The significance of laterality effects

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SUMMARY Language laterality can be unequivocally ascertained by comparing the effects of unilateral ECT to the right and the left hemisphere. It had been shown in right-handed depressed patients that a unilateral treatment to the left hemisphere resulted in transient dysphasia whereas unilateral ECT to the right hemisphere did not. The language laterality in a small group of *left*-handed depressed patients has been ascertained. Evidence is presented to show that neither dichotic listening nor hand position for writing provide satisfactory indices of language laterality. The ear advantage was more closely related to strength of sinistrality than to language laterality—that is *sidedness* appears to override *brainedness*. The results favour a spatial attention hypothesis rather than a structural hypothesis as the main determinant of laterality effects.

It has been known for many years that left-handers are not the mirror image of right-handers, in that some left-handers have their language systems lateralised to the left hemisphere. The most reliable evidence derives from the occurrence of transient dysphasia after unilateral ECT,^{1,2} and intracarotid sodium amytal injection in patients with acquired brain lesions.³ In both these investigations the incidence of language lateralised to the left hemisphere in left-handed subjects is in the order of 70% to 80%. The identification of these patients with crossed laterality is essential before a course of unilateral ECT and may often be an important consideration before brain surgery.

A reliable non-invasive technique for ascertaining language laterality would have obvious advantages, and a number of measures have been suggested. It has already been established that neither degree of sinistrality nor family history of sinistrality can be accepted as an indicator of right hemisphere language.² An ear advantage on a dichotic listening task is generally held to be one of the more robust predictors of language laterality; indeed it has been considered sufficiently secure to use it to validate other possible non-invasive techniques for assessing language laterality. These include hand-position while writing (a normal hand position indicating contralateral language specialisation⁴ and visual field superiority). However, before any of these indices can be accepted it is necessary to validate the measures by testing a group of left handed subjects

without organic brain disease whose language laterality has been definitively determined. Only one such validation study has been reported. Geffen *et al*⁵ have claimed that performance on a dichotic listening test can predict language laterality (which had been established by unilateral ECT). That there were only two “strongly” left handed subjects in the sample, neither of whom had language lateralised to the left hemisphere, must be regarded as a serious limitation of the generality of this claim. A right ear advantage in a right-handed subject could equally reflect an individual’s ear preference as the individual’s cerebral dominance for language. The critical cases are those subjects who are both strongly sinistral and are known to have language lateralised to the left hemisphere, for it is in these individuals that *brainedness* (language laterality) can be pitted against *sidedness* (sinistrality). We have assessed 13 left-handed patients, whose language laterality had been ascertained prior to a course of unilateral ECT, on two indices of language laterality, a dichotic listening task and position of the hand for writing. In addition we have documented the laterality preferences of these subjects.

Subjects

The subjects of this investigation were patients being treated by unilateral ECT (or who had been so treated in the past) for endogenous depression uncomplicated by organic neurological disease. Patients with abnormal or asymmetric hearing (tested by a pure tone) were excluded. The criterion for inclusion in this series was the preferential use of the left hand for writing, throwing, or using a tool, a routine inquiry for all patients being considered for ECT (see table 1). Language laterality was routinely

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Table 1

Case No	Age (yr)	Sex	Family history of sinistrality	Selection criterion		Oldfield quotient	Dysphasia No. correct (max 4)		Dichotic Listening		Test 1		Test 2	
				W	TH		ECT to right	ECT to left	R Ear score	L Ear score	R Ear score	L Ear score	R Ear score	L Ear score
1	62	F	+	R	L	60	4	2	55	9	106	74	R (p<0.02)	
2	49	M	-	R	L	+20	4	0	46	37	168	146	R (NS)	
3	36	M	-	L	L	-100	4	1	18	52	44	106	L (p<0.001)	
4	39	M	+	L	L	-100	4	0	45	58	104	164	L (p<0.001)	
5	59	M	+	L	L	-100	3	0	46	32	95	144	L (p<0.001)	
6	72	M	+	R	L	-80	4	0	29	48		NT		
7	49	F	+	L	E	-90	3	1	49	34		NT		
8	57	F	+	L	L	-100	4	0	46	49		NT		
9	35	M	-	R	L	+60	4	0	52	48		NT		
10	53	M	+	L	E	-60	4	0	50	46	122	146	L (p<0.05)	
11	66	M	+	R	L	-65	4	0	48	42		NT		
12	51	F	-	L	L	-100	0	4	41	35	128	113	R (NS)	
13	58	M	+	L	L	-100	4	3	37	58	80	149	L (p<0.001)	

+ = Positive, - = Negative, W = Writing, TH = Throwing, T = Tool, NT = Not tested.

ascertained by the asymmetry of response obtained on testing for dysphasia as the patient awakened from consecutive treatments to the right and left hemisphere following the procedure described by Pratt and Warrington.¹ The dysphasia scores after right and left hemisphere treatment (the number of objects, maximum four, named from description) are given in table 1. The degree of asymmetry of the "dysphasia" scores in this group of patients is comparable to the scores obtained in our original series of 55 right-handed subjects. In our experience a discrepancy score of two reliably identifies the language hemisphere. Thus in this group, 11 patients were considered to have language lateralised to the left hemisphere, one patient was considered to have language lateralised to the right hemisphere and in one patient no clear evidence of lateralisation of language emerged. In all but this one patient (case 13) subsequent treatment with unilateral ECT confirmed the original identification of the non-speech hemisphere insofar as no transient dysphasic symptoms were observed. It appears that in this series there is a higher incidence of subjects with crossed laterality than has previously been recorded.

Procedure

1 Dichotic Listening Test 1 The test stimuli were three pairs of digits (1-10), recorded on a two channel cassette using simulated speech heard through stereophonic headphones one of each pair to each ear. Each simultaneous pair was presented at a $\frac{1}{2}$ second rate. There were 10 sequences; each sequence was preceded by a 1 second warning tone and there was a 20 second interval between each sequence. The test sequences were preceded by two practice trials. This procedure was repeated on reversing the headphones, so that the right ear stimuli were now presented to the left ear and conversely. The number of digits correctly recalled (irrespective of order) from each channel was recorded.

Eight fully right-handed depressed patients being treated with unilateral ECT were tested. A right ear advantage was recorded in seven of these patients but in only two of these patients was the right ear advantage significant at or less than the 5% level (Wilcoxon Test). One of these fully right-handed subjects with language lateralised to the left hemisphere had a significant left ear advantage ($p < 0.05$).

2 Dichotic Listening Test 2 The test stimuli were three sets of digit sequences, two pairs, three pairs and four pairs (this tape was kindly provided by the late Dr J McFie). One of each pair was presented to the right ear and one to the left ear simultaneously on stereophonic headphones. For each set there were 10 sequences. The digits were spoken at a $\frac{1}{2}$ second rate and there was an interval of 5 seconds between each sequence. Recall was tested by verbal report. This procedure was repeated with the headphones reversed. The total number of digits recalled (irrespective of order and summing across the different length sequence trials) was recorded. For reasons irrelevant to the investigation only eight patients were given this test. A right ear advantage was recorded in seven of the eight control subjects (see above) but in only four of these patients was the right ear advantage

significant at or less than the 5% level (Wilcoxon Test). The one subject who had a significant left ear advantage on the Dichotic Listening Test 1 had a significant left ear advantage ($p < 0.001$).

3 Determination of laterality preferences The Oldfield⁶ handedness questionnaire was administered to each subject. Ear preference was established by stated preference. In addition each subject was required to telephone a secretary and write a dictated message. Hand position for writing, that is hooked or not hooked, was recorded.

Results

The Oldfield handedness quotients in this group of subjects ranged from +60 to -100 (see table 1). The right and the left ear recall scores together with the significance of the ear advantage (Wilcoxon Test) for each dichotic listening test are given in table 1. The correspondences of language laterality with hand preference for writing, handwriting position, ear preference and ear advantage for dichotic listening are summarised in table 2. For clarity of argument Case 13 whose language laterality was not ascertained is not further considered. First we are unable to confirm the claim that the normal hand position is indicative of contralateral language lateralisation. A normal handwriting position was observed in 10 patients, and in six of these patients this was not the case; their language laterality was ipsilateral to their preferred hand (see table 2). Secondly, in six of the 12 patients in whom language was lateralised there was a significant ear advantage. However, in only one of these six patients was the ear advantage *contralateral* to the language hemisphere; in the remaining five patients the ear advantage was *ipsilateral* to the language hemisphere. On the other hand, there appears to be a remarkably good concordance between a significant ear advantage and hand preference (five out of the six subjects). In short, those subjects who are most "left-sided" in spite of

having language functions lateralised to the left hemisphere appear to be most likely to have an ipsilateral ear advantage.

Discussion

It is widely accepted that the right ear advantage in right-handed subjects on dichotic listening tasks has a structural basis in the brain. The potency of the contralateral auditory pathways has been attributed both to there being direct access to the left hemisphere language systems⁷ and to suppression of the ipsilateral input.⁸ Whichever formulation is favoured, both predict ear advantage for verbal material contralateral to the hemisphere subserving language. This would appear not to be the case. In the present series, it can be argued that only one patient fits the structural hypothesis, whereas the results of five patients are incompatible with it (the results of the remaining five patients with language lateralised to the left hemisphere were uninformative because there was no significant ear advantage). Nor could Kinsbourne's⁹ hypothesis, that the relative degree of activation of the two hemispheres determines the subject's covert attention in the lateral plane, readily account for the present results. The task being verbal, his theory too would predict a contralateral ear advantage.

Morais and his collaborators have questioned the orthodox structural interpretation of the right ear advantage.¹⁰ In the context of a series of ingenious experiments in which he pits spatial cues against ear of entry, he has argued that ear advantage is at least in part determined by a spatial attentional factor: that is, *sidedness* can override *brainedness*. Our finding that there is a closer correspondence between strength and consistency of lateral preferences and ear advantage than between hemisphere language laterality and ear advantage accord well with this view. Following Morais¹¹ we suggest that each individual subject's performance on a dichotic listening task is determined at least in part by a subjective gradient of spatial attention. If this capacity to distribute spatial attention were less stereotyped in a group of left-handers than in fully right-handed subjects then our results would be entirely explicable.

Finally, our findings suggest that caution should be exercised when inferring language laterality from either lateral preferences, handwriting position or laterality effects. Since at least 70% of sinistrals have language lateralised to the left hemisphere, an *a priori* probability would have been a more reliable guide to language laterality than the indices considered in this study. The implications for research such as studies of normal interhemispheric specialisa-

Table 2

Case no	Language laterality	Hand preference	Hand position	Ear preference	Significant ear advantage
1	L	R	N	L	R
2	L	R	N	L	None
3	L	L	N	L	L
4	L	L	N	L	L
5	L	L	N	L	L
6	L	R	NT	L	L
7	L	L	N	L	None
8	L	L	N	L	None
9	L	R	N	R	None
10	L	L	N	L	L
11	L	R	NT	L	None
12	R	L	N	L	None
13	Bil	L	N	L	L

L=Left, R=Right, Bil=Bilateral, N=Normal, NT=Not Tested.

tion are far reaching; language laterality cannot yet be ascertained by a non-invasive technique.

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