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Unilateral electroconvulsive therapy and cerebral dominance: effect of right- and left-sided electrode placement on verbal memory

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SUMMARY Unilateral electroconvulsive therapy was given to 32 right-handed patients for relief of depression. Sixteen patients received electrode placement on the right side for the first treatment and on the left side for the second treatment. For the other 16 patients the order of sides was reversed. The word Associate Learning subtest of the Wechsler Memory Scale was administered about 20 minutes after each treatment (Wechsler, 1945). Results supported the hypothesis that performance on this test would be better when the electrodes were applied over the right than when they were applied over the left cerebral hemisphere. It is suggested that investigation along these lines could assist in establishing the cerebral dominance of individual patients.

Unilateral electroconvulsive therapy (ECT) was introduced as a regular clinical procedure in order to reduce the adverse effects of the bilateral mode of treatment (Frost, 1957; Lancaster, Steinert, and Frost, 1958; Cannicott, 1962). In the unilateral technique both electrodes are applied to the same side of the skull, commonly in a temporo-parietal position. In bilateral ECT a bifronto-temporal placement is usually employed. Both techniques produce generalized convulsions, although unilateral ECT may cause only a contralateral convulsion if inadequate current is passed. It has been claimed that, as regards effectiveness in relieving depression, unilateral is equivalent to bilateral ECT, but that unilateral ECT is preferable because post-ictal recovery is quicker and more comfortable and because side-effects, especially disturbance of memory, are less (Martin, Ford, McDanald, and Towler, 1965; Cannicott and Waggoner, 1967; Halliday, Davison, Browne, and Kreeger, 1968; Valentine, Keddie, and Dunne, 1968; Zinkin and Birtchnell, 1968; Fleminger, Horne, Nair, and Nott, 1970). As a result of these advantages some psychiatrists prefer the unilateral technique for routine use (Cannicott and Armin, 1968) and it has been found possible to give this treatment as often as five times a week without the undesirable confusion and amnesia that results from bilateral ECT given with similar frequency (Abrams, 1967). Although its usefulness as a routine clinical procedure has been challenged (Levy, 1968; Strain, Brunschwig, Duffy, Agle, Rosenbaum, and Bidder, 1968), the value of unilateral ECT in certain clinical circumstances does not appear to be in dispute. It is generally agreed that the main indication is the need to preserve intellectual and particularly memory functions.

Disturbance of memory by ECT has been much investigated and the subject is well summarized by Williams (1966). The use of unilateral ECT has introduced fresh aspects of the problem. It has been found that verbal memory is most likely to be impaired if the current is passed through the dominant hemisphere. Zamora and Kaelbling (1965) found that, after five unilateral ECTs to the non-dominant side (right side in right-handed patients) the scores on verbal subtests of the Wechsler memory scale increased by 10% compared with a decrease of 8% in the scores of an equivalent group of patients who received ECT to the dominant side. A recent study (Fleminger *et al.*, 1970) using the same test and two other investigations using different tests (Gottlieb and Wilson, 1965; Halliday *et al.*, 1968) have given confirmatory results. Therefore, if verbal memory is to be spared in a series of treatments, it is necessary to avoid unilateral electrode placement over the dominant hemisphere.

The complex inter-relationship of cerebral dominance, handedness, and psychological functions has received considerable study and is lucidly reviewed by Zangwill (1960), Brain (1965), and Piercy (1967).

It seems to be generally accepted that, whereas the left hemisphere is dominant for speech in the great majority of strongly right-handed individuals, it is also dominant in a substantial proportion of predominantly left-handed persons. We are faced, therefore, with the problem of which side to choose when giving unilateral ECT to a left-handed or ambidextrous patient.

In our earlier study we had examined all the Wechsler memory scale subtest scores and had found that the only one showing a significant difference between right- and left-sided treatment groups of strongly right-handed patients was the verbal Associate Learning test. We decided to investigate the effectiveness of this test for discriminating between the dominant and non-dominant hemisphere of individual patients by giving it after each of two successive treatments applied alternately to opposite sides. In 1952 Impastato and Pacella had reported the use of unilateral convulsions as a form of treatment. They applied the electrodes first to one side and then, a few minutes later, to the other side and passed only enough current to cause a contralateral convulsion. We are not aware of another account of non-accidental application of unilateral ECT to opposite sides of the head alternately in the same patient.

Our hypothesis was that, in a group of strongly right-handed patients, there would be significantly better performance on the Associate Learning subtest of the Wechsler Memory Scale after a single right-sided than after a single left-sided unilateral ECT.

METHOD

The subjects were 32 in-patients at the York Clinic, Guy's Hospital, for whom ECT was prescribed for the relief of depression.

All patients were strongly right-handed as measured by answers to four questions about hand preferences and a test of simultaneous writing. For each of the five items there was a score of 2 for right handed, 1 for ambidextrous and 0 for left handed. No subject had a dextrality score of less than 8 out of 10; 29 subjects scored 10.

Patients were allocated by toss of a coin to two groups of equal size. Group I received the first ECT on the right side and the second ECT on the left side; group II received the first ECT on the left size and the second ECT on the right side.

Details of sex and age of patients are given in Table 1. In group I there were nine women and seven men. In group II there were 10 women and six men. For group I the mean age was 44·6 years (range 26 to 63; S.D. 10·7). For group II the mean age was 50·3 years (range 30 to 69; S.D. 9·5). There is no significant difference between these means (t = 1·594).

TABLE 1

INDIVIDUAL SCORES OF 32 RIGHT-HANDED PATIENTS ON ASSOCIATE LEARNING SUBTEST OF THE WECHSLER MEMORY SCALE AFTER TWO CONSECUTIVE ECTS; ELECTRODES PLACED ALTERNATELY ON RIGHT AND LEFT SIDES (MAXIMUM SCORE = 21)

Subjects	*Sex*	*Age*	*Test scores*		
			1st	*2nd*	*2nd minus 1st*
		Group I (*n* = 16; *1st ECT right sided*)			
1	F	46	8·5	5·5	−3·0
2	M	39	10·5	6·0	−4·5
3	F	31	6·0	5·0	−1·0
4	M	36	16·0	7·0	−9·0
5	F	26	9·0	3·0	−6·0
6	M	51	7·5	8·0	+0·5
7	M	53	11·0	3·0	−8·0
8	M	57	7·5	7·0	−0·5
9	F	63	8·5	0·0	−8·5
10	F	45	6·0	4·0	−2·0
11	M	39	14·0	5·5	−8·5
12	F	53	8·0	7·5	−0·5
13	F	47	10·0	0·0	−10·0
14	F	26	4·0	8·0	+4·0
15	F	48	12·0	5·5	−6·5
16	M	54	2·0	2·0	0·0
		Group II (*n* = 16; *1st ECT left sided*)			
1	F	56	3·0	8·5	+5·5
2	F	52	6·5	5·5	−1·0
3	M	39	2·0	9·0	+7·0
4	F	42	5·0	20·0	+15·0
5	M	48	11·5	8·5	−3·0
6	F	59	8·0	9·0	+1·0
7	F	61	2·0	9·5	+7·5
8	F	30	2·0	5·0	+3·0
9	M	50	0·0	12·0	+12·0
10	F	59	0·0	7·0	+7·0
11	F	49	5·0	7·5	+2·5
12	F	69	4·0	7·5	+3·5
13	M	48	2·0	11·5	+9·5
14	M	55	0·0	7·0	+7·0
15	M	49	3·5	9·0	+5·5
16	F	39	0·0	0·0	

− = as predicted in Group I.
\+ = as predicted in Group II.

The investigation was confined to the first two treatments of each patient. There was an interval of two or three days between these treatments. The unilateral electrode placement described by Lancaster *et al.* (1958) was employed. Current was supplied by a standard Ectron machine delivering a rectified series of impulses at 50/sec at 150 V. A glissando technique was used. Full current passed for approximately one second. Bilateral convulsions occurred on all occasions. The anaesthetic was methohexitone sodium (Brietal) 100 mg, followed by succinylcholine 25-50 mg. It was ensured that all other medication, including anti-depressant drugs and premedication with atropine, was kept the same for each patient before both treatments.

The Associate Learning subtest of the Wechsler Memory Scale was given after each treatment; form 1 after the first and form II after the second. Testing was

started at 18 minutes after the current was passed, as experience had shown that this was the minimum time required for nearly every patient to be recovered sufficiently to cooperate with testing.

The investigation was conducted on a strictly double-blind basis. The patients were unaware of the difference between the two treatments. The tester was unaware of the side of the treatment.

RESULTS

The individual Associate Learning test scores are given in Table 1. The mean scores for each group are shown in Table 2.

TABLE 2

GROUP SCORES ON ASSOCIATE LEARNING SUBTEST OF THE WECHSLER MEMORY SCALE

	Group I (n = 16)			*Group II (n = 16)*		
		Scores			*Scores*	
	Side	*Mean*	*S.D.*	*Side*	*Mean*	*S.D.*
1st ECT	R	8·78	2·69	L	3·41	3·13
2nd ECT	L	4·81	2·54	R	8·53	4·05

It is evident that, as predicted, both groups obtained better scores after right-sided than after left-sided treatment.

These results were subjected to an analysis of variance. According to the F-ratio there was a highly significant difference between sides of treatment ($P<0·001$), but no significant difference between groups I and II or between the orders in which treatments were given.

Table 1 also shows the results obtained by subtracting the scores of the first testing from the scores of the second testing. These difference scores indicate whether or not the results were according to prediction in individual patients. There was a significant difference between the number of patients whose scores went in the predicted direction (26 patients) and the number whose scores were not as predicted (six patients), the latter including two patients in whom there was no difference between the first and second scores ($\chi^2 = 12·5$; $P<0·001$).

DISCUSSION

Our findings indicate a well-marked tendency for new word associations to be learned better by right-handed patients after unilateral ECT if the electrodes are applied to the right side than if they are applied to the left side of the head. This is independent of the order in which two treatments are given to alternate sides in the same individuals. This is consistent with earlier results of comparing matched groups receiving unilateral ECT applied only to one side or the other (Fleminger *et al.*, 1970).

Only 26 of the 32 patients (81%) produced scores that supported our hypothesis. Of the remaining six patients there were four (12·5%) whose scores were opposite to prediction. So that, although the performance of our patients on an associate learning task showed a clear tendency to differentiate, this fell short of full discrimination between the right and left sides. Unfortunately, we do not know the precise degree to which this represents failure to discriminate between dominant and non-dominant hemispheres because we are not yet able to make a confident estimate of the size of the small minority who are right-handed and have right cerebral dominance for speech. Using the intracarotid sodium amytal test, Branch, Milner, and Rasmussen (1964) found that 10% of their right-handed patients had right-sided dominance for speech. They suggested that, although it is unlikely that this represents the incidence in the general population 'such cases may be more frequent than is generally assumed'. They also pointed out that there had been clinical or other reasons for suspecting right hemisphere dominance in all their right-handed patients, although they were not brain damaged. From a survey of the literature from 1910 to 1954 (Ettlinger, Jackson, and Zangwill, 1955), it was found that, of 15 cases of aphasia due to right hemisphere lesions, nine had a family history of sinistral tendency. It is regrettable that we failed to obtain the family history of handedness of all our patients as this might have helped in the interpretation of our results.

It is clear that, if the technique of testing individual subjects for a differential effect of single alternate right- and left-sided ECTs is to lead to more precise conclusions and to have practical application, it will be necessary to carry out further investigations of a similar kind, especially on left-handed and ambidextrous patients. It may be that other tests would be more sensitive to functional differences between the hemispheres in this context. For example, in our previous study we had found that post-ECT testing for recall of material presented to patients immediately before ECT discriminated well between groups receiving right- and left-sided treatment, but for practical reasons we did not include this type of test in the present study. Non-verbal testing too might be employed. Using Rey Davis pegboards, Halliday and his colleagues (1968) found a non-verbal learning deficit after ECT to the non-dominant hemisphere corresponding to a verbal learning deficit after ECT to the dominant hemisphere. Also, analogous to the contralateral hemiparesis

produced by intracarotid sodium amytal, it may be profitable to limit the motor effect of electroconvulsive shock (ECS) to a contralateral convulsion: or subconvulsive doses might repay study along these lines.

Our results suggest to us that the technique reported here justifies development and could make a useful contribution to the elucidation of cerebral dominance of those patients who require this. Previously all such patients would have presented neurological or neurosurgical problems but the regular use of unilateral ECT now also raises the issue of cerebral dominance among psychiatric patients.

The incidence of left-handedness in the general population is probably between 5 and 10% (Brain, 1965). It is unlikely that the incidence is lower among those who require ECT. Yet we are not able to employ the unilateral form of electroconvulsive therapy for these individuals without substantial risk of applying the electrical stimulus to the dominant hemisphere. It is agreed that this and the consequent disturbance of memory are best avoided. Cerebral dominance, therefore, for the first time, has become a matter of considerable practical importance in clinical psychiatry.

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