Maternal Influences on Infant Hand-Use During Play with Toys

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Abstract:

Infant hand-use preferences are related to mother's, but not father's, handedness. Since infants match mother's hand-use during toy play, maternal handedness can affect infant hand-use. Twenty-eight mother— infant pairs (14 left-handed and 14 right-handed infants but all right- handed mothers) were videotaped while playing with six toys on the infant's 7-, 9-, and 11-month birthdays. Play was analyzed for five kinds of hand-use biasing situations, but maternal hand-use was the dominant influence. Infant matching of maternal hand-use increased with age and right-handed infants and female infants matched maternal hand-use more frequently. Concordance of hand-use preference between mother and infant seemed to account for both the matching and the stronger preferences of the right-handed compared to the left-handed infants.

KEY WORDS: infant handedness; maternal influences; familial handedness; infant imitation.

Article:

INTRODUCTION

Studies of familial handedness often reveal a significant association between measures of offspring handedness and measures of parental handedness (Annett, 1973, 1978; Ashton, 1982). However, the association is stronger with the mother's than with the father's handedness. Although the mother—offspring association depends primarily on the degree or strength of handedness, left-handed mothers are more likely than left-handed fathers to have left-handed offspring (McGee and Cozad, 1980). Even among right-handed parents, there is a stronger association between the handedness of offspring and that of the mother than between the handedness of offspring and that of the father.

Much of the research on the parent—offspring handedness relation focuses on the handedness of school-aged or older offspring. In part, this is because it is commonly believed that handedness in infants and preschool-aged children is variable and unrelated to adult handedness. However, handedness in 18- to 24-month-old children shows many adultlike characteristics (Archer et al. , 1988; Kaufman et al. , 1978). Moreover, after 5 to 6 months, most infants show clear evidence of hand-use preferences for reaching and other target-directed behaviors (McCormich and Maurer, 1988; Michel et al. , 1985; Young et al. , 1985), and these preferences remain quite stable throughout the first 18 months (Michel and Harkins, 1986). Therefore, it is quite likely that infant hand-use preference is related to adult handedness. Thus, it is not surprising that the maternal influence on offspring handedness has been observed in the hand-use preferences of 6- to 13-month-old infants (Harkins and Michel, 1988).

Although cytoplasmic inheritance (Boklage, 1980; Morgan, 1977), intrauterine influences (Bakan et al., 1973), and prenatal hormonal milieu (Geschwind and Galaburda, 1987) have been suggested to account for this maternal influence, postnatal social experience must be considered, as well. However, Carter-Saltzman (1980) noted that non-righthandedness does occur among adopted and biological children of two strongly right-handed

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parents. Of course, this is incompatible with the notion that imitation of parents is the primary explanation of non-righthandedness. In her study of individuals adopted as infants, she found no difference in the proportion of non-right-handers among those with a non-right-handed mother and those with a non-right-handed father. Therefore, she argued that her results ruled out the effects of prenatal and early maternal influences and she concluded that nonbiological parents have little influence on the child's handedness. However, there was a significant decrease in right-handedness in children whose adoptive mother was non-right-handed. Moreover, since her study found paternal influences that were much stronger than any reported previously or since (cf. Bishop, 1990), they await replication.

There is evidence that social pressure and training during the preschool and early grade-school period can affect the development of handedness (Porac et al. , 1986), and social experience during infancy also has been proposed to influence the development of handedness (Dennis, 1935; Hildreth, 1949). It is unlikely that mothers deliberately train their infants to use a particular hand. However, during play it is conceivable that the mother's handedness may bias the infant's hand-use (e.g., placing objects in the infant's right hand). Although such parental influence might not affect the direction of the offspring's handedness, it could affect the degree of lateralization of handedness. This would increase the shared variability in handedness correlations between mother and offspring.

Recently, Harkins and Uzgiris (1991) reported that 8- to 12-monthold infants tend to match the hand-use of their mothers during en face gesture and object play. This matching could have occurred either because infants imitate the hand use of their mothers or because mothers unintentionally maneuver toys and their actions in ways which elicit hand-use matches from their infants. In either case, it might be expected that infants from mother—infant pairs concordant for hand-use preference (R-R, IL-L) would have stronger hand-use preferences than infants from mother—infant pairs discordant for hand-use preference.

Unfortunately, Harkins and Uzgiris had to infer the handedness of both the mothers and the infants in their study. Also, they sought evidence of matching of hand-use only during episodes in which the specific manual action between the mother and the infant matched. That is, a match of hand-use between infant and mother would not be counted if the infant failed to match the mother's action. If the infant picked up the toy with the same hand that the mother just used to push the toy, for example, the match of hand-use would not be counted. Moreover, Harkins and Uzgiris did not attempt to identify any of the ways by which mothers can influence the infant's hand-use (e.g., placing the item in the infant's hand, placing the item closer to one hand, actively maneuvering the infant's hand).

The purpose of the present study was to describe some ways in which mother's hand-use can influence infant hand-use during object play. Lateral biases in object placement by the mother and her use of the structural and dynamic asymmetries of the objects were examined. Although all the mothers were right-handed, half of the infants had left hand-use preferences. Therefore, the effect of the hand-use preference of the infant on the mother's hand-use during play could be examined. It was expected that mothers of left-handed infants would use their left hand more frequently than mothers of right-handed infants. It was hypothesized also that both right- and left-handed infants would match the hand-use of their mother during play and that the mothers would use the right hand more than the left. It was expected that the mother's right hand-use preference would result in lateral biases of object placement and use of toy asymmetries during play which would promote more right hand-use by the infant. However, it was hypothesized also that mothers of left-handed infants would exhibit less of a rightward bias in toy play than mothers of right-handed infants.

METHOD

Subjects

Twenty-eight infants (14 males) and their mothers (recruited from the birth lists of the Beth Israel Hospital, Boston, MA) were examined at 7, 9, and 11 months of age. Fourteen of the infants (7 males) had left hand-use preferences for both reaching and unimanual manipulatory actions. The 28 infants were selected from a group of 119 infants according to the following criteria. Infants with left hand-use preferences (1) had to have

significant left hand-use preference scores for both reaching and manipulation for at least two of the three age periods of testing (7, 9, and 11 months); (2) had to have mothers with significant right-handedness scores; and (3) must never have exhibited a significant right hand- use preference for either reaching or manipulation during the 7- to 11- month age period. Infants with right hand-use preferences also had to have mothers with significant right-handedness scores and they had to have hand-use preferences scores for each age period that approximated (but with an opposite sign) those of infants with left hand-use preferences. All of these matches were made with regard to avoiding any confound with the infant's sex.

Procedure

Mother's handedness was assessed by the Briggs and Nebes (1976) adaptation of Annett's (1972) questionnaire. This questionnaire asks 12 questions about either unimanual (e.g., hold a hammer) or bimanual (e.g., hand at the top of a broom) hand-use for which there are five possible answers (always right, mostly right, right and left equally often, mostly left, and always left). The answers are scored + 2, + 1, 0, —1, and — 2, respectively. Thus the questionnaire scores can range from + 24 to — 24. Although the questionnaire scores correlate with measures of degree of lateralization of skill (Briggs and Nebes, 1975), the questionnaire can be used only to categorize the hand-use preference. Scores larger than + 16 were used to identify mothers with significant right handedness. There were no significant differences in the handedness scores of the mothers of right-handed (M = 20.3, SD = 1.7) and left- handed (M = 19.8, SD = 2.0) infants.

Infant hand-use preference was assessed at each visit by a procedure that has identified reliability and validity estimates (Michel et al. , 1985). This procedure involves the presentation of 28 items and provides separate scores for reaching for and manipulating toys (Michel et al. , 1985). Frequencies of right and left hand-use for reaching and manipulation were converted separately into z scores [(R-L)/v(R + L)], with scores larger than + 1.65 indicating significant right hand-use preference and scores smaller than —1.65 indicating significant left hand-use preference. Of the 119 infants tested, 49% (58 infants) had significant hand- use preference scores for both reaching and manipulation for at least two of the three age periods of testing. If the preferences were significant for only two of the three testing periods, then the preference score had to be nonsignificant in the remaining period. Of the other 61 infants, 49% (25% of the 119 infants) showed either only one or no significant preference score during the three testing periods and the rest (26% of the 119 infants) had preferences scores that varied between significant right and left hand-use.

The infant handedness assessment procedure provides a means for reliably and validly classifying infants into three handedness categories (significant right, significant left, no significant preference) according to their hand-use while playing with toys. It does not provide a measure of the infant's degree of lateralization of hand-use. Indeed, there is no such measure currently available. However, right-handed infants were matched as closely as possible to left-handed infants, according to the individual pattern of their test scores. Thus, there were no differences, except for direction, between right- and left-handed infants in their manner of handedness classification. However, it was possible, but not measurable, that the groups differed in degree of lateralization. Indeed, the research literature would predict that the left-handed infants of right-handed mothers would be less lateralized than right-handed infants of right-handed mothers.

Each visit to the laboratory began with the assessment of the infant's hand-use preference. Then, infant sat on the mother's lap facing a table on which six toys were placed one at a time. The mother was instructed to engage the infant in play (for 90 s) with each of the toys (plastic hedge-hog, wind-up hopping frog, three nesting cups, a small wooden cage containing a bell, a 3-in. -diameter clear plastic ball half-filled with water and containing two floating ducks, and a 9-in.-long plastic squeaky bear). Thus, there was a total of 9 min of play for each visit to the laboratory by a infant—mother pair.

The mother's and infant's hand actions were recorded on videotape by both an overhead and a left-side (90°) video camera. For scoring, the videotapes were paused every 10 s and the infant's hand-use (left, right, or both) was marked according to five "biasing" conditions: (1) the mother's hand-use; (2) the biasing dynamics of the item (whether the movement or structure of the toy favored one hand); (3) the mother's placement of the toy

(whether to the infant's left, right, or midline—as defined by the width of the infant's chest); (4) the mother's active maneuvering of one of the infant's hands; and (5) the mother's placement of an item in one hand of her infant. It should be noted that biasing conditions 4 and 5 occurred so infrequently that they were not included in the data analyses. Two coders scored the videotapes after each had achieved at least 95% reliability [(hits-misses)/total], with a third coder for the coding of three subjects.

Matches of hand-use were defined by the infant's use, within the 10-s scoring interval, of the same hand used by the mother. The occasional "matches" that occurred across 10-s intervals were not counted and it was possible for more than one match to occur within a scoring interval. All matches had to involve unimanual actions by both the mother and the infant. Use of both hands by either mothers or infants was not counted. Matches of item bias were defined by the infant's use of the hand closest to the structural (e.g., handle oriented to infant's left side) or dynamic (e.g., rolling toward the infant's right side) asymmetry of the object. Matches of placement were defined by the infant's use of the hand on the side to which the item was placed. Nonmatches were the reverse situations. Of course, placements could be nonbiased (midline) and the object's structural asymmetries or dynamic properties could be nonbiased (e.g., object's handle oriented toward infant's midline or object rolling in midline). The proportions of hand-use matching or non- matching was calculated using the total of biased and neutral conditions. Data were systematically examined by analysis of variance models with the infant's sex and hand-use preferences as between-subjects factors and the infant's age as one of the within-subjects factors. Additional factors depended on the specific data and these are specified in the results section. Post hoc analyses of mean differences were done with Tukey's A test.

RESULTS

The frequency of combined left and right unimanual hand-use during play with the mother was examined by analysis of variance. There were no significant differences between the male and the female or between the left-handed and the right-handed infants in frequency of unimanual hand-use. However, there were a significant difference according to the infant's age [$F(2,48) = 12.8, p < .001$] and a significant interaction of age with handedness [$F(2,48) = 4.6, p < .02$]. Left-handed infants showed a unilinear increase in frequency of hand use with age, whereas right-handed infants showed a curvilinear change in frequency with age (Fig. 1).

The proportion of unimanual actions in which the infant used the preferred hand when playing with the mother was examined by ANOVA. Male and female infants did not differ in their use of their preferred hand. However, left-handed infants used the preferred significantly less often ($M = 54\%$, $SD = 21.1$) than did right-handed infants ($M = 66\%$, $SD = 22.7$) [$F(1,24) = 11.7, p < .01$] (Fig. 2). No other differences were significant.

Nearly 54% of the infant's unimanual hand-use actions match the hand that the mother used ($M = 53.8\%$, $SD = 33.4$). Infant matching of mother's hand-use varied significantly with the infant's handedness [$F(1,24) = 7.6, p < .01$]. Right-handed infants matched more of their mother's hand actions ($M = 63\%$, $SD = 31$) than did left-handed infants ($M = 37\%$, $SD = 32$). Matching percentages also varied with age [$F(2,48) = 3.7, p < .05$], with the percentage of matches at 7 months ($M = 46\%$, $SD = 35$) significantly (Tukey's A test $p < .01$) less than the percentage at 11 months ($M = 62\%$, $SD = 32$). The 9-month

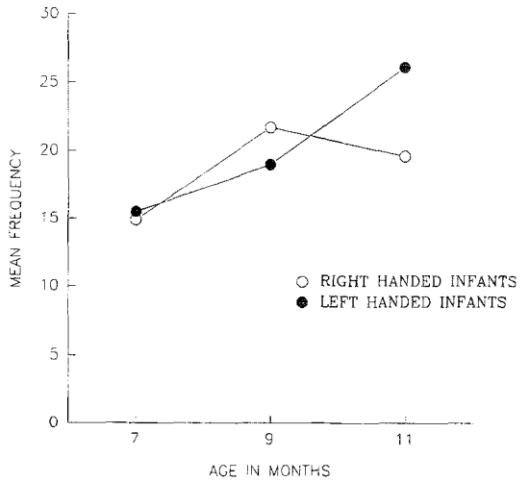

Fig. 1. Mean frequency of combined left and right unimanual hand-use actions for right- and left-handed infants at 7, 9, and 11 months of age.

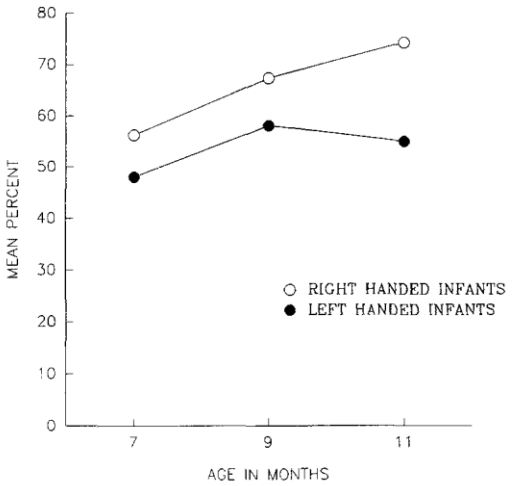

Fig. 2. Mean percentage of preferred-hand use by right- and left-handed infants during play with their right-handed mothers.

percentage (M = 54%, SD = 31) was not significantly different from that at either 7 or 11 months.

The percentage of infant matches of the hand used by the mother was significantly [$F(1,24) = 35.3$, $p < .001$], larger when the mother used her right hand (M = 65%, SD = 25) than when she used her left hand (M = 43%, SD = 35). Also, there was a significant interaction [$F(1,24) = 8.7$, $p < .01$] between the infant's handedness and the matching of the mother's right versus left hand-use (Fig. 3). Right-handed infants matched mother's hand-use when she used her right hand (M = 50%, SD = 23) more than when she used her left hand (M = 28%, SD = 13) [paired comparisons $t(13) = 2.94$, $p = .011$]. In contrast, left- handed infants matched mother's hand-use more when she used her left hand (M = 51%, SD = 28) than when she used her right hand (M = 36%, SD = 15) [paired comparisons $t(13) = 1.81$, $p < .05$, one-tailed].

The matching of the mother's right and left hand-use varied significantly according to the infant's sex [$F(1,24) = 4.6$, $p < .05$] (Fig. 4). Female infants matched both the mother's right (M = 67%, SD = 27) and the mother's left (M = 62%, SD = 37) hand-use more than did male infants (M = 62%, SD = 24 for mother's right hand-use; M = 52%, SD = 36, for mother's left hand-use).

The mother's proportion of right hand-use did not differ according to the handedness of the infant [F(1,24) = 0.03, p > .87], the sex of

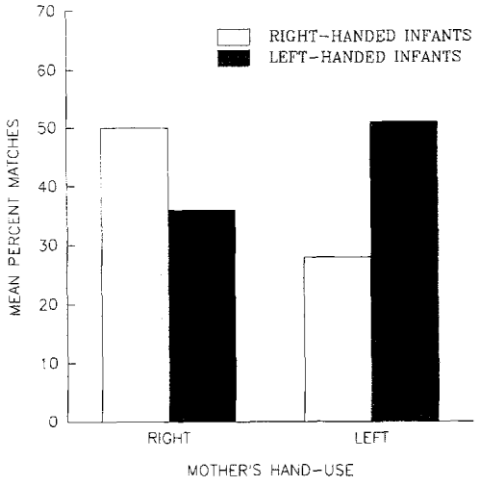

Fig. 3. Mean percentage of matches of mother's hand-use by right- and left-handed infants.

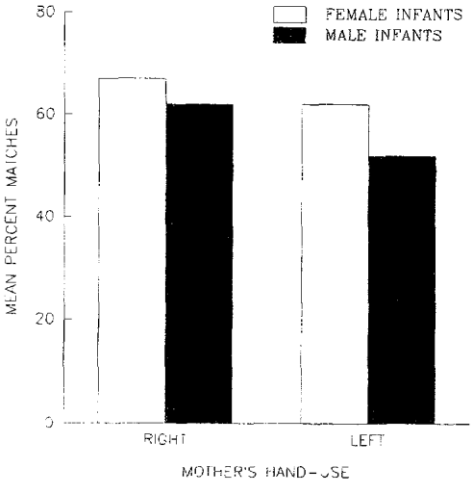

Fig. 4. Mean percentage of matches of mother's hand-use by male and female infants.

the infant [F(1,24) = 1.08, p > .3], or the age of the infant [F(2,48) = 1.58, p > .21]. No interactions were significant. Thus, the characteristics of the infant did not affect the pattern of the mother's right hand- use.

The majority of the mother's placement of a toy was to the infant's midline (M = 71%, SD = 13). However, when lateralized placements occurred, they occurred more frequently to the infant's right side (M = 58%, SD = 23). Neither the percentage of midline nor that of right-side placements varied significantly according to either the infant's handedness or the infant's sex. Hence, mothers do not appear to be adjusting their lateralized placements according to the characteristics of the infant.

Regardless of the infant's handedness or sex, infants used their right hand significantly more often with right-side placements (M = 79%, SD = 23) than with left-side placements (M = 31%, SD = 25) [F(1,24) = 69.2, p < .001]. When toys were placed in midline, left-handed infants used their right hand (M = 39%, SD = 10) significantly less than right-handed infants (M = 68%, SD = 18) [F(1,24) = 28.3,p < .001]. Also, there was a

significantly larger proportion of infant matches of mother's hand-use when the mother placed the object in midline (M = 51%, SD = 13) as compared to lateral placements (M = 35%, SD = 20) [$F(1,24) = 7.2$, $p < .02$], and this did not vary significantly with infant's sex or handedness. Since mothers were right-handed, they used primarily their right hands for midline placements. Yet both right- and left-handed infants matched the mothers' hand-use equally well. This means that for midline placements left-handed infants often used their right hand to match the mother's hand-use. In contrast, during lateral placements, the infant's hand-use matched placement position (M = 35%, SD = 20) significantly more often than it failed to match placement position (M = 3%, SD = 6) [$F(1,24) = 66.6$, $p < .001$].

Although mothers oriented the object's asymmetries primarily neutrally (M = 51%) relative to the infant's hands, the biases of the asymmetries of the item did affect infant hand-use [$F(1,24) = 4.21$, $p = .051$]. When the object asymmetry was oriented in a biased manner, hand-use more often matched object bias (M = 68%, SD = 18) than it failed to match object bias (M = 32%, SD = 16). However, infant matches of mother's hand-use occurred significantly [$F(2,48) = 53.3$, $p < .001$] more often when the item had no structural or dynamic bias and when it was placed in the midline (M = 32%, SD = 24) than when the item was biased or placed to one side (M = 22%, SD = 20).

DISCUSSION

The infant's hand-use does tend to match the mother's hand-use during play and this matching increases from 7 to 11 months of age. It is possible that matching of hand-use emerges from the simple concordance of mother and infant hand-use preferences. Therefore, since all mothers were right-handed, it would be expected that infants with right hand-use preferences would show a greater probability than those with left hand-use preferences of matching the mother's hand-use. Indeed, the results showed that an infant with a right hand-use preference is more likely to match the hand-use of the right-handed mother when she uses her right versus her left hand. In contrast, an infant with a left hand-use preference is more likely to match the hand-use of the right-handed mother when she uses her left rather than right hand. Thus, it would be expected that mother—infant pairs who were concordant, rather than discordant, for hand-use preference would show a greater matching of hand-use.

In order to identify matches of hand-use beyond that of simple concordance of hand-use preference, the frequency of observed matches ought to be compared to the frequency expected from the cross-products of the mother and infant's hand-use. Harkins and Uzgiris (1991) reported that infant matching of maternal hand-use occurred more often than would be expected from the cross-products of their relative frequencies of hand- use. Therefore, they concluded that matching of hand-use was not simply an artifact of a match of hand-use preference. Unfortunately, there is no way of estimating relative frequency of hand-use for either the mother or the infant in the present study. The measures of infant hand-use preference, although influenced by relative frequency of hand-use, do not provide frequency data. The questionnaire assessment of maternal handedness simply provides a rating of relative frequency of hand-use for a number of tasks.

Nevertheless, concordance of hand-use preferences would not account for left-handed infants matching mothers' right hand-use, especially after midline placements. Therefore, the possibility that the infants matched the hand-use of their mothers cannot be ruled out. However, the basis for such matching is unclear. Both the mother's placement of the toy and the structural and dynamic biases of the toy seemed to affect the infant's hand-use. Although mothers placed the toy in the infant's midline position over 70% of the time, when placement bias occurred, it was primarily to the infant's right side (perhaps because the mothers were right-handed) and it elicited right hand-use from both right- and left-handed infants. The less frequent left-side placements elicited left hand-use from both right- and left-handed infants. Since the infant's hand-use matched both the lateral placements of the objects and their structural and dynamic biases, these factors may contribute to the development of the strength of the infant's hand-use preference. However, these biasing activities occurred relatively infrequently and accounted for only a small proportion of the infant's matching of mother's hand-use. Perhaps, the mother's biasing activities were more subtle than our analyses could detect.

Mothers did not adjust either their hand-use or their biases in toy play to the preference of the infant. Therefore, mothers and infants who are discordant for hand-use preference could create conditions in which the strength of infant handedness would be weakened. This would account for the less frequent use of the preferred hand by left-handed, as compared to right-handed, infants in the present study. The role of concordance of hand-use preference between mother and infant for the development of the infant's manual skills should not be underestimated. Michel and Harkins (1985) showed that discordance of hand-use preference between an adult demonstrating a manual skill and another adult trying to learn that skill inhibited the acquisition of the skill. In contrast, concordance of hand-use preference between the demonstrator and the learner facilitated acquisition of the skill. If infants match or imitate the manual actions of the mother (Uzgiris et al. , 1989), then discordance of hand-use preference between mother and infant could inhibit such imitation and slow the acquisition of manual skill. Thus, mothers and infants who are concordant for handedness could create conditions in which the infant's handedness would be strengthened.

Infant matching of mother's hand-use could occur in several ways: (1) through concordance of hand-use preference between mother and infant, (2) through the mother's lateral placements of toys and/or her use of their structural and dynamic biases during play, and (3) through either very subtle maternal biasing activities or the infant's imitation of mother's hand-use. All of these ways provide conditions which affect the strength and possibly the direction of the infant's hand-use preference. Any of these ways would result in a stronger association of offspring handedness with mother's, as opposed to father's, handedness.

At present, there are two single-gene models of handedness. Annett's (1975) model proposes a single gene with two alleles (rs + and rs —). The population distribution of handedness would be a sum of three underlying distributions of the rs — — , rs + — , and rs + + genotypes. Variability in handedness would be the consequence of relatively random environmental factors upon which the rs + allele would impose a bias for right handedness. McManus (1984, 1985) proposed two alleles, D (dextral) and C (chance). Individuals who are DD are right-handed and those who are CC are either right- or left-handed, with their distribution determined by chance. Heterozygous individuals are 75% right-handed. Unlike Annett, McManus treats handedness as a categorical (right and left) rather than a continuous variable, with some variability in degree of handedness determined by environmental experiences. His reanalysis of Annett's peg-moving data showed a better fit with his model than with Annett's (McManus, 1985). However, too many untested or unsupported assumptions underlie the notion of handedness as a categorical variable (cf. Bishop, 1990). Therefore, Annett's model remains the one most commonly accepted.

It has been demonstrated that a polygenic threshold model can fit the family segregation data as well as Annett's model (Risch and Pringle, 1985). If environmental (social) factors are allowed to play a substantial role in a polygenic model, then current data do not allow discrimination between polygenic and single-gene models. Thus, both single-gene and polygenic models of handedness require detailed studies of the social and nonsocial factors affecting the development of infant hand-use preferences in order to interpret appropriately the results of family studies of handedness and to construct accurate genetic models. The results of the present study demonstrate that the types of social influences affecting the development of handedness are more subtle than generally conceived.

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