recently in the fossil record and, although the modern pattern initially overlaps in time with the primitive sulcal pattern, it alone is found in extant human populations (*4, 17*). The evidence shows that at least two taxa of early hominids coexisted in East Africa (*18*).

Whether endocasts from any of the East African specimens (for example, from Ethiopia) that are older than KNM-ER 1470 will show a human-like sulcal pattern is not yet known (*19*). Further elucidation of the allometric relation between brain size and sulcal pattern (*20*) should contribute to our understanding of the timing of human origination from pongid-like stock as well as enumeration of the qualitative (nonallometric) changes in external brain morphology that accompanied this event.

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16. P. V. Tobias [*Philos. Trans. R. Soc. London Ser. B* **292**, 43 (1981)] suggests that the "strong development of the posterior part of the inferior frontal convolution (Broca's area)" in KNM-ER 1470 and the development of the inferior parietal lobule in OH 24 together imply that articulate speech was present in *H. habilis*. Tobias also views speech as a "predominant component" of humanization [see also P. V. Tobias, *Anthropologie (Paris)* **18**, 115 (1980)].
17. Although whole endocasts of KNM-ER 3733 and KNM-ER 3883 (attributed to *H. erectus*) in the collection at the Kenya National Museum are too rough to permit the naming of specific sulci, the horizontal direction of furrows in the frontal lobes (*4*) and the general shape of these lobes give these endocasts a modern appearance (that is, similar to endocasts from extant humans).
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19. Since hominid endocasts rarely show obvious lunate sulci, the answer to this question will probably be provided by frontal lobe regions of endocasts.
20. It is well known that bigger primate (mammal) brains are characterized by more sulci than are smaller brains [L. B. Radinsky, in *The Primate Brain, Advances in Primatology*, C. R. Noback and W. Montagna, Eds. (Appleton-Century-Crofts, New York, 1970), vol. 1, pp. 209–224; ______, in *The Functional and Evolutionary Biology of Primates*, R. Tuttle, Ed. (Aldine, Chicago, 1972), pp. 175–184]. Since the endocast from KNM-ER 1470 is larger than that from KNM-ER 1805, it has been suggested that differences in their frontal lobe sulcal patterns might be related to allometry [H. J. Jerison, *Primate Brain Evolution: Methods and Concepts*, E. Armstrong and D. Falk, Eds. (Plenum, New York, 1982), pp. 77–84]. In any event the modern sulcal pattern seen in the region of Broca's area in KNM-ER 1470 does have a functional and behavioral correlate, at least in extant humans—speech.
21. I thank the government of Kenya for permission to conduct research, R. Leakey for access to specimens, and the staff of the Kenya National Museum for hospitality. I am grateful to L. Jacobs, E. Mbua, N. Boaz, A. Galaburda, R. Thorington, and W. Welker for assistance and to S. Kasinga for help with casting. This work was supported by grant BNS 8203764 from the National Science Foundation.

7 April 1983; revised 27 July 1983

Hand Preference Across Time Is Related to Intelligence in Young Girls, Not Boys

Abstract. *Consistency of hand preference was examined in a longitudinal study of children between 18 and 42 months of age. Results showed a sex-specific relationship between hand consistency and intellectual development. Across a variety of intellectual abilities at all ages, females with consistency of handedness were precocious compared to females without such consistency. This relationship did not hold for males.*

Handedness is related to the anatomical and physiological asymmetry of the brain (*1*). The relation between handedness and intellectual abilities in children and adults has been extensively studied for the past several decades and the findings have not led to definitive conclusions (*2*). Past studies have typically compared right-handers to left-handers (and occasionally mixed-handers) with handedness determined on a single occasion by preference across a variety of tasks, many of which have recently been found to be of low reliability (*3*). When sex was included as a factor, analyses were conducted between the sexes with no within-sex comparisons. Because of recent theory and empirical findings suggesting sex differences in neurological organization (*4*), we examined the relation of consistency of hand preference across time to intellectual development within sexes and found that such consistency was related to precocious development in females but not in males.

The present data were based on a longitudinal study of early development. Beginning at 12 months of age, 130 normal middle-class children were tested every 6 months until 42 months of age (*5*). Attrition was minimal throughout the investigation, with 91 percent (118) returning by the last assessment. At each assessment the children were given a battery of tests which included a major standardized intelligence scale. For the infant and preschool assessments the Bayley Mental Scale and the McCarthy Scales of Children's Abilities were used, respectively. Items on these scales (beginning at approximately 18 months on the Bayley) include children's performance on drawing tasks. When scoring these items, we recorded the hand the child used to draw on each of the trials administered. The hand the child used most often on these items at each age was designated as the preferred hand (in virtually all cases the same hand was used across trials at a given age). Thus, we had available a measure of hand preference across the five assessments (18 to 42 months). Drawing hand has been found to be one of the most reliable measures of hand preference (*3, 6*).

Consistency in hand preference was defined by the criterion of using the same hand across the five assessment periods. Those children displaying any change in preference were designated as nonconsistent. Data analyses were based on 89 children (48 males and 41 females) who qualified for one of the two groups. Those not included provided insufficient data to permit group assignment. For males, 24 were consistent and 24 were nonconsistent; for females, 23 were consistent and 18 were nonconsistent. A binomial test indicated that the proportion of children consistent across the five

Table 1. Mean scores (± standard deviations) for consistent and nonconsistent male and female groups on the Bayley Scale at 18 and 24 months and on the McCarthy Scales at 30, 36, and 42 months. There were no significant differences between groups for the males.

Mental test	Males		Females		
	Consistent	Nonconsistent	Consistent	Nonconsistent	Univariate t (females)
18 months, MDI	115.92 ± 14.47	113.58 ± 18.65	120.33 ± 13.68	109.39 ± 14.74	2.40*
24 months, MDI	112.44 ± 21.08	113.88 ± 22.49	124.95 ± 15.41	113.76 ± 14.00	2.32*
30 months					
General cognitive	113.00 ± 13.96	108.42 ± 17.94	119.52 ± 12.59	107.41 ± 8.57	3.38†
Verbal	60.24 ± 11.63	56.37 ± 11.80	61.10 ± 9.05	54.41 ± 5.85	2.63†
Perceptual	53.64 ± 6.02	52.00 ± 7.10	58.29 ± 6.97	51.00 ± 5.99	3.41‡
Quantitative	55.64 ± 9.38	52.79 ± 14.59	60.33 ± 9.73	55.06 ± 9.13	1.71
Memory	59.68 ± 10.39	56.11 ± 13.32	62.71 ± 8.99	57.41 ± 6.91	2.00
Motor	52.88 ± 6.74	51.84 ± 8.53	54.95 ± 7.59	54.71 ± 4.34	0.12
36 months					
General cognitive	108.08 ± 12.38	107.22 ± 14.80	115.48 ± 10.40	105.72 ± 9.58	3.03‡
Verbal	56.27 ± 9.46	55.70 ± 9.86	59.71 ± 7.75	54.67 ± 6.63	2.17*
Perceptual	52.08 ± 6.70	50.35 ± 7.32	56.24 ± 6.81	49.94 ± 4.43	3.36‡
Quantitative	53.92 ± 8.27	55.65 ± 9.84	60.52 ± 6.23	54.00 ± 7.72	2.92†
Memory	55.73 ± 8.83	54.61 ± 10.13	58.71 ± 7.83	53.39 ± 8.30	2.06*
Motor	48.92 ± 7.21	48.52 ± 7.43	54.05 ± 5.86	48.06 ± 5.92	3.17‡
42 months					
General cognitive	111.77 ± 10.16	110.25 ± 11.92	118.67 ± 6.09	111.94 ± 8.31	2.91†
Verbal	57.65 ± 6.72	56.79 ± 7.35	61.90 ± 6.12	57.72 ± 5.26	2.27*
Perceptual	52.62 ± 8.70	52.67 ± 8.07	58.38 ± 6.08	53.61 ± 6.67	2.34*
Quantitative	58.15 ± 6.98	57.67 ± 8.01	61.29 ± 4.14	55.67 ± 6.72	3.19‡
Memory	55.73 ± 7.41	54.92 ± 8.20	58.81 ± 5.59	56.33 ± 5.29	1.41
Motor	48.73 ± 10.03	48.46 ± 8.10	51.67 ± 6.83	50.61 ± 7.06	0.47

*$P < 0.05$. †$P < 0.01$. ‡$P < 0.005$.

assessments (0.53) was beyond chance expectation ($z = 8.77$, $P < 0.001$). Of those who were consistent, all but one (a male) showed right-hand preference. There were no significant differences between the proportions of males (0.50) and females (0.56) who were consistent.

Because gender is now recognized as a pertinent variable in the study of asymmetry of function, analyses were conducted separately for the sexes. At each age we compared the consistent to the nonconsistent group on the intelligence scales. Groups were compared at 18 and 24 months on the Bayley mental developmental index (MDI) and at 30, 36, and 42 months on the McCarthy general cognitive, verbal, perceptual performance, quantitative, memory, and motor indexes. For the 18- and 24-month data and for the 30-, 36-, and 42-month data, t-tests and Hotelling's T^2 tests were conducted, respectively. For males there were no significant differences between groups on any of the intelligence scales [18 months, $t(46) = 0.50$; 24 months, $t(45) = 0.23$; 30 months, T^2 (6, 35) = 1.79; 36 months, T^2 (6, 40) = 3.16; and 42 months, T^2 (6, 41) = 1.69; all P's > 0.62]. However, for females there were significant differences between the consistent and nonconsistent groups at every age. The Hotelling's T^2 values were as follows: 30 months, T^2 (6, 33) = 17.51, $P = 0.04$; 36 months, T^2 (6, 34) = 21.09, $P = 0.02$; 42 months, T^2 (6, 34) = 19.00, $P = 0.02$. The univariate t-test results, displayed in Table 1, show that the consistent female group performed better than the nonconsistent females on the Bayley index at 18 and 24 months, the McCarthy general cognitive, verbal, and perceptual performance indexes at 30, 36, and 42 months, the quantitative index at 36 and 42 months, and the memory and motor indexes at 36 months.

These findings provide the first evidence that consistency in hand preference across time is indicative of precocious intellectual development for females during infancy and the preschool years. Although there were no differences between males and females in consistency of hand preference or in intellectual development (*7*), the relationship between these variables is apparently sex-specific. Why this relation between consistency in hand preference and intellectual skills holds for females and not males is not known. Whether this relation is based on differences in neural anatomy, neural proximity, maturational factors, or degree of hemispheric lateralization remains to be determined (*8*).

However, the sex-specific relation in the present longitudinal study bears an interesting parallel to results in Bayley's Berkeley growth study and Moore's longitudinal study in London (*9*). Both investigators reported that verbal development in females during infancy was correlated with subsequent intellectual status. For males, Bayley and Moore found no correlation between these variables.

Contrary to the long-standing belief that handedness does not become established until school age (*10*), our data provide evidence that hand preference, when indexed by a single reliable measure such as drawing, may be stabilized for a significant proportion of children by 18 months and possibly earlier (*11*). These data raise the issue as to how handedness should be measured—across time on individual tasks or across tasks at one point in time. The choice one makes is related to whether one views hand preference as a unitary construct measured by an aggregate of various tasks or a multidimensional construct in which hand preferences are measured by separate nonaggregated tasks.

The present findings highlight the importance of (i) employing measures or consistency of hand preference across time in studies of handedness, (ii) analyzing within-sex comparisons when examining correlates of hand preference, and (iii) conducting longitudinal research in investigating psychoneural connections during the early years.

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7 February 1983; revised 2 May 1983

A Cholinergic-Sensitive Channel in the Cat Visual System Tuned to Low Spatial Frequencies

Abstract. *Visually evoked reponses to counterphased gratings were recorded from the cat visual cortex before and after physostigmine administration. Physostigmine markedly reduced the responses to low spatial frequencies, but minimally affected the response to high frequencies. This effect is considered cholinergic since it could be reversed by atropine. These results support at least a two-channel model of spatial frequency responsivity.*

The application of Fourier theory to the analysis of the visual system has revealed quantitative and systematic information about its dynamics and organization. Campbell and Robson (*1*) suggested that the human visual system contains channels that are sensitive to different bands of spatial frequency (*2*). Since then, numerous psychophysical (*3*) and single-unit electrophysiological (*4, 5*) experiments have been conducted to elucidate the existence and nature of the channels.

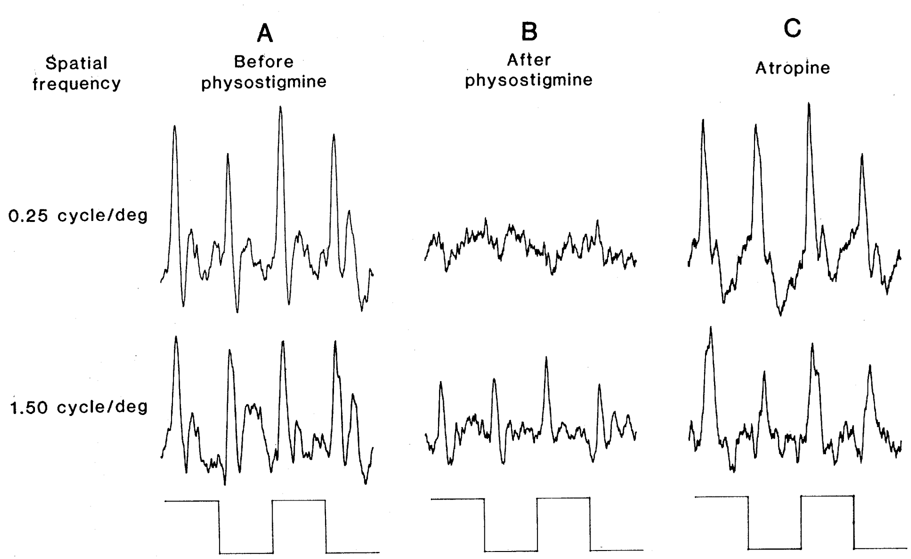

Fig. 1. Peristimulus histogram averages (120-second collection period with a 1-msec sampling interval) for two spatial frequencies from a single experiment (cat 24). (A) Baseline VER's. (B) VER's after an injection of physostigmine (0.5 mg/kg). (C) Recovery VER's after injection of atropine sulphate (0.5 mg/kg). The bottom row depicts the 2-Hz square-wave alternation of the grating pattern. All response averages were collected with sine-wave gratings of 0.40 contrast $[(L_{max} - L_{min}) \div (L_{max} + L_{min})$, where L is luminance].

According to the multichannel model, psychophysically obtained contrast sensitivity functions (*6*) are thought to represent the sensitivity of more than one detection mechanism and not the output of a single detector channel. In support of this model, visual cortical cells have been shown to be tuned relatively narrowly to spatial frequency (*5*). Problems are encountered, however, in trying to extrapolate single-unit response characteristics to their role in visual perception, for perception presumably represents the combined activity of populations of cells. Stronger agreement is observed between psychophysical results and results from experiments with visual evoked responses (VER's), which represent the sum of massed neural events. For example, psychophysically obtained contrast sensitivity functions are positively correlated with curves derived from VER measures (*7*).

Cholinergic influences have been found at various stages of processing within the primary visual pathway (*8*). Altering the normal cholinergic activity at these stages and measuring a physiological response which is correlated with results from a psychophysical detection task may provide clues to the types of cells involved in the perceptual task. We wish to show that the carbamate physostigmine, which binds acetylcholinesterase (AChE) and thus prevents the hydrolysis of acetylcholine (ACh) at synaptic sites, preferentially reduces the response to low spatial frequencies. We used the VER as a measure of responsivity.

Anesthesia was induced in adult cats by ventilation of 3 to 4 percent halothane in a 3:1 gas mixture of nitrous oxide and carbogen and maintained with 1 to 2 percent halothane during surgical preparation. Cannulas were inserted into the trachea, one of the femoral arteries, and the two saphenous veins. To reduce eye movements, the two sympathetic trunks were cut and the animal was paralyzed by an infusion of Flaxedil (30 mg kg^{-1} $hour^{-1}$) in an isotonic glucose solution. End-tidal CO_2 was maintained near 4 percent by adjusting the stroke volume of the respirator. The cat was held in a stereotaxic headholder, and core temperature was maintained at 37°C. During the experiment, halothane was removed from the gas mixture. Heart rate, blood pressure, lung resistance, and electroencephalogram (EEG) were continuously monitored. Arterial blood gas and cholin-