Intra- and inter-hemispheric tactile identification matching in young children

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The present study was conducted to examine the developmental changes of hemispheric specialization and integration in young children. A Handedness Inventory and Intra-/Inter-manual Tactile Identification Matching Test were given to each of 29 five years old children. The results showed that in the Intra-manual Matching condition, the performance level of the right-handers was higher than that of the ambidextrous group. In the right-handers, the left hand's performance was superior to that of the right hand in boys, whereas girls showed no hand difference. In children of ambidextrous, no hand difference was shown between boys and girls. In the Inter-manual Matching condition for the right-handers, boys made fewer errors in left hand first matching condition than in the right hand first matching condition, while girls showed no such difference. For the ambidextrous group, there was no difference between two conditions in both sexes. Based on these results, hemispheric specialization and integration in young children were discussed.

Key words: inter-hemispheric matching, intra-hemispheric matching, tactile function, handedness, children, development.

In previous studies concerning cerebral asymmetry, the primary emphasis has been on which hemisphere is responsible for a particular kind of processing and was motivated by a view of hemispheric processing that considered each hemisphere to function relatively independently to the other. It should be stressed that even in young children both hemispheres are linked to each other in contrast to those individuals with split brain. More attention should be paid to the problems of the nature of the interactional, incorporative, or synergistic work of both sides of the brain, because almost all intellectual activity can

be deemed to be the results of the collaborative work of the left and the right hemispheres (Basso, Bisiach, & Capitani, 1977; Dimond, 1980).

Dimond (1980) proposed a model as for the development of hemisphere specialization, particularly for intellectual activities, that each hemisphere develops its own functional organization, that is, hemispheric specialization, and then the two halves of the brain work collaboratively once this is completed. The present study aims to examine the plausibility for their model by investigating inter- and intra-manual tactile matching performances of the young children.

Krashen (1973) and Yamamoto (1980) indicated that five to six years old children were at the important period of cerebral specialization. Therefore the present study examined the development of the specialization and integration of both hemispheres in tactile recognition of five to six years old children.

An intra-manual matching task was used to examine the specialization of

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tactile recognition and an inter-manual matching task was used to examine the integration of the left and right hemispheres.

If the above model is a plausible one as for the development of hemisphere organization, the following results may be appeared between the right-handers and the ambidextrous children (in this study, the data of the left-handers were deleted due to the scarcity of population, so it may be regarded that the right-hander is handedness-established and the ambidextrous is handedness-nonestablished children). That is, (1) the performance level of the right-handers will be higher than that of the ambidextrous children, (2) the overall performance level on the intra-manual matching task will be higher than that on the inter-manual matching task, (3) the performance level of boys' left hand (right hemisphere) will be superior to that of the right hand (left hemisphere), whereas in girls the performance level of the left hand will be similar to that of the right hand as observed by elsewhere (Wolff & Cohen, 1980; Annett & Kilshaw, 1982).

Experiment 1

Method

Subjects. The subjects were 18 males and 15 female children. Their mean age was five years eight months, ranging from five years three months to six years two months. Four left-handers were not included in the following analysis. They all had average intelligence and no sign of behavioural abnormalities (e.g., hyperactivity, perceptual-motor impairment, emotional lability) by teachers' report.

Stimuli and apparatus. In the Tactile Form Identification Test, the stimuli used were 4 cm×4 cm×0.3 cm random shapes which were glued to the center of a 10 cm×10 cm×0.4 cm plywood board. These were identical used by Yamamoto and Hatta (1980). The apparatus consisted of an 18 cm×55 cm×1 cm acrylic resin plate

which had two squares in which to insert the tactile stimuli. The two concaves were located side by side with a distance of 25 cm between them.

Procedure. (1) Handedness Inventory: The handedness was assessed by administering a series of 10 unimanual tasks (writing, toothbrushing, hairbrushing, scissorsing, throwing, fingerpainting, lifting the lid, holding chopsticks, using an eraser, and pulling a doorknob) based on the H. N. Handedness Inventory (Hatta & Nakatsuka, 1975). (2) Tactile Form Identification Test: In the intra-manual matching, each subject sat at a table on which the experimental apparatus was placed facing the experimenter. First, the subject was allowed to freely examine each of the stimuli both tactually and visually. Then, each subject had his/her vision occluded with an eyemask, so that subject could see neither the experimenter nor stimuli, but could reach the concaves easily.

Each subject was allowed to manipulate the standard stimulus with one hand for 5 s, then the comparison stimulus was presented to the same hand. The subject was requested to judge if the standard and the comparison stimuli were identical or not as quickly and as accurately as possible. Fourteen trials were given to each hand, thus 28 tactile matchings were made by each subject. Half of the subjects conducted this matching with their left hand first, then with their right hand. The other half of the subjects completed these trials with their right hand first and left hand second. In a half of the trials of each hand condition, "same" responses were correct and in the other half trials, "different" responses were correct. The presentation order of the "same"/"different" pairs was randomly arranged.

Results

(1) Handedness Inventory: This inventory revealed that 17 subjects (nine boys and eight girls) were right-hander

Table 1
Mean correct percentages and *SDs* in the Tactile
Form Identification Test

Condition		Intra-manual matching			
Group		Right hander		Ambidextrous	
Sex		Boy	Girl	Boy	Girl
LH	M	88.1	87.5	72.8	73.8
	<i>SD</i>	12.2	9.3	18.2	14.2
RH	M	76.2	87.6	70.8	68.7
	<i>SD</i>	11.3	9.9	18.4	29.2
		Inter-manual matching			
LR	M	76.2	67.6	66.5	67.8
	<i>SD</i>	13.2	10.8	14.0	10.9
RL	M	65.2	69.6	83.8	70.2
	<i>SD</i>	15.0	9.5	13.6	7.8

LH: Left hand, RH: Right hand, LR: Left hand first condition, RL: Right hand first condition.

and four were left-hander, and 12 (six boys and six girls) were ambidextrous.

(2) Tactile Form Identification Test: The mean correct responses of the left and the right hands by boys and girls in each group are presented in Table 1. A three way analysis of variance (groups $\times$ hand $\times$ sex) revealed the main effect of groups was significant ($F(1,25)=5.03$, $p<.05$); the right handers showed greater accuracy than the ambidextrous group. Both main effects of hand and sex were not significant. Neither the interaction of groups by hand nor groups by sex was significant. The interaction of groups by sex by hand was significant ($F(1,25)=8.78$, $p<.001$). This interaction reflected the fact that the left hand was superior to the right hand ($F(1,15)=10.1$, $p<.001$) in boys, whereas girls showed no hand difference for the right-handers. For the ambidextrous group, boys and girls showed no hand difference.

Experiment 2

Method

Subjects. The same 29 subjects (15 boys

and 14 girls) participated in the first experiment were used.

Stimuli and apparatus. For the Handedness Inventory and the Tactile Form Identification Test, the apparatus for stimulus presentation was identical to those employed in the first experiment.

Procedure. In each trial for inter-manual matching, the subject had the standard stimulus presented to his/her hand, and then the comparison stimulus was presented to his/her opposite hand. In a half of the trials, the standard stimuli were presented to the left hand first, and in the other half of the trials the standard stimuli were presented to the right hand first. Half of the subjects completed their matchings with the left hand first and the right hand second, and the other half of the subjects performed the matchings with the reversed hand order.

As in the Experiment 1, half of the trials were "same" trials and the other half were "different" trials, and both were arranged randomly.

A total of 28 matching trials were given to each subject.

Results

Table 1 gives the mean correct percentages and standard deviations for each hand by boys and girls in the right-handers and ambidextrous groups. The analysis of variance (groups $\times$ hand order (left hand $\rightarrow$ right hand: L-R; right hand $\rightarrow$ left hand: R-L) $\times$ sex) was performed on these data. No main effect was significant. Neither the interaction of groups by sex, nor the interaction of hand order by sex was significant. However, the interaction of groups $\times$ hand order $\times$ sex marginally approached significance ($F(1,25)=3.40$, 3.16, $p<.10$). In the group of right handers, boys made significantly fewer errors in the L-R condition than the R-L condition ($t=1.91$, $df=15$, $p<.05$), while girls made equivalent errors in the L-R and R-L conditions. In the group of ambidextrous, there was no significant difference either

in boys or girls between the L-R and the R-L condition.

Discussion

The present study was conducted to examine the developmental processes of hemispheric specialization and integration and handedness establishment in tactile function. Toward this end, five to six years old children were given two tactile recognition tasks as Groden (1969) and Bruml (1972) reported that the handedness of the children is established around the age five, though until this age the handedness is not settled and seemed to be ambidextrous.

There was no significant difference between group performance levels in the inter-manual matching task, whereas the performance levels in the intra-manual matching task were higher in the group of right handers than in the group of ambidextrous. These results are parallel with previous lateralization studies that used handedness as an index of lateralization (Caplan & Kinsbourne, 1981; Miller, 1982).

As predicted, the performance level of the intra-manual matching task was higher than that of the inter-manual matching task. In the former task, two stimuli were projected into the same hemisphere, whereas in the latter task, the standard stimulus was projected to the one side of the hemisphere and the comparison stimulus to the other side of the hemisphere. Thus, in the inter-manual matching judgement, transfer of information via corpus callosum is needed.

Bisiach, Mini, Sterzi, and Vallar (1982) reported an experiment using a visual-tactile matching task. They reported that simple manual RTs to lateral visual stimuli were found to be faster in the intrahemispheric matching than in the interhemispheric matching condition. Their study are coincident with those of this study.

There was no difference in performance levels between boys and girls for the inter-

manual matching task. The performance level of the intra-manual matching task was higher with the right hand in boys, but equal performance levels were shown with both hands in girls. Burnstein, Bank, and Tarvik (1980) and several other studies (Vandenberg & Kuse, 1983; Wolff & Cohen, 1980) have reported that, for females, language may not be as specially located in the left hemisphere as it for males. Several lines of research indicate that males might be more lateralized than females, and this difference in cerebral organization is thought to underlie the observed sex differences in verbal and spatial abilities. Namely, the existence of greater hemispheric specialization in males than in females based upon observed difference in verbal and visuospatial performances may be due to greater cerebral lateralization among males. The results obtained from this study seem to be parallel with their claim.

Galin, Johnstone, Nakell, and Herron (1979) have investigated the development of cerebral specialization and hemispheric transfer in three to five years old children with a simple texture discrimination test. Their results were as follows; no significant difference was observed between hands for all age groups in the uncrossed condition, but there was a significant difference between the age groups in the crossed condition. Specially, crossed errors were more prominent than uncrossed errors in three years old, whereas crossed errors were equivalent to uncrossed errors in five years old. Galin et al. (1979) concluded from these results that in three years old children, cerebral specialization of tactile function is not complete whereas in five years old children, cerebral specialization has been completed but interhemispheric integration is still immature.

The present results were summarized as follows; in both handedness groups, the performance levels in the inter-manual matching task were similar. However, in the intra-manual matching task, the

performance level of the group of right handers was superior to that of the ambidextrous group. Furthermore, the group of right handers showed greater hemisphere specialization than the ambidextrous group.

The performance of the older/younger groups in Galin et al.'s (1979) study was similar to that of the both handedness groups.

Though further systematic examination is required, the present results indicate that, as Galin et al. suggested, age five may be an important period in hemispheric development. That is, cerebral specialization for tactile function is nearly completed but interhemispheric integration is still being developed.

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