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7. The gas chromatograph (Hewlett-Packard model 5840A) was equipped with a splitless injector system and a flame ionization detector. Apolar (SP2100) and polar (SP1000) 60 m by 0.25 m (inside diameter) glass open tubular capillary columns were used. Conditions of the chromatography were: helium flow 2 cm^3/min at 120°C; injector, 225°C; injector purge, 1.1 minute after injection; and temperature programmed 120°C at injection and held for 2 minutes followed by heating at 30°C per minute to 180°C (SP 1000) column) or 200°C (SP2100 column).
8. Combined glass open tubular capillary chromatography–mass spectrometry (GOTC-MS) studies of washings of the ovipositor from *H. zea* and *H. virescens* were conducted with a Finnigan model 4000 mass spectrometer equipped with Finnigan model 6110 data system. Heptane-soluble components were also epoxidized and studied by GOTC-MS to establish the position of unsaturation in the carbon chain of the olefinic compounds. The geometry of the olefins was determined by capillary chromatography retention data (J. A. Klun *et al.*, in preparation; J. A. Klun *et al.*, *J. Chem. Ecol.*, in press).
9. All Z olefinic compounds, except (*Z*)-9-hexadecenal, were prepared by the reaction of lithium acetylides with tetrahydropyranyl ethers of halohydrins in tetrahydrofuran-hexamethylphosphorotriamide [M. Schwarz and R. M. Waters, *Synthesis* **10**, 567 (1972)]; hydrogenation to the *Z* olefin followed the method of C. A. Brown and V. K. Ahuja [*J. Org. Chem.* **38**, 2226 (1973)], and oxidation of the resulting olefinic alcohols to aldehydes was by the method of R. W. Ratcliffe [*Org. Synth.* **55**, 84 (1976)]. (*Z*)-9-Hexadecenal was prepared by reduction of methyl palmitoleate (Tridom Chemicals Inc., Hauppauge, N.Y. 11787) with $LiAlH_4$ and subsequent oxidation to the aldehyde. Hexadecanal was prepared by oxidation of hexadecan-1-ol (Aldrich Chemical Co., Inc., Milwaukee, Wis. 53233) and tetradecanal was purchased from Aldrich Chemical Co., Inc. The compounds were purified first by high-pressure liquid chromatography on $AgNO_3$-impregnated silica or silica, with toluene as eluent, and subsequent gas-liquid chromatography showed purity > 99 percent.
10. Field tests were conducted in cotton fields near Tifton, Ga. Insect traps were baited nightly with cotton dental rolls (test 1) or cigarette filters (test 2) that were freshly treated with heptane solution containing test chemicals plus 5 μg 2,6-bis(1,1-dimethylethyl)-4-methylphenol, as antioxidant. Virgin females (*5*) used in the tests were 24 to 72 hours old. In test 1, three wind-vane-type insect traps [*U.S. Dep. Agri. ARS-S-173* (1978)] were used. The test was conducted in a complete randomized-block design. Treatment locations in the field were randomized nightly, and the test was replicated over six consecutive nights. In test 2, three electric grid traps [*U.S. Dep. Agri. ARS-S-42-3-1*, (1963)] were used. The test was conducted over 25 nights, and treatment locations in the field were randomized every 5 days.
11. We thank Dr. L. LaChance and Dr. D. Martin and W. D. Perkins for supply of insects; T. Kiss, American Agricultural Industries, Inc., Chicago, for use of his cornfields; E. D. DeVilbiss of the Organic Chemical Synthesis Laboratory, USDA, SEA, AR for obtaining mass spectral data; and J. E. Carpenter of the Southern Grain Insects Research Laboratory, USDA, SEA, AR for his assistance in the field tests. Supported in part by a grant from Mobil Foundation to UCLA.

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Development of the Capacity for Tactile Information Transfer Between Hemispheres in Normal Children

Abstract. *The hypothesis of less direct interaction between hemispheres in young children was supported by a behavioral test. Fabric samples were compared with either the same hand (same hemisphere) or with opposite hands (between hemispheres). Crossed errors were a significantly larger proportion of total errors in 3-year-olds than in 5-year-olds.*

Interaction between the two halves of the brain is mediated in part by the neocortical commissures. Developmental studies may offer a key to understanding hemispheric cooperation and conflict because the corpus callosum and other commissures are not completely formed at birth and mature very slowly. In very young children, therefore, there may be little communication between the hemispheres; they may each function relatively independently as in adult "split-brain" patients who have had the connections surgically severed (*1–3*).

The sequence of myelination in a given pathway has been taken as an index of the sequence of functional maturity. The corpus callosum is one of the last systems to begin and to complete myelination. In humans, myelination of the corpus callosum does not begin until the end of the first year; it is reported to be substantially advanced by age 4 and continues to increase to age 10 and beyond (*4*, *5*). Thus, the principal anatomical substrate for interhemispheric integration develops only slowly over the first decade of life. Recent electrophysiological evidence also supports this view (*6*).

Different functional components in the neocortical commissures may myelinate at different times, some callosal functions being fully established while others are still completely undeveloped. It is therefore important to test the behavior of young children and establish which aspects of hemispheric integration are functionally mature at different ages.

Since each hemisphere receives sensory input primarily from one side of the body or one visual half-field, an important commissural function is the simple transfer of sensory information between hemispheres, which makes possible a world picture integrated across the midline. For example, an inability to perform crossed tactile matching has been demonstrated as an enduring effect of surgical disconnection of the commissures (*1*, *7*). We have investigated the development of commissural transfer in young children with a simple texture discrimination test. Tactile matching with the same hand (same hemisphere) and between hands (between hemispheres) was compared in 3- and 5-year-olds. We predicted that the 3-year-olds would show more frequent errors in the crossed condition than in the uncrossed, and that 5-year-olds would show less if any difference between crossed and uncrossed errors.

Fifteen 3-year-old and 15 5-year-old right-handed girls (*8*) were tested. Approximately half of each age group was black and half white. The children were drawn from several San Francisco nursery schools including a working-class day-care center and an upper-middle-class private school. Handedness was assessed by asking the child to demonstrate the use of a pencil, spoon, comb, hammer, toothbrush; to pick up a coin; and to throw a ball. Right-handed responses were required on at least five of the seven items, and had to include right-handed use of the pencil. Screening information was gathered from parents and teachers; children who did not speak English at home or who had neurological, cognitive, or emotional problems were disqualified.

In testing very young children it is important to ensure that they understand and can comply with the demands of the task. We therefore developed screening and training procedures for the 3-year-olds to be certain that they had developed the concept of "same" and "different" and that they could and would use these verbal responses reliably (*9*).

Cotton-filled pillows approximately 2 inches square were covered with fabrics of various textures—linen, denim, rayon, rough wool, and so forth—and divided into sets of four different pillows each. In one set, each fabric was quite different from the others ("easy"), in one set they were quite similar ("difficult"), and the other two sets were "medium easy" and "medium difficult."

In order to eliminate ceiling effects, we tested each child to find a set of fabrics which, for her, elicited 15 to 30 percent errors in the uncrossed condition. This procedure left room to observe an excess of crossed errors (maximum = 50 percent). Thus, different materials were used for different children.

At the beginning of each tactile testing

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session the child was allowed to feel the four pillows in free vision. The child then placed her hands, palms up, beneath a cloth screen which blocked them from her view. Her eyes were closed. The experimenter rubbed one of the fabrics over the fingers of one hand (proximal to distal), and then used either the identical fabric or a different one to stimulate the same hand (uncrossed condition) or the opposite hand (crossed condition). The child was required to respond only that the fabric was the same or not the same (*10*).

The test consisted of a total of 64 trials divided into four sets of 16 in which crossed and uncrossed trials were presented in the following order: LL, LR, RR, RL, RL, RR, LR, LL (repeated). Each set contained eight "same" (S) and "not-same" (N-S) trials pseudorandomized with the constraint of no more than three of one type in a row. Each fabric comparison appeared an equal number of times in the crossed and uncrossed conditions.

The children were tested individually in a quiet room adjacent to their classroom and were generally eager to "play the game." They were tested for no more than 20 minutes each session, no more than twice per day. Complete testing including screening and training usually took three to five sessions.

For each subject the number of crossed errors was expressed as a proportion of total errors, thus providing a measure of the relative difficulty of the crossed and uncrossed tests independent of the absolute number of errors. The difficulty of the basic tactile discrimination seems to be fairly well matched across groups, each with an error rate (uncrossed) of about one-fifth (Table 1). No child made fewer than three or more than nine uncrossed errors. There was no significant difference in uncrossed errors between the left and right hands for either age group. The difference between the age groups in crossed errors relative to total errors was significant [t (28) = 4.31, P = .0002] (Table 1) (*11*). Thus, we conclude that 3-year-olds have more difficulty comparing tactile information between the two hemispheres than within a hemisphere and that this difference is reduced by the age of 5.

An alternative hypothesis unrelated to interhemispheric communication was also considered. We noted that in the uncrossed test the same patch of skin was stimulated with the sample and test fabrics, whereas in the crossed test two different skin sites were stimulated. It might be hypothesized that matching between different skin sites was intrinsically harder than at the same site, requiring some memory or schema-forming ability mastered by age 5 but not by age 3.

Table 1. Mean errors (and standard deviations) and relative difficulty of the task (crossed errors divided by total errors).

Group	Uncrossed errors		Crossed errors		Total errors		Relative difficulty (proportion)	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
3-year-olds ($N=15$)	6.0	1.2	11.4	3.1	17.4	3.6	.65	.08
5-year-olds ($N=15$)	6.9	1.4	7.6	1.6	14.5	2.2	.52	.08

Therefore, we tested a subset of subjects with a variant of our original procedure. Four 3-year-olds were retested with the same procedure except that, in the uncrossed condition, the sample fabric was presented to the hand and the test fabric was presented to the volar surface of the forearm of the same side; in the crossed condition the sample is presented to the forearm and the test fabric to the opposite forearm. The results were essentially as before; relatively more crossed than uncrossed errors [for the hand-arm method, the proportion of crossed to total errors was .62 (standard deviation (S.D.) = .06); for the original hand-hand method, the proportion was .70 (S.D = .08)].

Although tactile cross-matching seems to detect group differences between 3- and 5-year-olds, its potential usefulness for assessing maturation of hemispheric interactions in individual children depends on its reliability. We have made a preliminary effort at evaluating the reliability of this test with seven of our 3-year-olds who were available for retesting within 1 month of the first test. On the retest, the mean crossed error rates were 65.0 percent (S.D. = 5.2). A product-moment correlation between test and retest scores indicated some change in the absolute scores (r = .67), but rank order correlation showed the relative standing within the group to be well preserved (ρ = .93, P < .02). Thus, at least for this small sample, all tested by the same experimenter, the measure seems stable. The test might be improved by further standardizing the type of tactile stimulus, its locus on the hand, pressure, duration, and the interstimulus interval.

The 5-year-olds showed no difference in error rate between crossed and uncrossed trials. This should not be taken to indicate that commissural maturation is functionally complete by age 5; an excess of crossed errors might still be demonstrated with other tasks, different materials, or different sense modalities. The commissures presumably mediate many functions other than simple transfer of lateralized sensory input, such as synchronization of bilateral motor activity, reciprocal inhibition of homologous regions, transfer of complex information such as decisions for action, or evaluation of sensory data rather than the sense data itself (*5, 12, 13*). One might speculate that capacity for simple transfer of sensory information would be one of the earliest to develop.

This behavioral study directly demonstrates the developmental increase in functional communication between hemispheres, which has previously been inferred from anatomical and electrophysiological evidence. It thus further supports the hypothesis that the two hemispheres in very young children function relatively autonomously (*2, 3*). The autonomy could be expected to involve affective as well as cognitive behavior. The childhood development of anatomical connections between brain subsystems may in fact be related to the parallel development of integration between mental subsystems, such as parts of the personality, leading to unity of the self.

Numerous research studies have been directed toward characterizing the typical specialization of each hemisphere. In contrast there has been relatively little study of how the two half-brains cooperate or interfere with each other. Further research on hemispheric interactions may be of applied as well as basic theoretical value in relation to learning disabilities (*14*), psychiatric symptoms (*3, 15*), and the study of creativity and invention (*13*).

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8. We were not explicitly investigating possible sex differences in this study. We tested only girls to avoid confounding with possible sex factors and because results of pilot studies indicated that 3-year-old girls may tolerate the test procedures better than boys.
9. The "same"–"not-same" concept was introduced visually with a set of wooden blocks. Difference was marked by high contrast in color and number (one red versus four blue). When labeling became reliable, contrast was first reduced, then the child was switched to visual-plus-tactile discrimination of the fabrics, and finally to tactile discrimination alone. Criteria for admission to each succeeding step of pretesting were specified, and perseveration was guarded against. Of 20 3-year-olds available for testing, five were rejected from the sample, two for unreliable same-different judgments with blocks and three who could not generalize the judgments to the easiest pillows. Two 5-year-olds were rejected for unreliable tactile judgments. The 3-year-olds were briefly rescreened at the start of each session. We found this rescreening to be a useful indication of the child's attentiveness on that particular day. It was frequently necessary to stop testing the youngest children because they were too easily distracted and to continue the next day.
10. Five of the 3-year-olds were allowed to palpate the pillows briefly between the thumb and fingers rather than having the pillow rubbed over the fingers by the experimenter. The results were identical.
11. As an alternative statistical strategy, we also considered a repeated measures analysis of variance to compare uncrossed versus crossed errors (within-subject factor) as a function of age (between-subjects factor). However, we judged the t-test on crossed errors as percentages of total errors to be a more appropriate analysis both because it takes into account each child's total error rate and because it is the most direct test of our major hypothesis. The t-test was calculated on log transforms of percentage scores because logarithms are symmetrically distributed about 0. To completely analyze other factors in the data, two three-factor analyses of variance were computed, one for uncrossed errors and one for crossed errors. The two types of errors were analyzed separately because they involve different factors—hand stimulated for uncrossed, and direction of crossing for crossed errors. Uncrossed errors were analyzed in an age (3- versus 5-year-olds) by hand (right versus left) by trial type (same versus not same) repeated measures analysis of variance. Trial type was the only significant factor, showing more N-S errors ($P < .001$). This factor also interacted with age: the 5-year-olds made more N-S errors than the 3-year-olds ($P = .011$). These differences did not affect the crossed-uncrossed error difference between age groups. The age factor was not significant for uncrossed errors ($P = .064$). Crossed errors were analyzed in an age (3- versus 5-year-old) by direction (crossing from right to left hand verus left to right hand) by trial type (same versus not same) repeated measures analysis of variance. The 3-year-olds showed more crossed errors than the 5-year-olds ($P < .001$). This result is parallel to that of the t-test but does not have the benefit of correction for total error rate. There was also a main effect of direction, crossing from right to left producing more errors than from left to right ($P = .046$). The interpretation of this effect is not clear. Again, as with uncrossed errors, there was a main effect of trial type, showing more N-S than S errors ($P = .038$), although trial type did not interact with age in the crossed errors analysis. A significant triple interaction ($P = .018$) also appeared because the 5-year-olds tended to make more errors on N-S than S trials crossing in both directions, whereas the 3-year-olds made more S errors on right-to-left trials and more N-S errors on left-to-right trials. These more detailed analyses of trial type, hand stimulated, and direction of crossing do not elucidate the age dependence of crossed versus uncrossed error rate, which was similar for S and N-S errors as well as for crossing right to left and left to right.
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16. We acknowledge the contributions of R. Diamond who began the development of this experiment and P. Lund and S. May who helped collect the data. We also thank California Assemblyman John Vasconcellos. This work was supported by NIH biomedical research support grant 5S07 RR0575505. D.G. was supported in part by NIMH career award MH28457. We also thank the children, teachers, and school administrators for patience and cooperation.

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Search Image Formation in the Blue Jay *(Cyanocitta cristata)*

Abstract. *Blue jays trained to detect* Catocala *moths in slides were exposed to two types of slide series containing these moths: series of one species and series of two species intermixed. In one-species series, detection ability increased with successive encounters with one prey type. No similar effect occurred in two-species series. These results are a direct demonstration of a specific search image.*

Predators guided by vision often prey differentially on different prey types (*1*), a response frequently taken as evidence for a predator's use of a specific search image (*2, 3*). This evidence has included a number of different behavioral patterns, such as a predator's choosing one prey type more frequently than would be expected from the prey's relative density (*1*), a predator's responding to a familiar prey type before responding to a newly introduced type (*2*), or a predator's delaying before responding to a novel, cryptic prey type (*3*). However, as Dawkins (*4*) and Krebs (*5*) have pointed out, the search-image concept should be used only when the predator's ability to detect prey improves as a function of recent encounters with the prey type. Much of the existing evidence for search image can be explained by prey preferences, by differences in palatability, ease of capture, or handling time among the prey types, or avoidance of an unfamiliar food object (*4*). We present data showing direct effects of search image upon the detection of prey.

We studied blue jays searching for cryptic *Catocala* moths (Noctuidae), which are normally preyed upon by jays in the wild (*6*). We trained jays to respond differentially to the presence or absence of *Catocala* moths in projected images (*7*). To test for search image in these experienced birds, we controlled the sequence of images they encountered. The jays were exposed to a succession of slides of one prey type; their detection of the moths in this series was compared with that when the slide series contained two prey species intermixed (*8*). The search image hypothesis predicts that the jays should be increasingly able to detect the moths with successive encounters with one cryptic prey type, but should not show rapid changes in detection when searching for two species in a series of slides.

Five blue jays, obtained in the Amherst, Massachusetts, area when 10 to 12 days old and hand raised in the laboratory, were subjects. All birds had been trained to detect *Catocala* moths in projected images (*7*) and were familiar with the species used in this study. The birds were maintained at 80 percent of their free-feeding weight throughout the experiment. The apparatus was a pigeon chamber (Lehigh Valley Electronics). A food magazine was located centrally on the intelligence panel, with an 11.4- by 7.5-cm stimulus key mounted to the left of the magazine and a round advance key 2.54 cm in diameter mounted to the right. Slides were projected onto the stimulus key by a programmable projector (Kodak Carousel) mounted behind the panel. Reinforcement was half a *Tenebrio* larva delivered into the magazine by a feeder (Davis Universal) mounted on top of the chamber.

Positive slides contained the image of a moth and negative slides contained no moth. Each trial began with the illumination of the advance key with red light. When the advance key was pecked once, an image was projected onto the stimulus key. If the projected slide was positive, ten pecks at the stimulus key (correct response) resulted in reinforcement. Reinforcement was followed by a 10-second intertrial interval (ITI) to allow ingestion of the reward before the next trial began. A peck at the advance key on positive trials (incorrect response) produced a 60-