Laterality differences in the perception of pressure¹

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In an extensive determination of the effects on somatosensory functions of penetrating brain wounds in man, Semmes, Weinstein, Ghent, and Teuber (1960) noted that there appeared to be inherent differences in the cerebral organization for somesthesia. Cortical representation for the right hand was found to be somewhat focally concentrated within the somatosensory regions of the left hemisphere, while representation of the left hand was more diffusely distributed within the right hemisphere, and occasionally, also in the left hemisphere. These findings raised the possibility that if cerebral organization between hands differed, then it was likely that somatosensory functions could differentially affect each hand. In their study, a small group of normal right-handed subjects were found to have greater sensitivity to pressure on the left hand while a very limited number of normal left-handers showed greater sensitivity on the right hand.

Weinstein and Sersen (1961) extended this experiment to a large sample of normal right- and left-handers to determine whether lateralized sensitivity was the result of peripheral callus or a reflection of differential central organization. Testing palms, forearms, and soles, Weinstein and Sersen were unable to demonstrate significant directional differences in mean pressure thresholds for the right or left side. However, when frequency counts were made, it was noted that there was a consistent trend for the left side to be the more sensitive side for both handedness groups, particularly on the palms. Further analysis, according to the presence of a family history of sinistrality, altered the directional trends as follows: whereas non-familial sinistrals and dextrals continued to show a trend toward greater sensitivity on the left hand, familial sinistrals showed a significant trend toward greater sensitivity on the right hand.

The results of the study of Weinstein and Sersen (1961) discount the effects of peripheral factors on directional asymmetries in pressure sensitivity

and suggest two intriguing hypotheses: (1) that there may exist a cortical 'dominance' for sensory processes which is reflected in pressure threshold asymmetries; and (2) that 'sensory dominance' is related to language dominance and family history of sinistrality. These hypotheses, however, should be considered tentative and subject to question for the following reasons. First, the data available to support the existence of lateralized differences is not based upon differences between hands in mean pressure thresholds, but rather shows only the frequency with which one hand was more sensitive than the other. Further, analysis of frequency data, given non-significant mean differences, is a less than adequate statistical basis for attributing meaningfulness to directional differences. Finally, these findings should be replicated and the nature of the asymmetries more clearly defined before the transition is made from tentative data to inferences about cerebral dominance for speech or somesthesia.

The present study was addressed to an examination of pressure sensitivity thresholds for each hand in normal left- and right-handers to establish the nature of directional asymmetries and their relationship to handedness.

EXPERIMENT I

SUBJECTS Sixty-one right-handers and 50 left-handers drawn from the student, clinical, and professional population of the University of Florida served as subjects, who ranged in age from 17 to 39, with a mean age of 21.16. The dextral group consisted of 32 males and 29 females², while the sinistral group contained 19 males and 31 females. Each subject was asked to state his hand preference and to demonstrate his hand preference for the following tasks: writing, inserting a key in a lock, ironing, striking a match, applying make-up or shaving, brushing teeth, combing hair, using a cigarette lighter, throwing a baseball, and cutting with scissors. Subjects were also asked to indicate the incidence of sinistrality, if

²The sinistral group contained more females than males as a result of the greater number of females who responded to our request for left-handed subjects. Previous investigators have shown that the only sex difference which occurred was that female subjects tended to have lower pressure thresholds on both hands. There is no evidence that sex is related to directional asymmetries.

¹This research was supported in part by a grant from the National Institutes of Health (MH 12046) entitled: 'Laterality of sensory and motor functions in man'.

present, among the following relatives: mother, father, grandmother(s), grandfather(s), sister(s), and/or brother(s).

Subjects were then classified into four groups according to the following criteria: familial dextrals were subjects who stated and demonstrated a right hand preference on a majority of skills and had no family history of sinistrality; familial sinistrals were subjects who stated and demonstrated a left hand preference on a majority of skills and had a family history of sinistrality; mixed dextrals were subjects who stated and demonstrated a right hand preference on a majority of skills but had a family incidence of sinistrality; and nonfamilial sinistrals were subjects who stated and demonstrated a left hand preference on a majority of skills but who had no family history of sinistrality. This classification follows that of Weinstein and Sersen (1961).

PROCEDURE A modified Von Frey pressure aesthesiometer, designed by Semmes and Weinstein and identical to that used by Weinstein and Sersen (1961), was employed for the determination of pressure thresholds. Ten pressures were used: $10^{1.65}$, $10^{2.36}$, $10^{2.44}$, $10^{2.83}$, $10^{3.22}$, $10^{3.61}$, $10^{3.84}$, $10^{4.08}$, $10^{4.17}$, and $10^{4.31}$ tenths of a milligram of force. The subjects were seated at a table facing the examiner with arm resting palm up on the table, were blindfolded, and were told that filaments were to be applied to the palm. Their task was simply to tell the examiner whether or not they felt the stimulus as it was applied. As each stimulus was applied, the subject was required to state 'yes' or 'no', indicating whether or not the stimulus was felt, each time the examiners said 'now'. Ten trials per pressure level were given in a random sequence of presentation. The site of stimulation was the point of intersection of a line drawn between and parallel to the middle fingers with a line drawn perpendicular to the thumb joint. Responses were recorded by the examiner after each trial. The preferred hand was tested first, followed by a three-minute interval before testing the non-preferred hand. Threshold was defined as that amount of force to which the subject would respond 'yes' 50% of the time.

ANALYSIS Results were analysed by a mixed factorial design with repeated measures on the same subject (type I, Lindquist, 1953) in which handedness was the between-subjects factor and hands was the within-subjects factor.

RESULTS

Mean thresholds for the dextral group were as follows: right hand ($\bar{X} = 2.75$), left hand ($\bar{X} = 2.75$). The mean thresholds for the sinistral group were: right hand ($\bar{X} = 2.66$), left hand ($\bar{X} = 2.69$).

Analysis of variance disclosed no significant differences for pressure sensitivity thresholds either between ($F = 1.57$, d.f. = 1,109) handedness groups or within handedness groups ($F = 0.98$, d.f. = 1,111).

The data were then analysed (following Weinstein and Sersen, 1961) according to the frequency with

which directional asymmetries occurred. Table I presents the incidence of greater right hand sensitivity, greater left hand sensitivity, and no hand difference for both the sinistral and dextral subjects.

TABLE I
FREQUENCY OF LOWER PRESSURE THRESHOLDS
BY HANDS AND GROUPS¹

Group	Hands		
	Right	Left	Equal
Dextrals	34	25	2
Sinistrals	26	23	1
Total	60	48	3

¹Method of constant stimuli

Inspection of this table reveals a slight tendency toward lower thresholds on the right palm for both handedness groups, although χ^2 analysis failed to demonstrate significance ($\chi^2 = 3.22$, $P > 0.20$). When subjects were grouped according to family history (Table II), however, χ^2 analysis showed a significantly greater incidence of lower pressure thresholds on the right hand for familial sinistrals, as compared with the non-familial sinistrals ($\chi^2 = 4.33$, $P < 0.05$).

TABLE II
FREQUENCY OF LOWER PRESSURE THRESHOLDS
BY FAMILY HISTORY¹

Group	Hands		
	Right	Left	Equal
Familial dextrals	31	21	2
Mixed dextrals	3	4	0
Familial sinistrals	14	6	0
Non-familial sinistrals	12	17	1
Total	60	48	3

¹Method of constant stimuli

EXPERIMENT II

The general tendency toward lower thresholds on the right hand (experiment I) is at variance with previous investigators (Weinstein and Sersen, 1961) and led the authors to question whether use of a different psychophysical method might account for the experimental findings. For this reason, a second study using a new sample of subjects was run to compare the thresholds determined by the method of limits (after Weinstein and Sersen) with those obtained by the method of constant stimuli (experiment I).

SUBJECTS Twenty right-handers and 20 left-handers, enrolled in an introductory psychology course at the University of Florida, Gainesville, served as subjects. There were 10 males and 10 females in each group. Subjects ranged in age from 17 to 32, with a mean age of 21.03. There were no right-handed subjects who had

a family history of sinistrality, while within the sinistral group, eight of the subjects were classified by the criteria in experiment I as familial sinistrals.

PROCEDURE The 10 filaments of the Semmes-Weinstein pressure aesthesiometer used in experiment I were again employed to determine pressure sensitivity thresholds. Five ascending and five descending trials were alternately used by the method of limits. Each subject was stimulated at the site on the palm detailed in experiment I. After each subject had been seated, blindfolded and had placed his hand, palm up, on a table directly in front of him, he was asked to respond 'yes' or 'no' when the examiner said 'now' (as the filament was applied) to indicate whether or not the stimulus had been felt. Each stimulus was applied for a period of one second, with a five-second interval between stimuli. Testing of preferred or non-preferred hand first was balanced between subjects (ABAB).

ANALYSIS Results were analysed by a mixed factorial design with repeated measures on the same subject (type I, Lindquist, 1953), in which handedness was the between-subjects factor and hands was the within-subjects factor.

RESULTS

Mean thresholds for the dextral group were: right hand ($\bar{X} = 2.89$), left hand ($\bar{X} = 2.87$); the mean thresholds for the sinistral group were: right hand ($\bar{X} = 2.73$), left hand ($\bar{X} = 2.77$). Although these means are somewhat higher than those obtained in experiment I, they do not differ significantly from them. Results of the analysis of variance revealed no significant difference either between handedness

groups ($F = 1.76$, d.f. = 1,38), or within handedness groups ($F = 0.84$, d.f. = 1,40). When the data were analysed for the incidence of greater right hand or left hand sensitivity for all subjects and by family history of sinistrality (Tables III and IV), no significant differences were found.

DISCUSSION

The present study failed to demonstrate a significant asymmetry between hands for the perception of pressure. In addition, frequency analysis did not support the general findings of Weinstein and Sersen (1961) that dextrals and non-familial sinistrals tend to have lower pressure thresholds on the left hand. No significant trend toward greater sensitivity was found for the left hand in this study; in fact, there was a slight tendency for greater right-hand sensitivity among these subjects.

It appears, then, that the literature currently available on pressure sensitivity thresholds contains conflicting data with regard to pressure asymmetries. In all the studies to date, no evidence has been found to support the hypothesis that significant lateralized mean differences occur in the perception of pressure for the right and left hands in both sinistral and dextral subjects. What has been reported, however, is the tendency for a pattern of asymmetry to occur. Weinstein and Sersen (1961), as well as Semmes *et al.* (1960), found that right-handers as a group and left-handers who have no family history of sinistrality tend to have lower pressure thresholds on the left hand, whereas familial sinistrals tend to have lower pressure thresholds on the right hand. The present study, in contrast, found no consistently lower thresholds on the left hand for dextrals and non-familial sinistrals. This pattern of results was not altered by different methods, nor should it have been, if the phenomenon were real. The difference in testing procedure between these studies may explain the lower thresholds found by the present authors (the subject's expectation of stimulation could result in lower thresholds). It should not, however, alter any underlying asymmetry which existed between hands if experimental conditions were identical for both hands as they were.

Failure to replicate the findings of Weinstein and Sersen makes it difficult to accept their postulate of a relationship between pressure sensitivity, cerebral 'sensory dominance,' and, inferentially, speech dominance. If no difference exists between hands in the perception of sensory data (at least pressure) then it becomes difficult to quantify an entity called 'sensory dominance', particularly if the frequency data upon which this is based is not replicable. It would appear that, at present, evidence

TABLE III
FREQUENCY OF LOWER PRESSURE THRESHOLDS
BY HANDS AND GROUPS¹

Group	Hands		
	Right	Left	Equal
Dextrals	8	10	2
Sinistrals	10	8	2
Total	18	18	4

¹Method of limits

TABLE IV
FREQUENCY OF LOWER PRESSURE THRESHOLDS
BY FAMILY HISTORY¹

Group	Hands		
	Right	Left	Equal
Familial dextrals	8	10	2
Familial sinistrals	5	1	2
Non-familial sinistrals	5	7	0
Total	18	18	4

¹Method of limits

for the existence of sensory dominance is too tenuous to support such a concept.

The tendency for familial sinistrals in both studies to show lower pressure thresholds with the right hand is more difficult to explain. This consistent finding seems to warrant a re-examination of pressure thresholds, using, however, newer testing techniques in order to maximize the likelihood of demonstrating the real difference which may exist.

The rapidly expanding research on simultaneous stimulation has already disclosed differences in vision and audition for right- and left-handed normal and brain-injured subjects. These differences become apparent only when sensory systems are placed in competition, with a 'dominant' side emerging (Bartz, Satz, Fennell, and Lally, 1967; Bryden, 1964; Kimura, 1961; Sampson, 1964; Satz, Achenbach, Pattishall, and Fennell, 1965). It is imperative, then, that attempts be made to assess the effect of competition on sensory-perceptual processes to determine whether a 'dominance' will emerge. The authors are currently investigating this problem.

One final word of caution appears necessary. Until data on somesthetic asymmetries more clearly document the presence of laterality effects, speculation as to the relationship of such sensory data to language dominance may be hazardous and should be bound by the limitations of the evidence.

SUMMARY

An investigation of lateral differences in pressure sensitivity thresholds for normal dextrals and sinistrals disclosed no significant differences in mean thresholds between the right and left hands. When the data were analysed, according to direction

of differences in hands on pressure sensitivity, again no significant trends were obtained. Inclusion of information concerning family incidence of sinistrality, however, disclosed that familial sinistrals showed a significantly greater incidence of lower thresholds on the right hand than did non-familial sinistrals. The implications of these findings on the formulation of theoretical models of sensory dominance, speech dominance and their relationship to handedness were discussed. An alternative approach to the study of sensory asymmetries in man was offered.

The authors would like to express deep appreciation to Sally Wolking, research assistant, for her help in testing and collating data, and to Dr. Charles Vierck, Department of Behavioral Sciences, and Dr. Robert King, Department of Physiology, for their assistance in the preparation of this manuscript.

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