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Perceptual Asymmetry for Chimeric Faces across the Life Span

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Perceptual asymmetries for processing chimeric faces were investigated in dextral subjects, ranging in age from 5 years to elderly adults. The task involved deciding which member of a pair of face chimeras presented in free vision looks happier, the one with the smile to the left or its mirror image with the smile to the right (Levy, Heller, Banich, & Burton, 1983a, *Brain and Cognition*, **2**, 404–419). A leftward bias was found for all age groups. However, kindergarteners' mean asymmetry score was lower than that of all other groups combined, most likely due to noise in their data. The direction in which subjects drew circles with their left and right hands was also observed as an index of interhemispheric communication. All groups showed a bias toward drawing the circles in concordant directions except the kindergarteners. The relation between subjects' performance on the circle drawing and facebook tasks is discussed.

Differential right hemisphere involvement in the recognition of faces is supported by studies of patients with unilateral cortical lesions (e.g., Warrington & James, 1967; Benton & Van Allen, 1968; DeRenzi, Faglioni, & Spinnler, 1968), studies of commissurotomy patients (e.g., Levy, Trevarthen, & Sperry, 1972), and studies of normal adults (e.g., Geffen, Bradshaw, & Wallace, 1971; Rizzolatti, Umiltà, & Berlucchi, 1971; Hilliard, 1973; Klein, Moscovitch, & Vigna, 1976; Leehey, Carey, Diamond, & Cahn, 1978; Levine & Koch-Weser, 1982). In addition to supporting a

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right hemisphere advantage in the recognition of faces themselves, studies of unilaterally brain-damaged patients (e.g., Cicone, Wapner, & Gardner, 1980; DeKosky, Heilman, Bowers, & Valenstein, 1980; Kolb, Milner, & Taylor, 1983) and studies of normal adults (e.g., Buchtel, Campari, DeRisio, & Rota, 1978; Heller & Levy, 1981; Ley & Bryden, 1979; Làdavas, Umiltà, & Ricci-Bitti, 1980; Safer, 1981; Strauss & Moscovitch, 1981) provide evidence for a right hemisphere advantage in the recognition of emotional facial expressions.

Studies of perceptual asymmetries in normal adults have typically employed tachistoscopic presentation of stimuli to lateralized view. For the recognition of both faces and facial emotions, normal adults manifest a left visual field (LVF) (right hemisphere) recognition advantage (e.g., Geffen et al., 1971; Buchtel et al., 1978; Làdavas et al., 1980; Levine & Koch-Weser, 1982). Studies employing free vision presentation of face stimuli with normal subjects have also elicited leftward perceptual biases (Gilbert & Bakan, 1973; Campbell, 1978; Levy, Heller, Banich, & Burton, 1983a). The results of these studies suggest that it is not necessary to restrict initial input to a single hemisphere to elicit a perceptual bias in normal subjects. In fact, the results of the free vision face laterality tasks suggest that the LVF bias reported for tachistoscopically presented faces may in part reflect an attentional bias toward the left induced by selective activation of the right hemisphere, which is specialized for face processing (Kinsbourne, 1974; see also discussion in Levy, Heller, Banich, & Burton, 1983b).

Because of the brevity of the free vision face test of Levy et al., (1983a) (approximately 10 min), and the simplicity of the judgment involved (which of two faces looks happier), it seemed ideally suited for investigations of hemispheric specialization in children. Moreover, because there are no right or wrong answers on this task, interpretation of possible age changes in laterality is not affected by variations in performance level. The present study takes advantage of these features of the free vision face task to investigate whether there are age changes in direction or degree of perceptual asymmetry for processing face chimeras in subjects ranging in age from 5 years (kindergarten) to elderly adults (65 years and over).

In addition to the free vision facebook test all subjects except the elderly adults were asked to draw two circles on a piece of paper, one with their left hand and one with their right hand. There is some evidence that when circles are drawn in the same direction by the right and left hands, the drawing motions of the two hands are regulated by the dominant hemisphere. In contrast, when circles drawn by the right and left hands are in opposite directions, it appears that each hemisphere controls the drawing motion of the contralateral hand. Thus, Wilke and Sheeley (1979) found that right-handers typically draw circles in concordant directions with the two hands, but that left-handers typically draw circles in discordant directions. The authors suggest that interhemispheric control is diminished in left-handers, so that each hemisphere operates relatively independently of the other. We sought to determine whether drawing circles in discordant directions by the two hands would also be more common in younger than older children, since callosal maturation is a protracted developmental process not complete until the end of the first decade of life. We also investigated whether concordance/discordance in circle direction would relate to perceptual asymmetries shown on the face task.

METHOD

Subjects. Subjects were 180 right-handers, 20 in each of nine age groups [kindergarten (mean age 5 years 8 months, *SD* 4.9 months), Grade 1 (mean age 6 years 8 months, *SD* 4.8 months), Grade 2 (mean age 7 years 9 months, *SD* 4.2 months), Grade 4 (mean age 9 years 9 months, *SD* 3.4 months), Grade 6 (mean age 11 years 7 months, *SD* 3.8 months), Grade 8 (mean age 13 years 8 months, *SD* 3.3 months), Grade 10 (mean age 15 years 7 months, *SD* 3.5 months), Grade 12 (mean age 17 years 8 months, *SD* 5.6 months), and elderly adult (mean age 78 years 4 months, *SD* 9 years 6 months)]. Ten males and ten females were tested in each age group. All of the children tested attended the Laboratory Schools at the University of Chicago. The elderly adults attended an activities program at the Jewish Council for the Elderly in the same neighborhood.

For subjects in the younger age groups (kindergarten through sixth grade), handedness was assessed by observing subjects write their names, throw a ball, and use a spoon and a hammer. For subjects in the older age groups (eighth grade through adult) handedness was assessed by observing subjects write their names and by asking them which hand they used to perform the other activities. Eyedness was assessed by having subjects site the experimenter's nose through a cone. All subjects included in the study used their right hand to perform all four activities. Eye dominance was tested but was allowed to vary among subjects.

Procedure. The stimuli and procedures were the same as used by Levy et al. (1983a). Neutral and smiling photographs of each of nine male posers were used to construct 36 items. The two photographs from each poser were cut in half on the midsagittal axis and recombined to make two different chimeras, one with the smile produced by the left half of the poser's face and the neutral expression by the right half and vice versa. Each of the two chimeras was paired with its mirror image, once with the normal print at the top of the page and the mirror print at the bottom, and once with positions reversed. This yielded four pairs of stimuli for each poser, for a total of 36 items. For each stimulus pair, the smiling half face had been produced by one half of the poser's face and the neutral expression by the other, and one member of the pair was a normal print and the other was its mirror image. Each poser appeared once in each of the four quarters (nine trials) of the task.

Subjects in kindergarten through Grade 12 were tested individually and were shown the stimuli in a booklet form. For each stimulus pair, the subjects were encouraged to decide which of the faces looked happier. A "can't decide" response was allowed if the subject felt that a discrimination was impossible. Subjects were assured that there were no right or wrong answers. The experimenter recorded whether the top of bottom face was chosen on each trial.

Subjects in the elderly adult group were tested in a group and were presented with slides of the 36 pairs of face chimeras. After each trial, the subjects indicated whether the top or bottom face looked happier by recording a "T" or "B" on their response sheet. Levy et al. (1983a) found that the booklet and slide versions of the task yielded highly similar results.

Rightward responses were those in favor of chimeras in which the smile was to the viewer's right, and vice versa for leftward responses. The laterality measure was the number of pairs (N_R) in which a rightward response was shown minus the number of pairs (N_L) in which a leftward response was shown, divided by the total number of pairs ($N = 36$). Thus, the asymmetry measure, A_i, for an individual subject, i, is

$$A_i = \frac{N_{Ri} - N_{Li}}{36}, \qquad [1]$$

and the standard error of A_i is estimated by

$$SE_{A_i} = \sqrt{(N_{R_i} + N_{L_i})/N^2} \qquad [2]$$

under the null hypothesis that no asymmetry is present.

Split-half reliabilities of laterality scores were calculated by deriving, for each subject, an asymmetry measure based on the 18 odd-numbered items and another asymmetry measure based on the 18 even-numbered items. In addition, first half/second half reliabilities were calculated by deriving an asymmetry measure based on the first 18 trials and the second 18 trials.

Following administration of the free vision face task, each subject in grades K–12 was asked to draw a circle with the right hand on the top half of a piece of paper. Subsequently, the child was asked to draw a circle with the left hand on the bottom half of the paper. The direction in which each circle was drawn, clockwise or counterclockwise, was noted.

RESULTS

A t test performed on all subjects' asymmetry scores showed a highly significant leftward bias on the face task [$t(179) = -9.21$, $p < 1.63 \times 10^{-20}$, one-tailed]. An analysis of variance with Age and Sex as independent variables and Asymmetry Score as a dependent variable revealed that neither the main effects of Age or Sex, nor the Age × Sex interaction, approached significance ($F < 1$ in all cases). Although there was no age effect in the analysis of variance, it should be noted that the kindergarteners' mean asymmetry score was only −.092, compared to −.181 to −.331 for the other age groups (see Fig. 1). Moreover, the kindergarteners' mean asymmetry score differed significantly from the overall mean asymmetry score of the older age groups combined ($F(1, 178) = 4.33$, $p < .04$).

Analogous to Levy et al. (1983a), we classified subjects according to whether they showed a leftward bias, a rightward bias, or no bias, using three different classifying critera. Classification I simply places subjects into groups (Right Bias, No Bias, Left Bias) based on their observed asymmetry scores. Classifications II and III employ statistical criteria.

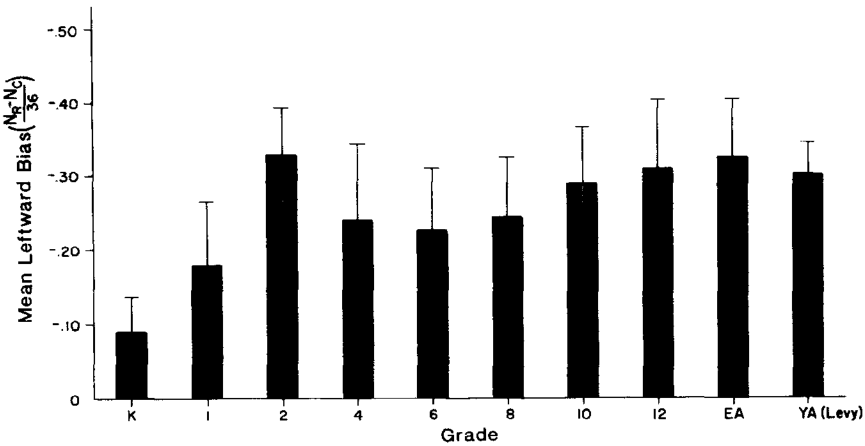

FIG. 1. Mean asymmetry score on the facebook task ($A_i = (N_{R_i} - N_{L_i})/36$) for the subjects in each age group [Kindergarten(K)–Elderly Adult (EA)]. The mean asymmetry score of young adult dextral subjects (YA) from the study of Levy et al. (1983) is plotted for comparison.

For each subject, the significance of the deviation of the asymmetry score from 0 was determined by using the Gaussian approximation corrected for continuity:

$$z_i = \frac{A_i \pm c_i}{SE_{A_i}} \qquad [3]$$

where c is the correction for continuity and equals 0.5/36. For Classification II, the criterion for rejection of the null hypothesis was set at $p = .10$, one-tailed. This level provides reasonable control for Type I errors without entailing an unreasonably high level of Type II errors. For Classification III, the criterion for rejection of the null hypothesis was set at $p = .05$, one-tailed, which decreases the probability of Type I errors and increases the probability of Type II errors. For Classifications II and III, subjects were placed in the No Bias group if their asymmetry scores did not differ significantly from 0 (see Table 1).

Examination of Fig. 2 reveals that the proportion of subjects in each age group who fall into the Left Bias, Right Bias, and No Bias categories based on raw scores (Classification I) is fairly steady with age. Note that these proportions are almost identical to those obtained by Levy et al. (1983a) for 111 dextral young adults. Figure 3 plots the proportion of subjects in each age group who fall into the Left Bias, Right Bias, and No Bias categories using the $p = .10$ criterion (Classification II). Examination of this plot reveals that the proportion of subjects who show a significant Right Bias is steady across age. However, compared to other age groups, the kindergarteners show the lowest proportion with

TABLE 1
DEVELOPMENTAL FACE BOOK BIAS DISTRIBUTIONS

	Mean	*SD*	*N*	Mean	*SD*	*N*	Mean	*SD*	*N*
	Kindergarten			Grade 1			Grade 2		
Classification I									
Right Bias	+.119	+.105	7	+.283	.18	5	+.056	.028	3
No Bias	0	0	2	0	0	2	0	0	1
Left Bias	−.242	.122	11	−.387	.276	13	−.424	.24	16
Classification II									
Right Bias	+.333	0	1	+.472	.04	2	0	0	0
No Bias	−.043	.127	15	−.003	.135	9	−.074	.115	9
Left Bias	−.382	.066	4	−.51	.240	9	−.541	.195	11
Classification III									
Right Bias	+.333	0	1	+.472	.04	2	0	0	0
No Bias	−.043	.127	15	−.046	.162	11	−.111	.132	11
Left Bias	−.382	.066	4	−.579	.226	7	−.599	.162	9
	Grade 4			Grade 6			Grade 8		
Classification I									
Right Bias	+.242	.139	7	+.352	.306	3	+.151	.135	7
No Bias	0	0	1	0	0	3	0	0	1
Left Bias	−.544	.332	12	−.401	.265	14	−.496	.235	12
Classification II									
Right Bias	+.333	.147	3	+.50	.236	2	+.334	.079	2
No Bias	+.075	.144	7	−.074	.096	9	+.025	.089	8
Left Bias	+.022	.183	10	−.543	.219	9	+.575	.159	10
Classification III									
Right Bias	+.417	.039	2	+.50	.236	2	+.389	0	1
No Bias	+.022	.183	10	−.095	.111	10	+.053	.118	9
Left Bias	−.736	.205	8	−.576	.209	8	−.575	.159	10
	Grade 10			Grade 12			Elderly		
Classification I									
Right Bias	+.352	.17	3	+.257	.212	4	+.185	.224	3
No Bias	0	0	0	0	0	0	0	0	1
Left Bias	−.404	.214	17	−.452	.326	16	−.442	.28	16
Classification II									
Right Bias	+.445	.079	2	+.536	0	1	+.444	0	1
No Bias	−.102	.139	6	−.018	.161	8	−.067	.108	8
Left Bias	−.507	.161	12	−.601	.280	11	−.584	.211	11
Classification III									
Right Bias	+.445	.079	2	+.556	0	1	+.444	0	1
No Bias	−.127	.144	7	−.07	.18	10	−.067	.10	8
Left Bias	−.528	.151	11	−.673	.258	9	−.584	.211	11

Note. Classification I, raw bias scores; Classification II, transformed scores, p = .10 criterion; Classification III, transformed scores, p = .05 criterion.

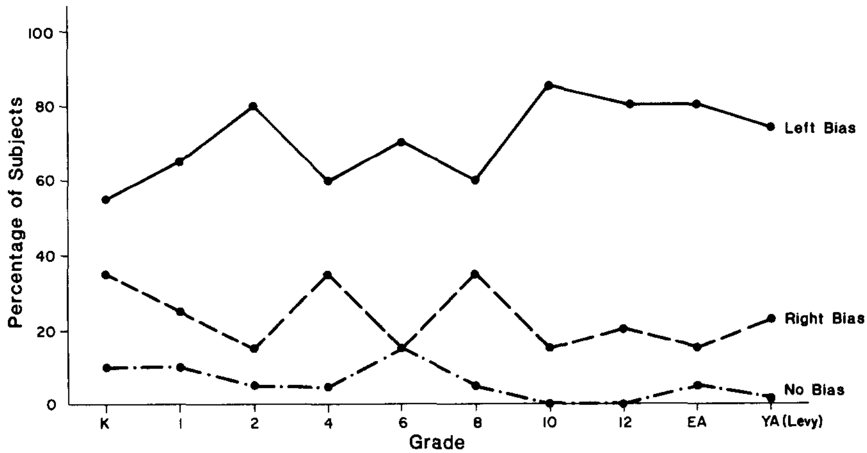

FIG. 2. Percentage of subjects in each age group who show a Left Bias, a Right Bias, and No Bias, according to Classification I, which is based on subjects' raw asymmetry scores. These data are also plotted for subjects in the study of Levy et al. (1983a) for comparison.

a leftward bias and the highest proportion with no bias. Classification III ($p = .05$) is not plotted, as it is almost identical to Classification II ($p = .10$). Thus, the finding that the mean leftward bias of the kindergarten group is somewhat lower than that of the other age groups is not attributable

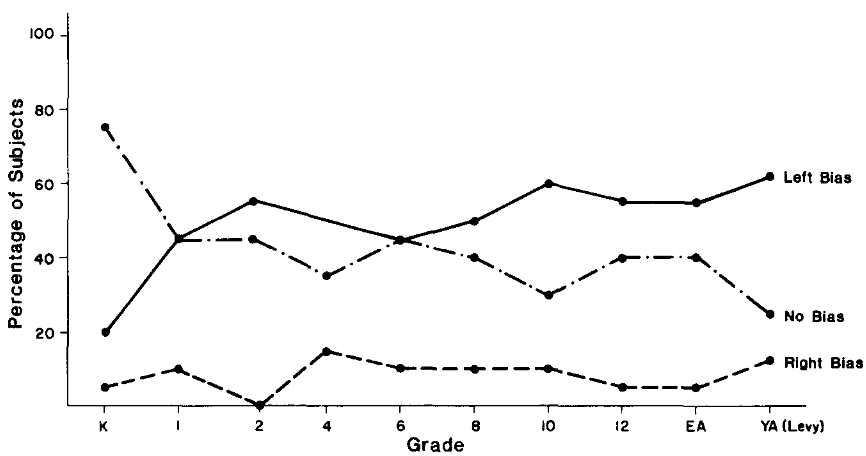

FIG. 3. Percentage of subjects in each age group who show a Left Bias, a Right Bias, and No Bias, according to Classification II, which is based on the statistical criterion that the left or right bias at least be significant at the $p = .10$ level. Data from the study of Levy et al. (1983a) are plotted for comparison.

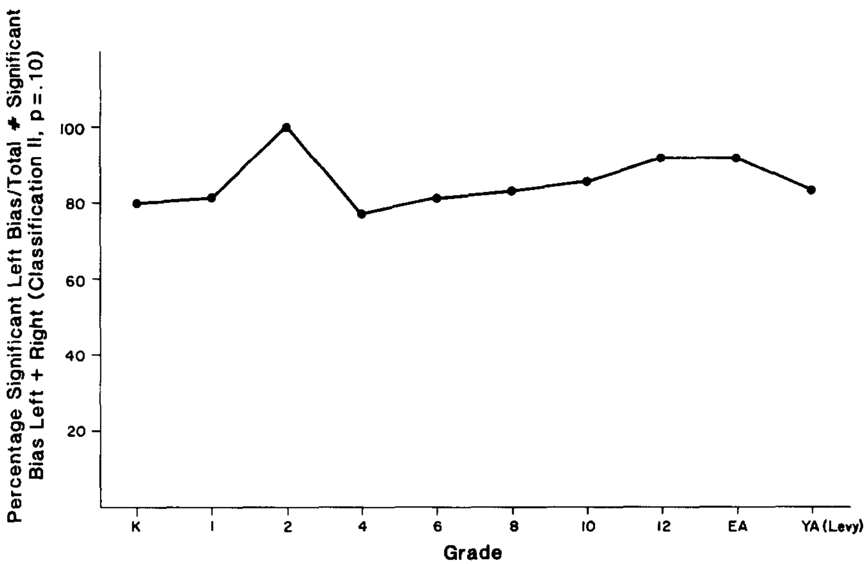

FIG. 4. Number of subjects in each age group who show a significant leftward bias compared to the total number of subjects who show a significant bias in either direction according to Classification II (p = .10). Data from the study of Levy et al. (1983a) are also plotted.

to a shift toward more subjects showing a rightward bias. Rather, the kindergarteners tend to show smaller leftward biases that do not significantly differ from zero, even using the rather liberal $p = .10$ criterion.

Figure 4 shows that the proportion of subjects in each age group who show a significant leftward bias compared to the total number of subjects in each age group who show a significant bias, either to the left or to the right, is extremely stable across age. What varies with age is the proportion of subjects who show a significant bias in either direction (see Fig. 5). Only 25% of kindergarteners show a significant bias to the left or right according to Classification II, compared to 55–70% for all other age groups (mean of other age groups = 60.00%, SD = 5.35%).

Split-half reliabilities (odd- vs. even-numbered trials) were calculated for each age group in order to determine whether the data of younger subjects were noisier than those of older subjects. Table 2 shows that although the kindergarteners attain a significant split-half reliability (r' = .57, $p < .05$), the reliabilities for other age groups from second grade on are higher (r' = .73–.92). Split-half reliability over all age groups combined was r' = .812. The lower split-half reliability for the kindergarteners supports the role of random error in lowering their mean asymmetry score compared to other age groups, and in decreasing the number

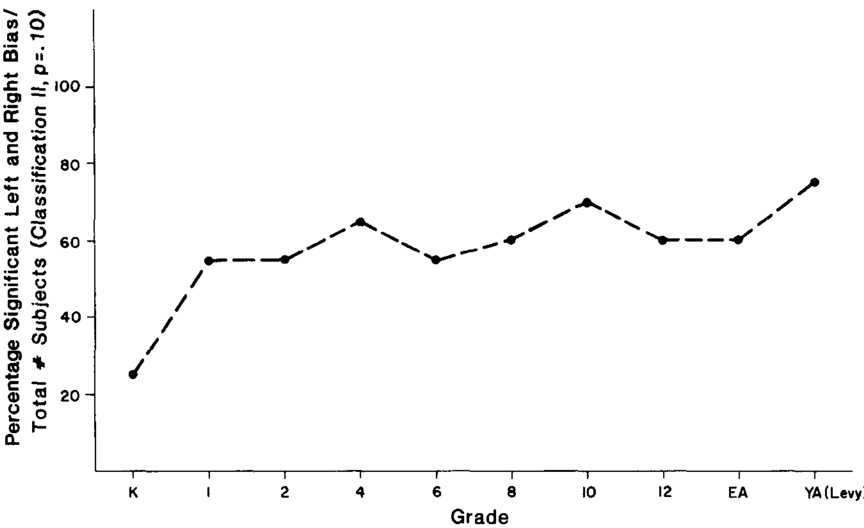

FIG. 5. Number of subjects in each age group who show a significant bias in either direction compared to the total number of subjects in each age group. Data from the study of Levy et al. (1983a) are plotted for comparison.

of subjects who show a significant leftward bias in this age group. Similarly, first half-second half reliabilities were lower for the kindergarteners (.363), as well as second graders (.383), than for the other age groups, who ranged from .578 to .914 (see Table 2).

In an attempt to determine whether a shorter version of the free vision face task would result in less noisy performance in kindergarten age subjects, the mean asymmetry scores of our kindergarteners were examined separately for each quarter of the task (nine trials/quarter). In fact, they

TABLE 2
SPLIT HALF RELIABILITIES

	(Odd/even)	(First half/second half)
K	.569	.363
1	.839	.810
2	.762	.383
4	.733	.914
6	.922	.631
8	.832	.578
10	.864	.867
12	.908	.789
Elderly adult	.870	.866
All groups combined	.812	.747

showed a larger mean left bias on the first block of trials, when they were less likely to be fatigued, than on any other block ($\bar{x} = -.172$). *t* tests reveal that the mean first-quarter asymmetry score of kindergarteners does not differ from the mean first-quarter asymmetry score pooled over the other age groups ($t < 1$), but either differs significantly or marginally significantly on all three subsequent trial blocks (Quarter 2: $t\ (178) = 2.73$, $p < .007$; Quarter 3: $t\ (178) = 1.87$, $p < .07$; Quarter 4: $t\ (178) = 1.60$, $p < .12$). In addition, the mean first-quarter asymmetry score of kindergarten subjects who showed a leftward bias on that trial block was $-.49$, while it was $+.264$ for subjects who showed a rightward bias on that trial block. These means are more similar to those obtained by older subjects on the entire 36-item task than the mean asymmetry scores of the kindergarteners on the entire task (see Table 1).

Intraclass correlations were computed for each age group for the four quarters (blocks) of the facebook test with the expectation that this correlation would be lower for the kindergarteners than for the older age groups. In fact, this correlation was only .127 for the kindergarteners, compared to .265–.661 for the other groups (see Table 3). Together with the finding that the kindergarteners were more similar to the other age groups on Block 1, these intraclass correlations results suggest that the overall asymmetry score of the kindergarteners was lowered by random noise, possibly attributable to inattention on later trial blocks.

The kindergarteners also differed from the other age groups on the circle drawing task. Pearson χ^2 tests showed that the proportion of kindergarten subjects drawing circles in discordant directions was significantly larger than any other age group ($p = .056$ for kindergarteners vs. first graders, the group most similar to the kindergarteners) as well as being significantly larger than the mean of all the other age groups combined ($p < .02$). Only 35% of kindergarteners drew circles in concordant directions vs. a mean of 75% for the other age groups combined. None of the other age groups differed significantly from each other in the frequency of subjects drawing circles in concordant vs. discordant circle directions (see Table 4).

TABLE 3
INTRACLASS (QUARTER) CORRELATIONS

K	.126
1	.539
2	.265
4	.661
6	.412
8	.419
10	.406
12	.637
Elderly adult	.539

TABLE 4
NUMBER OF SUBJECTS DRAWING CIRCLES IN CONCORDANT AND DISCORDANT DIRECTIONS

Grade	Concordant	Discordant	Other
K	7	13	0
1	13	7	0
2	16	4	0
4	17	3	0
6	15	4	1
8	15	3	2
10	15	5	0
12	14	6	0

It should be noted that on our paper and pencil task there was a strong bias toward drawing both circles in the counterclockwise direction for both sexes in every age group. Of the 112 subjects across age who drew circles in concordant directions, 104 (92.9%) drew them in a counterclockwise direction and only 8 (7.1%) drew them in a clockwise direction. Further, the increase in concordant circle drawing after kindergarten is totally attributable to an increase in the proportion of subjects drawing both circles in the *counterclockwise* direction. The finding of a counterclockwise bias is consistent with Burton's (1985) finding of an interaction between visual field and rotation direction on a lateralized tachistoscopic task investigating mental rotation rate. They observed that clockwise rotations were faster in the left visual field (LVF) and counterclockwise rotations were faster in the right visual field (RVF). Thus, a counterclockwise bias in circle drawing may indicate that the dominant left hemisphere controls the direction of circle drawing by both hands. Alternatively, and less interestingly, it may reflect writing patterns taught in school.

The higher incidence of discordant circle drawing among kindergarteners suggests that, for the majority of children in this age group, interhemispheric communication via the corpus callosum is not sufficient to result in left-hemisphere control over the direction of circle drawing by the left hand, perhaps because of an inadequate degree of callosal myelinization at this age. Recall that the kindergarteners also showed the smallest asymmetry on the facebook test. In order to determine whether concordant circle drawing is related to greater asymmetry on the facebook test, and especially so in younger age groups, an analysis of variance with Age and Circle Direction (Concordant/Discordant) as independent variables and Asymmetry Score as a dependent variable was performed. There were no significant main effects or interactions in this analysis, suggesting that direction of circle drawing is not related to facebook asymmetry for the group as a whole. However, it is possible that direction of circle drawing is related to mean asymmetry score on the facebook task for the kindergarteners, the age group that differs most from the other groups on both tasks. Indeed, the mean asymmetry score of kindergarteners with concordant circle directions ($\bar{A}_i$ = −.135, N = 7) was larger than that for those with discordant circle directions ($\bar{A}_i$ = −.068, N = 13).

Consider the possibility that for a certain proportion of kindergarteners, discordant circle direction reflects immaturity of interhemispheric pathways, resulting in an inability of the dominant left hemisphere motor pathways to control the left hand. In view of the fact that a certain number of older subjects continue to draw circles in discordant directions (which cannot be attributed to immaturity), the immaturity factor is likely to underlie the discordant direction of circle drawing in some, but not all, kindergarteners. It is also possible that the lower mean facebook asymmetry score of the kindergarteners as a whole reflects an immaturity factor. If this is the case, one would expect the magnitude of mean asymmetry scores to be less in kindergarteners drawing discordant circles than those drawing concordant circles, particularly those who drew concordant circles in the counterclockwise direction, as this is the pattern that develops with age. One would not expect this relation to be present in the other age groups, because, for these groups, discordant circle drawings no longer reflect immaturity. This follows from the fact that from the first grade on, the proportion of subjects drawing concordant vs. discordant circles does not change significantly.

In order to examine the relation of circle direction and facebook asymmetry score within the kindergarten age group, an analysis of variance was performed on kindergarteners only, with Circle Direction [counterclockwise–counterclockwise (CC–CC), discordant] and Facebook Task Half (first, second) as independent variables and Asymmetry Score as a dependent variable. Because more and less mature children would be expected to show a different relation between first- and second-half performances, task half was included as a factor. The two kindergarten subjects with clockwise–clockwise circle drawings were excluded from this analysis, as this pattern neither increased nor decreased with age. Although the main effect of Circle Direction was not significant, there was a significant interaction of Circle Direction × Task Half ($F(1, 16) = 5.16$, $p < .04$) such that kindergarteners with CC–CC vs. discordant circle directions did not differ significantly in mean asymmetry score on the first half of the task, but the CC–CC group showed a significantly larger mean asymmetry score on the second half than the discordant group ($p < .05$, two-tailed test) (see Fig. 6).

DISCUSSION

The results of this developmental study demonstrate that, pooled across age of subjects, the free vision face task yields a highly statistically

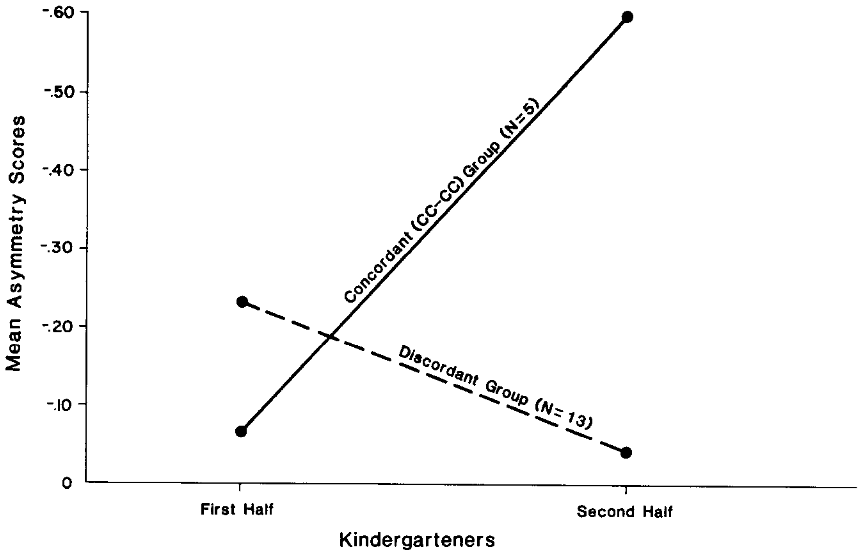

FIG. 6. First-half and second-half asymmetry scores of kindergarteners who drew circles with the two hands in a counterclockwise direction (CC–CC Group, $N = 5$) vs. those who drew the circles in discordant directions ($N = 13$).

significant leftward bias for right-handed subjects. Moreover, the absence of any main effects or interactions involving age of subjects suggests that the right hemisphere is differentially involved in certain aspects of face processing across much of the lifespan. The present findings extend those of Levy et al. (1983a) to dextrals as young as 5 years of age and as old as octogenerians.

The facebook task is extremely useful for both young and elderly subjects, as it only takes about 10 min to administer and is simple for the subject to perform. Analyses of the kindergarteners' data, whose overall leftward bias was somewhat less than older age groups', suggests that an even shorter version of the task may be better suited to their attentional capacities. Our results suggest that the lower overall asymmetry score of the kindergarteners is attributable to unreliability in their data, especially on later trial blocks. Of course, using a shorter version of the facebook task has some drawbacks, as Levy et al. (1983a) report that the items vary somewhat in the strength of the leftward bias that is elicited. With a short task, the risk that item sampling error would result in less valid scores is substantially increased. However, for kindergarten age children, and perhaps somewhat older children as well, a nine-item task may be most satisfactory.

The fact that the elderly manifest leftward perceptual biases as strong as those in Levy et al.'s (1983a) young adults is consistent with prior studies that show no age changes in visual field asymmetry on verbal or nonverbal tasks (Borod & Goodglass, 1980; Byrd & Moscovitch, 1984; Nebes, in press). These investigations and our own lend no support to the idea that right hemisphere function declines asymmetrically with aging. Also, the fact that children as young as 5 years of age show a leftward perceptual bias on the facebook task does not conflict with prior studies. Certain of these studies report that differential right hemisphere involvement in other aspects of face perception or in the expression of facial emotion does not emerge until age 10 or later (Làdavas, 1982; Levine, 1985). However, our findings do not indicate differential right hemisphere capacity on complex face perception and expression tasks by age 5, but merely indicate differential right hemisphere activation on the facebook task by this age.

The circle drawing task complemented the facebook task in that it also showed a difference between kindergarten age subjects and older age groups. Compared to older age groups, the kindergarteners were less likely to draw circles in the counterclockwise direction with both hands and were more likely to draw circles in discordant directions with the two hands. As previously discussed, the drawing of circles in concordant directions may reflect control of the dominant left hemisphere over the direction of circle drawing by both hands. In the case of the left hand, this dominance is via interhemispheric pathways and may well depend on the maturational state of the corpus callosum (Salamy, 1978; Yakovlev & Lecours, 1967). Other behavioral studies (Galin, Diamond, & Herron, 1977; Galin, Johnstone, Nakell, & Herron, 1979; O'Leary, 1980) show that integration between the hemispheres improves at least up to age 5, which is consistent with our data.

The finding of a significant Circle Direction (CC vs. discordant) by Facebook Task Half interaction in kindergarten children lends support to the hypothesis that the circle drawing task is tapping the maturational state of the corpus callosum in this age group. A possible explanation for why children who draw circles in discordant directions show significantly lower asymmetry scores during the second half of the facebook task than the children who draw both circles in a counterclockwise direction is that the discordant group has a shorter attention span, introducing more random noise to their asymmetry scores on the second half of the facebook task. Several studies report that commissurotomy patients are deficient in their ability to sustain attention on vigilance tasks (Dimond, 1976; Ellenberg & Sperry, 1979), suggesting that the corpus callosum plays a critical role in the maintenance of general arousal functions. Our inference is that kindergarten children draw discordant circles because of immaturity of callosal pathways. In consequence, they have shorter attention spans than their more mature classmates who draw concordant counterclockwise circles. Under this interpretation, the fall-off in asymmetry on the second half of facebook trials among the discordant circle drawers is not surprising.

In summary, the present findings support the differential role of the right hemisphere in certain aspects of face processing over much of the life span. Use of this simple free vision technique, for which there are no right or wrong answers, avoids floor and ceiling effects, which frequently interfere with the interpretation of developmental studies of lateral asymmetry. In addition, the circle drawing task sheds light on possible functional consequences of the developmental state of interhemispheric pathways.

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