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Investigation of cerebral dominance in 'left-handers' and 'right-handers' using unilateral electroconvulsive therapy

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SYNOPSIS Twenty-four patients receiving unilateral electroconvulsive therapy for depression were given the first treatment with electrodes on the left or right side of the head and the second treatment with electrodes on the opposite side. They were tested with the Word Associate Learning subtest of the Wechsler Memory Scale when fully responsive after the first ECT and after the same time interval following the second ECT. Twelve were left-handed and 12 were right-handed writers. In both groups, better scores were usually obtained after right-sided treatment. Redistribution of patients into sinistral, mixed, and dextral groups showed that this difference between the effects of left and right-sided ECT was significant only in dextrals. Only two right-handed writers had scores indicating right-sided dominance for speech; both were 'shifted sinistrals'. Left hemisphere dominance was indicated in 67% of all non-dextrals. Eight of nine patients in whom testing was repeated after a second pair of treatments on alternate sides obtained scores favouring the same side in both pairs of testing. Findings indicate the need for closer inquiry into handedness than is often made before unilateral ECT is prescribed. Further development of unilateral ECT for establishing cerebral dominance in individuals is supported by the results.

The use of unilateral electroconvulsive therapy (ECT) in the study of cerebral dominance was reported by Gottlieb and Wilson (1965). They compared verbal memory immediately after a single ECT in three groups of 'right-handed' patients with electrodes placed in the bifrontal, in the right-sided, and in the left-sided positions. They found that memory was most impaired in the group with left-sided placement. They concluded that this supported the view that the left temporo-parietal region is more concerned with verbal memory than either the frontal or right temporo-parietal areas. Later, the attempt was made to use unilateral ECT to discriminate between the dominant and non-dominant hemisphere in individual subjects (Fleminger *et al.*, 1970b). In that investigation, 32 'right-handed' patients received unilateral ECT, 16 with electrodes on the right side for the first treatment and on the left side for the second treatment. For the other 16 patients the sides were in the reverse order. The Word Associate Learning subtest of the Wechsler Memory Scale (Wechsler, 1945) was used to test verbal memory because it had been shown to be the best subtest of that scale for demonstrating a difference in memory impairment between groups of patients treated either with right-sided or with left-sided ECT (Fleminger *et al.*, 1970a). It was found that, regardless of the order of side to which ECT was given, there was a significant tendency for performance on the test to be better after right-sided treatment. These results encouraged the view that unilateral ECT should be developed as an instrument for establishing cerebral dominance in individuals. However, it was recognized that further studies should include the investigation of subjects who were not considered to be 'right-handed'. Pratt *et al.* (1971) found that asking patients to name objects from verbal description discriminated well between hemispheres in 12 'right-handers' after two right-sided and two

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left-sided treatments given alternately. The results of giving the same test to twelve 'left-handers' suggested that language was represented in the left hemisphere in eight patients and in the right hemisphere in two patients. In later studies, Pratt and Warrington (1972) and Warrington and Pratt (1973) used a similar brief naming test. They found, after a single pair of treatments, that of 55 'right-handed' patients, there was indication of left dominance in 45 and of right dominance in one patient; also, in 24 'left-handers' dominance appeared to be left-sided in 15 and right-sided in two patients. Using the same type of test, Annett *et al.* (1974) found that 17 of 24 'right-handed' patients did better after right-sided than after left-sided treatment.

Each of these studies had different criteria for handedness. Gottlieb and Wilson (1965) used the Harris Tests of Lateral Dominance. In order to select 'strongly right-handed' subjects, Fleminger *et al.* (1970b) asked four questions about hand preference, gave a test of simultaneous writing and obtained a 'dextrality' score. In an equally arbitrary way 'strongly right-handed' patients were identified by the absence of sinistral bias in cutting and throwing tests and six questions of hand preference (Fleminger *et al.*, 1970a). Pratt *et al.* (1971) asked three questions about hand preference and used 'a strong sinistral preference, and greater skill with the left hand' in one activity as their criterion for a 'left-hander'. Five of their 12 'left-handers' wrote with the right hand. Pratt and Warrington (1972) reported that all their patients were 'right-handed for writing, throwing and using a tool' but mention that only 44 of their 55 subjects were 'fully right-handed' according to the criteria of Oldfield (1971) and Annett (1970). Warrington and Pratt (1973) classified patients as 'left-handed' if 'they used the left hand preferentially for either writing, throwing or using a tool'. On this basis, of their 24 patients, only eight were fully left-handed and 12 were left-handed writers. Handedness was assessed by Annett *et al.* (1974) on the basis of questions of hand and foot preference and on the demonstration of the eye used for sighting and of manual speed in a peg-board test.

The electrode placements used by different investigators may have had important effects on results. A temporoparietal position was used by some (Gottlieb and Wilson, 1965; Fleminger *et al.*, 1970a, b); others used a frontomastoid placement (Pratt *et al.*, 1971; Pratt and Warrington, 1972; Annett *et al.*, 1974).

It seems that the testing of patients was done 'blind' in only one of these studies (Fleminger *et al.*, 1970b); yet we consider that, in this type of investigation, the knowledge of the side on which treatment has been given could be a source of error. With these problems in mind, the purpose of the present investigation was to explore further the relationship between handedness and verbal dominance as assessed by unilateral ECT with particular reference to non-dextral subjects.

METHOD

The investigation was carried out at the York Clinic, Guy's Hospital. The subjects were inpatients receiving ECT for depressive symptoms. None was known to have other cerebral disease or to have had ECT within the previous year. Twelve wrote with the left hand, 12 wrote with the right hand. All patients answered a 12-item handedness questionnaire (Annett, 1970), in which the answer to the question about the hand preferred for each activity could be 'right', 'left', or 'either'. This provided the basis for their selection for the trial and, later, for their subdivision into three handedness groups: (1) *sinistrals* (eight patients) who wrote with the left hand and did not prefer the right hand for any function; (2) *dextrals* (six patients) who wrote with the right hand and did not prefer the left hand for any function; (3) *mixed* (10 patients) who wrote with either left or right hand but who preferred to use the hand opposite to their writing hand for one or more activities.

The age and sex of patients are shown in Table 1. 'Right-handed' writers included six males and 'left-handed' writers included three males. The mean age for 'right-handed' writers was 43 years and for the 'left-handed' writers was 35 years. Neither of these differences is statistically significant at the 10% level. The only patient with a left-handed parent or sibling was subject 8, who said that she had a left-handed father.

Verbal memory was tested after each of the first two ECTs. The interval between treatments was two or three days during which any medication was unchanged. Theratronic's Transpsycon machine was used. The dose in joules was the same (usually 25) for each treatment; likewise the doses of anaesthetic methohexitone sodium and the muscle relaxant succinylcholine. Electrodes were placed in the same temporoparietal position described by Lancaster *et*

TABLE 1

SCORES ON WORD ASSOCIATE LEARNING SUBTEST OF WECHSLER MEMORY SCALE AFTER EACH OF TWO CONSECUTIVE UNILATERAL ECTS GIVEN ALTERNATELY ON RIGHT AND LEFT SIDE TO 24 PATIENTS: 12 LEFT-HANDED WRITERS AND 12 RIGHT-HANDED WRITERS

Subject	*Sex*	*Age (yr)*	*Side of 1st ECT*	*Associate Learning Scores*		
				Left side	*Right side*	*R−L*
			Left-handed writers (N=12)			
1	F	19	L	1.5	4.5	+3.0
2	F	48	R	8.0	3.0	−5.0
3	F	44	R	1.5	10.0	+8.5
4	F	27	R	0.0	15.0	+15.0
5	M	42	R	0.0	9.0	+9.0
6	F	52	R	1.5	6.0	+4.5
7	M	25	R	2.0	10.5	+8.5
8	F	25	R	13.5	11.5	−2.0
9	F	37	L	10.5	8.5	−2.0
10	F	33	L	7.5	5.5	−2.0
11	M	44	L	3.0	9.5	+6.5
12	F	29	L	2.5	9.5	+7.0
			Right-handed writers (N=12)			
i	M	46	R	9.5	15.0	+5.5
ii	F	68	R	7.0	9.0	+2.0
iii	F	32	R	6.5	14.5	+8.0
iv	F	34	R	0.0	9.5	+9.5
v	F	22	R	2.0	8.5	+6.5
vi	F	52	L	9.0	8.0	−1.0
vii	M	61	L	7.5	11.5	+4.0
viii	M	31	L	11.0	3.5	−7.5
ix	M	22	L	3.5	12.0	+8.5
x	M	40	L	3.0	11.5	+8.5
xi	M	48	R	15.5	16.0	+0.5
xii	F	60	R	1.5	11.0	+9.5

+ = Higher score after right-sided ECT.
− = Higher score after left-sided ECT.

al. (1958) as had been used previously (Fleminger *et al.*, 1970b). The side of the head on which electrodes were placed for the first treatment was selected randomly. For the second, ECT electrodes were placed on the opposite side.

While patients were recovering from their first ECT, they were asked to give their name and age, the day, month, and year, and the place in which they were. These questions were continued in the same order in rotation omitting those correctly answered until all had been answered correctly (Gottlieb and Wilson, 1965). Questioning was not continued beyond 30 minutes but all patients except subject 2 had completed all items by 26 minutes. Four to five minutes after this 'recovery time' testing with the Word Associate Learning subtest of the Wechsler Memory Scale was started. The interval was occupied with a standard word-fluency test which was intended as part of a separate study. After the second ECT, the same procedure was carried out but was cut short if necessary so that the Associate Learning test could be started at exactly the same time interval after the shock as on the first occasion. The average interval between the shock and the start of testing was 15.7 minutes (range two to 30 minutes). Form I of the test was given after the first and form II after the second treatment. The investigation was double-blind; neither patient nor tester was aware of the side on which electrodes had been placed.

RESULTS

Table 1 shows that, in both left-handed and right-handed writers, the Associate Learning test scores tended to be better (higher) after right-sided than after left-sided ECT. According to the Wilcoxon matched pairs test, this difference in favour of right-sided ECT is significant for both groups (LH writers $P<0.05$; RH writers $P<0.02$). The Mann-Whitney U test showed that the order of side on which treatment was given had no significant effect on the

TABLE 2

WORD ASSOCIATE LEARNING SCORES AFTER RIGHT- AND LEFT-SIDED ECT IN SINISTRAL, DEXTRAL, AND MIXED HANDEDNESS GROUPS. REPEAT SCORES (AFTER 3RD AND 4TH ECTS) ARE GIVEN IN PARENTHESES

Subjects	*Scores after left- and right-sided ECT*		
	Left	*Right*	*R−L*
	Sinistral Group (N=8)		
2	8.0 (13.5)	3.0 (9.0)	−5.0 (−4.5)
3	1.5	10.0	+8.5
4	0.0 (6.5)	15.0 (9.0)	+15.0 (+2.5)
5	0.0 (0.0)	9.0 (11.0)	+9.0 (+11.0)
6	1.5	6.0	+4.5
7	2.0	10.5	+8.5
9	10.5 (16.0)	8.5 (14.5)	−2.0 (−1.5)
10	7.5 (7.5)	5.5 (9.0)	−2.0 (+1.5)
	Dextral Group (N=6)		
i	9.5	15.0	+5.5
ii	7.0	9.0	+2.0
iii	6.5	14.5	+8.0
iv	0.0	9.5	+9.5
v	2.0	8.5	+6.5
x	3.0	11.5	+8.5
	Mixed Group (N=10)		
1	1.5	4.5	+3.0
8	13.5	11.5	−2.0
11	3.0	9.5	+6.5
12	2.5	9.5	+7.0
vi	9.0 (11.0)	8.0 (5.5)	−1.0 (−5.5)
vii	7.5 (7.5)	11.5 (15.0)	+4.0 (+7.5)
viii	11.0 (12.5)	3.5 (5.0)	−7.5 (−7.5)
ix	3.5	12.0	+8.5
xi	15.5 (16.0)	16.0 (20.0)	+0.5 (+4.0)
xii	1.5	11.0	+9.5

scores. When the scores after left-sided ECT were subtracted from scores after right-sided ECT, the difference-scores indicated right-sided dominance for verbal memory (higher score after left-sided treatment) in four left-handed writers (33.3%) and in two right-handed writers (16.7%). Both of these latter patients claimed to be 'shifted sinistrals'.

Table 2 sets out the scores of the same patients after redistribution into the three handedness groups: sinistral, mixed, and dextral. Now, according to the Wilcoxon matched pairs test there is no significant difference between the sides of treatment in the sinistral and mixed groups at the 5% level, but there is a significant difference in the dextral group at this level.

Right-sided verbal dominance is suggested by the scores in three of the sinistral group (37.5%), in three of the mixed group (30.0%), and in none of the dextral group. Thus, six of 18 (33.3%) non-dextral patients were assessed as having right-sided dominance.

In nine patients, testing was repeated after a second pair of treatments (third and fourth) given to alternate sides in the same order as the first pair. The results are shown in Table 2. Five were in the sinistral group and four were right-handed writers in the mixed group. In eight of these nine patients the second pair of treatments produced difference-scores in the same direction as the first pair. The first pair had indicated right-sided dominance in five of these patients. Repeat testing gave the same result in four of them, including the two right-handed writers. Failure to 'confirm' the result of the first pair of treatments occurred in a strongly left-handed patient (subject 10), but the right minus left scores were very small on both occasions.

DISCUSSION

In our group of 12 right-handed writers, 10 (83%) appeared to have left hemisphere dominance for verbal memory as assessed by a single pair of treatments. This is consistent with 26 of 32 (81%) 'right-handed' patients who gave a similar result in an earlier study (Fleminger *et al.*, 1970b). However, when patients with a substantial degree of sinistrality were omitted, all the remaining dextrals appeared to be left-sided dominant. This supports the suggestion that many 'right-handers', who are found to have verbal functions represented in the right hemisphere, will, on close examination, be likely to demonstrate or admit to mixed or equivocal handedness. It also reinforces the practical recommendation that, if strong sinistral preference is found in any 'right-hander', the doubt about dominance should indicate further investigation before proceeding to any cerebral intervention such as a series of unilateral ECT which involves a choice of side.

Both of our two right-handed writers with apparent right-sided dominance admitted to initial preference for writing with the left hand. These were the only certain 'shifted sinistrals' among our patients. One of them expressed strong, unsolicited preference for his left-sided treatment. The importance of this subgroup of handedness, especially as regards its pathogenesis, remains unclear. However, it is not a negligible minority: it constituted 5% of a recent survey of handedness among 800 psychiatric patients at Guy's Hospital.

Of our 12 left-handed writers, eight (67%) had scores suggesting left-sided dominance on a single pair of tests. Left dominance was indicated in five of eight sinistrals and in seven of 10 with mixed handedness. Thus, 12 of 18 (67%) of our non-dextral patients were left dominant on this assessment. This finding is in line with 28 of 44 (64%) left and mixed-handed patients in whom the intracarotid amylobarbitone test showed left speech dominance (Milner *et al.*, 1964), and we consider that it strengthens the case for developing unilateral ECT as a technique for establishing dominance. Results in accord with this were found in eight of 12 (67%) 'left-handers' after two alternating pairs of ECT (Pratt *et al.*, 1971) and in 15 of 24 (63%) 'left-handers' after a single pair of ECTs (Warrington and Pratt, 1973).

Right-sided speech dominance was indicated by a single pair of tests in four of 12 (33%) left-handed writers. Only three were given a second pair of tests. In this investigation repeat testing after the third and fourth ECTs is not satisfactory evidence of the reliability of the technique because the nine cases in which it was done were all non-dextrals, and therefore, the least predictable as regards dominance. Nevertheless, the fact that eight of nine patients scored in the same

way after the second as after the first pair of tests is encouraging. Also, our data provide evidence that may have increased value if this technique is found to have repeat reliability by further investigation. Meanwhile, our results suggest that of eight strongly left-handed patients, two (25%) were right dominant. This corresponds to 21% of 'left-handers' found to be right dominant using intracarotid amylobarbitone (Milner *et al.*, 1964).

The establishment of a time by which the patient is ready for testing after the first shock followed by testing at the same interval after the second shock proved to be an improvement. Zero scores at the first testing and, therefore, the risk of a spurious result were avoided. Nevertheless, it is recognized that we may have been comparing the recovery of responsiveness as well as verbal memory. However, these functions are known to be related. In groups of 'right-handed' patients having unilateral ECT, the rate of recovery is faster and verbal memory is better after right-sided than after left-sided treatment (Halliday *et al.*, 1968; Fleminger *et al.*, 1970a). Also, a relationship between consciousness and dominance for speech has been suggested by intracarotid amylobarbitone studies (Serafetinides *et al.*, 1965a, b), although this was not supported by a later report (Rosadini and Rossi, 1967). Annett *et al.* (1974) found that individual patients made more naming errors and took longer to complete a psychological examination after left-sided than after right-sided ECT. Their report that 'left minus right examination time differences were significantly correlated with left minus right hand speed differences' adds further support to the use of this approach to the study of handedness in relation to dominance.

As a group, 'right-handers' according to various criteria, in this and in other studies, show a differential response to left and to right-sided treatment that is significant and favours right-sided ECT. However, our results should alert clinicians to the fact that an individual patient who presents himself as 'right-handed' needs more than superficial inquiry about handedness before decision is taken on the appropriate side for treatment. We consider that our results with 'left-handers' strongly support the value of electrical stimulation of the brain, such as occurs in unilateral ECT, for investigating cerebral dominance in individuals.

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