Hemispheric Laterality Effects on Tactile Perception of Direction in Normal Subjects

著者	HONDA HITOSHI
journal or publication title	Tohoku psychologica folia
volume	36
page range	68-74
year	1978-03-20
URL	http://hdl.handle.net/10097/00064925

Tohoku Psychologica Folia
1977, **36**(1–4), 68–74

HEMISPHERIC LATERALITY EFFECTS ON TACTILE PERCEPTION OF DIRECTION IN NORMAL SUBJECTS

By

HITOSHI HONDA (本田仁視)

(Department of Psychology, Tohoku University, Sendai, Japan)

Twenty right handed normal subjects were required to judge the direction of an imaginary line which passes through the two tactually stimulated spots on the back of a flat opened hand. Perception of the direction was significantly more accurate on the left hand than on the right hand. The results confirmed earlier findings of left hand superiority in tactile perception of the direction, and was interpreted as indicating that the right hemisphere superiority in nonverbal spatial information processing is shown in somatosensory or tactile modality as well as in visual and auditory modalities

Problem

A great deal of information on the specific function of the right cerebral hemisphere has been obtained mainly by the studies of brain damaged patients (Milner 1964, Hécaen 1964) and of cerebral commissurotomy in man (Sperry 1966, Gazzaniga 1970). These studies showed that, while the left hemisphere is dominant for language function, the right hemisphere plays an important role in nonverbal visuo-spatial function. The specific function of the right hemisphere has been also studied by means of experimental psychological technique.

As regards visual perception, for example, many authors have shown that perceptual processing of nonverbal visuo-spatial informations such as line orientation, number of dots, dot location, human face, nonsense figures and so on is better in the left visual field than in the right visual field (Fontenot & Benton 1972, Geffen et al. 1971, Honda 1975, 1976, Kimura 1966, 1969, Kimura & Durnfold 1974). On the other hand, so called dichotic listening test has been employed to investigate the laterality differences in auditory perception. Some kinds of nonverbal auditory stimuli were found to be perceived better in the left ear than in the right ear when presented in dichotic competitive situation (Kimura 1964, King & Kimura 1972). According to Kimura, this left ear superiority was explained by the strong connection of the left ear to the contralateral right hemisphere, that is, the dominance of crossed auditory pathway suggested by electro-physiological studies.

However, there are very few psychological studies which examined the hemispheric laterality effects on somatosensory or tactile perception. Benton et al. examined the accuracy of perception of the direction of stimuli applied to the palmer surface of the hands in patients with unilateral cerebral disease, and showed an important role the right hemisphere plays in processing of this kind of informations (Carmon & Benton 1969, Fontenot & Benton 1971). In subsequent studies, they conducted similar experiments in normal subjects (*S*s), and showed perception of direction was significantly more accurate on the left hand than on the right hand (Benton et al. 1973, Verney & Benton 1975). It is very reasonable to think that these results imply the right hemisphere dominance in tactile perception of direction, for informations of tactile stimuli applied to one side of the body are known to be projected mainly to the contralateral cerebral hemisphere.

In this study, we examined the laterality difference in perception of direction of tactile stimuli applied to the back of the right and left hands of normal right handed *S*s. The aim of this study was, first, to show perceptual laterality difference in somatosensory modality, and secondly to obtain preliminary and basic experimental data for the study of inter-modal relationships in perceptual laterality effects (Honda, 1977).

METHOD

Subjects: Twenty right handed university students (10 males and 10 females) served as *S*s. Their age ranged from 20 to 28 years.

Apparatus and stimulus presentation: Tactile stimuli were presented by descending a pair of steel rods on the back of the flat opened right or left hand. In Fig. 1, the apparatus used in this study was shown. With this electromechanical stimulator, two steel rods (1.7 mm in diameter and 6.5 cm in length) were dropped from about 1.5 cm above the back of the hand, and after 500 msec the rods were raised to their original position. The weight of each steel rod was about 1 gram and the distance between the two rods was 2 cm. The axis which supports the rods can be freely rotated manually, and the stimuli were delivered in each of six different directions as shown in Fig. 2. The control of the duration of stimulus presentation was done electrically by TKK multi unit system. The *S*s were required to judge the direction of an imaginary line which passes through the two tactually stimulated points on the back of the hand.

Processure: After about 2 sec of a verbal warning signal, a pair of tactile stimuli were presented simultaneously on the center of the back of the flat opened right or left hand for 500 msec. The hand to be stimulated was placed out of view. Twenty-four stimuli, four in each direction shown in Fig. 2, were given to each hand. Each *S* was run on 4 blocks of 12 trials each in an ABBA order, i.e., 12 stimulations of one hand, 24 stimulations of the other hand, and 12 stimulations of the first hand. A right hand was chosen as the starting hand in 10 *S*s (5 males and 5 females), and a left hand in remaining 10 *S*s (5 males and 5 females). Before starting the test trials, each *S* was given practice trials, in which tactile stimuli were given only in a horizontal or vertical

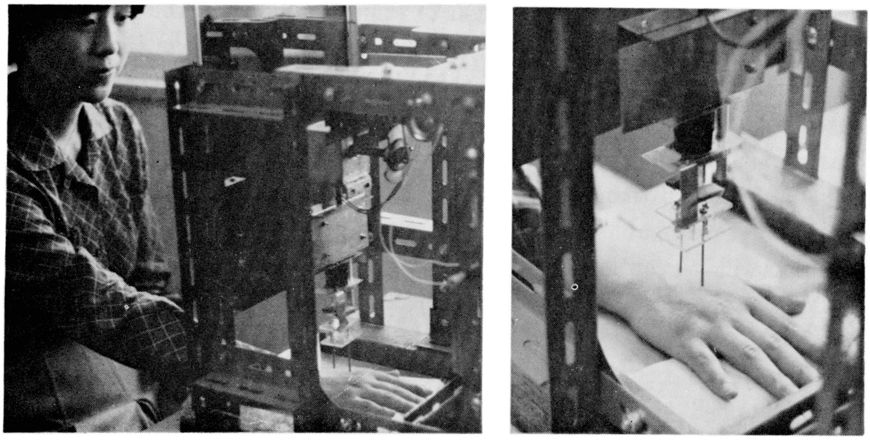

Fig. 1. Apparatus for tactile stimulation.

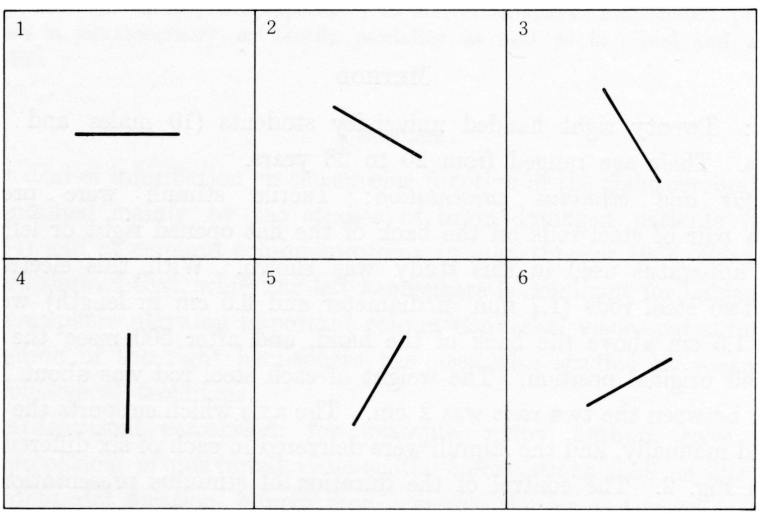

Fig. 2. Visual display for identification of direction of tactile stimulation.

direction. After the presentation of each test stimulus, *S* was required to judge the direction of an imaginary line which passes through the two stimulated points on the back of the hand. *S* responded by calling the figure attached to each line on a visual choice display (Fig. 2) which was placed in front of him. *S* was never informed whether his response was correct or not.

Results

The results were shown in Table 1 and Fig. 3. As shown in Table 1, 12 *S*s out of 20 *S*s showed a left hand superiority, while 5 *S*s showed a right hand superiority. In

Table 1. Correct responses in each hand in individual *S*s.

Sex		Male			Female	
Hand		Left	Right		Left	Right
Subject	S_1	16	11	S_{11}	20	11
	S_2	12	11	S_{12}	18	15
	S_3	11	8	S_{13}	14	10
	S_4	18	8	S_{14}	11	7
	S_5	12	10	S_{15}	10	7
	S_6	12	8	S_{16}	11	5
	S_7	7	7	S_{17}	13	13
	S_8	7	13	S_{18}	10	10
	S_9	11	12	S_{19}	12	14
	S_{10}	13	14	S_{20}	6	11
Mean		11.9	10.2		12.5	10.3
S.D.		3.2	2.3		3.8	3.1

Result of all subjects

Hand	Left	Right	
Mean	12.2	10.3	$p<.05$
S.D.	3.5	2.7	

Table 2. Summary of the analysis of variance of correct responses.

Source	*df*	MS	*F*
Sex (A)	1	1.23	0.09
Hand (B)	1	38.03	4.39 (p=.05)
A×B	1	0.63	0.07
Subjects (C)	18	13.51	-
B×C	18	8.65	-

addition, 3 *S*s showed equal acuity in the two hands. The mean score of the left hand was significantly higher than that of the right hand (t=2.095, df=19, $p<.05$). An analysis of variance on the data is shown in Table 2. The factor of the hand (B) was significant, whereas the sex difference (A) was not significant. A×B interaction was not significant. This means that, irrespective of sex difference, tactile perception of direction was more accurate on the left hand than on the right hand (Fig. 3). However, the left hand superiority was not significant, when *t*-test was applied to each sex group separately. This may be ascribed to the smallness of the sample in each group.

Discussion

In this study, a left hand superiority in tactile perception of the direction was shown. The results consist with Benton's report (Benton et al. 1973) in which tactile stimuli were presented on the palm of the hands.

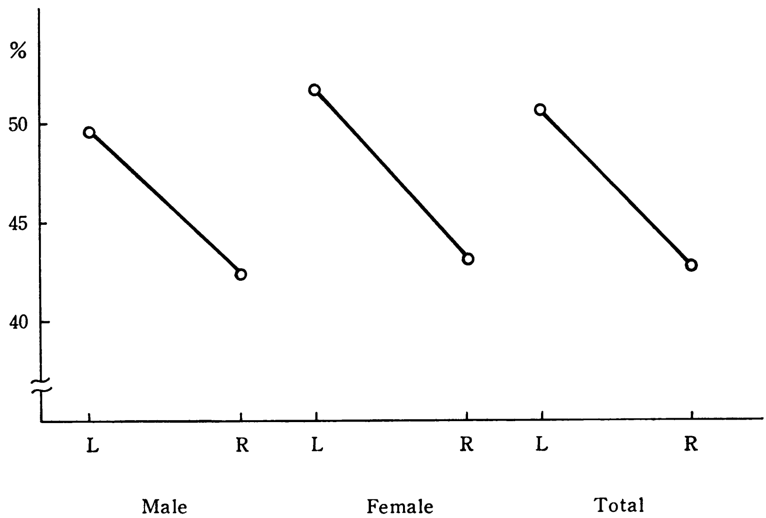

Fig. 3. Percentages of number of correct responses in each hand. L: Left hand. R: Right hand.

It is well known that the cerebral projection of various somatic afferent systems is largely contralateral for all regions of the body except the neck and head. Many studies on unilateral cerebral disease have shown that somatosensory disturbance by unilateral damage is usually restricted to the contralateral side of the body. Recently, Carmon (1971) compared the tactile sensitivity of ipsilateral hand of unilaterally damaged patients with that of normal control *S*s, and found bilateral or ipsilateral impairment in tactile sensitivity in a substantial number of patients with unilateral cerebral disease. However, according to Carmon, impairment was greater in the contralateral hand than in the ipsilateral hand irrespective of the side of lesion. Therefore, these findings support the concept that the contralateral somatosensory projections are dominant as compared with the ipsilateral projections.

Evidence for the contralateral projection of somatosensory informations was shown clearly by Gazzaniga's behavioral study on split brain patients. "With vision eliminated by a blindfold, the patients were required to localize, by pointing with their finger, the spot on the skin at which a brief, light, tactile stimulus was applied. .... The patients were able to find points of stimulation if both the stimulus and the response were kept to the same side of the body." In addition, "with no restrictions placed on hand use, the patients generally used the left hand for any point on the left half of the body and the right hand for any point on the right side, except in the facial region, where either hand was used with equal facility" (Gazzaniga, 1970). As shown in Gazzaniga's statement, it is very reasonable to think that the tactile informations applied on the back of the hand project to the contralateral cerebral hemisphere. That is, the tactile information on the left hand projects to the right hemisphere and that on the right hand to the left hemisphere.

In the present study the *S*s were required to judge the direction of an imaginary line which passes through the two spots on the skin to which tactile stimuli were applied. And the result was that the accuracy of tactile perception of the direction was superior on the left hand than on the right hand. The result seems not to be ascribed to the right-left hand difference in tactile thresholds reported by Ghent (1961), for the force of the tactile stimulation employed in this study was well above the sensitivity thresholds. Therefore, the finding in this study is thought to reflect a hemispheric laterality difference in processing the tactually applied spatial informations.

By the way, Kinsbourne (1973) recently showed that perceptual laterality difference shifted by loading of verbal or nonverbal tasks. It was interpreted that this interesting phenomena were due to asymmetric activation or priming of cerebral hemispheres. Honda (1977) pointed out that the kind of experimental paradigm employed in Kinsbourne's study is a significant method for investigating the functional organization between the two cerebral hemispheres connected by the corpus callosum. If the right-left difference in tactile perception obtained in this study is a reflection of the functional difference of right and left cerebral hemispheres, the tactile laterality will be expected to shift with verbal or nonverbal load to both hemispheres. Our unpublished observation with auditory verbal and nonverbal loads showed the expected results; the left hand superiority in recognition of the direction of a tactually presented line was increased under the nonverbal load, and weakened under the verbal load.

Many psychological or neurological studies have shown, with visual test materials, that the right hemisphere plays an important role in processing the nonverbal visuo-spatial informations. The finding of this study indicates that the right hemisphere superiority in spatial information processing is shown in somatosensory or tactile modality as well as in visual and auditory modalities.

References

Benton, A.L., Levin, H.S., & Varney, N.S. **1973** Tactile perception of direction in normal subjects. *Neurology*, **23**, 1248–1250.

Carmon, A. **1971** Disturbances of tactile sensitivity in patients with unilateral cerebral lesions. *Cortex*, **7**, 83–97.

Carmon, A. & Benton, A.L. **1969** Tactile perception of direction and number in patients with unilateral cerebral disease. *Neurology*, **19**, 525–532.

Fontenot, D.J. & Benton, A.L. **1971** Tactile perception of direction in relation to hemispheric locus of lesion. *Neuropsychologia*, **9**, 83–88.

Fontenot, D.J. & Benton, A.L. **1972** Recognition of direction in the right and left visual fields. *Neuropsychologia*, **10**, 447–452.

Gazzaniga, M.S. **1970** *The bisected brain.* New York: Appleton-Century-Crofts.

Geffen, G., Bradshaw, J.L., & Wallace, G. **1971** Interhemispheric effects on reaction time to verbal and nonverbal visual stimuli. *J. exp. Psychol.*, **87**, 415–422.

Ghent, L. **1961** Developmental changes in tactile thresholds on dominant and nondominant sides. *J. comp. physiol. Psychol.*, **54**, 670–673.

Hécaen, H. **1962** Clinical symptomatology in right and left hemispheric lesions. In Mountcastle, V.B. (Ed.) *Interhemispheric relations and cerebral dominance.* Baltimore: Johns

Hopkins Press, pp 215–243.
Honda, H. **1975** Laterality differences in the recognition of line orientation. *Tohoku Psychologica Folia*, **34**, 52–66.
Honda, H. **1976** Right hemisphere superiority in recognition of random dot patterns and effect of memory factor. *Tohoku Psychologica Folia*, **35**, 77–87.
Honda, H. **1977** Shift of perceptual laterality difference by loading of verbal and nonverbal discrimination tasks. *Jap. J. Psychol.*, **48**, 70–79. (in Japanese with English summary)
Kimura, D. **1964** Left-right differences in the perception of melodies. *Quart. J. exp. Psychol.*, **16**, 355–358.
Kimura, D. **1966** Dual functional asymmetry of the brain in visual perception. *Neuropsychologia*, **4**, 275–285.
Kimura, D. **1969** Spatial localization in left and right visual fields. *Canad. J. Psychol.*, **23**, 445–458.
Kimura, D. & Durnfold, M. **1974** Normal studies on the function of the right hemispheres in vision. In Dimond, S.L. & Beaumont, G. (Eds.), *Hemisphere function in the human brain.* London: Paul Elek (Scientific Books), pp 25–47.
King, F.L. & Kimura, D. **1972** Left ear superiority in dichotic perception of vocal nonsense sounds. *Canad. J. Psychol.*, **26**, 111–116.
Kinsbourne, M. **1973** The control of attention by interaction between the cerebral hemispheres. In Kornblum, S. (Ed.), *Attention and performance.* Vol. 4, New York: Academic Press. pp 239–256.
Milner, B. **1962** Laterality effects in audition. In Mountcastle, V.B. (Ed.), *Interhemispheric relations and cerebral dominance.* Baltimore: Johns Hopkins Press, pp 177–195.
Sperry, R.W. **1966** Brain bisection and consciousness. In Eccles, J.C. (Ed.), *Brain and conscions experience.* Heidelberg, Berlin and New York: Springer-Verlag, pp 298–308.
Varney, N.R. & Benton, A.L. **1971** Tactile perception of direction in relation to handedness and familial handedness. *Neuropsychologia*, **13**, 449–454.

(Received October 25, 1977)