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ABSTRACT

A follow-up study was made of cross-sectional research on the development of dichhaptic lateralization. One hundred and eighty students in grades 3, 5, 7, 9, and 11 from two school districts were tested. Participants were 9 boys and 9 girls from each grade level for each district. Subjects were at least 90 percent right-handed, as determined by the unimanual tests from the Harris Test of Lateral Dominance, and were observed to use the right hand for writing. When subjects were first tested one year earlier, the mean age of subjects at each grade level was, respectively, 97, 121, 146, 170, and 192 months. During the treatment phase of the study, subjects sat in front of a wooden box, placed their hands into holes, manually explored two irregular wooden shapes with their fingers for three seconds, viewed a slide projecting a shape for three seconds, and indicated whether one of the shapes they had felt--and with which hand--was the one depicted on the screen. The experimental design included verbal and manual response conditions, with 40 trials for each condition. Overall, boys were more accurate than girls, and subjects displayed a left-hand advantage for nonlinguistic shapes on the manual task. Higher order interactions were found which suggested that lateralization develops with age. It is concluded that longitudinal studies will reveal developmental trends in lateralization and that changes in lateralization will be greatest during the early school years. (RH)

A Longitudinal Study of the Development of Dichhaptic Lateralization

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Abstract

This study examined the ontogenic development of dichhaptic lateralization. A total of 180 students from grades 2 through 11 were each tested twice, 12 months apart, on a dichhaptic procedure. There were both verbal and manual response modalities. Overall, boys were more accurate than girls, and subjects displayed a left-hand advantage for nonlinguistic shapes on the manual task. There were also higher order interactions which suggested that lateralization develops with age.

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Questions concerning the development of cerebral lateralization have remained largely unanswered during the past decade. It has been hypothesized that cerebral asymmetries are not present at birth, but then develop with ontogeny. However, few studies have actually demonstrated the hypothesized developmental trends, whereas several have found no developmental trends.

It is quite possibly that the small number of positive findings are partly attributable to the type of research design that has been employed. With few exceptions, these studies have used cross-sectional designs - that is, individuals at one age are compared to other individuals, either younger or older. It may be more appropriate when studying a developmental trend to use a longitudinal design and to look for intraindividual changes that occur over time (Bakker, Hoefkens, and Van der Vlugt, 1979). Such designs often have greater power to detect developmental differences.

The single study that did find developmental trends for the lateralization of haptic perception was reported by Flanery and Balling (1979). They used a nonlinguistic tactual task and found that although first and third graders did not display any hand difference, fifth graders and adults did display a left-hand advantage. Other studies (Witelson, 1974, 1976; Gibson and Bryden, 1983; Van Blerkom, 1985) have all failed to find any consistent developmental trends.

The study reported here was a follow-up to a cross-sectional study of the development of dichhaptic lateralization (Van Blerkom, 1985). Subjects were retested approximately one year after initial testing to determine what within-subjects changes had occurred.

Method

Subjects

A total of 180 students in grades three, five, seven, nine, and eleven from two working- and middle-class western Pennsylvania school districts were tested during the 1983-1984 school year. There were nine boys and nine girls from each grade level for each school district involved in this study. Subjects were all at least 90% right handed, as determined by the unimanual tests from the Harris Test of Lateral Dominance (Harris, 1974). All subjects were observed to use their right hand for writing. At the time

of the original testing (one year prior to this study), the mean age of subjects at each grade level was, respectively, 97 months, 121 months, 146 months, 170 months, and 192 months.

Procedures

The stimuli were ten irregular wooden shapes, approximately 4 x 4 x 1-cm, mounted on mat board squares. The testing apparatus was a wooden box with two holes cut into the front where subjects could place their hands. There were two depressions cut into the floor of the box into which the mat board squares, with the stimulus shapes, could fit. On the top of the box was a Singer Caramate rear screen projector which displayed likenesses of the individual shapes.

During the previous year 200 subjects had been screened on the Harris test and given the dichhaptic task. One hundred eighty of the original 200 were identified as still being available and were retested approximately 12 month after their initial testing.

All subjects sat in front of the wooden box and placed their hands into the holes. They were told that they would be feeling wooden shapes with the middle three fingers of each hand. They heard a tone which was their signal to begin to simultaneously feel a shape with each hand. After three seconds they heard a second tone which signaled them to lift their hands from the shapes. Simultaneously, a slide appeared, for three seconds, on the screen in front of them. At that point they identified if they had felt the shape shown on the screen. The brief stimulus and response times were employed in order to reduce any confounding influences of memory processes.

There were verbal and manual response conditions, with 40 trials for each condition. In the verbal condition subjects responded to each slide with a verbal "left," "right," or "neither." In the manual condition they responded by raising the index finger on the hand that had felt the designated shape. A "neither" reponse was indicated by pointing down with both index fingers simultaneously. For each condition there were a total of ten left-matches, ten right-matches, and 20 no-matches.

Results

These data were analyzed by means of a five-factor analysis of variance with cohort and gender as between-subjects factors and response modality, hand, and year of testing (first year and second year testing) as within-subjects factors. This resulted in a significant Year x Modality x Hand interaction, F (1, 170) = 15.74, $p < .001$, which made interpretations fairly difficult. Therefore, to make interpretations somewhat easier these data were reanalyzed by a separate four-factor analysis of variance for each response modality.

The analysis of the verbal responses resulted in significant main effects for cohort, F (4, 170) = 16.36, $p < .001$; gender, F (1, 170) = 8.11, $p < .01$; and year, F (1, 170) = 9.44, $p < .005$ (see Table 1). Older students displayed greater accuracy than younger students, boys were more accurate than girls, and accuracy was greater at retesting. No other effects were significant.

The analysis of the manual responses resulted in eight significant effects (see Table 2). All four main effects were significant, including a main effect for hand, F (1, 170) = 25.35, $p < .001$ - that is, there was a significant left-hand advantage for this spatial task. The main effects for cohort, F (4, 170) = 17.09, $p < .001$; gender, F (1, 170) = 5.27, $p < .03$; and year, F (1, 170) = 4.07, $p < .05$, were all in the same direction as they were for the verbal responses. There were also significant interactions for Gender x Year x Hand, F (1, 170) = 4.19, $p < .05$; for Cohort x Gender x Hand, F (4, 170) = 2.45, $p < .05$; for Year x Hand, F (1, 170) = 12.33, $p < .002$; and for Cohort x Gender, F (4, 170) = 2.90, $p < .03$.

Two of the above interactions require some further explanation. The Gender x Year x Hand interaction revealed that, overall, upon first testing neither boys nor girls displayed any hand advantage. However, upon retesting boys displayed a significant left-hand advantage, whereas the left-hand advantage for girls was not significant. The Cohort x Gender x Hand interaction indicated that, averaged over the two testing sessions, the cohort group of boys that displayed the greatest left-hand advantage was the sixth and seventh graders. The girls from the same cohort displayed the smallest hand difference compared to all other girls. Girls displayed their largest hand difference at the eighth and ninth grades.

Discussion

What is clearly most striking about these data is that the youngest two cohorts (second and third graders, and fourth and fifth graders) displayed nearly identical behavior in the manual response condition (see Figure 1). At the first testing both groups performed equally well with either hand. However, upon retesting, one year later, right-hand accuracy displayed nonsignificant decreases while left-hand accuracy increased significantly, resulting in a left-hand advantage. In fact, over all 180 subjects, the Year x Hand interaction was highly significant ($p < .002$), resulting in a left-hand advantage at retesting.

The design of the study resulted in the effects of testing and maturation confounding one another. Separate control groups would be required to partial out the effects of testing. However, retesting effects can be estimated by examining regression equations estimating second year right-hand and left-hand performance from the first-year testing. Such an analysis indicated that the retesting effect was greatest for the youngest cohort group. Of all groups they displayed the largest left-hand advantage during the second year.

In order for these data to clearly demonstrate a developmental trend in lateralization it would be necessary to have a significant Cohort x Year x Hand interaction, which was not present. Although other significant findings suggest the presence of developmental trends, they all do so less clearly.

Even though this study does have some limitations that make interpretations difficult, it still strongly suggests that longitudinal studies will reveal developmental trends in lateralization. It also suggests that changes in lateralization will be the greatest during the early school years.

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Table 1
Analysis of Variance Summary Table:
Verbal Response Condition

Source	SS	df	F	p
Between Subjects				
Cohort	30,858.89	4	16.36	.001
Gender	3,827.22	1	8.11	.005
Cohort x Gender	1,239.44	4	0.66	.623
Error	80,188.89	170		
Within Subjects				
Year	2,722.22	1	9.44	.002
Cohort x Year	863.89	4	0.75	.560
Gender x Year	845.00	1	2.93	.089
Cohort x Gender x Year	785.56	4	0.68	.606
Error	49,033.31	170		
Hand	27.22	1	0.11	.741
Cohort x Hand	650.56	4	0.66	.623
Gender x Hand	568.89	1	2.30	.131
Cohort x Gender x Hand	220.00	4	0.22	.926
Error	40,083.33	170		
Year x Hand	405.00	1	2.29	.132
Cohort x Year x Hand	447.78	4	0.63	.634
Gender x Year x Hand	320.00	1	1.81	.180
Cohort x Gender x Year x Hand	1,049.44	4	1.49	.209
Error	30,027.78	170		

Table 2
Analysis of Variance Summary Table:
Manual Response Condition

Source	SS	df	F	p
Between Subjects				
Cohort	29,993.89	4	17.09	.001
Gender	2,311.25	1	5.27	.023
Cohort x Gender	5,083.89	4	2.90	.024
Error	74,584.73	170		
Within Subjects				
Year	1,416.81	1	4.07	.045
Cohort x Year	1,025.56	4	0.74	.568
Gender x Year	306.81	1	0.88	.349
Cohort x Gender x Year	485.56	4	0.35	.845
Error	59,140.28	170		
Hand	5,173.47	1	25.35	.001
Cohort x Hand	546.67	4	0.67	.614
Gender x Hand	50.14	1	0.25	.621
Cohort x Gender x Hand	2,003.33	4	2.45	.048
Error	34,701.39	170		
Year x Hand	2,683.47	1	12.33	.001
Cohort x Year x Hand	1,283.89	4	1.47	.212
Gender x Year x Hand	911.25	1	4.19	.042
Cohort x Gender x Year x Hand	783.89	4	0.90	.465
Error	37,012.50	170		

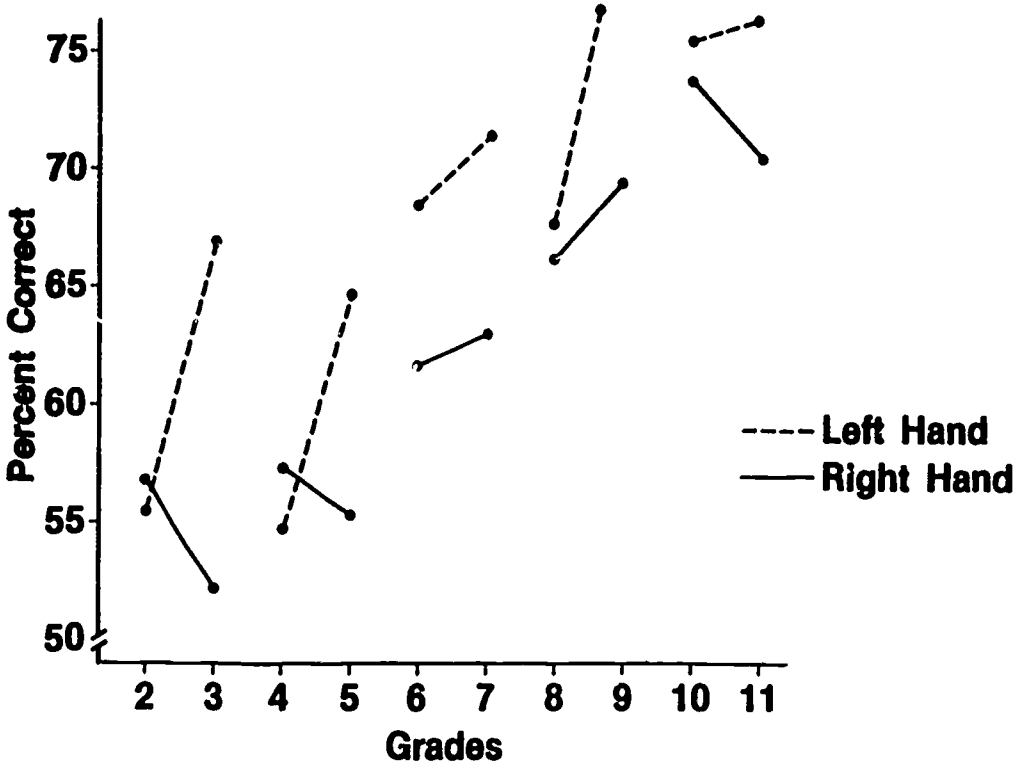

Figure 1: Developmental changes in lateralization among five cohort groups over a two-year period - manual response condition