原 著

聖徳栄養短期大学紀要No.18 (1987)

Original

Handedness (II):Laterality of Spatial and Weight Discrimination Guided by Kinesthesis

Sho Nishizawa

ABSTRACT

Studies on cerebral hemispheric lateralization of handedness, language activity, spatial perception, and manual task were reviewed to examine the experimental hypothesis. The identical task procedure for kinesthetically guided thumb angle discrimination and weight discrimination was employed to investigate whether lateral dominance was consistent or not. Only spatial task produced laterality effect, suggesting that handedness should be carefully assessed if a manual task is used.

In the previous report[22], a topic of functional asymmetries of the hand was reviewed from the stand point of cerebral hemispheric laterality and the origin of handedness was proposed to be innate rather than acquired. Since the cerebral dominance for the language activity and that for the manual task would relate, the commonality of these two areas in the left brain is strongly believed to exist. In this paper, the theories of handedness was reviewed and the experimental results of the cerebral hemispheric lateralities with respect to kinesthesis were reported.

Geschwind and Levitsky (1968)[16] demonstrated that there was an easily detectable asymmetry in the human brain that involved the upper surface of the posterior portion of the left temporal lobe. This area is called "*planum temporale*" and constitutes the temporal speech region. This asymmetry was reported to exist even in the brain of human fetus and infant[6)27)28]. Lemay and Culebras (1972)[19] discovered the brain asymmetry of the sylvian fissures in human ancestors. These findings strongly suggested the importance of genetic or intrauterine influences. As Geschwind and Galaburda (1985)[13)14)15] suggested that there is a strong relationship between handedness and speech control. If he or she is right handed, the speech center locates in the left hemisphere with very few exceptions[25]. Although there are strong implications of hereditary influence, the studies of family handedness do not always reveal the

Key words : Handedness, Kinesthesis, Lateral dominance, Difference limen, Constant error

same results explained by the major gene model[1) 20)].

Different variations between right and left handedness have been reported. OLDFIELD (1971)[24)] reported that left-handedness is usually found to be more common in male than female. Strong left-handedness is more frequent in dyslexia and stuttering[16)]. Judging from the fact that males show more frequent developmental disorder, GESCHWIND et al. [13) 14) 15)] proposed that the male hormone, teststerone, would play important role for the cause of hemispheric laterality in fetus. On the other hand, ANNETT (1978)[2)] explained the origin of handedness as that both nongenetic accidental influences on early physical growth and genetic factor to dextrality played important roles in the formation of handedness. Although the origin of handedness is not clear at present, research results suggest that handedness relates with hemispheric laterality.

In the study of cereberal lateralities, anatomical, functional, and chemical asymmetries of the brain are the main research subjects. The functional asymmetries especially have been investigated most intensively. Among them, visual and auditory stimulus were most often used[12) 18)] and kinesthetically guided manual tasks have not been used intensively. One of the main purposes of this stdy is to investigate the asymmetry through the modality of kinesthesis.

While most manual tasks show right hand supeiority[3)], there are some tasks on which the left hand performs better. The tactile line orientation test reported by Benton, VARNEY and HAMSHER(1978)[4)], finger flexion task by KIMURA and VANDERWOLF (1970)[18)], finger spatial task by NACSHON and CARMON (1975)[21)], and hand posturing and finger spacing tasks of INGRAM (1975)[17)] all showed a left hand advantage. On the other hand, relatively few studies have assessed asymmetry in processing kinesthetic input.

Roy and MacKENZIE(1978)[26)], using "bimanual" or simultaneous movement of the two arms, did not observe the lateralization effect, but did show left thumb superiority over the right in reproducing angles when both thumbs were moved simultaneously. COLLEY (1984)[7)], however, failed to replicate Roy and MacKENZIE's findings for the thumbs. NISHIZAWA(1987)[23)], using a thumb angle positioning task, reported that the left thumb showed greater sensitivity of angular position detection than the right. Those findings suggest that regardless of the handedness, the left hand performs better than the right in this kind of tasks. This might be due to better processing of spatial information in these tasks by the right hemisphere.

However, if a task is free from eiter sequential or spatial judgement, the functional dominance of the hand can not be predicted. To examine this hypothesis, the thumb positioning task with weight was employed and whether the thumb laterality would be consistent or inconsistent between spatial and weight tasks was examined.

METHOD

Fifty female students majoring nutrition served as the subjects in this experiment. The subjects were divided into two groups, Group 1 (Space judgement group) and Group 2 (Weight judgement group).

Through the thumb positioning task, each subject was instructed to judge whether the test thumb position is larger or smaller than the standard position (Group 1) or whether the test weignt is heavier or lighter than the stand ard weight (Group 2). The experimental procedure was identical between two groups except for what she judges. Each subject made judgements with both right and left thumbs but the order of the side to start was counterbalanced.

The experimental apparatus is shown in Fig. 1. For both groups, the resting angle between

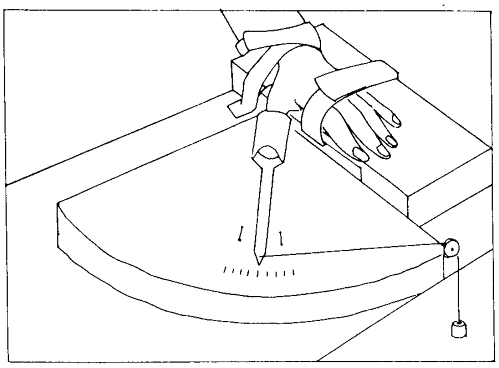

Fig. 1. Experimental Apparatus.

trials was set at 30 degrees. The standard angle was 45 degrees and the comparison angle ranged between 42 and 48 degrees in one-degree of seven steps. Each of the seven comparison angles including same degree as the standard was given seven times for a total run of 49 trials. As shown in the Fig. 1., a line was tied on the top of the needle and a magnet plate was attached on the other end of line through a pulley. The load was attached on the magnet and used as the stimulus weight. The weights ranged seven steps from 24.0 to 36.0 grams at 1.0 gram interval with 30.0 grams as the standard weight. At the message "Up to standard", the subject moved her thumb until being blocked by a stop set at 45 degrees with standard weight of 30.0 grams. After holding this position for three sec, the thumb was returned to the resting position in response to the instruction "Down to rest" and hold for 3 more sec. Then at the next command "Up to test", the thumb was again abducted until the comparison angle with one of seven weight and held for 3 sec. Finally, the instruction "Judge and down" terminated the trial. The subject was instructed to say "Larger" or "Smaller" at the end of each trial. Eventually, each angle had seven different weights, making 49 (7 angles times 7 weights) combinations with no duplication of angle weight combination. The subjects in Group 2 moved their thumbs with the same procedure as the Group 1 and discriminated the weight.

RESULTS AND DISCUSSION

The percentage of responses in which comparison was judged to be larger than standard was plotted against the comparisom angle (Fig. 2).

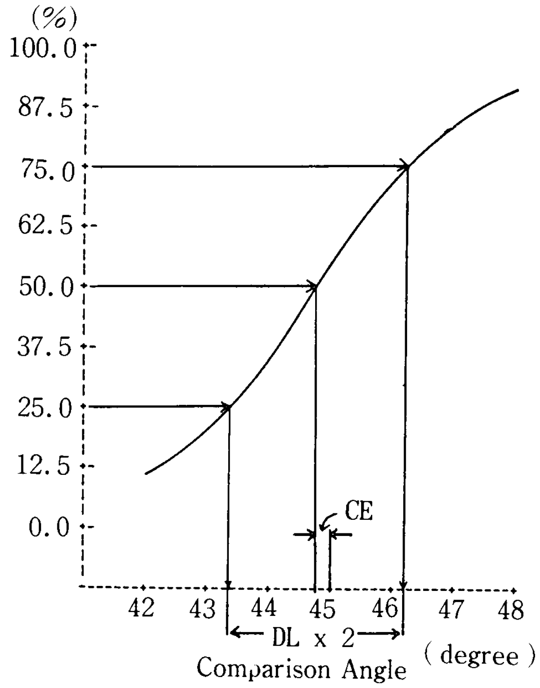

Fig. 2. pictorial presentation of Difference Limen and Constant Error

The difference limen was calculated as one-half the difference between the angle or weight judged larger 75% of the time and that judged as larger only 25% of the time than the standard angle or weight, as indicated by GALANTER (1962)[11]. Another dependent variable, constant error, was obtained as the difference between the angle or weight judged larger 50% of the time and the standard. Since the relationship between per-cent larger judgements and stimulus intensity was sigmoid rather than linear, a "probit analysis" was used to estimate the 25th, 50th, and 75th percentiles of each subject's responses.

Means and standard deviations of each side on difference limen and constant error are given in Table 1 and 2. The difference limen and constant error between the right and left thumbs were tested by a related t-test for the position and weight discrimination tasks respectively. Only difference limen of spatial task (angle discrimination) showed significant difference ($t=1.8407$, $df=24$, $p<0.05$, one-tailed) between hands.

Table 1. Difference Limen: Means and Standard Deviations

Group	1 (Space) (degree)		2 (Weight) (gram)	
Side	R	L	R	L
Mean	1.10 *	0.92	1.29	1.38
S.D.	0.429	0.255	0.515	0.636
N	25	25	25	25

* $p<0.05$

Table 2. Constant Error: Means and Standard Deviations

Group	1 (Space) (degree)		2 (Weight) (gram)	
Side	R	L	R	L
Mean	0.09	0.06	-0.29	-0.30
S.D.	0.415	0.488	0.692	0.765
N	25	25	25	25

The results of this experiment indicated that the left thumb had more sensitive angular position discriminability than the right thumb in the right handed subjects. Although the experimental procedure was identical between two tasks, the observed lateral difference was inconsistent. In the brain, spatial judgement was dominantly processed in the right hemisphere as indicated by other sensory modalities. This might have caused the left thumb dominance. However, the weight discrimination ability, which is believed to be evolutionally old function, was not lateralized in the present study. These findings support the assumption that the direction of lateral dominance of manual task is predictable.

REFERENCE

1) ANNETT, M.:Ann. Hum. Genet: **37**, 93 (1973).

2) ANNETT, M.:Behavior Genetics : **8**, 227 (1978).

3) BEAUMONT, J.G.:Hemispheric Function in the Human Brain, John Wiley and Sons, 89 (1974).

4) BENTON, A.L.,VARNEY, N.R.,and HAMSHER, K.S.: Neuropsychol. 16, 109 (1978).

5) BOKLAGE, C.E.:Acta. Genet. Med. Gemellol., **30**, 167 (1981).

6) CHI, J.D.,DOOLING, E.C.,and GILLES, F.H.:Arch. Neurol **34**, 346 (1977).

7) COLLEY, A.:Cortex, **20**, 47 (1984).

8) CORBALLIS, M.C.and MORGAN, M.J.:Behav. Brain. Sci., **2**, 261 (1978)。

9) DURNFORD, M. and KIMURA, D.:Nature, **231**, 394 (1971).

10) FINNEY, D.J.Probit Analysis, London, Cambridge Univ. Press (1971).

11) GALANTER, F.New Direction in Psychology, N.Y., Halt, Rinehart, and Winston, 87 (1962).

12) GAZZANIGA, M.S., BOGEN, J.E., and SPERRY, R.W. Brain, **88**, 221 (1965).

13) GESCHWIND, N.G. and GALABURDA, A.M.: Arch. Neurol. **42**, 428 (1985).

14) GESCHWIND, N.G. and GALABURDA, A.M.: Arch. Neueol. **42**, 521 (1985).

15) GESCHWIND, N.G. and GALABURDA, A.M.: Arch. Neurol. **42**, 634 (1985).

16) GESCHWIND, N.G.and LEVITSKY, W.:Science, **161**, 186 (1968).

17) INGRAM, D.:Neuropsychol. 13, 95 (1975).

18) KIMURA,D.and VANDERWOLF,C.H.:Brain, **93**, 769 (1970).

19) LEMAY, M and CULEBRAS :New Engl. J.Med., **286**, 168 (1972).

20) LEVY,J.:Neuropsychol. **15**, 187 (1977).

21) NACHSHON, I.and CARMON, A.:Cortex, **11**, 123 (1975).

22) NISHIZAWA, S.:Memoirs, S.J.C.N., **16**, 59 (1985).

23) Nishizawa, S.:Cortex, **23**, 485 (1987).
24) Oldfield,R.G.:Neuropsychol. **9**, 97 (1971).
25) Rasmussen, T. and Milner,B.:In S.Diamond and D.Biizzard (eds), Evolution and lateralization of the brain :N.Y.,N.Y.Academy of Science, 355, (1977).
26) Roy, E.A.and MacKenzie, C.:Cortex, **14**, 250 (1978).
27) Witelson, S.F.and Pallie,W.:Brain, **96**, 641 (1973).
28) Wada, J.A., Clarke, R., and Hamm, A.:Arch. Neurol. **32**, 239 (1975).

利き手考（Ⅱ）：筋感覚依存による空間知覚と重量知覚の差異について

西沢　昭

脳優位性の観点から，実験手順はまったく同一の筋感覚テストを右手利きの二つのグループに実施した。第１のグループは拇指角度の弁別を，第２のグループ拇指による重量の弁別を行わせた。空間知覚は筋感覚依存の場合も右脳が優位であることから，左手での成績がよいことが考えられた。重量知覚は脳優位性の観点からは偏側性は予知できない。実験の結果は，拇指の角度弁別で左がよく，重量弁別では左右差は無かった。これらは説を支持するものである。これらのことから，利き手を機能的優位性として捉えると，課題の種類により利き手は決定されること，及び質問による場合には運動プログラムに影響されない項目を作ることの重要性が示唆された。