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# Birth Stress and Lateral Preferences

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# BIRTH STRESS AND LATERAL PREFERENCES

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Why do some individuals prefer using the left side of their body for certain functions whereas most individuals prefer using the right side (Nachshon, Denno and Aurand, 1983; Porac, Coren and Duncan, 1980)? This question has engaged numerous students of neuropsychology in the last few decades. Over the years three major hypothesis have emerged concerning the etiology of left side preferences: genetic (e.g., Annett, 1972, 1973; Corballis and Morgan, 1978; Hicks, 1976; Levy and Nagylaki, 1972; Morgan and Corballis, 1978), environmental (e.g., Blau, 1946; Dawson, 1977; Hildreth, 1949), and interactive (e.g., Collins, 1977; Corballis, 1980). Among the nongenetic hypotheses, those explaining left-side preferences in terms of birth stress events have gained a considerable amount of attention; particularly with regard to left hand preference. Bakan and his associates (Bakan, 1971, 1975, 1977, 1978; Bakan, Dibb and Reed, 1973) linked left hand preference to prenatal and perinatal stress conditions. They argued that whenever stressful events affect the left hemisphere, the contralateral right side functions may be impaired; consequently preference may shift from the right to the left hand.

Buttressing his hypothesis, Bakan (1971, 1975) pointed to populations with higher than normal incidence of both birth complications and left-hand preference such as twins, stutterers, dyslexics, mental-retardates, epileptics, alcoholics, delinquents and psychopaths. He and his associates further argued that wherever a great risk of birth stress exists (e.g., during deliveries of first borns and of children born to old mothers — fourth or later borns), the incidence of (pathological) left hand preference increases. This increase is particularly evident for males since they are more vulnerable than females to prenatal and perinatal stress (Shapiro, 1968).

Bakan's hypothesis has been subsequently tested with mainly negative results. Only two authors have corroborated previous findings (Badian, 1983; Leviton and Kilty, 1976), whereas numerous others have found no evidence for an association between birth order and hand preference (as

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well as other lateral preferences), either for males or for females (Annett and Ockwell, 1980; Dusek and Hicks, 1980; Ehrlichman, Zoccolotti and Owen, 1982; Hicks, Evans and Pellegrini, 1978; Hicks et al., 1979; Hicks, Pellegrini and Evans, 1978; Hubbard, 1971; Leiber and Axelrod, 1981; Nachshon and Denno, 1986; Schwartz, 1977; Searleman, Tsao and Balzer, 1980; Tan and Nettleton, 1980).

A variant of Bakan's hypothesis was advocated by Satz and his associates (Satz, 1972, 1973, 1979; Satz et al., 1985; Silva and Satz, 1979; Soper and Satz, 1984), who similarly attributed pathological left-hand preference to left hemisphere dysfunction due to an early brain damage. But unlike Bakan and his associates, they maintained that left hand preference may also be genetic (see Soper and Satz, 1984).

Satz's hypothesis is indirectly supported by evidence showing that pathological conditions which are associated with left hemisphere dysfunction are also related to left-side preferences (e.g., Bocklage, 1977; Colby and Parkinson, 1977; Dvirskii, 1976; Flor-Henry, 1979; Gur, 1977; Hicks and Barton, 1975; Lishman and McMeekan, 1976; Luchins, Pollin and Wyatt, 1980; Oddy and Lobstein, 1972; Piran et al., 1982; Satz, 1972, 1973, 1979; Walker and Birch, 1970). However a more direct test of the hypothesis would be by demonstrating an actual link between birth stress events and left-hand preferences.

Such a link was examined in a number of studies by using self reports of birth stress. In a study conducted by Bakan, Dibb and Reed (1973), 510 students with right- and left-hand preferences reported the complications their mothers had experienced during their births. Significantly more subjects with left (40%) than right (22%) hand preference reported the presence of stressful birth events which included multiple births, premature birth, prolonged labor, Caesarian birth, blue baby, and breathing difficulties at birth. However, using the same self-report methodology and birth-stress criteria, Searleman, Tsao and Balzer (1980) failed to replicate Bakan et al.'s (1973) findings. Similarly, no association between self-reported birth complications and left-side preferences were found by Schwartz (1977), and Leiber and Axelrod (1981). An association between hand preference and self-reported birth complications, documented by Hicks et al. (1980), was considered too small to account for the incidence of left-hand preference in their sample.

However, self-reports may not be valid for determining conditions at birth (Coren, Searleman and Porac, 1982). Mothers' reports of birth events would appear to provide a better answer to the question of whether birth-stress is associated with left hand preference. In Coren and Porac's (1980) study maternal reports of birth stress were collected from 4000 families who were contacted by mail. Stress events included premature birth, prolonged labor, breech birth, blue baby, low birth weight, Cae-

sarian section, multiple births, Rh incompatibility, instrument birth, and the like. Supporting Bakan's (1971) hypothesis, Coren and Porac (1980) found that birth complications were associated with a decrease in right hand preference in males only. This finding was subsequently corroborated by Coren, Searleman and Porac (1982). In addition, Liederman and Coryell (1982) correlated maternal reports of birth stress events with infants' spontaneous turning biases observed between four and six weeks of age. Results showed that infants who had experienced birth complications lacked the normal right turning bias and the lateralization of the asymmetric tonic neck reflex. Obtaining reports on birth stress through home visits, Annett and Ockwell (1980) failed, however, to find an association between birth stress and left hand preference. Similarly, Tan and Nettleton (1980) found no association between maternal reports of birth complications with left-hand preference, either for males or for females.

Studies using hospital records, the most valid source of information on birth complications, have also produced conflicting results concerning the association between birth stress and lateral preferences. For example, no significant differences between hand preference on unimanual tasks and perinatal stress were reported when both hospital records and maternal reports were used as sources of information (Schwartz, 1985). Similarly, McManus (1981) found no relationship between hand preference and birth trauma as indicated by hospital records of over 12,000 children. However, in another recent study (Orsini, Satz and Zemansky, 1985), hospital-documented cerebral insults were associated with a relatively high incidence (31%) of left-hand preference in the left hemisphere group.

Ehrlichman, Zoccolotti and Owen (1982) correlated hospital-recorded delivery data with lateral preferences of hand, eye, and foot in a sample of 1838 males and 3061 females. Delivery events included those examined by Bakan, Dibb and Reed (1973) plus birth weight, maternal age, birth position, and Apgar, (an indicator of an infant's immediate postnatal health). Overall, no associations were found among the different birth complications and hand and foot preferences. However, left-eye preference in males was associated with some of the complications, such as breech presentation, high and low birth weight, Caesarian section, multiple births, premature birth, or administered oxygen.

The hypothesis that birth stress might be related to eye rather than hand or foot preferences was recently supported by Nachshon and Denno (1987). They reported an increased incidence of left eye (but not hand or foot) preference among very violent offenders, who have been found in some research to have a higher than normal incidence of left-hemisphere dysfunction (see Nachshon, 1983).

Ehrlichman et al.'s (1982) and Nachshon and Denno's (1987) recent findings accentuate the importance of examining further the relationships among various lateral preferences and birth stress. The purpose of the present study was to analyze select, medically-recorded birth stress events with patterns of lateral preferences of hand, eye, and foot in a sample of nearly one thousand boys and girls. Efforts were made to control for methodological and measurement problems encountered in past birth stress and laterality research.

## MATERIALS AND METHOD

### *Subjects*

Subjects came from a pool of 6839 black children whose mothers participated in the Philadelphia Collaborative Perinatal Project (CPP) at Pennsylvania Hospital between 1959 and 1966 (For further details see Nachshon et al., 1983). Pennsylvania Hospital was one of twelve medical centers selected by the National Institute of Neurological Diseases and Stroke (NINDS) in a nationwide study of genetic, biological, and enviromental influences upon child development. A description of the CPP study may be found in Broman, Nichols and Kennedy (1975) and Niswander and Gordon (1972).

The sample used for analyses included all 987 subjects (487 males and 500 females) who had complete birth stress and lateral preference data. Birth stress items were measured by experienced pediatricians at the time of the mother's prenatal examinations, during delivery, and immediately after the child's birth at Pennsylvania Hospital. Lateral preference tests were administered by trained psychologists while the subjects attended neurological and pediatric examinations at the Hospital of the University of Pennsylvania when they were 7 years ± 6 months. In the present study, the small number of subjects with "variable" or ambidextrous hand preference and "variable" eye preference were excluded from analyses, in order to ensure the validity of the measures of left and right side preferences.

### *Lateral Preference Measures*

The procedures used to measure lateral preferences of hand, eye and foot are described as follows (see U.S. Department of Healt, Education and Welfare, 1966, pp. 22-23):

#### *Hand preference*

Hand preference was treated as a dichotomous variable. Predominantly left-handed individuals constituted one group, and predominantly right-handed individuals constituted the other group. Hand preference in the CPP was observed by placing three differently colored pencils directly in front of the child who was then asked to make an "X" on a piece of paper with each pencil. If the same hand was not used with each of the three pencils, the test was repeated two more times. Any preference which occurred fewer than four out of five times was coded as "variable".

### *Eye preference*

Eye preference was treated as a dichotomous variable. Predominantly left-eyed individuals constituted one group, and predominantly right-eyed individuals constituted the other group. Eye preference in the CPP was observed by asking a child to look through a kaleidoscope after picking it up with both hands. The test was repeated three times with both hands on the kaleidoscope. Any preference less than perfect was coded as "variable".

### *Foot preference*

Foot preference was treated as a trichotomous variable. Predominantly left-footed individuals constituted the first group; predominantly right-footed individuals constituted the second group; and individuals with variable foot preference constituted the third group. Foot preference in the CPP was observed by asking a child to stand with both feet together and kick a 3- to 4-inch Wiffle ball which was placed one foot directly in front of the child. A consistent foot preference was then noted by the experimenter during three trials. If two right and one left (or vice versa) responses were observed, two more trials were performed. Any preference less than four out of five was coded as "variable".

## *Birth Stress Measures*

Birth stress measures selected for the present study are described as follows (for rationale of variable selection see Denno, 1982):

### *Apgar Score*

The Apgar score (Apgar, 1953) is an evaluation of an infant's physical condition at one (Apgar 1) and five (Apgar 5) minutes after birth based upon five indices: Heart rate, respiratory effort, muscle tone, reflex irritability, and color. Each indicator is assigned a score of 0 (poor condition), 1 (moderate condition), or 2 (good condition). The Apgar score is the total sum of the scores for all indices and ranges from 0 to 10. In general, a total score of 0 to 3 suggests that the infant is severely depressed and asphyxiated; a score of 4 to 6 indicates that the infant is moderately depressed with usually no need for special resuscitative measures; whereas a score of 7 to 10 demonstrates that the infant's health is good to excellent (for more details, see Apgar et al., 1958; U.S. Department of Health, Education and Welfare, 1966, Part III-B, pp. 3-4).

### *Gestational age*

Gestational age is the time between the first day of the last menstrual period (LMP) reported by the gravida and the day of delivery. In order to eliminate errors due to inaccurate recall of a menstrual date or to variations in menstrution or bleeding, a specially-trained interviewer recorded both the date of the LMP and the date of onset of the preceding period at the time of the prenatal registration. The hospital staff and the obstetrician independently collected additional information regarding the LMP, including an estimate of the duration of the

pregnancy based on the gravida's physical changes and history. This estimate was reevaluated at each prenatal visit. Moreover, the primary obstetrician noted any inconsistencies which were found in the data when the pregnancy terminated (for further details, see Hardy, Drage and Jackson, 1979, pp. 38-39; U.S. Department of Health, Education and Welfare, 1966, Part III-A, p. 60).

*Birth weight*

The birth weight of an infant was measured in pounds and ounces immediately upon delivery (for details, see U.S. Department of Health, Education and Welfare, 1966, Part III-B, p. 7).

*Duration of labor*

Duration of labor (stages 1 and 2) was measured in hours and minutes from the onset of labor. The time of onset was self-reported by the gravida if labor occurred prior to admission to the hospital, or it was observed on the hospital. Duration of the first stage of labor, which lasts on the average about eight hours, is defined as the time from the onset of regular contractions to full dilation of the cervix. Duration of the second stage of labor, which lasts on the average about one half hour, is defined as the period of time between the full dilation of the cervix and the completed delivery of the infant (a third stage of labor which lasts about five minutes, was excluded from analysis because it is not associated with fetal condition) (for further details, see Niswander and Gordon, 1972; pp. 292-314).

*Mother's Smoking Habits*

Smoking habits were measured by the mean number of cigarettes a mother smoked per day during her pregnancy. Heavy smoking has been found to be associated with pregnancy complications and developmental defects among children, including prematurity, low birth weigth, congenital anomalies, and delayed physical growth during childhood (Broman et al., 1975; Butler and Goldstein, 1973; Garn, Shaw and McCabe, 1977; Goldstein, 1971; Naeye, 1978a, b).

*Mother's Age*

Mother's age was reported at the time of the mother's registration into the CPP during her pregnancy. Mothers who are 35 years of age or older have been found to have significantly more difficulty with fertility and fecundity, regardless of parity (DeCherney and Berkowitz, 1982; Federation CECOS, Schwartz and Mayaux, 1982). Significant relationships between mother's age at either extreme of the age continuum (young or old) and subsequent pregnancy and delivery complications have also been reported (Hardy, Drage and Jackson, 1979).

*Caesarian Section*

Delivery by Caesarian section is suggested for some cases of malpresentations or other troublesome events. Possible consequences of Caesarian sections include

abnormal fuctions of the central nervous system, prematurity, and respiratory distress (for further details see Drillien, 1972; Drorbaugh, Moore and Warren, 1975; Hardy, Drage and Jackson, 1979, p. 155; Naeye, 1977; Niswander and Gordon, 1972; Taylor, 1976, pp. 539-543).

## RESULTS

Mean distributions for males and females on birth stress and lateral preference measures are presented in Tables I and II.

Group differences were determined by analyses of variance, chi square tests and Duncan multiple range tests, as applicable. Duncan test is one of the most powerful of several statistical techniques appropriate for a posteriori contrasts of all possible pairs of group means (see Winer, 1971).

Data analyses showed no statistically significant differences between males and females on distributions of birth stress or lateral preference measures. Furthermore, except for males with right-eye preference who had a significantly ($p < .05$, Duncan Test) longer gestational age than males with left-eye preference, there were no statistically significant associations among birth stress and lateral preference measures for either males or females.

## DISCUSSION

Since subjects with different lateral preferences showed similar scores on a variety of birth-related measures, the results of the present study seem to indicate that birth stress and lateral preferences may not be associated. While it is true that eye preference and gestational age were found to be interrelated among males, considering the large number of differences being tested for the eight birth stress and three lateral preference measures, it is not unlikely that this one significant difference was due to chance alone.

These findings contradict those hypotheses which link all left-side preferences (Bakan, 1971, 1975, 1977, 1978; Bakan, Dibb and Reed, 1973; Badian, 1983; Leviton and Kilty, 1976) or some of them (Satz, 1972, 1973, 1979; Satz et al., 1985; Silva and Satz, 1979; Soper and Satz, 1984) to birth stress events. It is noteworthy that of the six birth stress events linked by Bakan, Dibb and Reed (1973) to hand preference, five (gestational age, prolonged labor, Caesarin birth, blue baby, and breathing difficulties) were not associated with lateral preference in the present study. Consistent with Bakan's hypothesis, duration of labor and Caesarian section

TABLE I

*Lateral Preferences and Birth Variables: Males*

| Variable | Value | Lateral preference[1] | | | | | | | Total (487) |
|---|---|---|---|---|---|---|---|---|---|
| | | Hand | | Eye | | Foot | | | |
| | | Left (58) | Right (429) | Left (205) | Right (282) | Left (50) | Right (409) | Variable (28) | |
| Apgar 1 minute | 1-10 | 7.78 | 7.68 | 7.79 | 7.62 | 7.52 | 7.68 | 8.07 | 7.73 |
| Apgar 5 minutes | 1-10 | 8.72 | 8.90 | 8.88 | 8.88 | 8.80 | 8.89 | 8.89 | 8.85 |
| Gestational age | weeks | 38.13 | 38.35 | 37.91 | 38.63 | 38.70 | 38.29 | 38.14 | 38.30 |
| Birth weight | pounds | 7.20 | 7.02 | 7.04 | 7.05 | 7.22 | 7.02 | 7.10 | 7.09 |
| Labor duration | hours | 8.18 | 7.83 | 7.87 | 7.87 | 8.56 | 7.93 | 7.04 | 7.89 |
| Mother's smoking | cigarettes | 3.59 | 4.34 | 4.33 | 4.20 | 4.25 | 4.22 | 4.75 | 4.24 |
| Mother's age | years | 23.20 | 24.31 | 24.55 | 23.91 | 24.38 | 24.21 | 23.35 | 23.98 |
| Caesarian section | percent present | 6.90 | 3.26 | 3.41 | 3.90 | 6.00 | 3.67 | 0.00 | 3.87 |
| Overall risk | | 12.96 | 12.71 | 12.72 | 12.63 | 13.17 | 12.73 | 12.16 | 12.74 |

[1]All figures, except for the Caesarian section, represent mean scores; the figures in parentheses indicate number of subjects; overall risk score represents the mean of all eight birth variables.

TABLE II

*Lateral Preferences and Birth Variables: Females*

| Variable | Value | Lateral preference[1] | | | | | | | Total (500) |
|---|---|---|---|---|---|---|---|---|---|
| | | Hand | | Eye | | Foot | | | |
| | | Left (50) | Right (450) | Left (211) | Right (289) | Left (53) | Right (385) | Variable (62) | |
| Apgar 1 minute | 1-10 | 7.87 | 7.81 | 7.71 | 7.89 | 7.97 | 7.84 | 7.52 | 7.80 |
| Apgar 5 minutes | 1-10 | 8.96 | 8.89 | 8.84 | 8.94 | 9.06 | 8.92 | 8.64 | 8.89 |
| Gestational age | weeks | 37.80 | 38.26 | 38.38 | 38.10 | 37.75 | 38.31 | 38.01 | 38.08 |
| Birth weight | pounds | 6.47 | 6.70 | 6.70 | 6.65 | 6.46 | 6.69 | 6.69 | 6.62 |
| Labor duration | hours | 7.52 | 7.57 | 6.95 | 8.02 | 7.78 | 7.58 | 7.32 | 7.53 |
| Mother's smoking | cigarettes | 3.80 | 5.16 | 5.54 | 4.64 | 5.52 | 5.24 | 3.26 | 4.73 |
| Mother's age | years | 24.92 | 24.52 | 25.14 | 24.13 | 24.47 | 24.67 | 23.95 | 24.54 |
| Caesarian section | percent present | 8.00 | 5.11 | 7.58 | 3.81 | 1.89 | 5.19 | 9.68 | 5.89 |
| Overall risk | | 13.19 | 13.00 | 13.23 | 12.77 | 12.61 | 13.05 | 13.13 | 13.01 |

[1] All figures, except for the Caesarian section, represent mean scores; the figures in parentheses indicate number of subjects; overal risk score represents the mean of all eight birth variables.

were found in the present study to be more prevalent among mothers of left-handed than right-handed boys (Caesarian sections were also more prevalent among mothers of left handed girls). However, these differences were not statistically significant.

The data of the present study thus corroborate previous findings showing no link between left side preferences and birth complications; whether those complications were self-reported (Searleman, Tsao and Balzer, 1980; Schwartz, 1977; Leiber and Axelrod, 1981), reported by mothers (Annett and Ockwell, 1980; Tan and Nettleton, 1980), or obtained through hospital records (Ehrlichman, Zoccolotti and Owen, 1982; McManus, 1981; Schwartz, 1985).

Recently, however, Orsini, Satz and Zemansky (1980) reported an association between documented cerebral insults and incidence of left-hand preference. Coren and Porac (1980) and Searleman, Porac and Coren (1982) further showed that in line with Bakan's (1971) hypothesis, maternal reports indicate that this association holds true for males only. Finally, in line with Nachshon and Denno's (1987) hypothesis, Ehrlichman, Zoccolotti and Owen (1982) found a link between certain birth complications and eye preference.

Promoting the hypothesis of a link between left side preferences and birth stress, Coren, Searleman and Porac (1982) argued that methodological limitations, rather than an absence of a relationship, might account for the predominantly negative findings reported in the literature. According to the authors those limitations are: Self-reports, which are unreliable for determining birth events; summation across birth stress categories, which may mask existing relationships among side preferences and specific birth events; examination of hand preference only, which ignores possible associations with other side preferences such as eye and foot; and consideration of hand preference as a dichotomy rather than as a continuum, which may produce inaccurate results.

In the present study, three of Coren et al.'s (1982) requirements were met: Birth stress information was retrieved directly from medical records; the various birth events were analyzed separately; and eye and foot, as well as hand preferences, were considered. Hence it seems unlikely that the negative results obtained in the present study are due to methodological artifacts. Partial support for this conclusion comes from Tan and Nettleton's (1980) study, in which the relationship between hand preference and more than a dozen birth complications (as reported by the mothers) was examined. Item analysis showed that none of the birth stress variables, separately analyzed, was associated with incidence of left hand preference. While it is true that Ehrlichman et al.'s (1982) finding of an association between birth complications and eye preference is based on the same data source (CPP) as the present study, in which such associa-

tions were usually absent, it is conceivable that demographic factors might have contributed to the differential outcomes of the two studies. In Ehrlichman et al.'s (1982) study the children were born to white mothers in the Boston area, whereas in the present study they were blacks from the Philadelphia area. As Nachshon, Denno and Aurand (1983) pointed out, a few race differences in laterality have been reported.

Recently, however, Searleman, Porac and Coren (1982) showed that certain birth complications (premature birth, prolonged labor, low birth weight, and Caesarian section) are associated with inverted writing among left-handed males. Altogether, 93.8% of the the subjects who experienced some kind of birth complications wrote with an inverted posture, whereas only 40.5% without birth complications wrote with that posture.

In the present study, Searleman et al.'s (1982) hypothesis could not be examined because no hand posture data were available. Regardless, the relationship between inverted hand posture and birth stress applies to only a very small segment of the population and therefore does not adequately account for the wide range of different lateral preferences.

Together with previous research (Annett and Ockwell, 1980; Leiber and Axelrod, 1981; McManus, 1981; Schwartz 1975, 1977; Searleman, Tsao and Balzer, 1980; Tan and Nettleton, 1980) the results of the present study thus indicate that, in general, lateral preferences and birth stress are not interrelated. Alternative explanations for the origin of lateral preferences should therefore be explored. For example, recent evidence (Geschwind and Behan, 1982) suggests that left-hand preference may be associated with the relatively slower growth of the left hemisphere due to prenatal and postnatal hormonal alterations. More intensive study of early hormonal effects, as well as other kinds of influences which may be involved in both genetic and pathological left-handedness, could provide explanations for the etiology and development of left-side preferences.

## ABSTRACT

Conflicting evidence exists concerning the possible role of birth stress in the etiology of left-sided lateral preferences. In order to clarify this issue, associations among lateral preferences of hand, eye, and foot and eight indices of prenatal and perinatal stress were examined in the present study on a sample of 987 boys and girls who participated in the Philadelphia Collaborative Perinatal Project. Controls were instituted for some of the methodological and measurement problems encountered in past birth stress and laterality research. Results showed that subjects with different lateral preferences did not differ significantly in their distributions of all but one birth stress items. Hence, there was no substantial evidence for a link between birth stress and left-sided preferences. Alternative hypotheses for the etiology of left-sidedness should therefore be explored.

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