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Right-Handedness: A Consequence of Infant Supine Head-Orientation Preference?

Abstract. *Most newborn infants (65 percent) preferred to lie with their heads turned to the right, whereas 15 percent showed a distinct preference for the left. Orientation preference is maintained for at least 2 months and predicts preferential hand use in reaching tasks at both 16 and 22 weeks. Right head-orientation preference in early infancy may contribute to the early development of right-handedness.*

Right- and left-handedness are associated with individual differences in a wide variety of psychological phenomena from cognitive styles to recovery of function after brain damage (*1*), but the causes of these associations are unknown. Studying the development of hand preference may disclose some causes of these functional associations. The two characteristics to be explained in human handedness are individual variability, which is common to humans and other mammalian species, and the predominance of right-handedness, which is unique to humans. In nonhuman species, limb preference is randomly distributed among right-, mixed-, and left-limb use (*2*).

Although individual variability could be genetic in origin, the evidence from breeding studies in mice and ontogenetic studies of monkeys favors a nongenetic origin (*3*). Collins reported that mice reared under conditions favoring the use of the right limb develop a right-limb preference, whereas mice reared under conditions favoring the use of the left limb develop a left-limb preference (*4*). If environmental circumstances can bias the distribution of limb preferences of mice, then, since every human culture provides some pressure in favor of the right hand (*5*), culture might constitute the bias responsible for the predominance of right-handedness in humans. If so, however, this would leave unanswered why all cultures should favor right-handedness. Annett has argued that cultural pressures can maintain and increase the bias toward the right hand, but they probably cannot explain its initial occurrence and universal prevalence (*6*). Therefore, she concluded that the source of the right bias must be genetic.

Of the various genetic models of human handedness that have been proposed, only Annett's accounts for all of the genealogical data, particularly the proportion of right-handedness among the offspring of two left-handed parents (*7*). Her model postulates a single allele, which, when present, superimposes a dextral bias on individual variability in handedness, but, when absent—as in the offspring of two left-handed parents—permits individual handedness to assort in the random proportions typical of mammals. Her model also implies that this allele may not affect handedness directly, but instead may produce asymmetries for other functions, which, in turn, produce the dextral bias.

Most newborn infants orient their heads toward their right sides while supine (*8*). This right bias has been thought to contribute to the development of the right bias in handedness by producing lateral asymmetries in visual experience of the hands and differences between the hands in neuromotor activity (*9*). This study was designed to examine the relation between neonatal head-orientation preference and the right bias in handedness during infancy. If head-orientation preference contributes to the development of hand preference, a majority of neonates should prefer to keep their heads turned to the right and a minority toward the left. Furthermore, infants who prefer to orient their heads to the left should exhibit an early left-hand preference. I thus assessed the distribution of neonatal head-orientation preference and examined the association between orientation preference in the neonatal period and hand use during the first half year of infancy.

The direction of supine head orientation was determined for 150 normal, full-term, vaginally delivered neonates (81 males and 69 females) by two separate assessments during the 16 to 48 hours after birth. Each assessment consisted of three 2-minute trials. For each trial the infant's head was first held gently in a midline position for 1 minute and then released. The direction of head orientation (right, chin to the right of the infant's right nipple; midline, chin between the right and left nipple; and left) was recorded immediately thereafter on a check sheet every 6 seconds for 1 minute. The number of 6-second intervals for right, left, and midline orientations were summed independently across three trials.

An infant's head-orientation preference was coded for each assessment period by the formula $(R - L)/(R + L)^{1/2}$, where R equals the number of intervals in which the head was oriented right and L the number oriented left. The protocols were scored for both strength and consistency of head orientation. Infants with scores of ± 1.8 for any assessment were classified as having a strong preference. Infants with two assessment scores of $+1.8$ or greater or -1.8 or less were classified as having a consistent and strong preference to orient their heads toward the right or left side, respectively. Infants with two positive assessment scores, one or both less than 1.8, or two negative scores, one or both greater than -1.8, were classified as biased to the right or left, respectively. Those with one positive and one negative score were classified as having a mixed head-orientation preference.

The distribution of preferences was significantly biased to the right [χ^2 (*4*) = 87.7, $P < .001$] in proportions approximating the right bias in handedness (*10*). The right head bias was present in both males [χ^2 (*4*) = 36.9, $P < .005$] and females [χ^2 (*4*) = 59.7, $P < .001$], and sex differences were not significant [χ^2 (*3*) = 1.7] but corresponded to those sometimes reported for adult handedness (*11*).

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Table 1. Distribution of neonatal head-orientation preference.

Group	Head-orientation preference					
	Right	Right bias	Mixed	Left bias	Left	Total
Males	35	11	22	7	6	81
Females	38	13	9	6	3	69
Total	73	24	31	13	9	150

By itself, the distribution of neonatal head orientation does not provide direct evidence for the hypothesis that its right bias contributes to the development of right-handedness. It is first necessary to demonstrate a correspondence between head-orientation bias and hand bias.

Twenty neonates (11 males and 9 females) with consistent head-orientation preferences were selected from the original sample to test the relation between that preference and handedness. Ten neonates consistently oriented to the right and ten oriented to the left. Each infant was observed 3, 6, 8, 12, 16, and 22 weeks after birth.

At 3, 6, and 8 weeks, the infant's head orientation was assessed by a more extensive procedure than that used for neonates. After placing the infant supine on a mat, the first 30 seconds of each of four 150-second trials began with the infant's head gently held (i) in a midline position, (ii) right ear and cheek gently pressed flat on the mat, or (iii) left ear and cheek pressed flat on the mat. Trials 1 and 4 always began with the midline position. After 30 seconds the head was released, and the infant's posture and behavior were recorded on videotape by an overhead camera.

In this experiment, R and L refer to the total time (summed across the four trials) that the head was oriented toward the left or the right. The expression $(R - L)/(R + L) \times 100$ yielded a ratio score, with negative numbers indicating a head-left orientation. The scores for the three visits were averaged to yield an overall index of supine head-orientation preference (Table 2). The neonatal assessment was a good but not completely reliable estimate of the infant's supine head-orientation preference when 3 to 8 weeks old. The difference between the two groups is significant (Mann-Whitney $U = 22$, $P < .05$, two-tailed).

During each visit, the infant's visually guided reaching was assessed by placing it in an infant seat inclined 35°, for four separate reaching conditions, each consisting of a 2-minute exposure to (i) a large (diameter, 5 cm) or (ii) a small (2 cm) yellow ball suspended by a spring 2 cm long from a blue 8 cm by 6 cm backboard or (iii) two large or (iv) two small yellow balls. The single stimuli were placed in the midline position and the two identical large or small balls were placed directly in front of each of the infant's shoulders. The distance between the infant and the ball or balls was adjusted so that the infant's reach would extend fingers just to the center of the ball. Reaching performance was simultaneously recorded from two cameras, one directly overhead and one 90° to the side; the videotapes were analyzed for the number of occasions when the infant's eyes and hand were directed to the object which the hand had contacted (*12*). Hand-use preference was scored as (i) the initial hand used for reaching in at least three of the four stimulus conditions and (ii) the hand used most frequently during the 2-minute exposure for each stimulus condition. Frequency was indexed by the formula $(R - L)/(R + L)^{1/2}$, where R and L are the number of right- and left-handed reaches.

Table 2. Association of preferred head orientation with hand preferred during reaching.

Subject	Head-orientation score		Hand-use preference			
	Neonatal (16 to 48 hours)	Supine (3 to 8 weeks)	Initial reach		Frequency score	
			16 weeks	22 weeks	16 weeks	22 weeks
Right neonatal head-orientation preference						
Male	15	17	R	R	1.4	1.0
Male	30	99	R	R	1.3	0.4
Male	83	8	R	R	1.4	2.0
Male	69	60	*	R	0.0	1.2
Male	47	−11	L	*	−0.6	0.2
Male	40	−24	L	L	−1.4	−2.5
Female	100	18	*	R	0.0	1.5
Female	100	85	R	R	2.0	1.3
Female	18	8	R	R	2.0	1.9
Female	39	26	R	R	0.2	1.9
Left neonatal head-orientation preference						
Male	−21	−6	*	L	0.0	−2.3
Male	−48	−45	L	L	−2.2	−2.3
Male	−15	15	R	*	1.4	0.0
Male	−47	−36	L	L	−1.9	−1.4
Male	−59	72	R	R	0.2	1.3
Female	−62	−41	L	L	−2.1	−1.9
Female	−39	−13	*	L	0.0	−2.3
Female	−92	−26	L	L	−1.4	−1.0
Female	−28	−65	L	L	−2.0	−1.0
Female	−54	41	L	R	−0.5	1.8

*Each hand was used for initial reaching in half of the conditions.

The direction of neonatal head orientation preference significantly predicted both the initial hand used ($P < .05$ at 16 weeks; $P = .007$ at 22 weeks) and reaching frequency preference ($P < .05$ at 16 weeks; $P = .01$ at 22 weeks) (at 16 weeks Tocher's modification of the Fisher exact probability test was used, the standard version of which was used at 22 weeks). However, the more extensive assessment of head-orientation preference during the 3- to 8-week postnatal period seems to be a better predictor of both initial reaching preference (Fisher exact probability test: at 16 weeks, $P = .007$; at 22 weeks, $P = .0001$) and reaching frequency preference (at 16 weeks, $P = .0007$; at 22 weeks, $P = .0001$). Infants with consistent preferences to turn their heads left for both neonatal and supine assessments show a significant left-hand bias in both initial reaching and reaching frequency at 16 (binomial test, $P = .031$) and 22 weeks ($P = .008$). Infants with right orientation preferences for both neonatal and later assessments showed significant right bias in initial reaching and reaching frequency at 16 (binomial test, $P = .016$) and 22 weeks ($P = .004$).

The results support the prediction that the infant's head orientation is related to handedness in infancy. The proportion of neonates who preferred to keep their heads turned right (65 percent) or left (15 percent) corresponds to the distribution of right- and left-handedness in adults. The neonate's head-orientation preference, which is maintained for at least 2 months after birth, reliably predicts the infant's preferred hand when reaching for objects. Therefore, a majority of infants prefer to use their right hands for reaching.

The mechanism linking infant head-orientation preference to hand preference in reaching was not identified in this study. However, infants who keep their heads turned to the right see their right hands more often than their left (*9*). With more opportunity to observe their right hands, infants may develop better eye-hand coordination with that hand, thereby giving it an advantage over the left in visually guided reaching. Thus, head-orientation preference could be associated with hand preference because of differences in visuomotor experience of the hands. Alternatively, head orientation and handedness could be independently determined by the same underlying factor. This latter interpretation would require two underlying factors, one for the right and one for the left preferences. This traditional two-factor model, unlike Annett's single-factor model, fails to account adequately for the distribution of handedness among the offspring of two left-handed parents.

An association between head-orientation preference and handedness is compatible with Annett's genetic model if we assume that head orientation, rather than handedness, is directly affected by the right-biasing factor. As such, the absence of the factor responsible for the right bias in head-orientation preference should result in a random binomial distribution of both head-orientation preferences and, subsequently, handedness. Within individuals, however, handedness and head-orientation preference should still be associated as they were in this study.

Although the results of this short-term longitudinal study do not disclose the relation between infant hand preferences and adult handedness, head-orientation preferences of supine infants did predict the early development of handedness and probably contribute to the development of the right bias in human handedness.

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Cholecystokinin Antibody Injected in Cerebral Ventricles Stimulates Feeding in Sheep

Abstract. *The role of brain cholecystokinin peptides in satiety was further assessed by using antibody to cholecystokinin to reduce cholecystokinin activity in the cerebrospinal fluid of sheep. Food intakes were increased approximately 100 percent during the 2-hour continuous injection of antibody into the cerebrospinal fluid. This supports the hypothesis that, during feeding, cholecystokinin is released into the cerobrospinal fluid, which transports it to the receptors that elicit satiety.*

Cholecystokinin (CCK) peptides are present in both the brain and the gastrointestinal tract (*1, 2*). Although many of the functions of intestinal CCK are well documented, those for brain CCK peptides are only now being investigated. The primary form of CCK in the brain, CCK-octapeptide (CCK-OP), is present in discrete areas in the cortex, thalamus, hypothalamus, mesencephalon, and brainstem (*3*), and specific CCK receptors appear to be distributed among many of the same areas (*4*). Certain properties of brain CCK-OP suggest that this peptide may have neurotransmitter or neurohormonal functions; it is concentrated in the synaptosome-rich fractions, and its release is calcium-dependent (*5*).

There is evidence that brain CCK-OP is important in the control of food intake. When administered as a continuous lateral cerebral ventricular (LV) injection, CCK-OP is a potent suppressor of feeding in sheep; femtomole amounts of this peptide significantly decrease food intake in sheep (*6*). The effect of CCK-OP is specific for feeding behavior, since neither drinking nor body temperature is affected (*6*). In addition, only peptides meeting the minimum structural requirements for CCK activity peripherally decrease feeding behavior when administered centrally, thus supporting the concept that specific CCK receptors in the brain mediate the effect on feeding behavior (*7*).

In rats, experimental results are conflicting. Stern *et al.* (*8*) and Maddison (*9*) showed that CCK peptides injected centrally decreased food intake in rats, whereas we (*6*) and others (*10, 11*) have found no effect. McCaleb and Myers (*12*) showed that intrahypothalamic injections of CCK suppressed feeding behavior that was elicited by norepinephrine subsequently injected in the same sites. This suggests that CCK acts directly on hypothalamic noradrenergic systems to mediate its effect on feeding. Although Schneider *et al.* (*13*) found no difference, Straus and Yalow (*14*) reported a lower concentration of CCK-OP in brains of genetically obese mice *(ob/ob)* compared to their lean littermates (*OB/*−) and have also shown that starved mice have reduced brain CCK-OP concentrations in comparison with fed mice. Thus, the role of CCK in the brain of rodents in the control of feeding is controversial.

On the basis of the results of our studies in sheep, we have proposed that CCK-OP is released during meals and acts as a signal of satiety (*6*). The demonstration that behavior indicating satiety follows administration of exogenous peptide is not sufficient to prove that endogenous CCK-OP participates in feeding behavior, however. Thus, we have carried out experiments to deter-

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