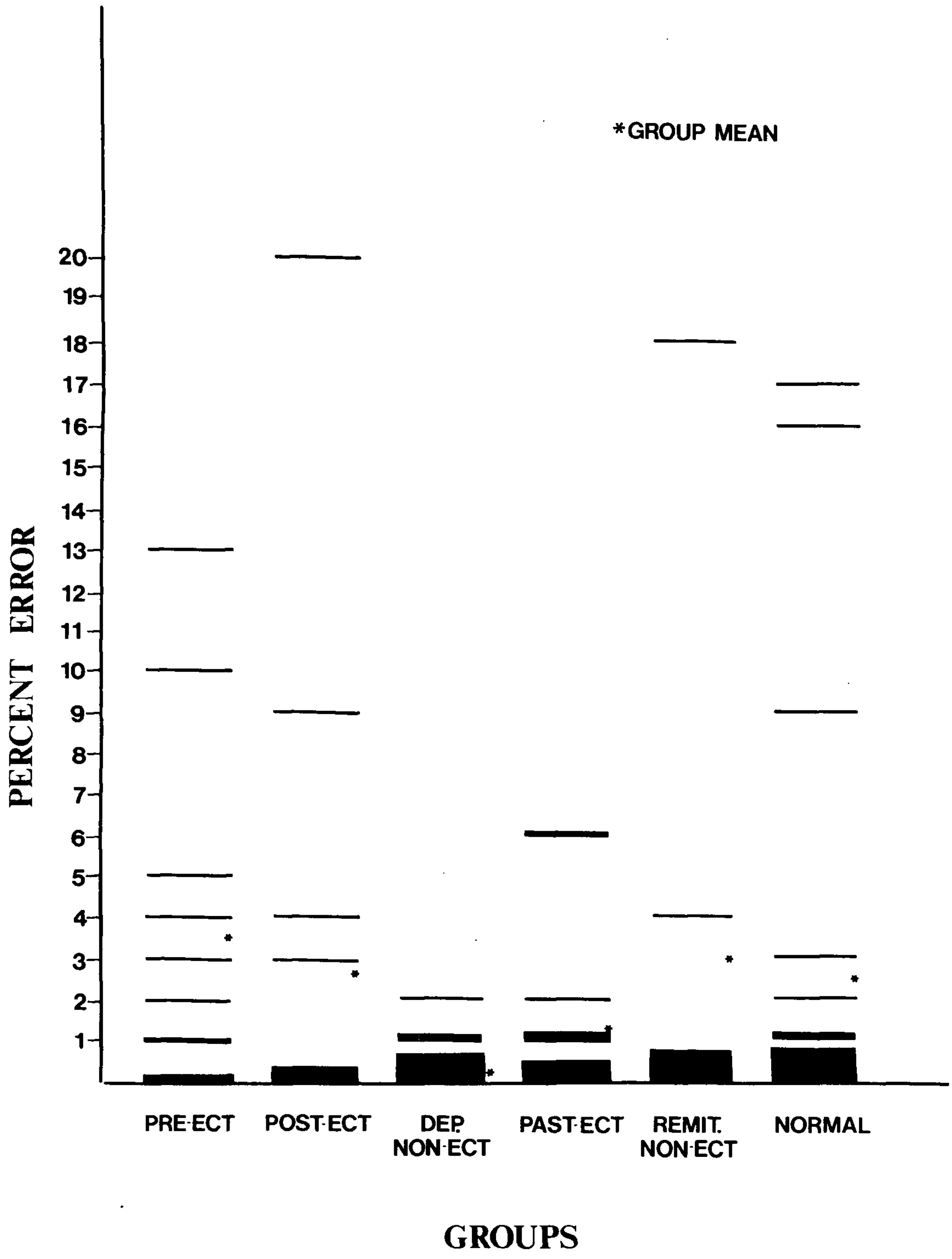


FIGURE 11. SSW CONDITION

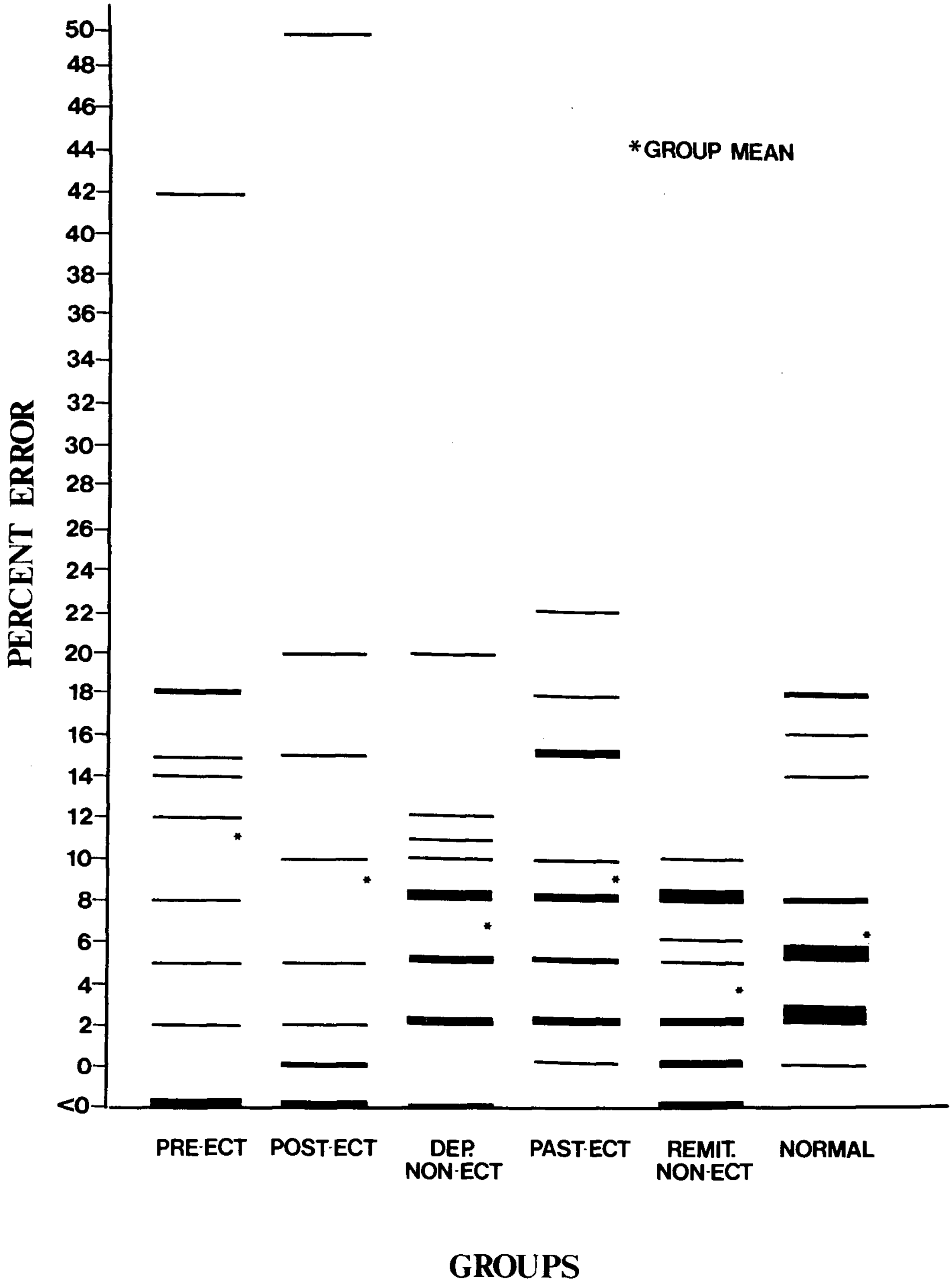
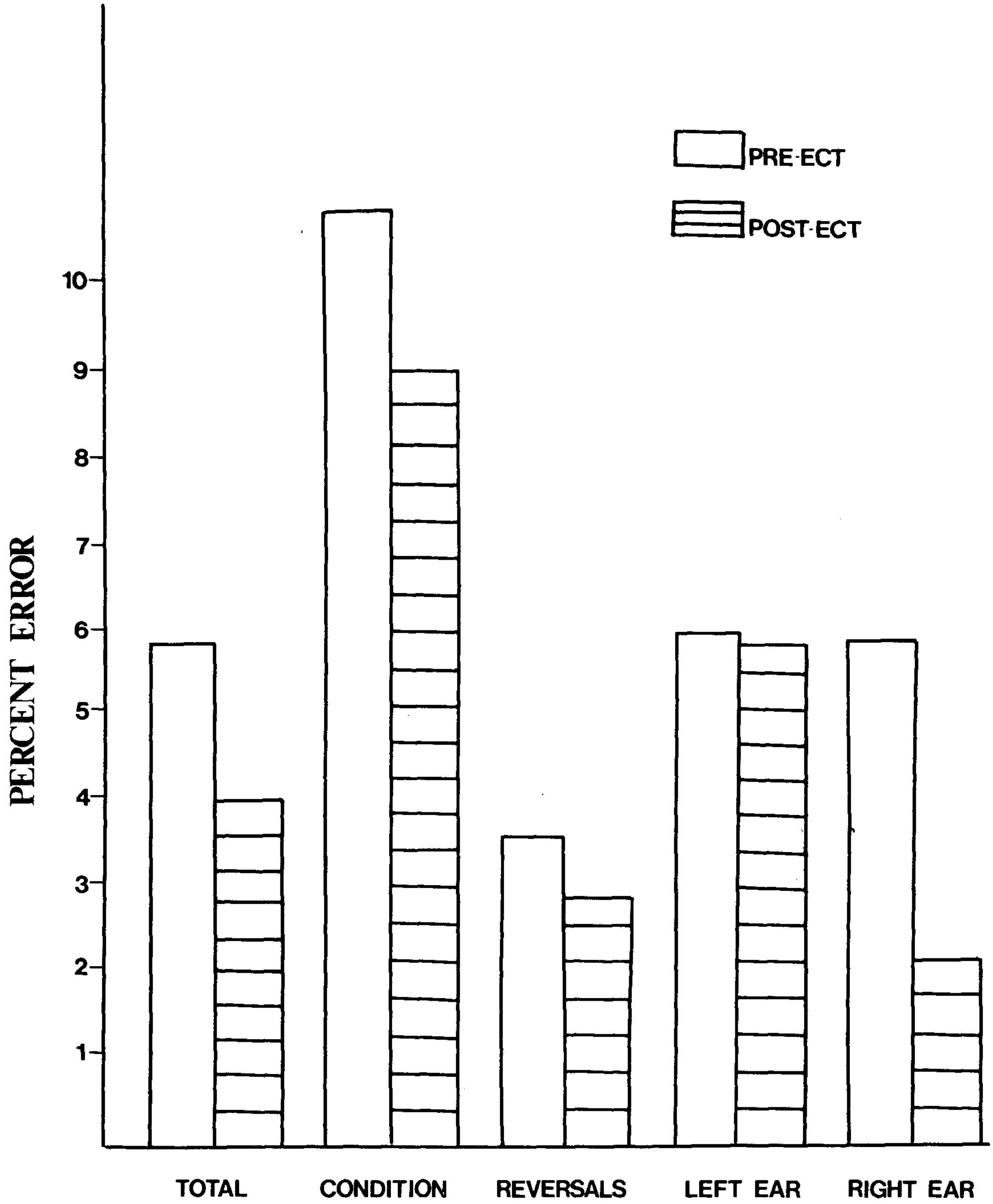


FIGURE 12. CURRENT ECT GROUP-SSW TEST



SSW TEST MEASURE

FIGURE 13. CURRENT ECT GROUP NEUROPSYCHOLOGICAL PERFORMANCE

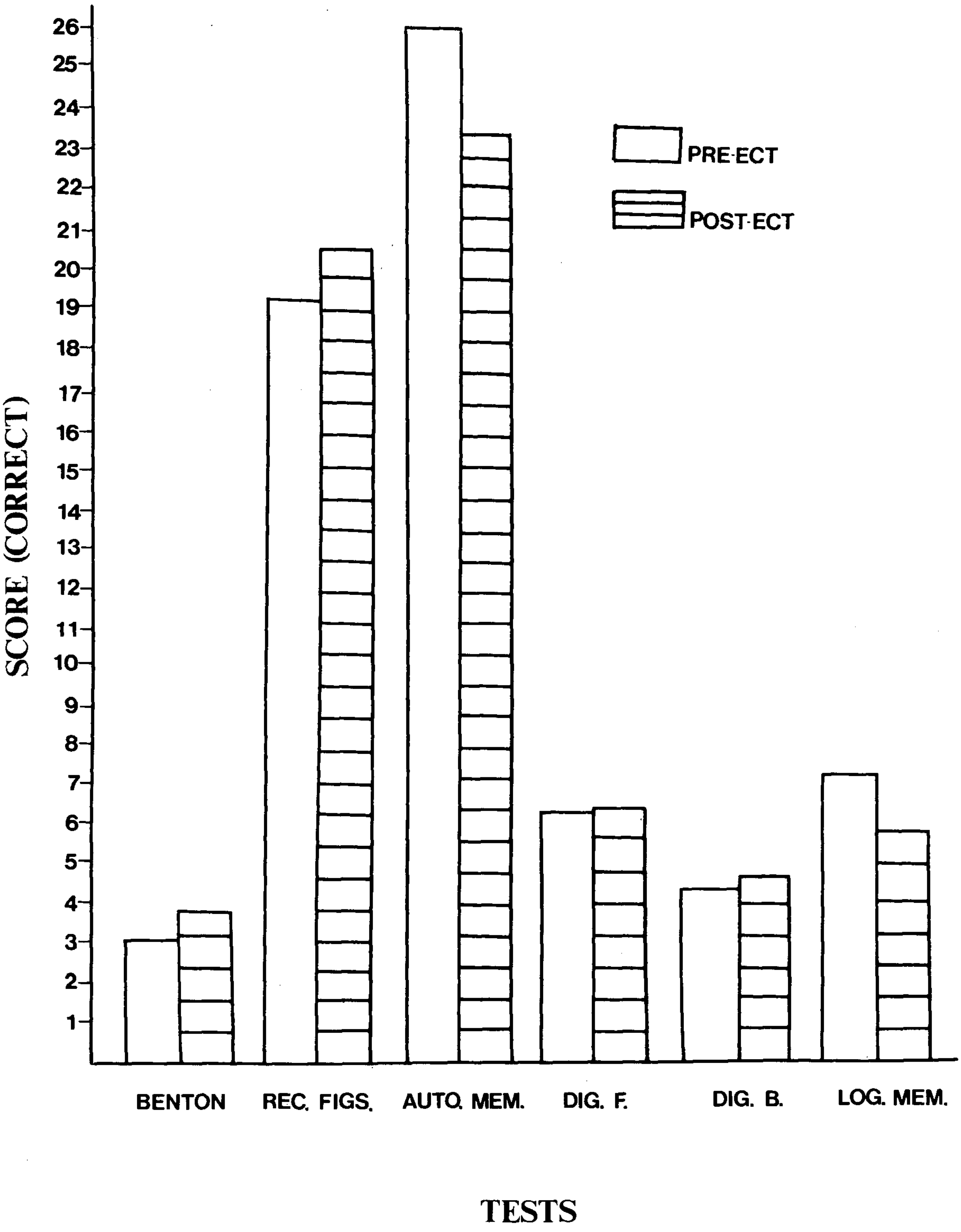


Table 4

Boundaries for SSW Test Performance

	Over-corrected	Normal	Mildly Abnormal	Moderately Abnormal	Severely Abnormal
Total	-5	-4 to 5	6 to 15	16 to 35	36 to 100
Ear	-7	-6 to 10	11 to 20	21 to 40	41 to 100
Condition	-10	-9 to 15	16 to 25	26 to 45	46 to 100

(Adapted from J. Katz (1973). The SSW test manual. Brentwood, Mo: Auditec.)

Table 5

Neuropsychological and Dichotic Performance by Group

		Pre-ECT	Post-ECT	Dep Med	Past ECT	Remit Med	Normal
AutoMem	M:	26.09	23.60	28.73	28.87	29.82	29.85
	SD:	3.11	5.02	3.45	2.44	2.00	2.75
RecFigs	M:	19.18	20.50	24.87	22.07	26.12	26.70
	SD:	9.32	9.37	6.85	7.78	7.02	8.26
Dig F	M:	6.27	6.30	6.20	6.33	6.76	6.95
	SD:	1.27	1.34	1.26	1.18	1.15	0.89
Dig B	M:	4.36	4.50	4.53	4.53	5.18	4.70
	SD:	1.12	1.35	1.12	0.92	1.47	0.73
LogMem	M:	7.36	5.60	9.00	8.87	10.65	12.75
	SD:	3.29	3.78	3.25	4.08	3.69	2.77
Benton	M:	3.00	3.78	6.87	5.93	7.06	7.95
	SD:	2.57	2.82	2.55	2.66	2.77	1.82
SSWTot[a]	M:	5.82	3.90	2.80	2.13	0.94	2.35
	SD:	8.40	7.59	3.67	2.26	1.98	2.39
SSWCond	M:	10.82	9.00	6.80	9.00	3.56	6.30
	SD:	13.85	16.64	5.54	6.66	4.88	5.68
SSWRev	M:	3.55	2.70	0.33	1.20	3.19	2.45
	SD:	4.32	6.25	0.62	2.04	8.01	5.24
LftError	M:	5.91	5.70	4.27	4.27	1.50	3.40
	SD:	8.14	10.46	5.42	3.95	2.37	3.35
RtError	M:	5.82	2.10	1.40	0.00	0.62	1.20
	SD:	9.38	5.92	2.75	5.13	2.75	1.76

[a]SSW Test data are presented in terms of percent error. A high score therefore reflects poor performance.

= 1.29, $p > .20$. However, groups did differ significantly in terms of age, $F(4, 73) = 3.61$, $p < .01$. A posteriori multiple comparisons that utilized the Tukey Studentized Range Test (Tukey, 1953) revealed that the Current ECT group was significantly older than both the Depressed non-ECT group and the Normal group but that the other groups did not differ significantly. The higher average age of the Current ECT group -- although probably an accurate reflection of clinical reality, inasmuch as patients selected for ECT tend to be older than those treated with alternative methods -- formed the basis for the decision to employ analysis of covariance techniques in a number of the statistical comparisons described below.

Level of Depression

To determine whether groups differed in level of depression (in particular whether the Depressed non-ECT and the Current ECT subjects differed in severity of depression) and to verify the direction of group differences in level of depression two, one-way analyses of variance were performed. In these analyses comparisons were made between the Current ECT group, before and after treatment, and the other treatment groups, including the Normal group. The score on the Beck Depression Inventory (BDI) was used as the dependent variable. The BDI was utilized as the criterion for depression because it was obtained on the day subjects were tested and thus best reflected the current mood status of the subject. These analyses revealed significant differences among groups, $F(4, 73) = 39.61$, $p < .001$ and $F(4, 72) = 26.10$, $p < .001$ for pre-ECT and post-ECT comparisons, respectively. Multiple comparisons (Tukey method) indicated that before commencing treatment the subjects in the Current ECT group were on average significantly more depressed than those in all of the other groups with the exception of the Depressed non-ECT group. The subjects in the latter group were in turn more depressed than the subjects in all of the other groups except for those in the Current ECT group. However, after completion of therapy the patients in the Current ECT group differed only from those in the Depressed non-ECT group (the latter group had a higher level of depression than the former) in terms of scores on the BDI. A summary of BDI scores is included in Table 3. The analyses pertaining to age, education and depression are summarized in Appendix C.01.

Sex

To verify that groups did not differ in sex composition, a chi-square test was used to determine whether the proportion of males and females differed among the five treatment groups. The obtained χ^2 = 2.48, df = 4, $p > .50$, indicated that the groups did not so differ. Because the number of male subjects was small relative to the number of female subjects, it was necessary to ensure that any significant main effects were not masked by an interaction between gender and dichotic perceptual ability. The performance of males and females on the SSW Test was therfore compared with a one-way MANOVA in which the dependent measures were the SSW Total, RE, LE, Condition, and Reversal scores. This analysis, by Wilk's Lambda Criterion, did not reveal any significant differences among males and females in dichotic perceptual ability, $F(5, 72) = 1.63$, $p > .15$. In light of these results, it was not considered necessary to treat sex as a factor in the analyses that were performed to evaluate the main hypotheses.

Medication Effects

To examine the possibility that antidepressant medication exerted an influence upon performance on the dichotic listening task a MANOVA was performed in which the SSW variables were used as dependent measures. This analysis revealed no significant differences among medicated and unmedicated subjects, $F(5, 52) = 1.55$, $p > .10$. To determine whether either the medicated or the unmedicated samples exhibited significant laterality effects on the SSW Test a 2 (Medicated/Unmedicated) X 2 (Ears) analysis of variance with repeated measures was performed. The results of this analysis indicated that the medicated and unmedicated subjects did not differ in terms of error in dichotic perception at the two ears and that both groups of subjects possessed an overall right-ear advantage, $F(1, 56) = 0.63$, $p > .40$ and $F(1, 56) = 11.24$, $p < .001$, respectively. The ear X medication status interaction effect was not significant, $F(1, 56) = 0.51$, $p > .40$. Accordingly, medication was not included as a factor in the evaluation of the principal hypotheses.

Approach Taken to Tests of Hypotheses

To determine whether groups differed in their neuropsychological and dichotic perceptual performance, a series of multivariate and univariate analyses of variance and covariance was conducted. Because of their conceptual distinctiveness, analyses were undertaken separately for the dichotic and the neuropsychological measures. Separate analyses were employed to compare: (a) the Current ECT group before commencement, and after conclusion, of the series of ECT treatments; (b) the Current ECT group (pre-treatment) and the four other treatment groups (i.e., Depressed non-ECT, Past ECT, Remitted non-ECT, and Normal); and (c) the Current ECT group (post-treatment) and the four other treatment groups. Although inspection of the data had suggested that the DL data was somewhat skewed, parametric analyses were utilized due to the high level of power and the overall robustness of such statistical procedures (e.g., Hays, 1973). Multivariate analyses of variance were employed initially to test for significant main effects. Multivariate analysis of variance (MANOVA) is useful to provide control of the experiment-wise error rate, and in so doing to reduce the chance of Type I error. However, because the MANOVA is quite a liberal test, and because it was considered to be important that conservative tests of the hypotheses be utilized, Bonferroni-corrected alpha levels were employed to test the significance of univariate analyses and multiple comparisons. Bonferroni adjustments were calculated by dividing the overall significance level of 5 percent by the number of tests of each of the six major hypotheses. The Bonferroni-corrected probability level was calculated separately when each of the major hypotheses was evaluated. This was done because it was felt that computation of one Bonferroni-corrected level on the basis of the large number of individual univariate tests that were conducted overall would have resulted in unnecessarily stringent tests of significance -- and subsequent elevation of Type II risk. Univariate analyses and a posteriori comparisons were used to follow-up significant multivariate effects.

Comparisons Between Subjects Pre- and Post-ECT

Analyses were undertaken to determine whether the subjects in the Current ECT group exhibited significant changes in performance from before to after treatment. Such analyses were of particular interest in order to evaluate the hypothesis that there would be a significant alteration in performance on the DL task, and possibly a change in memory capability, after treatment with ECT. The number of subjects in the Current ECT group who underwent testing both before and after treatment (N = 10) was smaller than the total number of dependent measures. As such, it was not possible to utilize a multivariate test to compare scores obtained pre- and post-ECT because the generation of a singular matrix, rather than a variance-covariance dispersion matrix, would have resulted. Accordingly, the performance of the Current ECT patients before and after treatment was compared by means of a series of univariate single-factor repeated measures analyses of variance. A Bonferroni-corrected probability level of .005 (.05/number of dependent variables) was employed. The results of these analyses, summarized in Appendix C.02, indicated that no significant changes in performance on the neuropsychological or dichotic perception tasks occurred in the interval during which the course of ECT was given.

Comparisons of Pre-ECT Subjects With Other Subjects

Neuropsychological Data

To evaluate the hypothesis that the subjects in the Current ECT group (pre-treatment), the Past ECT group and the Depressed Non-ECT group would have somewhat reduced efficiency of memory, and that the normal subjects and the remitted depressives would have no memory impairment, scores on the tests of memory (Digits Forward, Digits Backward, Autobiographical Memory, Recurring Figures, and the Benton Visual Retention Test) that were obtained by the Current ECT group (pre-treatment) and the other groups were subjected to multivariate analyses. Due to the small number (N=2) of patients in the Past ECT group who were depressed at the time of testing it was not possible to compare specifically remitted and unremitted Past ECT subjects. Nevertheless, it was of interest to investigate whether the functioning of the subjects in the Past ECT group differed from that of normal control subjects and remitted non-ECT depressives. If the Past ECT and the Current ECT subjects had been found to differ from all other subjects, for example, this would have suggested that patients selected for ECT differ from those who receive other forms of treatment.

Due to the fact that the subjects in the Current ECT group were on average significantly older than the subjects in both the Depressed non-ECT group and the Normal group there existed the possibility that age was implicated in the neuropsychological performance of the subjects. Accordingly, a multivariate analysis of covariance was performed to test for the presence of differences among groups when age was utilized as a covariate. This analysis yielded a significant multivariate effect, $F(24, 234.95) = 1.69$, $p < .05$. Univariate analyses of covariance were therefore conducted, with age as the covariate. Bonferroni-corrected alpha levels were set at .01. Prior to each of these analyses the assumption of homogeneous regression coefficients was tested. These tests indicated that the assumption of equal regression slopes was in each case tenable and that conventional analyses of covariance were applicable. The results of these analyses of covariance indicated that groups differed significantly on the basis of Logical Memory and Benton test performance, $F(4, 73) = 4.37$, $p < .01$ and $F(4, 73) = 4.41$, $p < .01$, respectively. Groups did not differ significantly on the tests of Digits Forward, Digits Backward, Autobiographical Memory or Recurring Figures. The results are summarized in Appendix C.03. Tukey multiple comparisons applied to the adjusted group means revealed that the subjects in the Current ECT group (pre-treatment) had significantly poorer performance on the test of Logical Memory than did the subjects in the Normal group. On the Benton test the subjects from the Current ECT group were significantly poorer in performance than the Remitted non-ECT patients and the Normal subjects. To summarize, analyses revealed that before commencement of treatment with ECT the subjects in the Current ECT group showed deficits of performance on the test of Logical Memory and on the Benton Visual Retention test.

In light of the above results, and given the significant differences among groups in level of depression, it was of interest to examine the possibility that the differences among the groups that were detected initially were attributable to the high level of depression present among the subjects in the Current ECT group prior to treatment. Accordingly, additional analyses of covariance were performed. In these analyses the Current ECT group (pre-treatment) and the other treatment groups were compared on Logical Memory and Benton test performance when both age and score on the BDI were used as covariates. The results of these analyses revealed no significant differences among groups, $F(4, 73) = 2.08$, $p > .05$ (Logical Memory) and $F(4, 73) = 2.13$, $p > .05$ (Benton).

Dichotic Perception Data

The dichotic perceptual performance of the subjects in the Current ECT group (pre-treatment) and the other groups of subjects was compared statistically to examine whether any of the groups exhibited significant deviations of response to the dichotic listening (DL) task. It will be recalled that in the present study it had been proposed that the Past ECT group would show abnormal DL performance in terms of an exaggeration of the right-ear advantage that is normally found on verbal DL tasks. Also of considerable interest were the patterns of DL performance exhibited by the subjects in the Depressed Non-ECT group and the subjects in the Current ECT group prior to treatment. Although no significant abnormalities of dichotic perception had been hypothesized for the latter two groups, it was of interest to determine whether the high level of depression present among the subjects in those groups would alter patterns of response to the DL task. A multivariate analysis of covariance, with age as the covariate, was employed to determine whether the Current ECT group (pre-treatment) differed significantly from the other treatment groups on the SSW test measures. The results of this analysis indicated no significant differences among groups, $F(20, 219.85) = 1.28$, $p > .10$.

In summary, the results of the analyses described above indicated that:

1. The subjects in the Current ECT group were on average significantly older than the subjects in the Depressed non-ECT group and the Normal group. The subjects in the Current ECT group (pre-treatment) and the Depressed non-ECT group were significantly more depressed than the subjects in the other groups, but did not differ from one another in level of depression. After the subjects in the Current ECT group had undergone treatment, only the Depressed non-ECT group differed significantly from the other groups in level of depression. There were no significant differences among groups in sex composition or level of education.

2. There were no significant changes in performance among the subjects in the Current ECT group from before to after ECT.

3. Prior to treatment with electroconvulsive therapy the subjects in the Current ECT group exhibited poorer performance on tests of Logical Memory than did the subjects in the Normal group.

4. Prior to treatment the subjects in the Current ECT group exhibited poorer performance on the Benton test than did the subjects in the Normal group and those in the Remitted non-ECT group.

5. Group differences in Logical Memory and Benton test performance were not significant when score on the BDI was employed as a covariate.

6. The Current ECT group (pre-treatment) and the other treatment groups did not differ significantly in terms of dichotic perceptual ability.

Comparisons of Post-ECT Subjects With Other Subjects

Neuropsychological Data

Comparisons of the Current ECT group (pre-treatment) with the other groups had indicated that before treatment the subjects in the Current ECT group exhibted some deficiencies of memory relative to the subjects in the other groups. To investigate whether, as had been hypothesized, the subjects in the Current ECT group continued to demonstrate memory deficits after treatment, the memory capability of the subjects in the Current ECT group (post-treatment) and the other groups was compared statistically. A multivariate analysis of covariance, with age as the covariate, was performed to determine the presence of significant differences in memory functioning among groups. The dependent measures were Digits Forward, Digits Backward, Autobiographical Memory, Recurring Figures, Logical Memory, and Benton test scores. This analysis yielded a significant multivariate effect, $F(24, 227.97) = 1.93$, $p < .01$. Accordingly, univariate analyses of covariance were employed as follow-up tests to compare the performance of the groups of subjects on the neuropsychological measures. The Bonferroni-corrected significance level was set at .01. Initial tests conducted prior to the analyses of covariance indicated that the assumption of equal regression slopes was tenable for each of the dependent variables, thus permitting the use of conventional analyses of covariance. The analyses of covariance, summarized in Appendix C.04, revealed that groups differed significantly in performance on the Logical Memory test and the test of autobiographical memory, $F(4, 72) = 5.05$, $p < .005$ and $F(4, 72) = 5.97$, $p < .001$, respectively. Groups did not differ significantly in performance on Digits Forward, Digits Backward, the Recurring Figures test or the Benton Visual Retention Test. Tukey multiple comparisons applied to the Logical Memory and Autobiographical Memory data revealed that after treatment the average Logical Memory test performance of the patients in the Current ECT group was significantly worse than that of the subjects in the Normal group. On the test of autobiographical recall the subjects in the Current ECT group performed significantly more poorly than the subjects in all of the other groups.

The analyses that were conducted to test for any changes in the performance of the subjects in the Current ECT group from pre- to post-treatment had yielded no significant overall effects. However, in light of the significant deficits in autobiographical recall exhibited after treatment by the subjects in the Current ECT group in comparison to the subjects in the other treatment groups, it was of interest to examine the possibility that after ECT there had been a reduction in proficiency to recall a specific category of autobiographical material. Accordingly, two t-tests for correlated samples were performed to determine whether there existed a significant decline, from before to after ECT, in the ability to respond correctly to questions designed to elicit data from the recent past (i.e., less than three years prior to treatment) and questions that pertained to the remote past. These analyses revealed that from before to after treatment there was a decline in the ability of the Current ECT patients to recall personal information from the recent past, but no such decline in ability to recall information from the remote past, $t = -2.45$, $df = 9$, $p < .05$ and $t = 0.99$, $df = 9$, $p > .05$, respectively.

Dichotic Perception Data

It had been hypothesized that after ECT the patients in the Current ECT group and the Past ECT group would exhibit significant deviations of response on the DL task. Specifically, it had been proposed that these subjects would display an exaggeration of the normal right-ear advantage in dichotic perception. To evaluate this hypothesis, a one-way MANCOVA, with age as the covariate, was conducted. In this analysis the SSW test performance of the Current ECT subjects (post-treatment) was compared with that of the four other treatment groups. The results of this analysis did not suggest the presence of any significant differences among groups, $F(20, 216.53) = 0.91$, $p > .55$.

To summarize, analyses that were undertaken to compare the performance of the Current ECT group (post-treatment), the Depressed non-ECT group, the Past ECT group, the Remitted non-ECT group and the Normal group revealed that:

1. After completion of treatment the performance of the subjects in the Current ECT group on the Logical Memory test was on average significantly poorer than that of the subjects in the Normal group.

2. After treatment the subjects in the Current ECT group were on average significantly poorer than the subjects in all of the other groups in their ability to recall autobiographical material, especially that of recent origin.

3. There were no significant statistical differences among groups in dichotic perceptual capability.

Laterality Effects

Previous work that has been undertaken to investigate the dichotic perceptual ability and hemispheric activation of subjects during conditions of psychopathology has focused directly upon the relative levels of accuracy of dichotic perception at the right and left ears. It was therefore of interest to investigate more directly whether any of the groups possessed atypical patterns of relative hemispheric dominance, in order to relate the present study to prior research. That is, to determine whether the right- and left-ear scores of the subjects in each of the groups differed significantly. It was possible, for example, that although the groups did not differ significantly in terms of right- and left-ear scores there existed within-groups differences in scores. The knowledge of such differences would permit further evaluation of the hypotheses concerning the asymmetry of response to dichotic stimuli. To determine whether groups exhibited differences in asymmetry of dichotic perception at the right and left ears, two, 5 (Groups) X 2 (Ears) analyses of covariance with repeated measures were conducted. The results of these analyses confirmed that groups did not differ significantly in errors of dichotic perception at the right and left ears, when groups were compared before and after the Current ECT group underwent treatment, $F(4, 73) = 1.69$, $p > .15$ and $F(4, 72) = 1.02$, $p > .40$, respectively. However, a significant ear effect indicated that there existed an overall right-ear advantage for dichotic perception, $F(1, 73) = 14.11$, $p < .001$ (pre-ECT) and $F(1, 72) = 20.54$, $p < .0001$ (post-ECT). Interaction effects were not significant, $F(4, 73) = 1.63$, $p > .15$ and $F(4, 72) = 0.94$, $p > .40$. To establish whether the subjects in the groups exhibited differences in terms of ear asymmetry in SSW test performance, t-tests with adjustment for correlated data were performed separately for each group to examine whether right-ear (RE) dichotic perceptual ability differed significantly from that of left-ear (LE) dichotic perceptual ability. These analyses utilized as dependent measures the RE percentage error score and the LE percentage error score obtained on the SSW Test. Because specific predictions were tested, one-tailed probability levels were employed. Moreover, because retention of the null hypothesis would in some cases have supported specific predictions, a conventional alpha level of .05, rather than a Bonferroni-corrected level, was used to test significance. The results of these analyses are summarized in Appendix C.05. The hypothesis that the subjects in the Normal group would display a significant RE advantage in the ability to process dichotic stimuli was supported, $t = 3.66$, df = 19, $p < .005$. The hypothesis that the subjects in the Remitted non-ECT group would exhibit a RE advantage was also supported, $t = 2.16$, df = 15, $p < .005$. The hypothesis that the subjects in the Depressed non-ECT group would lack the right-sided superiority, inasmuch as they would not display an overall RE advantage in dichotic perceptual ability, was not affirmed, $t = 2.11$, df = 14, $p < .05$. The subjects in the Current ECT group were found to lack a significant difference between RE and LE dichotic perceptual ability both before and after treatment, $t = 0.07$, df = 10, $p > .05$ and $t = 1.49$, df = 9, $p > .05$, respectively. An additional t-test for correlated samples revealed that the subjects in the Past ECT group did exhibit a significant right-ear advantage in the perception of dichotic stimuli, $t = 2.09$, df = 14, $p < .05$. Moreover, when the RE and LE data of the unipolar and bipolar depressed patients were analyzed regardless of treatment group membership, it was found that there existed an absence of significant laterality in both of these diagnostic groups: Patients in the unipolar diagnostic category as well as those in the bipolar category failed to exhibit significant ear dominance in dichotic perception, $t = 1.59$, df = 18, $p > .05$ and $t = 1.04$, df = 6, $p > .05$, respectively.

To determine the strength of the relationship between level of depression and degree of hemispheric lateralization, a product-moment coefficient of correlation was calculated for scores on the BDI and Difference Scores that had been calculated for each subject by the subtraction of the RE (percent error) score from the LE (percent error) score. All groups were utilized in this analysis. The coefficient, which was equal to .008, suggested that there was no relationship between the severity of depression and relative hemispheric activity.

The investigations of hemispheric functioning, as reflected by errors in dichotic perception at each ear, may be summarized as follows:

1. The subjects in the Normal group, the Past ECT group, the Remitted non-ECT group and the Depressed non-ECT group displayed significant RE (left-hemispheric) superiority in the perception of verbal stimuli presented dichotically.

2. The subjects in the Current ECT group (both before and after treatment) exhibited no lateral advantage in dichotic perceptual ability.

3. Laterality effects were not found to be a function of diagnosis as a unipolar or bipolar depressive.

4. No significant relationship was detected between level of depression and ear asymmetry in dichotic perception.

Summary of Results

To summarize, the analyses described above revealed that before commencement of ECT the subjects in the Current ECT group exhibited deficits in performance on the Logical Memory test and on the Benton Visual Retention test. However, when the level of depression was controlled, these differences were not significant. This indicated that the pre-ECT deficits in memory were attributable to the high level of depression present among the subjects in the Current ECT group prior to treatment.

There were no significant overall changes in functioning on the memory or DL tests among the subjects in the Current ECT group, from before to after ECT. However, two weeks following the conclusion of treatment the Current ECT subjects manifested significant deficits in the ability to recall autobiographical material and continued to show deficits in performance on the Logical Memory test.

Despite the absence of significant differences among groups in dichotic perceptual ability, within-groups comparisons revealed that there was an absence of normal levels of ear asymmetry in dichotic perception among the subjects in the Current ECT group. This absence of asymmetry was observed also among the unipolar and bipolar depressed subjects when the performance of those individuals was evaluated irrespective of treatment group membership.

Discussion

In summary, the results of the present study indicate that prior to treatment with electroconvulsive shock therapy the patients in the Current ECT group showed significant deficits on tests of Logical Memory relative to normal subjects. Before undergoing treatment the patients in the Current ECT group also showed significant deficiencies in performance on the Benton test, relative to subjects in both the Normal group and the Remitted non-ECT group. However, the finding that group differences were no longer significant when level of depression was used as a covariate suggests that the deficits were attributable to the high level of depression present among the subjects in the Current ECT group prior to treatment. After treatment, the subjects in the Current ECT group continued to demonstrate significant performance deficits on the tests of Logical Memory relative to the performance of the normal control subjects. The differences in performance on the Benton test that had been present prior to treatment were no longer present after treatment. Examination of group means and variances (see Table 5) suggests that the disappearance of group differences in performance on the Benton test may have been attributable to a slight improvement in performance on this test by the patients in the Current ECT group. However, after completion of their course of electroconvulsive therapy the subjects in the Current ECT group exhibited significant deficits, relative to all of the other groups, in the ability to recall autobiographical material. These deficits in performance existed despite the fact that after treatment the subjects in the Current ECT group were in clinical remission and were retested with an Autobiographical

Memories scale that was identical to the scale administered prior to treatment. The post-ECT deficits in autobiographical recall appear to have been attributable primarily to a reduced ability to recall information from the recent (that is, up to 3 years prior to treatment) past. There was no evidence of retrograde amnesia for events that occurred several years prior to ECT. This observation is consistent with the findings derived from much of the previous work that has been undertaken to examine the effects of ECT upon memory. Such work has suggested that the ability of the patient to recall data from the remote past tends to remain intact after ECT, whereas the ability to recall information from the recent past is disturbed at least temporarily (e.g., Squire, Slater, & Chace, 1975; Squire et al., 1981).

With regard to dichotic perceptual performance, the results of the present study indicate that groups did not differ significantly in their performance on the SSW Test. No significant differences were observed when groups were compared before and after the patients in the Current ECT group had undergone treatment, or when the performance of the patients in the Current ECT group before and after treatment was compared. Evaluation of the data (Table 5) indicates that the average SSW Test performance of the subjects in the Current ECT group tended to be worse than that of the subjects in the other groups. As such, it is possible that the large amount of variability in performance among subjects in the Current ECT group obscured any differences among groups.

It should be emphasized that the statistical approach taken in the present study was a conservative one intended to minimize the risk of Type I error. As such, certain tests of hypotheses that were shown to be non-significant would have reached statistical significance were more liberal interpretations to have been made. It is recognized that in order to reach an informed decision as to whether the risks inherent to a particular treatment are acceptable in light of the benefits to be derived, a more liberal interpretation of the results may be desired. The reader who wishes to evaluate the outcome of specific tests on the basis of such an approach should consult Appendix C, wherein are listed the probability values associated with the statistical tests.

As noted in the introductory section of the present paper, it may be reasonable to expect that the depressed patients would exhibit lower levels of performance on tests of memory merely as a consequence of their affective state. The deleterious influence of depressed mood upon cognitive functioning would help to explain the deficits in performance observed among the subjects in the Current ECT group prior to treatment. It should be noted, however, that before treatment the average level of depression among the subjects in the Current ECT group did not differ significantly from that of the subjects in the Depressed non-ECT group (whose levels of cognitive functioning were not significantly reduced). Thus, absolute levels of depression alone do not seem to explain satisfactorily the diminished levels of cognitive functioning that were evident among the subjects who were to receive ECT. Apparently, more subtle aspects of the depressed state -- perhaps those pertaining to psychomotor, anxiety, or motivational features -- exerted a detrimental influence upon performance on the neuropsychological tests. Although no obvious differences in clinical presentation discriminated the Current ECT patients from the Depressed non-ECT patients, it is noteworthy that ECT tends to be a treatment of last resort, and that patients who receive such therapy often have a lengthy history of mood disturbance and failure to respond to pharmacotherapy. As such, the patients who are prescribed ECT may well be qualitatively different from patients who do not receive ECT: The former tend to be older, perhaps more acutely suicidal, and possibly different in other, as yet unquantified, ways. For example, subtle attentional deficits induced as a function of ruminative mental activity could impair concentration sufficiently to lower overall performance on certain tests.

It is unclear why deficits would be apparent on tests such as Logical Memory and the Benton and not be revealed on tests such as Digit Span. Possibly, the delays incorporated into the administration of the Logical Memory test and the Benton test (it will be recalled that delays of between 15 seconds and 5 minutes separated the presentation and recall of the stimulus material on these tests) were sufficient to allow the deleterious effects of ruminative interference to become manifest. An alternative explanation is that both the Logical Memory test and the Benton Visual Retention test require the retrieval of memories. The difficulties on these tasks that were encountered by the subjects in the Current ECT group may indicate that these individuals were unable to retrieve data satisfactorily -- particularly after a delay -- but that they were able to encode and recognize the information requisite to normal levels of performance on Digit Span and the Recurring Figures test (the latter requires the encoding and recognition, rather than the recall, of material). Such problems of memory retrieval might also help to account for the deficits in performance on the test of autobiographical recall that were exhibited by the Current ECT subjects after the completion of treatment.

What is clear is that depressed mood alone does not explain why deficits in functioning on the tests of Logical Memory persisted among the Current ECT subjects after treatment, or why deficiencies in the ability to recall autobiographical material became apparent in those subjects following electroconvulsive therapy. The average level of depression of the subjects in the Current ECT group, as reflected by the BDI, was 29.64 prior to treatment and 12.20 after treatment. Only one patient remained clinically depressed following the completion of treatment, as defined by a BDI score above 21. It would appear that ECT exerted a detrimental influence upon both Logical memory and Autobiographical memory, so that capability in these areas was reduced despite improvement in mood. The observation that diminished levels of performance on tests of memory -- particularly on those tests that incorporate material of an autobiographical nature -- are present among patients who have recently undergone ECT is similar to that observed previously by a number of workers (e.g., Squire et al., 1975). The results of the present study suggest not only that the effects of ECT upon the memory functions can be quite disruptive, but also that such disruption is detected only by performance on a particular subset of neuropsychological tests.

It should be noted that the results of the present study do not provide support for the hypothesis that long-term -- that is, 6 months or more after electroconvulsive therapy -- deficits in cognitive functioning are present after ECT. The subjects in the Past ECT group did not differ significantly in cognitive functioning from normal individuals or patients who had never received ECT. Specifically, the data provided by the SSW Test did not indicate any deficits in functioning localized in the right temporo-parietal region of the brain: The percentage of left-ear (right-hemispheric) errors in the perception of dichotic material committed by the patients in the Past ECT group did not differ significantly from that of the other groups of subjects. Indeed, none of the groups differed significantly on any of the DL dependent measures.

In the present study, immediate post-ECT deficits in memory capability were indicated by tests that were essentially verbal in nature (that is, Logical Memory and Autobiographical Memory) but were not reflected by performance on tests that measured visuospatial capability (that is, Recurring Figures and the Benton). This is of interest when it is considered that all of the patients in the Current ECT group were administered shock over the right hemisphere of the brain. A possible explanation for this phenomenon is that the sequellae of the shock were sufficiently disruptive that global cognitive deficits ensued, but that the tests of visuospatial functioning that were employed in the present study were of a sensitivity insufficient to detect such effects. Certainly, it is known that the functions of the brain cannot usually be neatly compartmentalized and that the cerebral hemispheres are by no means independent of each other in their functioning. Moreover, a factor that adds to the complexity of interpretation of the results of the present study is the observation that the hemispheres of the brain functioned differently under conditions of affective disturbance than they did normally. The data provided by the SSW Test indicated that the relative functioning of the cerebral hemispheres, as reflected by the accuracy of dichotic perception at each ear, was on average different in the patients who were depressed. The subjects in the Current ECT group as well as the unipolar and the bipolar depressed subjects overall (that is, combined regardless of group membership) failed to demonstrate significant differences in accuracy of dichotic perception at the right and left ears. The subjects in the Normal group, the Past ECT group, the Depressed non-ECT group, and the Remitted non-ECT group displayed a significant superiority in verbal dichotic perceptual ability at the right ear.

It should be noted that there was considerable variability in laterality (ear asymmetry) in all of the groups except the Normal group, and that the subjects in the Depressed non-ECT group showed --on average -- normal patterns of laterality. As such, it cannot be stated that every depressed individual exhibits abnormalities in relative hemispheric functioning. Moreover, it is unclear why the subjects in the Depressed non-ECT group demonstrated a significant right-ear advantage in dichotic perception, whereas the subjects in the Current ECT group exhibited no such lateral asymmetry. Conceivably, the reason for this difference in lateralization may have been that the depression of the subjects in the Current ECT group (pre-treatment) differed qualitatively from that of the subjects in the Depressed non-ECT group. For example, the depressed state of Current ECT subjects may have been more resistant to treatment than was that of the Depressed non-ECT subjects. It is possible that a particular cluster of characteristics of depression are necessary for abnormalities of laterality to become manifest. It can be concluded from the information provided by the present investigation, however, that on average those individuals who were severely depressed showed patterns of relative hemispheric activity that differed from those of non-depressed individuals. The patterns of performance on the SSW Test exhibited by the depressed subjects suggest that these differences are ones of diminished left-hemispheric activity, as inferred by increased errors at the right ear, and/or enhanced levels of right-hemispheric activity.

With regard to the specific hypotheses pertaining to laterality that were proposed in the introductory section of the present paper (see page 45), the results support the hypothesis that normal subjects exhibit a right-ear advantage on the test of dichotic perception of verbal stimuli. The results of the present study do not support the hypothesis that depressed patients would display no significant deviations in dichotic perception. Rather, they support the argument endorsed by workers such as Moscovitch et al. (1981) that a subset of depressed patients tends not to exhibit a significant right-ear advantage in dichotic perception. Although the results of the Moscovitch study indicated a normalization of lateralization after ECT (that is, the patients developed a significant right-ear advantage after treatment), the data provided by the present study do not show such a change after ECT. However, inspection of the data does reveal a marked trend toward right-ear superiority after treatment with ECT: The mean error in perception at the right ear was 5.82 percent before treatment and 2.10 percent after ECT, whereas the mean error at the left ear remained quite stable pre- and post-treatment. One possibility is that the therapeutic efficacy of ECT as it was applied to the subjects in the present investigation was not equal to that provided to the subjects of the Moscovitch study, and that the level of symptom remission among ECT patients was not equivalent in the two studies. Unfortunately, because Moscovitch et al. provided no information on the level of depression in their patients it is not possible to compare the two samples. An alternative, and equally plausible, explanation is that the amount of variablility in performance among the subjects -- particularly in terms of left-ear errors post-ECT -- obscured significant levels of ear asymmetry.

As noted in the introductory section to the present paper, a variety of research has been undertaken previously to investigate the effects of psychopathology upon hemispheric activation (e.g., Gruzelier, 1973; Gur, 1977, 1978; Hare, 1979; Iacono, 1982). This research has utilized a number of dependent measures (e.g., electroencephalographic, tachistoscopic, electrodermal, dichotic listening, neuropsychological) with a diverse array of patient groups (e.g., schizophrenic, depressed, manic, psychopathic). The information and conclusions derived from such investigations has by no means been consistent: Some of the research has indicated that there exist clear differences in hemispheric functioning in those individuals with psychopathology (e.g., Gur, 1978), other work has revealed no distinct differences in laterality (e.g., Colbourn & Lishman, 1979), and still other work has produced rather complex and equivocal data (e.g., Gruzelier & Hammond, 1980). Previous work in which the dichotic perceptual capability of affectively disordered patients has been examined has generally provided evidence of an imbalance of hemispheric activation in such patients. Of seven studies that were reviewed (Bruder, Sutton, Berger-Gross, Quitkin & Davies, 1981; Colbourn & Lishman, 1979; Johnson & Crockett, 1982; Lishman, Toone, Colbourne, McMeekan, & Mance, 1978; Moscovitch et al., 1981; Wexler & Heninger, 1979; Yozawitz et al., 1979), five contained data that signalled the presence of abnormal patterns of cerebral laterality among unipolar and bipolar patients (Bruder et al., 1981; Johnson & Crockett, 1982; Lishman et al., 1978; Moscovitch et al., 1981; Yozawitz et al., 1979). These reports noted a lack of asymmetry among depressives, whereby the patients failed to demonstrate a significant right-ear advantage on verbal DL tasks or a significant left-ear advantage on nonverbal DL tasks. Conversely, manic patients tended to show abnormally high levels of left-hemispheric activation. In two studies (Colbourn & Lishman, 1979; Wexler & Heninger, 1979), no differences in ear asymmetry among patient and control groups were observed. The findings of the present study therefore appear to support those of a majority of the previous research that has investigated the dichotic perceptual performance of patients with affective disorders.

Taken together, the literature on hemispheric activation in patients with affective disorders suggests that the right cerebral hemisphere assumes a relatively dominant role during states of depression. As noted, the results of the present study support such a suggestion. Nevertheless, the results of the present study do not indicate that the degree of hemispheric imbalance is related to the severity of the depression. No relationship was found between the size of the Difference Score -- which, it will be recalled, is a reflection of the difference between dichotic perceptual accuracy at the right ear and at the left ear -- and score on the Beck Depression Inventory (BDI). A possible explanation for the absence of relationship between severity of depression and degree of ear asymmetry is that the BDI did not provide a valid representation of clinical status. The BDI is a self-report measure comprised of questions whose meaning is fully transparent. As such, it is subject to the biases inherent to any line of questioning that has obvious intent. However, the BDI has been the focus of a considerable body of validation research (e.g., Burns & Beck, 1978) that has tended to support the validity of the BDI as an instrument for the assessment of depression.

A second possible explanation for the lack of relationship between level of depression and degree of ear asymmetry is that the Difference Score was itself an inadequate reflection of hemispheric asymmetry. Bruder (1983) cautions that the use of a simple difference score may be problematical because of the relationship between difference scores and total accuracy on the DL task. Usually, the worse the performance the higher the difference score. It is possible therefore that in the present study Difference Scores were influenced by overall levels of performance and that the relationship between levels of depression and levels of asymmetry was obscured. A third possibility, of course, is simply that there is no relationship between the severity of depression and the extent of asymmetry: Hemispheric asymmetry in a given individual may be an all-or-none phenomenon that is present during some states of acute affective illness but absent otherwise.

Another methodological factor that should be examined as a potential source of influence upon the results of the present study is that of the medication status of the patients. The information that has been gathered to date is equivocal with regard to the effects of antipsychotic and antidepressant medication upon measures of hemispheric asymmetry. In two studies (Goode, Manning, & Middleton, 1981; Gruzelier & Hammond, 1980) no changes in ear asymmetry on tests of dichotic perception were attributable to medication. However, other work (Perris, 1974; Roemer, Shagass, Straumanis, & Amadeo, 1978; Serafetinides, 1972) has suggested that changes in hemispheric asymmetry may accompany the administration of antipsychotic or antidepressant medication. In the present study, no differences in dichotic perception were attributable to medication: patients who were receiving antidepressant medication (N = 46) did not perform significantly differently from subjects who were drug-free when tested (N = 12). Both groups of patients exhibited an overall right-ear advantage for the perception of dichotic stimuli. It is also noteworthy that the patients who were drug-free had been so for quite some time: The drug washout period for the drug-free patients ranged from 1 month to the lifetime of the patient. The results of the present study therefore support those of previous work that has failed to observe changes in hemispheric activation on the basis of medication status.

A clinical variable that has been discussed (Bruder, 1983) as being a possible influence upon hemispheric activation is that of status as a unipolar or a bipolar patient. As noted above, some of the research in which verbal dichotic listening tasks have been employed with bipolar patients (Lishman et al., 1978; Yozawitz et al., 1979) has suggested that such individuals may exhibit an abnormally large right-ear advantage, whereas similar work with unipolar patients has tended to show an absence of ear asymmetry among those patients (e.g., Johnson & Crockett, 1982; Moscovitch et al., 1981). Bruder et al. (1981) compared the performance of unipolar and bipolar patients on a nonverbal dichotic listening task and observed that the bipolar patients exhibited an abnormal direction of ear asymmetry -- specifically, a right-ear advantage -- whereas the unipolar patients had no ear asymmetry. However, in the present study both the unipolar and the bipolar patients failed to exhibit ear asymmetry on the SSW Test.

It is quite possible that this absence of significant differences in ear asymmetry between unipolar and bipolar patients is a function of the clinical status of the patients at the time of testing. For example, none of the bipolar patients, when judged on the basis of clinical presentation and symptomatology, was in a manic or hypomanic state when examined in the present study. If bipolar patients exhibited signs or symptoms of affective disturbance, as they did in the case of the patients in the Current ECT and Depressed non-ECT groups, those clinical features were ones of depression, rather than ones of elation or euphoria. Conceivably, if the same patients had been tested when they were in a hypomanic or manic state the results of the SSW Test may have been quite different.

Attempts to impute causality on the basis of correlative data are at best risky and at worst dangerously misleading. Notwithstanding, it is necessary to speculate as to why changes in the relative levels of hemispheric activity have been noted frequently among depressed individuals. One possibility (discussed, for example, by Swartzburg, 1983) is that the left hemisphere forms a biological substrate for positive affective states and that the right hemisphere provides a biological basis for negative affective states. Support for such a model, although both correlative and somewhat tenuous in nature, is nevertheless quite compelling. For example, patients with unilateral brain damage have reportedly experienced changes in mood that correspond to the above model: Negative affective states such as those associated with catastrophic reactions and depression are more likely to follow left-hemispheric lesions than right-sided lesions, whereas affective states of relative euphoria, pleasure or indifference have been reported more commonly after right-sided damage (e.g., Denney-Brown, Meyer, & Horenstein, 1952; Gainotti, 1972; Galin, 1974).

Researchers who have used the Wada technique of unilateral carotid injection of barbiturates (Wada & Rasmussen, 1960) have also lent support to the hemispheric model outlined above (Flor-Henry, 1969; Nebes, 1978;

Perria, Rosadini, & Rossi, 1961; Terzian, 1964). Patients who have had their left cerebral hemispheres anesthetized have tended to report feelings of depression more frequently than have patients who have undergone right-hemispheric anesthesia. The latter group have tended to report positive affective states such as those of euphoria. The recording of electroencephalographic activity during various affective states has also provided evidence in favor of the theory that the right hemisphere is relatively dominant in activity during states of negative affect (Davidson & Fox, 1982; Tucker, Stenslie, Roth, & Shearer, 1981), although electroencephalographic data have also provided evidence of left-hemispheric activation during such negative states (Harman & Ray, 1977). Thus, the evidence accrued to date is suggestive but it is by no means unequivocal.

Clearly, the cerebral hemispheres are implicated in the generation of affective states: to argue otherwise would be to support a hypothesis of incorporeality. Precisely how or why relative levels of hemispheric activation should be correlated with various alterations of mood remains unclear. According to one popular model (noted by Swartzburg, 1983) the functions of the right hemisphere are considered to be generally inhibitory in nature. As such, right-hemispheric activation -- whether due to enhancement of right-sided cerebral activity or diminution of left-sided cerebral activity -- would tend to result in "inhibited" emotional states. (It is to be assumed that inhibited affective states are closely allied to negative affective states.)

For a number of reasons one must exercise caution in the proposition and interpretation of models such as these. First, the inhibitory effects of the right hemisphere are presumably confined to emotional effects. To my knowledge, there is no evidence to suggest that right-hemispheric cognitive functions are inhibitory in an overall sense. Second, it is difficult to relate differences in the emotional or affective role of the cerebral hemispheres to observed hemispheric differences among groups. It remains to be demonstrated, for example, whether left-handed individuals, females (who may possess less hemispheric lateralization than males), or those people with high levels of ability in functions that are mediated by the right hemisphere (e.g., artists, musicians, and architects) are more susceptible to the inhibitory effects of right-sided dominance. A third reason for caution lies in the essentially correlative nature of the data used to support the model of right-hemispheric dominance. For instance, the changes in affective tone that have been reported after injection of sodium amytal into the left hemisphere could be attributed as easily to a diminution of left-sided analytical functions or to aphasia as they could to a primary affective disturbance. Moreover, the evidence that has been gathered to support the hemispheric model must be weighed against the data that refute such a model. Patients with affective disorders -- whether functional or organic in nature -- frequently do not demonstrate features of the hypothesized abnormalities of hemispheric activation. Thus, if such abnormalities are implicated etiologically in the affective disorders they are not detected with complete reliability.

Having taken such an exercise in caution, it must nevertheless be noted that the data provided by several bodies of research, including the present study, do suggest that many depressed patients show a tendency to exhibit the abnormal patterns of cerebral hemispheric activity discussed above. One explanation for such observations is that the findings are merely those obtained by chance. Certainly, there is a need for careful implementation and replication of studies to examine patterns of hemispheric activity among well-defined clinical populations. Another possibility, as alluded to above, is that the findings are merely correlative in nature or that the direction of causality is the reverse of that which is commonly maintained. Conceivably, the negative affective state could accompany, precede, or even cause the observed changes in hemispheric activation. (Perhaps the left-hemispheric functions are more susceptible to the global impairment of cognitive activity that are induced by the depressed state.) A third possibility, however, is that the two sides of the brain are restricted or specialized in their emotional roles and that the various affective states -- particularly when they are manifested in an extreme fashion, as they are in the affective disorders -- are linked causally with the underlying neurophysiology of the cerebral hemispheres.

Indeed, support for such a position can be found in the studies that have been undertaken to examine the comparative therapeutic efficacy of bilateral (BL) and (right- and left-sided) unilateral (UL) ECT. Although the focus of discussion concerning UL and BL ECT in the introductory section of this paper was upon the relative degree of memory impairment related to the two forms of treatment, it should be noted that there has also been a great deal of investigation of the relative therapeutic effectiveness of such variations in the administration of ECT. A large majority of this research has indicated that there are few discernible differences in the effectiveness of right UL ECT and BL ECT but that right UL ECT is more effective therapeutically than left UL ECT (e.g., Cohen, Penick, & Tarter, 1974; Costello et al., 1970; Malitz, Sackeim, & Decina, 1982). The literature reviewed in the introduction to the present study suggests that ECT is associated with cognitive deficits that are related to the side of administration. As such, it appears that ECT may suppress neural activity selectively in the hemisphere over which the shock is applied. Taken together, such evidence would appear to support the interpretation that the negative affective state that is characteristic of depression is associated differentially with right-hemispheric activity.

To summarize, the results of the present study do not indicate that any long-term deficits in cognitive functioning are associated with the administration of electroconvulsive shock therapy. The results do suggest that short-term (2 weeks post-ECT) deficits in verbal memory and autobiographical recall accompany ECT. The data derived from the present research are provocative in terms of the information they provide concerning relative levels of cerebral hemispheric efficiency, as reflected by patterns of ear asymmetry on the test of dichotic perception, during the depressed condition. The data support previous work that has indicated that there may be a deviation from normal ear asymmetry during the state of depression. These deviations in laterality, which are ones of increased error at the right ear, may be indicative of deficiencies in left-hemispheric functioning, enhanced levels of right-hemispheric activity, or a combination of these factors. The abnormalities in functioning are absent during periods of remission from the depressed state. Accordingly, it would be of considerable interest to follow affectively disordered patients during periods of acute illness and clinical remission to determine whether changes in hemispheric imbalance accompany changes in clinical state. It is to be hoped that further explorations of such a nature will be undertaken.

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Appendix A.01

Subject Questionnaire

Subject Status_______________
Age _______________
Sex _______________
Date _______________

Background Data

Subject's ID Number:_______________
Date signed consent form: Month__Day__Year__

1. Medications. (COMPLETE TABLE BELOW. IF NO MEDICATION, RECORD LENGTH OF DRUG-FREE PERIOD.)

a) Current Medications:

Name	Dose	Frequency	Date began prescription

b) Medications terminated during the last month:

Name	Dose	Frequency	Date began/Date ended

c) People have different attitudes toward taking medication. In the last month, what percentage of the time have you taken the medications as prescribed?
Percentage of time:_____________

2. Have you ever received electroconvulsive therapy in the past?
Yes__ When?________ Number sessions:__________
No __

3. How much have you been drinking in an average week over the last month?

Type	Quantity	Frequency	Date of last use

4. A. During the last month, have you taken anything on your own for sleeping, or your mood, or to get high -- like Dexedrine, Seconal or some other barbiturate?

Appendix A.01, continued

B. How about marijuana, narcotics, LSD or things like that?

C. Have you used anything else to get high, lose weight, or stay awake?

Type	Quantity	Frequency	Date of last use

DEPRESSION

I would like to get an idea of any things that might have been bothering you in the past.

1. In your lifetime, have you ever had two weeks or more during which you felt sad, blue, depressed or lost all interest and pleasure in things that you usually cared about or enjoyed?
   Yes___ (ASK a & b) 5
   No ___ 1
   a. For how long did this depressed (OR Ss EQUIVALENT) feeling last?_________
   b. Have you been feeling depressed during the past 2 weeks?
      Yes______ No_______ (IF YES ASK c & d)
   c. When during the day is your depression usually worst? __________
   d. Is your depression different from the kind of feeling you might experience if a loved one died? Yes___ No___

2. Has there ever been a period of two weeks or longer when you lost <u>appetite</u>?
   Yes___(ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. For how long did this appetite loss last?___________
   b. Have you had an appetite for the last 2 weeks? Yes__ No__

3. Have you ever lost any weight without trying to -- as much as two pounds a week for several weeks?
   Yes___(ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. How much weight did you lose?______
   b. Have you been losing weight in the past 2 weeks? Yes__ No__

4. Have you ever had a period when your eating increased so much that you have gained as much as two pounds a week for several weeks?
   Yes___(ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. How much weight did you gain? ________

   b. Have you been gaining weight in the past 2 weeks? Yes__ No__

Appendix A.01, continued

5. Have you ever had a period of two weeks or more when you had trouble falling asleep, staying asleep or waking up too early?
   Yes___ (ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. For how long did you have trouble falling asleep? ________
   b. Have you been having trouble falling asleep during the past 2 weeks? Yes___ No___

6. Have you ever had a period of two weeks or longer when you were sleeping too much?
   Yes___ (ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. For how long were you sleeping too much? _______
   b. Have you been sleeping too much during the past 2 weeks? Yes___ No___

7. Has there ever been a period lasting two weeks or more when you felt tired out all the time?
   Yes___ (ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. For how long did you feel tired out all the time?_________
   b. Have you been feeling tired out during the past 2 weeks? Yes___ No___

8. Has there ever been a period of two weeks or more when you talked or moved more slowly than is normal for you?
   Yes___ (ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. For how long did you move more slowly?_______
   b. Have you been moving more slowly than is normal for you during the past 2 weeks? Yes___ No___

9. Has there ever been a period of two weeks or more when you had to be moving all the time -- that is, you couldn't sit still and paced up and down?
   Yes___ (ASK a & b AND PROBE Q's) 1 3 4 5
   No ___
   a. For how long did you feel that you had to be moving all the time?________
   b. Have you been feeling that you have to keep moving during the past 2 weeks? Yes___ No___

10. Was there ever a period of several weeks when your interest in sex was a lot less than usual?
    Yes___ (ASK a & b AND PROBE USING "decreased interest in sex")
    No ___ 1 2 3 4 5 6
    a. How long did this decreased interest in sex last?_______
    b. Have you had less interest in sex than usual during the past 2 weeks? Yes___ No___

Appendix A.01, continued

11. Has there ever been a period of two weeks or more when you felt worthless, sinful or guilty?
    Yes___ (ASK a & b) 5
    No ___ 1
    a. How long did this feeling of worthlessness last? _________
    b. Have you been feeling worthless during the past 2 weeks?
       Yes___ No___

12. Has there ever been a period of two weeks or more when you had a lot more trouble concentrating than is normal for you?
    Yes___ (ASK a & b AND PROBE Q's) 1 3 4 5
    No ___
    a. For how long did you have trouble concentrating? _______
    b. Have you been having trouble concentrating during the past 2 weeks? Yes___ No___

13. Has there ever been a period of two weeks or more when your thoughts came much slower than usual or seemed mixed up?
    Yes___ (ASK a & b AND PROBE Q's) 1 3 4 5
    No ___
    a. For how long did your thoughts come slower than usual?_________
    b. Have your thoughts been coming slower than usual during the past 2 weeks? Yes___ No___

14. Has there ever been a period of two weeks or more when you thought a lot about death -- either your own, someone else's, or death in general?
    Yes___ (ASK a & b) 5
    No ___ 1
    a. How long did these thoughts about death last? _______
    b. Have you been having these thoughts about death during the past 2 weeks? Yes__ No___

15. Has there ever been a period of two weeks or more when you felt like you wanted to die?
    Yes___ (ASK a & b) 5
    No ___ 1
    a. How long did you feel like you wanted to die?
    b. Have you been feeling like you want to die during the past 2 weeks? Yes___ No___

16. Have you ever felt so low you thought of comitting suicide?
    Yes___ (ASK a & b) 5
    No ___ 1
    a. For how long did you think of committing suicide? _______
    b. Have you thought about committing suicide during the past 2 weeks? Yes___ No___

17. Have you ever attempted suicide?
    Yes___ (ASK a) 5

Appendix A.01, continued

No ___ 1
a. Have you attempted suicide during the past 2 weeks?
Yes___ No___

18. (ASK IF DEPRESSION IS DENIED AND SOME OF THE DEPRESSION ITEMS ARE ANSWERED IN THE POSITIVE)
When you were having some of these problems (LIST Sx CODED IN Q's 2-16), at the same time were you feeling okay, or were you feeling low, gloomy, blue, or disinterested in everything?
Okay___
Gloomy, low, etc.___

19. In your lifetime, how many spells when you felt both (depressed) and had some of the other problems like (sx) have you had that lasted two weeks or more? # of spells: _________

20. How old were you the first time you had such a spell for two weeks or more? Age:_____

MANIA

21. Has there ever been a period when you were so happy or excited, or high that you got into trouble, or your family or friends worried about it, or a doctor said you were manic?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5
No ___ Alc/Med____
a. For how long did you feel happy and excited?____
b. Are you feeling happy and excited now? Yes___ No___

22. Has there ever been a period when you were so much more active than usual that you or your family or friends were concerned about it?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5
No ___ Alc/Med____
a. For how long were you more active than usual?____
b. Are you still more active than usual? Yes___ No___

23. Has there ever been a period when you went on spending sprees -- spending so much money that it caused you or your family some financial trouble?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5
No ___ Alc/Med____
a. For how long did this spending spree last?_____
b. Have you been going on spending sprees in the last week?
Yes___ No___

24. Has there ever been a period when your interest in sex was so much stronger than is typical for you that you wanted to have sex a lot more frequently than is normal for you or with people you wouldn't normally be interested in?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5

Appendix A.01, continued

No ___ Alc/Med_____
a. For how long did you have an increased interest in sex?_____
b. Do you have an increased interest in sex at the present time?
Yes___ No___

25. Has there ever been a period when you talked so fast that people said they couldn't understand you?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5
No ___ Alc/Med_____
a. For how long did this fast talking last?_____
b. Have you been talking fast in the last week? Yes___ No___

26. Has there ever been a period when your thoughts raced through your head so fast that you couldn't keep track of them?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5
No ___ Alc/Med_____

a. For how long did your thoughts race?_____
b. Have your thoughts raced in the last week? Yes___ No___

27. Has there ever been a period when you felt you had a special gift or special powers to do things others couldn't do, or that you were a specially important person? (Refers to supernatural powers.)
Yes___
(ASK FOR AN EXAMPLE BEFORE PROBING)______________________
(ASK a & b AND PROBE Q's)
No ___ 1 3 5
Alc/Med_____
a. How long did you feel that you had a special gift or special powers?______
b. Do you feel that you have special gifts or powers now?
Yes___ No___

28. Has there ever been a period when you hardly slept but still didn't feel tired or sleepy?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5
No ___ Alc/Med_____
a. For how long did you sleep very little?_________
b. Do you still sleep very little? Yes___ No___

29. Has there ever been a period when you were easily distracted so that any little interruption could get you off track?
Yes___ (ASK a & b AND PROBE Q's) 1 3 5
No ___ Alc/Med_____
a. For how long were you easily distracted?_________
b. Are you still easily distracted? Yes___ No___

30. In your lifetime, how many spells when you felt both (manic) and had some of the other problems like (sx) have you had that lasted one week or more?
spells:_____

Appendix A.01, continued

31. How old were you when you first had such a spell for one week or more?
    Age:_____

SCHIZOPHRENIA

CODE: 1 = no 4 = med. exp.
2 = below crit. 5 = yes
3 = drugs or alc.

INTERVIEWER: FOR Q's 32-44 ASK FOR AN EXAMPLE BEFORE PROBING. DO NOT USE EXAMPLES IN PROBING. DO USE UNDERLINED WORDS.

32. Now I want to ask about some ideas you might have about other people. Have you ever believed people were watching you or spying on you? (IF YES ASK a AND PROBE Q's)
    Ex:____*
    1 2 3 4 5 6
    MD:____________SELF:____________
    IF QUALIFIES AS 5, BUT PLAUSIBLE OR JUST SELF-CONSCIOUS, CODE 6.
    a. Do you still feel people are watching you? Yes___ No___

33. Was there ever a time when you believed people were following you? (IF YES ASK a AND PROBE Q's)
    Ex:____*
    1 2 3 4 5 6
    MD:____________ SELF:____________
    IF QUALIFIES AS 5, BUT PLAUSIBLE, CODE 6.
    a. Do you still feel people are following you? Yes___ No___

34. Have you ever believed that someone was plotting against you or trying to hurt you or poison you? (IF YES ASK a AND PROBE Q's)
    Ex:____*
    1 2 3 4 5 6
    MD:__________SELF:____________

    IF QUALIFIES AS 5, BUT PLAUSIBLE, CODE 6.
    a. Do you still feel someone is plotting against you or trying to hurt you? Yes___ No___

35. Have you ever believed that someone was reading your mind?
    INTERVIEWER: IF NO, CODE 1. ALL OTHERS ASK A.
    A. Did they actually know what you thought or were they just guessing from the look on your face or from knowing you for a long time? (IF "KNOW" ASK a AND PROBE Q's)

Appendix A.01, continued

INTERVIEWER: IF "JUST GUESS" CODE 1. OTHERS ASK FOR AN EXAMPLE AND BEGIN PROBING.

Ex:____ *

1 2 3 4 5

MD:____________SELF:____________

a. Do you still feel someone is reading your mind? Yes___ No___

36. Have you ever felt that you could actually hear what another person was thinking, even though he was not speaking, or believed that others could hear your thoughts? (IF YES ASK a AND PROBE Q's)

Ex:____ *

1 2 3 4 5

MD:____________SELF:____________

a. Do you still feel that you can hear what others are thinking or that others can hear your thoughts? Yes___ No___

37. Have you ever believed that <u>others</u> were <u>controlling how you moved or what you thought, against your will</u>? (IF YES ASK a AND PROBE Q's)

Ex:____ *

1 2 3 4 5

MD:____________SELF:____________

a. Do you still think others are controlling how you move or what you think? Yes___ No___

38. Have you ever felt that <u>someone or something could put strange thoughts directly into your mind</u> or could take <u>or steal your thoughts out of your mind</u>? (IF YES ASK a AND PROBE Q's)

Ex:____ *

1 2 3 4 5

MD:____________SELF:____________

a. Do you still feel that others can put in or remove strange thoughts from your mind? Yes___ No___

39. Have you ever felt that you were <u>being sent special messages through television or the radio</u>? (IF YES ASK a AND PROBE Q's)

Ex:____ *

1 2 3 4 5

MD:____________SELF:____________

a. Do you still feel that you are being sent special messages through the television or radio? Yes___ No___

40. INTERVIEWER: RECORD ANY VOLUNTEERED DELUSIONS NOT CODEABLE IN Q's 32-39. DO NOT ASK. (IF ANY VOLUNTEERED ASK a AND PROBE Q's.)
IF NONE, CODE 1.
IF ANY, DESCRIBE.

____

____

1 2 3 4 5

Appendix A.01, continued

MD:____________SELF:____________
a. Do you still feel (Sx) is the case? Yes___ No___

41. Have you ever had the experience of <u>seeing something or someone that others who were present could not see</u> -- that is, had a vision when you were completely awake? (IF YES ASK a & b AND PROBE Q's)
a. What did you see? RECORD BELOW AND THEN BEGIN PROBING.

____
____ *
1 2 3 4 5

MD:____________SELF:____________
b. Have you had the experience of seeing something or someone that others who were present could not see in the last day or two?
Yes___ No___

42. Have you more than once ever had the experience of <u>hearing things other people couldn't hear</u>, such as a voice? (IF YES ASK a AND PROBE Q's)
a. What did you hear? RECORD BELOW AND THEN BEGIN PROBING

____
____ *
1 2 3 4 5

IF CODED 2-5: ASK b,c, AND d
b. Did you hear voices commenting on what you were doing or thinking?
No 1
Yes 5
c. Did you hear two or more voices talking to each other?
No 1
Yes 5
d. Have you heard these things in the past day or two?
Yes___ No___

43. Have you ever been <u>bothered by strange smells around you that nobody else seemed to be able to smell</u>, perhaps even odors coming from your own body? (IF YES ASK a & b AND PROBE Q's)
a. What did you smell? RECORD BELOW AND THEN BEGIN PROBING.

____
____ *
1 2 3 4 5

MD:__________SELF:____________
b. Have you noticed these smells in the past day or two?
Yes___ No___

44. Have you ever had <u>unusual feelings inside or on your body</u> --like being touched when nothing was there or feeling something moving inside your body? (IF YES ASK a & b AND PROBE Q's)
INTERVIEWER: IF NO: CODE 1. ALL OTHERS ASK a.

Appendix A.01, continued

a. What did you feel? RECORD BELOW AND THEN BEGIN PROBING.

____

____

1 2 3 4 5

MD:____________SELF:____________

b. Have you had unusual feelings inside or on your body in the last day or two? Yes___ No___

INTERVIEWER: ASK 45-47 IF ANY 5's ARE RECORDED IN Q's 32-44.

45. At the time you had these beliefs or experiences (LIST Sx CODED 5 IN Q's 32-44) were you your normal self, or were you feeling nervous, upset, unable to work, unable to go places or unable to enjoy yourself?

Normal self 1

Not normal (ASK a) 5

a. For how long did you feel nervous, upset, unable to work or unable to enjoy yourself? ___________

b. Are you feeling nervous, upset, unable to work or enjoy yourself now? Yes___ No___

(IF YES SKIP TO 48, IF NO ASK 46-47.)

46. After you had these beliefs or experiences, did you find that you were less able to do your work well?

No effect 1

Less able 5

47. After you had these beliefs or experiences (LIST Sx CODED 5 IN Q's 32-44), were you less able to enjoy social relationships with other people?

No 1

Yes 5

48. At the time you had these beliefs and experiences, were you also feeling (depressed) or (manic) and did you have the other problems (sx) that you mentioned earlier?

No 1

Yes 5

INTERVIEWER: CODE Q49 WITHOUT ASKING

49. Blunted affect (expressionless face and voice, uniform blunting whatever the topic of conversation, indifference to distressing topics, whether delusional or normal.

No blunted affect 0

Blunting not uniform, e.g., at times responds affectively but at other times is markedly flat; or responds with some evidence of affect, but definitely less than expected 1

Appendix A.01, continued

Severe and uniform blunting 2

50. A. During the last month have you been working (including working as a housewife) or going to school?
Yes___ (COMPLETE TABLE BELOW, BE SPECIFIC)
No ___

nature of job/school	% full time	date began/ended	why ended

B. Would you say your (work/school performance) during the last month has been above average, average, or below average compared to others who (have the same job/follow same course of study)?
above average ______
average ______
below average ______

Appendix A.02

Beck Depression Inventory

Please pick out the statement in the groups below which best describes the way you feel today, that is, right now. Indicate your answer by circling your choice.

A. 0 I do not feel sad.
   1 I feel blue or sad.
   2a I am blue or sad all the time and I can't snap out of it.
   2b I am so sad or unhappy that it is quite painful.
   3 I am so sad or unhappy that I can't stand it.

B. 0 I am not particularly pessimistic or discouraged about the future.
   1a I feel discouraged about the future.
   2a I feel I have nothing to look forward to.
   2b I feel that I won't ever get over my troubles.
   3 I feel that the future is hopeless and that things cannot improve.

C. 0 I do not feel like a failure.
   1 I feel that I have failed more than the average person.
   2a I feel I have accomplished very little that is worthwhile or that means anything.
   2b As I look back on my life, all I can see is a lot of failure.
   3 I feel I am a complete failure as a person (parent, husband, wife).

D. 0 I am not particularly dissatisfied.
   1a I feel bored most of the time.
   1b I don't enjoy things the way I used to.
   2 I don't get satisfaction out of anything anymore.

E. 0 I don't feel particularly guilty.
   1 I feel bad or unworthy a good part of the time.
   2a I feel quite guilty.
   2b I feel bad or unworthy practically all the time now.
   3 I feel as though I am very bad or worthless.

F. 0 I don't feel that I am being punished.
   1 I have a feeling that something bad may happen to me.
   2 I feel I am being punished or will be punished.
   3a I feel I deserve to be punished.
   3b I want to be punished.

G. 0 I don't feel disappointed in myself.
   1a I am disappointed in myself.
   1b I don't like myself.
   2 I am disgusted with myself.
   3 I hate myself.

Appendix A.02, continued

H. 0 I don't feel I am any worse than anybody else.
1 I am critical of myself for my weaknesses or mistakes.
2 I blame myself for my faults.
3 I blame myself for everything bad that happens.

I. 0 I don't have any thoughts of harming myself.
1 I have thoughts of harming myself but I would not carry them out.
2a I feel I would be better off dead.
2b I feel my family would be better off if I were dead.
3a I have definite plans about committing suicide.
3b I would kill myself if I could.

J. 0 I don't cry any more than usual.
1 I cry more now than I used to.
2 I cry all the time now; I can't stop it.
3 I used to be able to cry but now I can't cry at all even though I want to.

K. 0 I am no more irritated now than I ever am.
1 I feel annoyed or irritated more easily than I used to.
2 I feel irritated all the time.
3 I don't get irritated at all at the things that used to irritate me.

L. 0 I have not lost interest in other people.
1 I am less interested in other people now than I used to be.
2 I have lost most of my interest in other people and have little feeling for them.
3 I have lost all my interest in other people and don't care about them at all.

M. 0 I make decisions about as well as ever.
1 I try to put off making decisions.
2 I have great difficulty in making decisions.
3 I can't make any decisions at all anymore.

N. 0 I don't feel I look any worse than I used to.
1 I am worried that I am looking old or unattractive.
2 I feel that there are permanent changes in my appearance and they make me look unattractive.
3 I feel that I am ugly or repulsive looking.

O. 0 I can work about as well as before.
1a It takes extra effort to get started at doing something.
1b I don't work as well as I used to.
2 I have to push myself very hard to do anything.
3 I can't do any work at all.

Appendix A.02, continued

P. 0 I can sleep as well as usual.
1 I wake up more tired than I used to in the morning.
2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
3 I wake up early every day and can't get more than 5 hours sleep.

Q. 0 I don't get any more tired than usual.
1 I get tired more easily than I used to.
2 I get tired from doing anything.
3 I get too tired to do anything.

R. 0 My appetite is no worse than usual.
1 My appetite is not as good as it used to be.
2 My appetite is much worse now.
3 I have no appetite at all now.

S. 0 I haven't lost much weight, if any, lately.
1 I have lost more than 5 pounds.
2 I have lost more than 10 pounds.
3 I have lost more than 15 pounds.

T. 0 I am no more concerned about my health than usual.
1 I am concerned about aches and pains or upset stomach or constipation.
2 I am so concerned with how I feel or what I feel that it's hard to think of much else.
3 I am completely absorbed in what I feel.

U. 0 I have not noticed any recent change in my interest in sex.
1 I am less interested in sex than I used to be.
2 I am much less interested in sex now.
3 I have lost interest in sex completely.

Appendix A.03

Hamilton Depression Scale

For each item, write the correct number (only one response).

1. DEPRESSED MOOD (Sadness, hopeless, worthless)
   0 = Absent
   1 = These feeling states indicated only on questioning
   2 = These feeling states spontaneously reported verbally
   3 = Communicates feeling states non-verbally -- i.e., through facial expression, posture, voice, and tendency to weep
   4 = Patient reports VIRTUALLY ONLY these feeling states in his spontaneous verbal and non-verbal communication

2. FEELINGS OF GUILT
   0 = Absent
   1 = Self-reproach, feels he has let people down
   2 = Ideas of guilt or rumination over past errors or sinful deeds
   3 = Present illness is a punishment. Delusions of guilt
   4 = Hears accusatory or denunciatory voices and/or experiences threatening visual hallucinations

3. SUICIDE
   0 = Absent
   1 = Feels life is not worth living
   2 = Wishes he were dead or any thoughts of possible death to self
   3 = Suicide ideas or gesture
   4 = Attempts at suicide (Any serious attempt rates 4)

4. INSOMNIA EARLY
   0 = No difficulty falling asleep
   1 = Complains of occasional difficulty falling asleep -- i.e., more than 1/2 hour
   2 = Complains of nightly difficulty falling asleep

5. INSOMNIA MIDDLE
   0 = No difficulty
   1 = Patient complains of being restless and disturbed during the night
   2 = Waking during the night -- any getting out of bed rates 2 (except for purposes of voiding)

6. INSOMNIA LATE
   0 = No difficulty
   1 = Waking in early hours of the morning but goes back to sleep
   2 = Unable to fall asleep again if he gets out of bed

Appendix A.03, continued

7. WORK AND ACTIVITIES
   0 = No difficulty
   1 = Thoughts and feelings of incapacity, fatigue or weakness related to activities, work or hobbies
   2 = Loss of interest in activity, hobbies or work -- either directly reported by patient; or indirect in listlessness, indecision and vacillation (feels he has to push self to work or activities)
   3 = Decrease in actual time spent in activities or decrease in productivity. In hospital, rate 3 if patient does not spend at least three hours a day in activities (hospital job or hobbies) exclusive of ward chores
   4 = Stopped working because of present illness. In hospital, rate 4 if patient engages in no activities except ward chores, or if patient fails to perform ward chores unassisted

8. RETARDATION (Slowness of thought and speech; impaired ability to concentrate; decreased motor activity)
   0 = Normal speech and thought
   1 = Slight retardation at interview
   2 = Obvious retardation at interview
   3 = Interview difficult
   4 = Complete stupor

9. AGITATION
   0 = None
   1 = "Playing with" hands, hair, etc.
   2 = Hand-wringing, nail-biting, hair-pulling, biting of lips

10. ANXIETY PSYCHIC
   0 = No difficulty
   1 = Subjective tension and irritability
   2 = Worrying about minor matters
   3 = Apprehensive attitude apparent in face or speech
   4 = Fears expressed without questioning

11. ANXIETY SOMATIC

0 = Absent	Physiological concomitants of anxiety, such as:
1 = Mild	Gastro-intestinal -- dry mouth, wind, indigestion, diarrhea, cramps, belching
2 = Moderate	
3 = Severe	Cardiovascular -- palpitations, headaches
4 = Incapacitating	Respiratory -- hyperventilation, sighing
	Urinary frequency
	Sweating

12. SOMATIC SYMPTOMS GASTROINTESTINAL
   0 = None
   1 = Loss of appetite but eating without staff encouragement
   Heavy feelings in abdomen
   2 = Difficulty eating without staff urging. Requests or requires laxatives or medication for bowels or medication for G.I. symptoms

Appendix A.03, continued

13. SOMATIC SYMPTOMS GENERAL
    0 = None
    1 = Heaviness in limbs, back or head. Backaches, headaches, muscle aches. Loss of energy and fatigability
    2 = Any clear-cut symptom rates 2

14. GENITAL SYMPTOMS
    0 = Absent Symptoms such as: Loss of libido
    1 = Mild Menstrual disturbances
    2 = Severe

15. HYPOCHONDRIASIS
    0 = Not present
    1 = Self-absorption (bodily)
    2 = Preoccupation with health
    3 = Frequent complaints, requests for help, etc.
    4 = Hypochondriacal delusions

16. LOSS OF WEIGHT Rate either A or B
  A. When Rating by History:
    0 = No weight loss
    1 = Probable weight loss associated with present illness
    2 = Definite (according to patient) weight loss
  B. On Weekly Ratings by Ward Psychiatrist. When Actual Weight Changes Are Measured:
    0 = Less than or equal to 1 lb. weight loss in week
    1 = Greater than 1 lb. but less than or equal to 2 lb. weight loss in week
    2 = Greater than 2 lb. weight loss in week

17. INSIGHT
    0 = Acknowledges being depressed and ill
    1 = Acknowledges illness but attributes cause to bad food, climate, overwork, virus, need for rest, etc.
    2 = Denies being ill at all

18. DIURNAL VARIATION Rate both A and B, but ADD 18b only into total score.
  A. Note whether symptoms are worse in morning or evening. If NO diurnal variation, mark none.
    0 = No variation
    1 = Worse in A.M.
    2 = Worse in P.M.
  B. When present, mark the severity of the variation. Mark "None" if NO variation.
    0 = None
    1 = Mild
    2 = Severe

Appendix A.03, continued

19. DEPERSONALIZATION AND DEREALIZATION
    0 = Absent   Such as: Feelings of unreality
    1 = Mild
    2 = Moderate
    3 = Severe
    4 = Incapacitating

20. PARANOID SYMPTOMS
    0 = None
    1 = Suspicious
    2 = Ideas of reference
    3 = Delusions of reference and persecution

21. OBSESSIONAL AND COMPULSIVE SYMPTOMS
    0 = Absent
    1 = Mild
    2 = Severe

Appendix A.04

Handedness Scale

Name ______________________________ Date ____________

INSTRUCTIONS: Please picture yourself doing each of the following tasks (e.g., throwing something, using scissors, striking a match) and then decide how strongly you prefer to use your right (or left) hand for the purpose. Score yourself 1 to 5 on each item, using the scale shown below.

1	2	3	4	5
Left hand only	Left hand preferred	Either hand (no prefer.)	Right hand preferred	Right hand only

EXAMPLE: In using a broom, I usually have my right hand on the handle above my left, but not always. Hence, I score myself '4' on this item.

_______ 1. Writing

_______ 2. Drawing

_______ 3. Throwing

_______ 4. Scissors

______ 5. Toothbrush

______ 6. Knife (without fork)

______ 7. Spoon

______ 8. Broom (upper hand)

______ 9. Striking Match (hand holding match)

______ 10. Opening Box (hand holding lid)

______ TOTAL

Appendix A.05

<u>Subject Information Form</u>

The Department of Psychology, University of British Columbia and the Department of Psychiatry, Shaughnessy Hospital are conducting a research project that is intended to determine the long-term effects of depression, and its treatment, on the brain. In order to complete our research, and to help us to develop better ways of treating depression, people who are currently being treated for depression as well as people who were in the past treated for depression are being invited to participate in the project as volunteers.

Should you volunteer to participate, you would be asked to devote about one hour of your time to our study. During that hour you would be examined with a few simple, non-invasive (i.e., no needles or discomfort) procedures designed to test your hearing and your memory. You would also be asked to fill out a few forms and answer some questions concerning the way you are feeling at the moment and the way you have felt in the past.

In return for your kind participation, we would be pleased to give you feedback about your hearing ability and about how your memory is functioning. Also -- and perhaps of more importance to you -- you would have the satisfaction of knowing that you would be helping others by contributing to our efforts to provide safer and more effective treatments for depression.

Appendix A.06

Subject Consent Form

Dichotic Perception and Memory Capability After
Right Unilateral Electroconvulsive Therapy

Investigators: W.G. Iacono, Ph.D.
K.M. Williams, M.A.
Department of Psychology
University of British Columbia

I have been asked to participate in a study that is intended to investigate the effects of electroconvulsive therapy on the brain. In this study I will have my memory tested and I will take part in a dichotic listening task. The dichotic task involves listening to signals presented through headphones and reporting what signals I hear. In all, the procedure will take approximately one hour. No side-effects, danger or discomfort to myself is involved. Also, any questions that I have concerning the test procedures will be answered to ensure my complete understanding about what is involved.

I understand that all of the information obtained in this project will be kept confidential and used only for the purposes of this study. By signing this form I agree to participate, although I realize I am free to withdraw from this study at any time without prejudice to current and future care and treatment.

I acknowledge receipt of a copy of this consent form.

____
Signature

____
Witness

____
Date

____
Assigned I.D.

Appendix A.07

Glossary of Audiological and SSW Test Terms

C-SSW Score:	Corrected SSW Test score, expressed as percent error. Computed by subtraction of the Speech Discrimination Score from the R-SSW score.
Pure tone threshold:	The lowest intensity at which the subject responds to pure tone stimuli 50% of the time. Used in audiometric assessment.
R-SSW Score:	Raw SSW Test score, expressed as percent error.
Speech Discrimination Score:	The accuracy with which the subject repeats a series of words presented at 30-dB above speech reception threshold. Expressed as percent error.
Speech Reception Threshold:	The lowest intensity at which 50 percent of spondaic words are repeated correctly. Used in audiometric assessment.
Spondee:	A metrical foot comprised of two long syllables.
SSW:	Staggered Spondaic Word Test.
SSW Condition:	The maximum percentage of error present in any of the four SSW listening conditions.
SSW Listening Conditions:	1. Right non-competing: Right ear receives spondee while left ear receives no stimulation. 2. Right competing: Right ear receives spondee while left ear receives competing stimulation. 3. Left competing: Left ear receives spondee while right ear receives competing stimulation. 4. Left non-competing: Left ear receives spondee while right ear receives no stimulation.
SSW Left-Ear Score:	The percentage of errors committed in the perception of stimuli directed to the left ear.

Appendix A.07, continued

SSW Right-Ear Score:	The percentage of errors committed in the perception of stimuli directed to the right ear.
SSW Reversals:	Rearrangements or reversals of word sequences reported by the subject in response to the stimuli.
SSW Total Score:	The mean of the right-ear C-SSW score and the left-ear C-SSW score, expressed as percent error.

Appendix B.01

Digit Span

Digits Forward

"I am going to say some numbers and when I am through I want you to say them right after me. Listen carefully."

Trial 1	Trial 2	#Digits
3-8-6	6-1-2	3 _____
6-4-3-9	7-2-8-6	4 _____
4-2-7-3-1	7-5-8-3-6	5 _____
6-1-9-4-7-3	3-9-2-4-8-7	6 _____
5-9-1-7-4-2-3	4-1-7-9-3-8-6	7 _____
5-8-1-9-2-6-4-7	3-8-2-9-5-1-7-4	8 _____

Score _____
(Maximum = 8)

Digits Backward

Trial 1	Trial 2	#Digits
2-5	6-3	2 _____
2-8-3	4-1-5	3 _____
3-2-7-9	4-9-6-8	4 _____
1-5-2-8-6	6-1-8-4-3	5 _____
5-3-9-4-1-8	7-2-4-8-5-6	6 _____
8-1-2-9-3-6-5	4-7-3-9-1-2-8	7 _____

Score _____
(Maximum = 7)

(Scoring for both Digits Forward and Digits Backward: Score = Maximum number of digits repeated correctly. e.g., If S repeats 5 digits on either of 2 trials, score = 5. Discontinue after both sets of a series are failed successively.)

Appendix B.02

Logical Memory Scale

I

"I am going to read you a little selection of about 4 or 5 lines. Listen carefully because when I am through I want you to tell me everything I read to you. Are you ready?"

(A)

Anna Thompson / of South / Boston / employed / as a scrubwoman / in an office building / reported / at the City Hall / Station / that she had been held up / on State Street / the night before / and robbed / of fifteen dollars. / She had four / little children / the rent / was due, / and they had not eaten / for 2 days./ The officers /touched by the woman's story / made up a purse / for her. /

"Now what did I read to you? Tell me everything and begin at the beginning." (Record verbatim)

Number of memories: _____

"Now I am going to read you another little selection and see how much more you can remember on this. Listen carefully."

(B)

The American / liner / New York / struck a mine / near Liverpool / Monday / evening. / In spite of a blinding / snowstorm / and darkness / the sixty / passengers, including 18 / women, / were all rescued, / though the boats / were tossed about / like corks / in the heavy sea. / They were brought into port / the next day / by a British / steamer. /

"Now what did I read to you this time? Once again tell me everything and begin at the beginning." (Record verbatim)

Number of Memories _____

Average Score = $\frac{(A + B)}{2}$ = (Maximum = 23)

Appendix B.02, continued

II

"I am going to read you a little selection of about 4 or 5 lines. Listen carefully because when I am through I want you to tell me everything I read to you. Are you ready?"

(A)

Dogs / are trained / to find / the wounded / in war time./ Police dogs / are also trained / to rescue / drowning people. / Instead of running / down to the water / and striking out, / they are taught / to make / a flying leap, / by which they save / many swimming strokes / and valuable/ seconds of time./ The European sheep dog / makes the best / police / dog./

"Now what did I read to you? Tell me everything and begin at the beginning." (Record verbatim)

Number of memories _____

"Now I am going to read you another little selection and see how much more you can remember on this. Listen carefully."

(B)

Many / school / children / in northern / France / were killed / or fatally hurt, / and others / seriously injured / when a shell / wrecked / the schoolhouse / in their village. / The children / were thrown / down a hillside / and across / a ravine / a long distance / from the schoolhouse./ Only two / children / escaped uninjured. /

"Now what did I read to you this time? Once again tell me everything and begin at the beginning." (Record verbatim)

Number of memories _____

Average Score = $\frac{(A + B)}{2}$ = (Maximum = 23)

Appendix B.03

Personal Data Questionnaire

1. Name:________________________

2. Date of Birth:________________

3. Place of Birth:________________

4. Present address and telephone number:______________________________

   ____

5. Very briefly, what did you do one week ago today?

   ____

   ____

6. Very briefly, what were you doing one year ago this month?

   ____

   ____

7. Please give the following information about your present (or most recent) job:

   (a) Type of work and work title____________________________________

   (b) Name of a co-worker____

   (c) Name of company____

   (d) Name of your supervisor_______________________________________

8. What is the name of your closest friend?____________________________

9. Who is the Prime Minister of Canada?______________________________

10. Very briefly, what did you do for Christmas, 1984?___________________

    ____

11. What did you do for Christmas, 1983?______________________________

    ____

12. What did you do during your 1984 summer vacation?___________________

    ____

Appendix B.03, continued

13. What did you do during your 1983 summer vacation?________________

____

14. What is your favorite television program?________________________

15. What was your favorite TV program during the 1970's?______________

16. Please give the following information about your first job:

    (a) Type of work and work title____________________________

    (b) Name of a co-worker__________________________________

    (c) Name of company_____________________________________

    (d) Name of your supervisor_______________________________

17. What was your occupation in 1969?_______________________________

18. What were you doing on the day of the first manned lunar landing?

____

____

19. What was your mother's maiden name?_____________________________

20. What was the name of one of your high school classmates?__________

21. What was the name of one of your high school teachers?____________

22. What was your address when you were 16 years old?________________

____

23. What was the name of your first pet?_____________________________

24. What was the name of your best friend when you were 10 years old?

____

25. What was the name of one of your elementary school classmates?

____

26. What was the name of one of your elementary school teachers?

____

Appendix C.01

Demographic and Clinical Variables

Summary of Analyses of Variance

Source of Variation	df	MS	F	p
Age				
Between-Groups	4	539.28	3.61	.0096
Within-Groups	73	149.19		
Education				
Between-Groups	4	9.69	1.29	.2826
Within-Groups	73	7.52		
Depression: Pre-ECT				
Between-Groups	4	2310.76	39.61	.0000
Within-Groups	73	58.33		
Depression: Post-ECT				
Between-Groups	4	1539.16	26.10	.0000
Within-Groups	72	58.96		

Appendix C.02

Current ECT Group Performance Pre- and Post-ECT

Source of Variation	df	MS	F	p
Digits Forward				
Between Measures	1	00.00	00.00	1.0000
Residual	9	00.44		
Digits Backward				
Between Measures	1	00.05	00.10	.7577
Residual	9	00.49		
Auto Memory				
Between Measures	1	36.45	4.05	.0751
Residual	9	9.00		
Logical Memory				
Between Measures	1	20.00	3.67	.0875
Residual	9	5.44		
Recurring Figures				
Between Measures	1	7.20	00.38	.5554
Residual	9	19.20		
Benton				
Between Measures	1	3.20	3.27	.1039
Residual	9	00.98		
SSW Total				
Between Measures	1	51.20	7.46	.0232
Residual	9	6.87		
SSW Right Ear				
Between Measures	1	120.05	7.92	.0202
Residual	9	15.16		
SSW Left Ear				
Between Measures	1	12.80	00.79	.3978
Residual	9	16.24		
SSW Condition				
Between Measures	1	80.00	2.87	.1246
Residual	9	27.89		
SSW Reversals				
Between Measures	1	4.05	00.12	.7389
Residual	9	34.27		

Appendix C.03

Neuropsychological Measures

Summary of Analyses of Covariance

Source of Variation	df	MS	F	p
Digits Forward				
Between-Groups	4	1.59	1.26	.2924
Within-Groups	73	1.26		
Digits Backward				
Between-Groups	4	1.37	1.16	.3340
Within-Groups	73	1.18		
Autobiographical Memory				
Between-Groups	4	23.81	3.10	.0206
Within-Groups	73	7.67		
Logical Memory				
Between-Groups	4	46.42	4.37	.0032
Within-Groups	73	10.61		
Recurring Figures				
Between-Groups	4	64.71	1.12	.3520
Within-Groups	73	57.57		
Benton				
Between-Groups	4	20.54	4.41	.0030
Within-Groups	73	4.66		

Appendix C.04

Neuropsychological Measures: II

Summary of Analyses of Covariance

Source of Variation	df	MS	F	p
Digits Forward				
Between-Groups	4	1.57	1.21	.3141
Within-Groups	72	1.30		
Digits Backward				
Between-Groups	4	1.26	1.00	.4142
Within-Groups	72	1.26		
Autobiographical Memory				
Between-Groups	4	57.70	5.97	.0003
Within-Groups	72	9.66		
Logical Memory				
Between-Groups	4	56.42	5.05	.0012
Within-Groups	72	11.18		
Recurring Figures				
Between-Groups	4	45.95	0.77	.5421
Within-Groups	72	58.93		
Benton				
Between-Groups	4	10.49	2.18	.0797
Within-Groups	71	4.80		

Appendix C.05

Tests of Ear Asymmetry Within-Groups

Group		Rt Ear % Error		Lft Ear % Error	t	p
Normal	M	1.20	M	3.40	3.66	.0015
	SD	1.76	SD	3.35		
Remit. Non-ECT	M	0.62	M	1.50	2.16	.0237
	SD	2.75	SD	2.37		
Dep. Non-ECT	M	1.40	M	4.27	2.11	.0273
	SD	2.75	SD	5.42		
Current ECT (Pre)	M	5.82	M	5.91	0.07	.4732
	SD	9.38	SD	8.14		
Current ECT (Post)	M	2.10	M	5.70	1.49	.0881
	SD	5.92	SD	10.46		
Past ECT	M	0.00	M	4.27	2.09	.0286
	SD	5.13	SD	3.95		
Depressed Unipolar	M	3.47	M	3.37	1.59	.0851
	SD	7.21	SD	6.71		
Depressed Bipolar	M	4.00	M	6.57	1.04	.1566
	SD	4.47	SD	7.34		