How Supine Postural Preferences of Infants Can Contribute Toward the Development of Handedness*

By: JANE F. CORYELL and GEORGE F. MICHEL

Coryell, J & Michel, GF. How supine postural preference of infants can contribute towards the development of handedness. Infant Behavior & Development. 1978; 1:245-257.

*****Note: Figures may be missing from this format of the document**

Abstract:
During their first three months postpartum, infants manifest an asymmetrically lateralized head position preference, typically turned to the right. This head position preference elicits an asymmetrical tonic neck reflex, which places one hand in the infant's visual field. As a result, infants have differential visual experience of their two hands. The majority of infants have more visual experience with their right hands than their left. Knowledge of which hand an infant has had more visual experience of, as a result of its postural preference, reliably predicts the hand that will be used most in a visually-elicited reaching task at ¹2 weeks postpartum. Therefore, the origin of human handedness status may reside in an asymmetrical postural preference during early infancy, which biases visual experience of the hands, giving one hand an advantage in eye-hand coordination tasks.

Article:
Most mammals exhibit an asymmetrically lateralized limb preference when performing unimanual tasks (Warren, 1977). The consistent use of one paw or hand for such tasks provides the advantage of more rapid and efficient performance (Flowers, 1975). Asymmetrically lateralized preference and skilled use of the hands are also present in human populations. However, there are two characteristics of human lateralized manual preference which distinguishes it from that of other animals. Humans are much more consistent in their preference among tasks, whereas there appears to be little consistency of preference in animals among distinctly different unimanual tasks (Annett, 1972; Raczkowski, Kalat, & Nebes, 1974; Warren, 1977). It is also the case that the preferred use of the right and left limb appears to be evenly distributed among the members of any animal species, while the human species exhibits a marked prevalence of right handedness (Annett, 1970a). Annett labeled this characteristic of humans the "right-shift phenomenon."

This right shift in lateralized manual preference appears to be a genuinely species-typical character. Not only has it not been observed in other mammals, but no human culture has ever exhibited either a left-shift, or even an equality, of manual preference among its members (Annett, 1972; Hardyck & Petrinovich, 1977). Estimates of the distribution of manual preference identify 60-70% of the human population as consistently right- handed, and only 4-12% of the population as consistently left-handed, thereby marking the right-shift phenomenon (Annett, 1972). Of course, cultural factors and specific training are recognized as contributing toward the sharpness of this asymmetry (Provins, 1956; Provins & Cunliffe, 1972). However, neither of these factors can adequately account for the universal and species-typical nature of the right-shift phenomenon. Annett concluded, therefore, that while culture may maintain, and even enhance, the right-shift phenomenon, it cannot be responsible for its initial occurrence and prevalence throughout the history of human societies.

Annett also argued that while many "accidental" factors, occurring before and after birth (e.g., position of placenta, birth position, medical condition at birth, early handling of infant), might affect any particular individual's handedness status, they could not be responsible for the right-shift phenomenon. That is, she

* This study was supported by Boston University Graduate School Grant (GRS-379-PS). Requests for reprints should be addressed to George F. Michel, Department of Psychology, University of Massachusetts, Boston, Massachusetts 02125.

assumed that any accidental factors would be randomly distributed among the members of the population, and therefore concluded that they could not account for the nonrandom bias in handedness distribution.

Consequently, Annett was forced to conclude that the right-shift phenomenon was genetic in origin and that left-handedness was a consequence of accidental, or very specific, cultural and training factors. She found support for her conclusion in two types of investigation. The handedness distribution of children as young as 31/2 to 8 years of age was remarkably similar to the distribution of adults (Annett, 1970b). This suggested that there was little change in handedness during development. While other investigators have reported changes in individual hand preferences during both earlier and equivalent age periods, the right-shift phenomenon appears to be a very early occurring and stable characteristic (Gesell & Ames, 1947; Giesecke, 1936; Lederer, 1939).

The handedness status of offspring of two parents with consistent left- handedness exhibited a typical (though weakened) right-shift phenomenon (Annett, 1974). Annett concluded that these results argued against the notion that environmental influences provided by the family are responsible for handedness status, and apparently supported a genetic mechanism for right- handedness, but not for left-handedness.

Despite the clarity and strength of Annett's formulation of the origins of the right-shift factor, one can question the assumption of a random distribution of some of the events included in the "accidental factors" category. There is some evidence that most infants during the newborn period, and for some weeks after birth, have a.spontaneous preference for lying with their heads turned toward the right, while supine (Gesell, 1938; Turkewitz, Gordon, & Birch, 1965). By itself, this asymmetric postural preference might mean little more than an early indication of lateralization of function. However, during the first month postpartum, the position of the infant's head begins to influence the position of the rest of the body through its elicitation of the asymmetric tonic neck reflex. That is, the turned head results in an extension of the limbs on the face side and a flexion of the limbs on the skull side of the body, producing a "fencer's posture."

One possible consequence of a consistent asymmetric tonic neck reflex to the right would be that the infant's right hand would be placed in the visual field more often than would the left, thereby providing the infant with more of an opportunity of establishing eye-hand coordination with the right hand. Visual experience of the hands has been considered a significant factor in the establishment of the kind of eye-hand coordination necessary for visually guided reaching and for the manipulation and examination of objects (Piaget, 1953; White, 1969; White & Held, 1966).

The present study was designed to determine answers for the following four questions:

1. Do infants typically manifest a consistent head-right supine postural preference during their first three months postpartum?
2. Does the infant's head position reliably elicit an asymmetric tonic neck reflex?
3. Does the infant's asymmetrical head position preference and tonic neck reflex place the right hand in the visual field more frequently than the left hand?
4. Does differential visual experience of the two hands result in differential hand-use in visually-elicited reaching tasks?

Therefore, we attempted to identify and specify a consistent, self-generated asymmetrically lateralized bias which, when manifested by infants early in their development, could contribute to the occurrence of the right-shift phenomenon in the handedness distribution of children and adults.

METHOD

Subjects

Eight male and 8 female infants, whose birth weights ranged from 2868 to 3684 g (x = 3318 g) and whose births were single unstressful deliveries (7 were delivered without anesthesia), were recruited through a local natural childbirth training center. The study was described during one of the meetings, and interested parents were given a written description of the procedure and a means for contaeting us after the baby's birth. At the beginning of the first visit the procedure was described again, and the mother was allowed to read and discuss an informed consent form. The consent form was approved by Boston University's Clinical Research Review Committee.

Procedure

Each infant was visited at home, 7 times during the period from 1 week to 12 weeks postpartum. These visits were made as near as possible to the infants' first, second, fourth, sixth, eighth, tenth, and twelfth week of age. During each visit, the infants' spontaneous behavior, including head and limb positions, was recorded on videotape as the infant lay in a supine position. For the second- through twelfth-week visits, the infants' visually-elicited reaching performance was also videotaped as the infant reclined in a specially designed seat. (A more complete description and illustration of this seat is provided in Coryell, 1977.)

Visits occurred around the infants' feeding times to insure that they would be awake and alert, and a return visit was scheduled when the infant became cranky or upset. These return visits occurred only nine times during the total 112 visits.

For recording the supine positions, the infants were placed on the floor on a 1 m square mat of 2 cm plastic foam and covered with blue-green vinyl. In order to eliminate the influence of potentially interesting asymmetrically localized, visual displays, a blue sheet was draped over chairs on each side of the mat. For the visually-elicited reaching sequence, the infant was reclined in a padded infant seat, inclined 30° above the horizontal. The seat was also placed between the draped-sheet arrangement. Attached to the rear of the seat was a set of aluminum tubes to which a stimulus object could be attached. By this means the stimulus object could be rotated 180° from side to side in front of the infant, and arched from above the infant's head forward and downward to eye-level, and returned. The stimulus object was a 9cm in diameter sphere covered with a checkerboard pattern of red and white squares. The ball was adjusted to appear at eye level and was within arms' reach for each infant.

A Sony Portapak videotape recorder was used to record each segment. For the supine position, the tripod and camera were placed at the edge of the mat and the camera elevated 1.5 m. The infant was placed with feet toward the camera. The infant's head was held in a midline position for 1 min before videotaping began. Each infant was videotaped for three 5-min periods during each visit, with at least a 3-min interval between periods, during which the infant was with the mother.

For visually-elicited reaching, the camera was placed approximately 1.5 m in front of the infant seat and elevated about 1 m. An assistant knelt behind the seat and operated the stimulus object holder. The object moved from a point immediately outside of the infant's visual field to a midposition, stopped, and then continued to move out of the visual field on the other side. Each of these three segments lasted 10 sec, and was timed with a stopwatch. On each visit, the infant was presented with the object three times, with the direction of object movement varied systematically for all infants in an equivalent session, and among all sessions for a single infant.

Coding

During the coding of the videotaped supine position sequences, the tape was paused every 10 sec, and information was recorded for head position, state, and asymmetrical tonic neck reflex (ATNR). These positions were determined using a protractor centered on the infant's sternum—crotch and shoulder axes. Head position was coded right or left, if the nose was to one side or the other of midline. The ATNR was determined as present or absent in the arms when the head was turned to the side. Since the infant could be in the ATNR position by chance one-third of the time, instances of reverse or anti-ATNR were also determined for comparison with ATNR frequency, to rule out the possibility that the reflex was not present. In the anti-ATNR posture the head is in a turned position, but the limbs are flexed on the face side and extended on the skull side of the body.

The positions of the infant's hands relative to body landmarks were used to denote hand visualization, because it was not always possible to determine accurately the precise orientation of the infant's gaze. However, the probability of the infant's being able to look at his/ her hand when it is in one position can be higher than when it is in another position. Therefore, criteria for visualization of the hand included position of hand relative to body landmarks and elbow flexion. The hand was considered most likely to be within focal vision, both when it was between the top of the infant's head and nose if the elbow was flexed 90° or less, and when it was between the top of his/her head and shoulder level if the arm was extended beyond 90°. The hand was considered likely to be in the infant's peripheral visual field, both when it was between the infant's nose and nipple line if the arm was flexed 90° or less, and when it was between the shoulder and nipple line if the arm was extended beyond 90°.

The videotapes of visually-elicited reaching were paused for coding every 3 sec. Information was collected on the infant's visual regard of the ball (eyes open and oriented in line with ball, .97 reliability), ball position and movement, position of the hands, and state. The hand positions were coded by placing a transparent plastic sheet, marked in 1.25 cm squares, over the screen of a Sony 9-in, TV monitor. The center of the grid was placed on the area of the infant's sternal notch. Since each horizontal line was lettered and each vertical line was numbered, the infant's hand position could be noted. Hand activation was described when hand position from one time to the next varied by 2 squares in one direction, or 1 square in two directions. Most of the data from both conditions, were coded by an assistant familiar with the hypotheses. However, the reliabilities for all behavior categories were measured by comparing the number of matches between a "blind" coder and the knowledgeable assistant on a random sample of 10% of the data.

RESULTS

All data were examined for sex differences, but since there were no significant differences, the data for males and females were combined in the present analyses. Unless otherwise specified, data were statistically analyzed by two-way analysis of variance (group by visit) with trend analysis.

For the supine position infants did maintain a significant head-right posture ($F(1, 30) = 23.55$, $p < .005$), while awake and alert. Though the differences among visits were not significant, there was a significant (F)1, 30) = 5.05, $p < .05$) linear decrease from the first through the twelfth weeks (see Fig. 1). All infants, however, did not maintain a consistent head position. Therefore, an index of head position was calculated for each infant using the formula $(L - R)/(R + L)^{1/2}$, which expresses the difference between right- and left-head-turning in standard deviation units. An index of 1.96 or greater indicates that an infant held its head to one side significantly ($p < .05$) more often than to the other side.[1] Fourteen of the 16 infants maintained a, significant head position, according to his index, while awake/ alert. Twelve (75%) maintained a significant head-right position and two (13%) maintained a significant head-left position. Two infants did not exhibit a significant head position. A significantly greater number of the infants maintained a head- right position ($x^2(1) = 12.57$, $p < .0005$).

The infant's self-initiated turned-head preference was an adequate stimulus for eliciting the asymmetric tonic neck reflex (ATNR) during each of the 7 visits. That is, there was a significant difference ($F(1, 180) = 35.6$, $p < .005$) between the number of times infants, while awake/ alert demonstrated the ATNR position and the anti-ATNR position (see Fig. 2). The ATNR increased from the first to sixth weeks and then decreased; the anti-ATNR was self-elicited significantly more often ($F (I, 180) = 5.6$, $p < .025$) on the right than on the left side. The number of times the ATNR was self-elicited to

[1] This index was calculated for each infant's head position preference, hand visualization scores, and hand activation scores, and was used in all relevant statistical analyses.

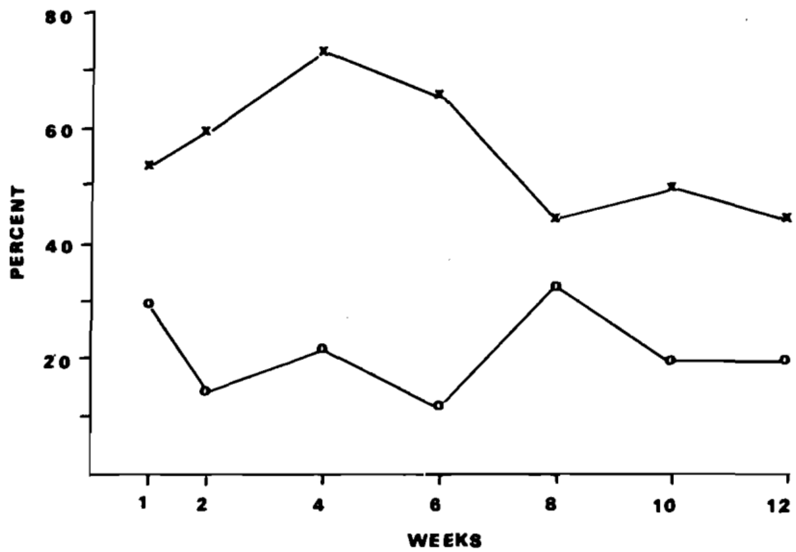

FIG. 1 Mean percentage of the time infants turned their heads to the right (Xs) or to the left (Os) while in an awake/alert state during their first 3 months.

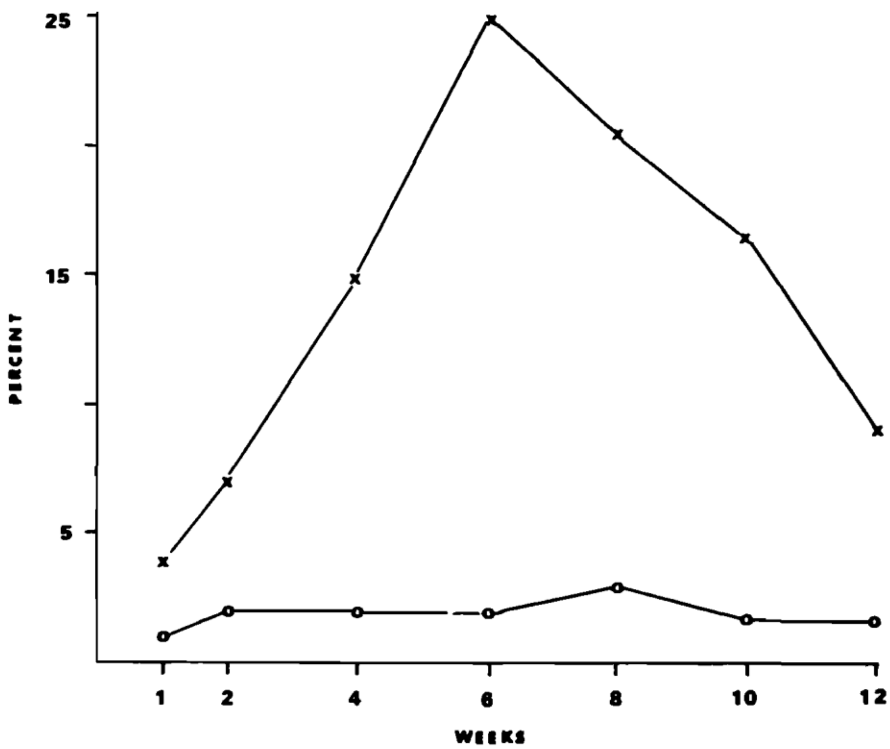

FIG. 2 Mean percentage of the time infants exhibited an ATNR posture (Xs) or an anti-ATNR posture (Os) while in an awake/alert state.

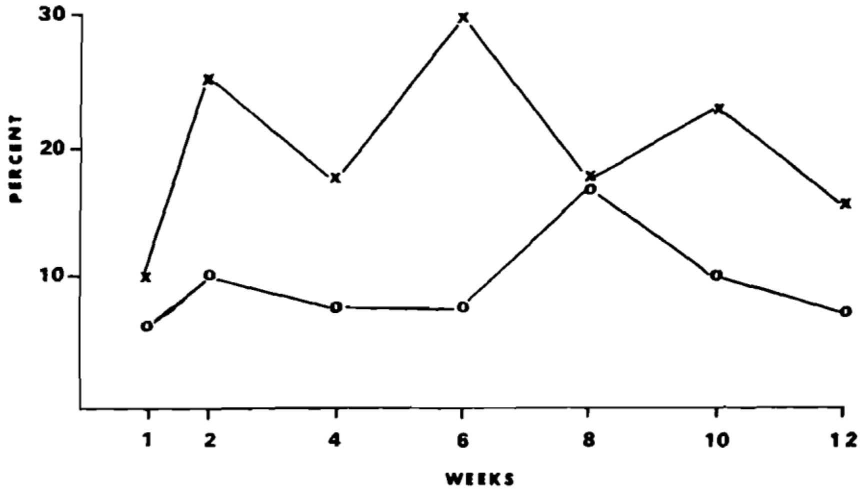

FIG. 3 Mean percentage of time infants were able to visually experience their right hand (Xs) and left hand (Os) while awake/alert.

each side was highly correlated with the position to which the infant turned its head ($r = .86$, $p < .005$). Thus, infants who held their heads consistently to one side also tended to exhibit an ATNR on that side.

The turned head and ATNR position preference placed the infants' right hands within their visual fields significantly ($F(1, 180) = 6.6$, $p < .025$) more often than the left hand (see Fig. 3). Of the 16 infants, 14 held one hand in the visual field significantly more often than the other. The right hand was held in the visual field significantly more often for 69% of the infants, the left hand for 18%, and neither hand for 12% of the infants.

During the visually-elicited reaching task, the infant looked at the ball for 54% of all coding segments. The number of times that the infants' hands were activated increased significantly ($F(4, 120) = 4.1$, $p < .01$) in a linear fashion, and there was a significant ($F(1, 120) = 4.98$, $p < .05$) difference in hand activation when looking and not looking for weeks 4 to 10 (see Fig. 4). However, at the twelfth week, infants activated their hands significantly ($p < .01$, Newman-Keuls) more often while they were looking at the stimulus object (see Fig. 4). However, the right hand was significantly ($p < .025$, Wilcoxon T test) more active than the left when looking at the ball at 12 weeks of age (see Fig. 5). According to the index of hand activation at the twelfth week, 62% of the infants tended to activate their right hand more frequently when looking at the ball, and 13% activated their left hand more frequently.

The relationship between hand visualization and hand activation for those 14 infants with a significant hand visualization index was $r = +.47$ ($p <.05$). When multiple regression analysis was performed with both the total head

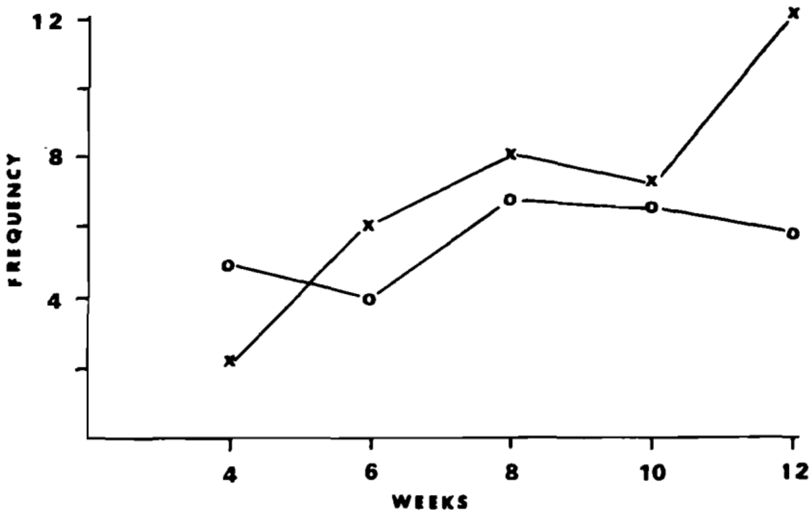

FIG. 4 Mean frequency (in number of 3-sec intervals) of hand activation by infants when they are looking (Xs) and not looking (Os) at the stimulus object.

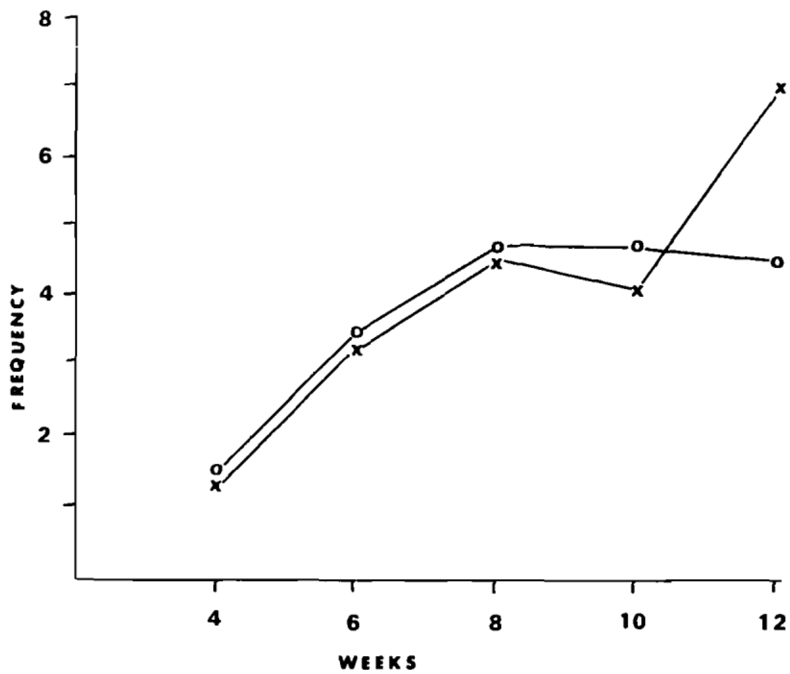

FIG. 5 Mean frequency of right-hand (Xs) and left-hand (Os) activation when infants are looking at the stimulus object.

position preference and hand visualization during the 7 visits as predictors of hand activation during visually-elicited reaching at visit 7, the multiple R = .49. However, when ATNR is included as a third predictor variable, the multiple R = .61. Thus, all three variables (head position preference, ATNR, and hand visualization together) account for 37% of the variance in differential hand activation in a visually-elicited reaching task.

DISCUSSION

Several conclusions may be drawn from the pattern of results in this study.

1. An overwhelming majority of infants may normally exhibit an asymmetrical supine postural preference during, at least, their first three months postpartum. This finding is consistent with Gesell's more casual observation of a similar asymmetry in supine posture supposedly maintained by infants throughout the first year (Gesell & Halverson, 1942). Our results also confirm and extend the reports by Turkewitz and his colleagues that newborn infants typically exhibit a consistent head-turned-right

supine position preference (Turkewitz et al., 1965). Only a small percentage of our infants showed either a head-turned-left preference or no significant head preference. One relatively unique aspect of the present study was the use of an index, which directly specified chance levels of differences between right- and left-head position, and right- and left-hand visualization or use. Too many studies treat any difference between right and left measures as being "significant" without determining chance levels.

2. The asymmetric head position preference is a reliable elicitor of an asymmetric tonic neck reflex. Again, this finding is consistent with reports that the ATNR is often more reliably elicited by the infant's self-generated head turning, than by an externally applied turn of the head (Paine, Brazelton, Donovan, Drorbaugh, Hubbell, & Sears, 1964). Therefore, the ATNR limb pattern feeds into a typical head-position preference pattern to create a characteristic asymmetrically lateralized supine postural preference during early infancy.

3. As a consequence of their supine asymmetrical postural preference, infants typically will acquire greater visual experience of one hand than of the other. For the majority of infants, their asymmetrical postural preference will provide them with more visual experience of their right hand than of their left hand. It has been well-documented that visual experience of the hands is essential for the establishment of refined eye-hand coordination in reaching for, and manipulating, objects. However, there have been no studies which have examined the effects of differential amounts of visual experience of the hands on the differences between the hands in eye-hand coordination. One study did show that differential reinforcement to the two hands of a baboon, in manipulation study, lead to a switch in hand preference (Gazzaniga, 1971). Though both hands could easily perform the task, the hand that received the most reinforcement became the preferred hand. Therefore, it may not be too unreasonable to suppose that differential visual experience of the hands may lead to their differential use.

4. Hand activation in response to a visually-presented object gradually develops during the infants' first three months, becoming significant only at 12 weeks of age. Others have reported indications of reaching for visually- presented objects in much younger infants (Bower, 1974). However, these results apparently are not replicable (Field, 1977; Lasky, 1977; Ruff & Halton, 1977). Since the young infant is generally more active than many have presumed, it is important to take measures of hand movement and reaching patterns when the stimulus object is not present, or when the infant is clearly not looking at it. The infant's performance at these times serves as a useful control against overinterpretation of the infant's spontaneous activity patterns. Our results seem to conform with recent reports which found little or no visually-elicited reaching by infants younger than 21/2 to 3 months of age (Field, 1977; Lasky, 1977).

5. At 12 weeks of age infants begin to exhibit a difference between their left- and right-hand's response to a visually-presented object. Thus, at a time when infants begin to significantly "reach for" an object, they also show a significant difference in activation between their two hands. The close temporal relation between first beginning to respond clearly to a visual object, and a difference between the hands in that response, may be taken by some to mean that the infant's handedness status was always present, but could not be demonstrated, until the infant was capable of responding to visually- presented objects. Unfortunately, this notion, because it appears in many different forms, is impossible to refute completely. However, our results do indicate that information about the hand which is most visualized, as a result of the infant's asymmetrical supine postural preference, reliably predicts the hand which will be most activated when the infant looks at an object at 12 weeks of age.

We know of no way to prove, irrefutably, that the infant's differential visual experience of its two hands, as a consequence of its asymmetrical supine postural preference, is responsible for the initial organization of handedness status. However, we have shown how it can be. We also have demonstrated a possible postnatal lateral bias in human infants, which may contribute to the occurrence of the right-shift phenomenon of human handedness status. Since handedness status is .related to asymmetrical specialization of functioning of the cerebral hemispheres (Hardyck & Petrinovich, 1977; Hecaen & Sauguet, 1971; Searleman, 1977), the results also provide support for the notion that the difference in mode of operation between the hemispheres may depend upon rather specific asymmetric sensorimotor experiences common to most infants.

ACKNOWLEDGMENTS

We would like to thank Frank Curcio for helpful criticisms of an early draft of this paper. The assistance of Carolyn J. Mebert is also greatly appreciated.

REFERENCES

Annett, M. A. Classification of hand preference by association analysis. British Journal of Psychology, 1970, 61, 303-321. (a)

Annett, M. A. The growth of manual preference and speed. British Journal of Psychology, 1970, 61, 545-558. (b)

Annett, M. A. The distribution of manual asymmetry. British Journal of Psychology, 1972, 63, 343-358.

Annett, M. A. Handedness in the children of two left-handed parents. British Journal of Psychology, 1974, 65, 129-131.

Bower, T. G. R. Development in infancy. San Francisco: Freeman, 1974.

Coryell, J. F. Contribution of head position and the asymmetrical tonic neck reflex to the development of handedness in 1- to 12-week-old infants. Unpublished Ph.D. dissertation, Boston University, 1977.

Field, J. Coordination of vision and prehension in young infants. Child Development. 1977, 48, 97-103.

Flowers, K. Handedness and controlled movements. British Journal of Psychology. 1975, 66, 39-52.

Gazzaniga, M. S. Changing hemispheric dominance by differential rewards. Experimental Neurology, 1971, 33, 412-419.

Gesell, A. The tonic neck reflex in the human infant. Journal of Pediatrics. 1938, 13.455-464. Gesell, A., & Ames, L. B. The development of handedness. Journal of Genetic Psychology, 1947, 70, 155-175.

Gesell, A., & Halverson. H. The daily maturation of infant behavior: A cinema study of postures, movements, and laterality. Journal of Genetic Psychology, 1942, 61, 3-32.

Giesecke, M. The genesis of hand preference. Monographs of the Society for Research in Child Development, 1936, I.

Hardyck, C., & Petrinovich, L.Left-handedness. Psychological Bulletin, 1977, 84, 385-404.

Hecaen, H., & Sauguet, J. Cereb. dominance in left-handed subjects. Cortex. 1971, 7, 19-48. Lasky, R. E. The effect of visual feedback of the hand on reaching and retrieval behavior of young infants. Child Development, 1977, 48, 112-117.

Lederer, R. K. An exploratory investigation of handed status in the first two years of life. University of Iowa Studies in Infant Behavior, 1939, 16.

Paine, R. S., Brazelton, T. B., Donovan. D. E., Drorbaugh, J. E., Hubbell, J. P. Jr., & Sears, E. M. Evolution of postural reflexes in normal infants and in the presence of chronic brain syndromes. Neurology. 1964, 14, 1036-1048.

Piaget, J. The origins of intelligence. New York: Basic Books. 1953.

Provins, K. A. "Handedness" and skill. Quarterly Journal of Experimental Psychology, 1956, 8, 79-95.

Provins, K. A., & Cunliffe, P. The reliability of some motor performance tests of handedness. Neuropsychologia, 1972, /0. 199-206.

Raczkowski, D., Kalat, J., & Nebes, R. Reliability and validity of some handedness questionnaire items. Neuropsychologia, 1974, 12, 43-47.

Ruff, H. A., & Halton, A. Is there directed reaching in the human neonate? Paper presented at Biennial Meeting of the Society for Research in Child Development, New Orleans, April, 1977.

Searleman, A. Right hemisphere linguistic capabilities. Psychological Bulletin, 1977, 84, 503-528.

Turkewitz, G., Gordon, E. W., & Birch, H. G. Head turning in the human neonate: Spontaneous patterns. Journal of Genetic Psychology, 1965, 107, 143-158.

Warren, J. M. Handedness in monkeys. In S. Hamad, R. W. Doty, L. Goldstein, J. Jaynes, & G. Krathamer (Eds.), Lateralization in the nervous system. New York: Academic Press, 1977. White, B. L. Initial coordination of sensorimotor schemes in human infants. In D. Elkind &J.

Flavell (Eds.), Studies in cognitive development. New York: Oxford, 1969.
White, B. L. & Held, R. Plasticity of sensorimotor development in the human infant. 1n J. F. Rosenblith & W. Allinsmith (Eds.), The causes of behavior, 2nd. ed. Boston: Allyn & Bacon, 1966.