NEONATAL LATERALIZATION: ASYMMETRICAL ATTAINMENT AND MAINTENANCE OF HEAD POSTURE

by

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ABSTRACT

Normal full-term newborn infants will usually show a side preference for turning their heads away from the cephalo-caudal body midline when supine-positioned. This preference is typically rightward. Empirical investigation concerning this phenomenon has been directed toward understanding the phenomenon and its posited antecedents and consequences. A review of the research indicates that this typically-rightward bias is manifested at two levels. At the first, basic level, there is a lateral bias in spontaneous, attained, or maintained head posture. At the second level, there is a responsive asymmetry to lateralized stimuli: an ipsilateral turning response is more easily elicited by right-sided stimulation than by left-sided stimulation. The current study was designed to be an in-depth investigation of the level one lateral bias. The goals of this study were to examine the lateral bias in a testing situation which was minimally asymmetric in stimulation, to determine the generalizability of the bias in a setting independent to prior test settings, to examine the lateral bias along three potential dimensions of lateral consistency: initial turning preference

subsequent to midline head release, turning preference for all turns over the course of the test session, and which side the infant spent the majority of time turned toward, and, finally, to examine the relationship between these indices of lateral consistency and a set of attribute variables (i.e., uterine head position, parental handedness, age at testing, sex, state during testing, spontaneous head posture prior to testing, birth status, delivery type, maternal age and maternal medication). The lateral bias of fifty healthy, full-term male and female neonates was examined in a repeated-trial observation session. Each trial involved the following sequence: restricting the neonate's head to the midline until no pressure to turn in either direction was felt, head release, and one minute of free head movement by the neonate. The majority of the sample manifested a lateral bias, most often rightward, along all three dimensions. The only significant relationship between the measures and the set of attribute variables was with spontaneous head posture. The contribution of these results to the available literature is discussed. A valid assessment of the theoretical and clinical neuropsychological significance of the literature awaits further multi-dimensional investigation with both normal and clinical samples.

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TABLE OF CONTENTS

Abstract..... i

Table of Contents..... iv

List of Tables..... vi

List of Figures..... viii

Acknowledgments..... ix

Introduction..... 1

What is the Phenomenon?..... 4

Spontaneous Level One Studies..... 4

Restricted Position Level One Studies..... 9

Level Two Studies..... 15

What are the Antecedents of the Phenomenon?..... 28

Uterine Head Position..... 29

Level One Influences..... 30

Parental Handedness..... 31

Prior Head Position..... 32

Maternal Holding Preference..... 33

What are the Consequences of the Phenomena?..... 34

Hand Use..... 35

Dichotic Listening Performance..... 38

Maternal Holding Preference..... 39

What is the Neuropsychological Significance of the Phenomena?..... 40

Conclusions..... 44

Purpose of the Present Investigation..... 48

Methods..... 50

Subjects..... 50

Procedures..... 54

Data Reduction..... 58

Results..... 61

Level One Lateral Bias..... 61

Relation Between Level One Lateral Bias and Attribute Variables..... 66

Uterine Head Position..... 66

Parental Handedness..... 66

Modal State..... 67

Sex..... 67

Spontaneous Head Position..... 67

Age at Testing..... 67

Apgar Status at Birth..... 67

Maternal Medication..... 68

Maternal Age..... 68

Cesarean Section..... 68

Discussion..... 69

Bibliography..... 74

Appendix A..... 82

Appendix B..... 83

Appendix C..... 84

Appendix D..... 85

Appendix E..... 86

LIST OF TABLES

1. Sample Characteristics..... 91

2. Frequency distribution of the direction of the initial head turn following midline release per trial (right, no turn, left)..... 92

3. Frequency distribution of the direction of the majority of head turns following midline release (right, no bias, left)..... 93

4. Frequency distribution of the direction of the majority of total time per trial (right, left)..... 94

5. Results of analyses examining potentially-artifactual relations. (i) room position, (ii) length of midline restriction..... 95

6. Frequency distribution of the lateral consistency of the direction of the initial head turns following midline release for the testing session..... 96

7. Frequency distribution of the lateral consistency of the direction of all head turns following midline release for the testing session..... 97

8. Frequency distribution of the lateral consistency in majority trial time for the testing session..... 98

9. Concordance of the three indices of lateral consistency..... 99

10. Contigency tables for uterine head position by the three lateral consistency indices..... 100

11. Contigency tables for parental handedness by the three lateral consistency indices..... 101

12. Contigency tables for modal state by the three lateral consistency indices..... 102

13. Contigency tables for sex by the three lateral consistency indices..... 103

14. Contingency tables for spontaneous head position by the three lateral consistency indices..... 104

15. Contingency tables for age at testing by the three lateral consistency indices..... 105

16. Contingency tables for Apgar score by the three lateral consistency indices..... 106

17. Contingency tables for maternal medication by the three lateral consistency indices..... 107

18. Contingency tables for maternal age by the three lateral consistency indices..... 108

19. Contingency tables for delivery by the three lateral consistency indices..... 109

LIST OF FIGURES

1. Frequency distribution of the index of lateral consistency in the direction of the initial head turn following midline releases..... 110

2. Frequency distribution of the index of lateral consistency in the direction of the total number of head turns following midline releases..... 111

3. Frequency distribution of the index of lateral consistency in the direction of head position for the majority of trial time following midline releases..... 112

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To Ludwig van Beethoven.

NEONATAL LATERALIZATION: ASYMMETRICAL ATTAINMENT AND MAINTAINENCE OF HEAD POSTURE

A common observation by new parents, maternity nursing staff, obstetricians, and pediatricians is that when a newborn infant is placed on his back, i.e., is supine positioned, he tends to consistently turn his head away from the body midline, predominantly toward the right side. Original empirical interest in this phenomenon by developmental psychologists and behavioral neurologists reflected the prevalent zeitgeist of the first half of the century that the young infant was purely a reflexive organism. Arnold Gesell published several germinal papers on the lateral behavior dealing with the phenomenon in terms of the asymmetric tonic neck reflex (ATNR), citing its greater rightward incidence as well as its relationship to the development of handedness (Gesell, 1938; Gesell & Ames, 1947). H.F.R. Prechtl (1958) and Hanus Paposeuk (1961) each published research findings viewing the head turning phenomenon as a component of a feeding reflex.

It was not until the 1960's, perhaps due to a new conceptualization of the newborn infant as entering the world with an active central nervous system and a full repertoire of sophisticated behaviors (e.g., see Bridger, 1961),that the head turning phenomenon became a subject of interest in its own right. It has not been until quite recently that the phenomenon has been seriously examined directly as an issue of neuropsychological concern. From 1965 until the present, approximately 20 studies have been published which are directly relevant to an understanding of the lateral head turning phenomenon.

In evaluating the studies that deal with the lateral head turning phenomenon and in designing further work in the area, four relevant questions need to be addressed:

(1) What is the phenomenon? Is it a unitary phenomenon? Under what conditions does it manifest itself? Does its presence vary with neonatal attributes (e.g., infant's state, time since delivery)?

(2) What are the antecedents of the phenomenon? That is, can early life correlates or causes of the phenomenon be determined? For example, can the turning phenomenon be explained with knowledge of head position in utero or by an assessment of lateral components in the neonate's environment?

(3) What are the consequences of the phenomenon? For example, does a consistent head turning direction lead to greater visualization of one of the two hands which, in turn, results in greater manual use on that side?

(4) Finally, is the phenomenon of significance to theoretical and clinical neuropsychological conceptualizations of the neonate and neonatal precursors of later-life phenomenon? Theoretically, could the head turning laterality be viewed as an early life precursor to later adult-relevant lateralization, as evidence of cortical maturity, as evidence for the presence of lateralized cortical control at birth, or as a behavior which is minimally involved with concurrent or subsequent cortical lateralization? Equally important, is the phenomenon of clinical significance? For example, is the absence of a lateral bias clinically suggestive of aberrance?

A review of the literature relevant to each of the above questions follows.

WHAT IS THE PHENOMENON?

For conceptual and methodological clarity, lateralized phenomena at two levels can be discerned. At the first and more basic level ('level one lateral bias'), the spontaneous attainment and maintenance of a particular head position can be evaluated. At the second level, ('level two responsive asymmetry'), the attainment of a head position as a response to lateral stimulation can be evaluated. All studies have directed attention to either the first or the second level asymmetry. As will be seen below, a distinction between the two behaviors has been made in studies examining the influences of level one lateral biases on the level two responsive asymmetry. Two subgroups of behaviors have been examined with respect to the level one asymmetry: the spontaneous maintenance of a particular head position as recorded during non-interfering observation and the attainment and maintenance of a head position following a period of time during which the infant's head is deliberately restricted to the cephalo-caudal body midline axis, a non-lateralized position.

Spontaneous-position level one studies. Studies designed to explore patterns of spontaneous maintenance of

head position concern themselves with the relatively simple questions of whether or not newborn infants, upon non-interfering observation, individually maintain a particular head position rightward or leftward and whether or not, as a group, a similar pattern of head positioning is seen. Four studies are available in the literature that directly address this issue: three have observed full-term healthy newborn infants while in the fourth study pre-term infants were observed periodically from birth to the 39th gestational week. Unfortunately, two of the three studies of full-term infants are reduced to a near-anecdotal status as many important aspects of their design are left unreported, leaving the reader uncertain as to the design which was actually employed.

In the original study (Turkewitz, Gordon & Birch, 1965a), head turning was observed in twenty full-term neonates between 60 and 79 hours of age during a five minute examination period. All subjects were observed while supine positioned in an examination room adjacent to the main nursery. The authors report that bassinets were not placed consistently in one part of the room to avoid directionalized stimulation (e.g., lighting) but do not report the influence that any such stimulation might have had for individual subjects.

Seventeen of the 20 subjects spent the observation time with their heads turned rightward, the remaining three spent the time turning both rightward and leftward. No subject was found to have spent the majority of the session turned leftward. Two subgroups were reported among the 17 rightward-turned infants: one subgroup repeatedly moved their heads between rightward and midline while the second subgroup maintained their heads within a 45 degree angle of the mattressed bassinet-base on their right sides.

Additional analyses revealed no trend in the frequency of head turning over the observation period nor were differences found as a function of time since previous feeding period or sex of subject. In both awake and sleeping infants, the total number of head movements was correlated with the total number of arm movements and arm-face touches but was not correlated with the number of leg movements.

Noted in this same paper is a second set of data dealing with the spontaneous head positions of ''several hundred'' supine-positioned infants from birth to four days of age. All but three were found to be laying with heads rightward of the body midline. Although the authors

present very few particulars of the design of their study (e.g., subject stimulus environments, length of the observation period, subject state at the time of observation), they conclude that neither the presence of any lateralized stimulation nor differential placement of infants into their bassinets by nursing staff were responsible for the observed predominance of a rightward postural position.

Further, Turkewitz & Birch (1971) cite an earlier, unpublished set of data by their research group dealing with 3000 observations of 100 babies from birth to 100 hours. In 88% of these time periods the subject being observed was lying in a head rightward position; in a head leftward position, 9.2%; with head in the body midline, 2.8% of the observations. Individual infants spent 90% of the time periods during which they were observed to have their head out of the body midline with their heads turned rightward. Again, no infant was found who maintained his head predominantly leftward. Unfortunately, little information is presented by the authors on relevant aspects of the design of their study.

Similar head turning lateral biases were observed in premature babies by Gardner, Lewkowicz & Turkewitz (1977).

The head position of 95 infants, born between 30 and 37 weeks gestational age were observed every 15 minutes for two hours weekly from birth until the 39th gestational week. No lateral bias rightward or leftward was evidenced in subjects observed before the 35th week. During the 35th week, and increasing thereafter, significantly more time was spent by subjects with their heads turned rightward than to the left. By the 39th week, these infants manifested rightward biases which were very similar to those of full-term infants. This increase in rightward lateral bias appeared to be independent of intrauterine and extrauterine experience as neither gestational age at birth nor time since birth was significantly related to the presence of the lateral bias. By the 39th gestational week, 88% of the infants spent at least 80% of their observed time with head positioned rightward.

In sum, these four studies indicate that the full-term newborn infant, as well as the premature infant by the 39th gestational week, manifests a consistently-rightward lateral head position. The analyses presented in these studies suggest that the presence of this lateral bias is independent of sex, gross behavioral state at testing, time spent in-utero and ex-utero, and experience in a potentially-lateralized environment.

The methodological limitations of these studies are of a serious nature. For instance, unless effort is made to insure the absence of lateralized environmental stimulation concurrent with observation or immediately prior to the observation period, then position biases due to unsystematic lateral differences in lighting, noise, tactile stimulation, etc. might well confound results. To present an extreme scenario, the presence of a very loud noise source on one side of the nursery might well initiate opposite-side head maintenance as an avoidance response to aversive stimulation. Clearly, such situation-specific influences need to be minimized and, if present, reported if the integrity of the research design is to be maintained.

Restricted-position level one studies. The basic design of the second subset of studies dealing with the level one asymmetry involves recording what head position the infant attains subsequent to release from the neutral, non-lateral midline position. A few of these studies have also examined subsequent maintenance of the attained head position. These studies differ in several respects from those dealing with spontaneous patterns: (1) head position immediately prior to recording the lateral phenomenon is systematically controlled and assumed to be unbiased, (2)

a distinction between the initial head turn and subsequent head position is examinable. The null hypothesis of these studies state that the initial head turn would be randomly rightward or leftward and that the subsequent maintenance of a head position would, likewise, be random in direction.

Systematically restricting the neonate's head to a midline position prior to observation of head position bias raises several parametric issues of concern. For example, does the length of the initial head restriction influence the subsequent relative proportions of rightward and leftward positioning? If so, short-term modification of the lateral bias would need be addressed. By what mechanisms of influence would such an effect be manifested; that is, would the restriction influence subsequent lateral bias directly or indirectly?

Turkewitz and Creighton (1974) report patterns of head position attainment and maintenance for 70 full-term, healthy babies between birth and 72 hours. Infants were tested in their nursery; all bassinets were placed in a single testing position in the room to ''maintain equivalent lateral sources of ambient stimulation''. In this study the infant's head was initially maintained for 15 minutes in the neutral midline position, released, and

initial head positioning recorded during a 15 minute observation period.

In the sample, 75.7% of the subjects made initial turns rightward after midline release while 24.3% turned leftward. Of the 56 infants in the sample who made at least one full 90 degree head turn during the 15 minute session (i.e., a turn so that one side of the face touched the mattressed bassinet-base), 87.5% did so to their right while only 12.5% did so to their left.

The authors report an age effect: infants who were less than 12 hours of age at testing were equally likely to turn leftward as rightward following the 15 minute head restriction, unlike the predominant rightward lateral bias seen in infants older than 12 hours. To determine a possible explanation for this effect, twenty additional subjects under 12 hours of age were tested. In this case, however, the length of the midline hold was much shorter: the infants heads were released when the experimenter felt no lateral pressure from the infant to turn in either direction. Under this condition, unlike the 15 minute condition, 75% of the very young newborns turned rightward subsequent to release while 25% turned leftward. It was concluded that the length of the midline hold appeared to

be responsible for disrupting the presence of the lateral bias in the younger group of infants. Thus, even infants younger than 12 hours of age manifest a consistent pattern of rightward lateral bias. Among this very young group, however, the bias appears to be less resistent to attenuation by the midline restriction.

Saling (1980) has presented a replication of a portion of these findings. He examined head position following the shorter midline restriction (i.e., restriction until subjects showed no lateral pressure to turn rightward or leftward) in 40 healthy, full-term neonates. Subjects were examined on two occasions: days two and three. Seventy-five percent of the sample turned rightward on day two, while 70% did so on the third day. The direction of the initial head turn on the two days was consistent in 90% of the sample.

Rightward head turning in neonates subsequent to midline restriction has also been reported by Michel and Goodwin (1979) and Michel (1980), and in infants examined seven times from the first to the twelfth week by Coryell and Michel (1978). Unlike studies which have employed simply the direction of the initial head turn or head position at a single point in time, these researchers have employed a lateral bias index using head position recorded

every six seconds (Michel & Goodwin) or every 10 seconds (Coryell & Michel) over the course of the observation period. Seventy-five percent of Michel and Goodwin's sample manifested a rightward bias, 25% a leftward bias. The index was transformed to Z-scores to determine individual significance. In this sample, 43% manifested a significant right bias (i.e., $Z > 1.96$) while 9% manifested a significant left bias (i.e., $Z < -1.96$). In Coryell & Michel's sample of 16 infants followed to 12 weeks, 75% manifested a significant right bias while 13% manifested a significant left bias.

An unfortunate restriction may exist in placing the detailed evaluation of head position accomplished by Michel and Goodwin in direct comparison to the other work done in this subset of studies; their index score is derived from behaviors which are collapsed across three conditions that probably are different enough in their influence on behavior so as not to justify such collapsing. That is, the index reflects head turning behavior subsequent to one minute head restrictions in midline, to the right of the body midline, and to the left of the body midline. It appears, however, that in neonates (D. Lewkowicz, personal communication) and in young infants (Liederman & Coryell, 1980) the effects of

restricting a baby's head ipsilateral and contralateral to his preferred side are significantly different. Increased irritability and crying are observed in subjects restricted to the side opposite their preferred head turning direction. The results of an index of behavior across these different conditions may lose any direct comparability to the other relevant work. It is also possible that in the counterbalanced design of their study, a trial-by-behavior interaction might exist, those subjects who begin the session with the head-left restriction may be more irritable throughout the session than those who begin with the head-right or head in midline conditions. Unfortunately, the authors do not address the issue nor do they present evidence indicating that behaviors across conditions did not significantly differ to justify collapsing behavior into a single representative index.

In a very recent study, Michel (1980) has reported the results from a design which, fortunately, does not have this potential confound. In a sample of 150 healthy, full-term infants observed twice between 16 and 48 hours, 49% showed a significant rightward bias, 15% showed a nonsignificant rightward bias, 21% showed a mixed bias, 9% showed a nonsignificant leftward bias, and 6% showed a significant leftward bias.

In summary, like the first subset of findings, this second subset of findings from studies examining the level one lateral bias are very consistent: the majority of infants turn their heads rightward following a period of non-biased midline restriction and most tend to maintain a consistent lateral bias rightward subsequent to the initial turn. The reliability of this set of findings is observed by their consistent manifestation among different research groups in different settings. However, the results of several studies have been reported without a great deal of concern for also reporting relevant specifics of the testing situation. The study by Michel and Goodwin might well need to be considered tentative awaiting a proper account of the soundness of employing a single index to represent behaviors that may be differentially influenced by the conditions under which they are manifested.

Level two studies. The studies dealing with the level two responsive asymmetry have employed designs in which the head turning phenomenon is investigated as a response to stimulation. Typically, lateralized stimuli are presented to the neonate and the presence and direction of a lateral response within a delineated time period is recorded. Issues that are addressed in this set of studies

include whether or not the right and left halves of the body are differentially responsive to stimulation and whether or not stimulation in either half of space is differentially effective in eliciting ipsilateral head turning. The research designs in this set are more diverse and their results more equivocal than those in the previously-described series. Additional parametric issues of concern in level two asymmetry studies that have been examined include the type and duration of stimulation, the aversity of stimulation, the habituability of the turning response, and the nature of the influence of the pretest restriction on responsiveness.

The design of level two asymmetry studies raises distinct methodological issues that need to be considered. First, consideration of the employed dependent measure is necessary. In level two asymmetry studies, head turning must occur within a relatively short time interval, usually less than five seconds, in order for the turn to be considered a response to stimulation. This poses a problem: a response that may require a longer period of time to be manifested is not included as a response. For example, a subject may for organismic, delivery-related (e.g., strong maternal medication), or session-related (e.g., subtle changes in the ambient stimulus environment)

reasons be capable of responding but is not so scored due to a longer response latency. If, however, more time were allowed in which a turn was considered as a response, then the probability that the recorded behavior is, in fact, a response to the stimulus, is decreased.

A second issue involves the stimulus per se. In a given study, are the obtained results specific to the stimulus parameters employed or would the same results obtain if the stimulus were to differ in intensity, in complexity, in duration, in modality?

A final and serious issue to be dealt with in examining level two studies is the role of the basic level one lateral bias in the manifestation of the level two asymmetry and the extent to which this role is controlled within the design of the study. The results of the level one studies state that the base rate probability of a head turn following release from the neutral midline position strongly favors a rightward head turn. Would a finding that infants turn rightward to right-sided stimulation more so than leftward to left-sided stimulation necessarily indicate an asymmetric responsiveness to stimulation? It may simply be a manifestation of the basic level one lateral bias that would be evidenced even in the

absence of a lateral stimulus. Unless the possibility of such an occurence is minimized by adequate experimental control, the internal validity of the study would need to be regarded as suspect.

In the first-reported level two asymmetry study (Turkewitz, Gordon & Birch, 1965b), 36 healthy newborn babies between 48 and 72 hours were tested for their responsiveness to lateral perioral somesthetic stimulation. The principal findings of the study were: (1) the incidence of head turning was greater in response to stimulation (63.1%) than in the absence of stimulation (6.5%). (2) The incidence of an ipsilateral head turning response (96.8%) was greater than a contralateral response (3.2%). (3) The ratio of ipsilateral to contralateral responses was greater during right-sided trials (99:1) than during left-sided trials (47:3). (4) Rightward head turning was greater than leftward turning on those trials without stimulus presentation (74.3% and 25.7%, respectively), indirectly providing further information about the basic level one asymmetry. (5) Parameters of stimulus duration (.5, 1.0, 1.5 secs), stimulus intensity (three types of camel's hair brushes), and length of the period alloted for a turn to be considered a response (one and five seconds) were examined. No significant differences were found for any of the varied parameters.

The authors also report the results of a successful replication of these findings.

A second study (Turkewitz, Moreau & Birch, 1968) revealed a relationship between birth condition as assessed by one minute Apgar score (see Apgar & James, 1962) and head turning to somesthetic stimulation. A sample of 130 infants ranging in age from 24 to 81 hours, all in good condition at the time of testing, were subjected to 30 trials of one second lateral perioral stimulation. Turns within one second of stimulus offset/head release from midline were recorded as a response to the stimulation. Based on the Apgar score, each baby was assigned to one of three groups: low Apgar (1 to 6), intermediate Apgar (7 to 8), and high Apgar (9 to 10). High and intermediate groups were more responsive to right-sided than to left-sided stimulation while the low group was equally responsive to left and right stimulation. In the full sample, 91% of the head turns were ipsilateral, 9% were contralateral to the stimulus. A greater proportion of the low Apgar group infants, however, made at least one contralateral response than did either the intermediate or the high Apgar groups.

Group differences also emerged on an index of ''overall lateral differentiation'',i.e., the number of right ipsilateral responses minus the number of left ipsilateral responses. An analysis of variance of the index revealed significant differences between the low and the high groups and between the low and the intermediate groups. In both cases, the low group was less laterally differentiated. Neither age nor sex of subject was a significant factor in any of the analyses. Unlike the initial study, this study did not include control trials during which head turning in the absence of stimulation could be recorded.

In a recent study, Lewkowicz, Gardner & Turkewitz (1979) examined head turning responsiveness to lateral somesthetic stimulation in a sample of 25 premature infants. Responses within one second of stimulus offset/head release were recorded and, as in Turkewitz, Gordon & Birch (1965b), control trials involving no stimulus were included in the design. As with full-term infants, the characteristic response of the premature infants was a turn in the ipsilateral direction of the stimulus (61% ipsilateral, 39% contralateral). However, this difference failed to reach conventional levels of statistical significance. Unlike full-term infants, the

premature infants responded ipsilaterally regardless of the side of stimulation (48% to right-sided stimulation, 52% to left-sided stimulation). A head turn occured within one second on 39.6% of stimulus trials and 18.3% of the no stimulus trials. Gestationally older infants (i.e., birth during the 34th to the 37th gestational week) made more ipsilateral responses than younger infants (i.e., birth less than 34 gestational weeks). However, an age influence was not apparent for the lateral bias in the response.

Two principal views exist regarding the proposed nature of the causal mechanisms of this responsive bias. The first view stresses the role of alterations in lateral muscle tonus and sensory thresholds subsequent to the naturally-occuring level one lateral bias (e.g., see Turkewitz, 1980). That is, one consequence of the level one bias is to predispose the neonate to respond more easily on the turned-toward side. The second view proposes that asymmetrical cortical control of motoric function is of prime importance for the observed lateral bias in responsiveness (Liederman & Kinsbourne, 1980a, b). The assumed mechanisms of the responsive bias has been examined in the following six studies.

The conclusions reached by Turkewitz, Moreau & Birch (1966) and in an indirectly relevant study by Turkewitz, Moreau, Birch & Crystal (1967) were that asymmetries seen in response to either auditory or somesthetic lateral stimulation were at least partially explainable in terms of influences caused by head posture immediately preceding the stimulation period. The typical rightward level one lateral bias decreases auditory stimulation to the occluded right ear, thus reducing its threshold to later right-sided stimulation, and increases stimulation on the right side of the face, thus ''priming'' that region to respond to subsequent right-sided stimulation. The authors present evidence that the procedure of restricting the infant's head to midline for the 15 minutes preceding the test session attenuated the lateral consequences of the level one lateral bias.

Turkewitz, Moreau, Davis & Birch (1969) include asymmetric muscle tonus as another consequence of the level one lateral bias by which the level two lateral responsiveness may be manifested. Further, they attribute the attenuation of the short-term influence to the 15 minute midline restriction.

Kinsbourne (personal communication) has speculated that the actual consequence of the 15 minute midline restriction is to produce muscle fatigue on the right side due to the efforts of the infant to turn rightward while being experimentally restricted to the midline. The absence of a response asymmetry subsequent to this restriction is actually a manifestation of this induced muscle fatigue rather than an equalization of response thresholds or a true attenuation of muscle tonus.

Moreau, Helfgott, Weinstein, & Milner (1978) provide evidence that although the midline restriction may initially result in attenuated lateral biases, such attenuation is short-lived. Lateral differences in the rate of habituation of ipsilateral responsiveness to tactile stimulation were examined in 44 healthy full-term infants randomly assigned to either a right-stimulation group, a left-stimulation group, or a non-stimulated control group. Following the 15 minute midline restriction, 50 trials of one-second stimuli were presented. For each trial, infant heads were returned to midline and released simultaneously with stimulus offset. Head turns within two seconds of stimulus onset were recorded as responses.

On the first trial after the midline restriction period, subjects were as likely to make an ipsilateral response to right stimulation (40% of the right-stimulation group) as they were to left stimulation (40% of the left-stimulation group). In the control group, 43% made a rightward turn, 14% a leftward turn (not significant).

Significantly, repeated stimulation resulted in an overall decrease in ipsilateral responding in both groups but the left-stimulated group did so more rapidly than did the right-sided group. As well, in the control group, leftward turning decreased rapidly and systematically whereas rightward turning did not. Therefore, even following the attenuation of influences directly attributable to prior lateral position biases, lateral rightward results were obtained. Whether this lateral resistence to habituation was due to an unstudied further component of the level two bias or whether it was due to the re-establishment of components attributable to the level one asymmetry cannot be determined from their data.

Hammer and Turkewitz (1974) provide further evidence that a sensory component is involved in the level two response asymmetry, although these results have been

subjected to a good deal of debate (Liederman & Kinsbourne 1980a, Turkewitz, 1980; Liederman and Kinsbourne, 1980b). Hammer and Turkewitz report that cardiac acceleration occured more frequently to right perioral somesthetic stimulation than to left somesthetic stimulation. The lateral cardiac responsiveness occured regardless of the concurrent presence of a head turn response (which, when it occured, was most often ipsilateral to the stimulus). Liederman and Kinsbourne, in examining this study, claim that the available neonatal heart rate literature would suggest that cardiac deceleration, rather than acceleration, is the more apropriate component of heart rate in such work and, also, that the observed cardiac difference in responsiveness was actually due to covert changes in somesthetic motor activity. In responding, Turkewitz (1980) has challenged the interpretation of the literature put forward by Liederman and Kinsbourne and cites Pomerleau-Malcuit, Malcuit, & Clifton's (1975) finding that both somatic and cardiac responding are due to central processing of the stimulus.

Liederman and Kinsbourne (1980a) have attempted to determine whether the phenomenon is of a sensory or a motoric nature. They examined the responsiveness asymmetry in a three-by-two repeated measures factorial

design employing visual, tactile, and gustatory stimulation that were either aversive or non-aversive in nature. Simply stated, if the infant turned ipsilateral to the stimulus regardless of its aversiveness one could posit a motoric rather than a sensory explanation. However, if the aversive nature of the stimulus influenced the directionality of the response, then a sensory rather than a motoric explanation could be entertained. Responsiveness was gauged on three indices: one, the direction of the initial head turn for each trial; two, relative time right and left (i.e., R-L / R+L); and, three, relative number of turns right and left (i.e., R-L / R+L).

Healthy full-term offspring of right-handed parents turned predominantly rightward, regardless of stimulus aversiveness. Infants who had been lying on their left sides immediately prior to testing showed a significantly less rightward bias on the second and third indices (albeit still remaining rightward biased) than those infants who had been on their right sides prior to testing. Although the initial head turns by both groups were not significantly different, the authors report a statistical trend in the same direction as the significant findings.

The study has several problems in design. These may limit the value of the findings and necessitate a careful replication: First, the long duration of stimulus presentation (25 seconds) makes it highly probable that an initial head turn would occur prior to the offset of the stimulus seriously confounding the directional integrity of the stimulus as being lateralized right or left. Second, no control group or control trials are included in the design of this study to examine head turning in the absence of stimulation. Accordingly, no analysis can be put forward that the responsive asymmetry is significantly different from that which could be expected from the level one lateral bias base rate. Finally, the assumption that the newborn infant has adequate motor control to maintain its head in midline for extended periods of time is implicit in the design of the study. Empirical evidence in support of this assumption is not stated. Given the findings reported by Turkewitz and Birch (1971) that in only 2.8% of 3000 spontaneous observations were midline head positions observed, such an assumption may well be questionable.

In sum, studies examining level two lateral responsive biases present a 'mixed bag' of designs and findings. One consistent finding is the relative predominance of

ipsilateral rightward responsiveness to lateral stimulation. When contralateral turning occurs, it is chiefly as a response to left-sided stimulation. The mechanism(s) of the lateral responsive bias has yet to be determined. Two principal views co-exist: one stresses the role of both alterations in lateral muscle tonus and sensory thresholds subsequent to the level one lateral bias, the other stresses asymmetrical cortical control of motoric function. At the moment, neither of the two positions enjoys definitive empirical support.

WHAT ARE THE ANTECEDENTS OF THE PHENOMENA?

A good deal of the available evidence relevant to this question concerns the influence of level one lateral bias on the level two lateral responsiveness via alterations in muscle tonus and sensory thresholds which have been discussed previously. However, other work has addressed the potential relationships between the lateral phenomena and uterine head position (Michel & Goodwin, 1979), parental handedness (Liederman & Kinsbourne, 1980c), and head position prior to testing (Liederman & Kinsbourne, 1980a). Environmental influences such as maternal holding

and feeding preferences have yet to be carefully examined as potential antecedents.

Uterine head position. It is standard obstetric practice to record the presentation of the fetus prior to the delivery process, during delivery, and at birth (see Pritchard & MacDonald, 1976, for a description of the technique). In vertex presentations (roughly 95% of all fetal presentations), approximately two-thirds of the fetuses are left occiput positioned and one-third are right occiput positioned relative to the mother's body midline. In the left occiput anterior (LOA) and right occiput anterior (ROA) the baby's midline is equivalent to the mother's, therefore a baby who presents LOA generally has its face turned rightward and a baby who presents ROA generally has its face turned leftward of the body midline. In posterior presentations (i.e., LOP and ROP), the mother's left becomes the baby's right. A third type of presentation is a transverse one (LOT/ROT). As the technique is indirect and subjective, a good deal of variance might be expected in determining intrauterine lateral biases. The use of intrauterine ultrasound technology utilizing sound waves to visualize the uterine region is currently being examined as a more precise method of determining fetal head position (G. Michel, personal communication).

Churchill, Igna & Senf (1962) have reported an association between this perinatal head position and a measure of hand use at two years. In a sample of 1,102 cases, 602 (54.6%) were LOA and 500 (45.4%) ROA. In the LOA group, 5.8% were left handed and 14.6% were ambidextrous while in the ROA group, 11.6% were left-handed and 17.0% were ambidextrous.

Michel and Goodwin (1979) provide data associating uterine head position and their index of level one lateral bias. Of 47 infants with a significant (i.e., Z-score > 1.96) head right score on the index, 33 (70%) were born in either a LOA or a LOT position while eight of ten (80%) of infants with significant (i.e., Z-score < -1.96) head left scores were born ROA or ROT. However, looked at prospectively to avoid the potential fallacies inherent in viewing a relationship from a retrospective time frame (e.g., see Gottfried, 1973), 60% of the infants born LOA/LOT scored significantly rightward and only 16% of the ROA/ROT group scored significantly leftward.

Level one influences. While it has been speculated that the level one rightward lateral bias results in short-term alterations in muscle tonus and sensory threshold levels, the experimental technique employed to

remove or dissipate these influences has yet to be conclusively shown to eliminate either the subsequent occurence of the level one asymmetry (except in very young neonates) or the level two lateral responsiveness (except in premature infants). Therefore, the relationship between the level one and level two asymmetries has yet to be adequately documented.

Parental handedness. Liederman & Kinsbourne (1980c) report results of a study examining the level two lateral responsive bias in offspring of right-handed parents and offspring with at least one ''non-right-handed'' parent. The design of the study is very similar to one previously reviewed and criticized (viz. Liederman & Kinsbourne, 1980a). Of 104 subjects, 21 did not complete the session due to excessive irritability or sleepiness or because of lack of a head turn to one or two of the stimulus treatment modalities. Of the remaining sample, 62 were offspring of right-handed parents and 21 were offspring with at least one ''non-right-handed'' parent. The four examined measures were: (i) proportion of initial turns rightward, (ii) relative turns rightward and leftward (R-L / R+L), and two indices of relative time rightward and leftward: (iii) (R-L / 25) and, (iv) (R-L / R+L).

The third measure, i.e., time spent rightward and leftward, differed significantly for the two groups of offspring in all three modalities. The authors re-examined their data removing the visual stimulus presentation trials as these were least effective in eliciting head turns. The second set of analyses of variance was significant for all four measures. The authors interpret these results as indicating the presence of a rightward bias in the offspring of right-handed parents but not for offspring who had at least one ''non-right-handed'' parent, regardless of whether the parent was the mother or the father.

Prior head position. In the sole study attempting to systematically alter the prior lateral head position, Liederman & Kinsbourne (1980a, Exp. II) report that restricting the head position of a sample of neonates either rightward or leftward during the night prior to testing affected the lateral responsiveness bias on measures of initial head turning, total relative head turns rightward and leftward, and total relative time in either direction. No information is provided, however, on the stability of the restricted position during the night.

Maternal holding preference. It has been reported that nearly 80% of a sample of mothers preferred to hold their newborn babies on their left side, regardless of their handedness or previous parity (reported in de Chateau & Andersson, 1976). The sole study relating this phenomenon to neonatal lateralization is Ginzburg et al (1979), who conclude that the holding preference is a consequence of neonatal head position (see the next section below). Despite the conclusions reached by these authors, the holding preferences of the newborn infant's caretaker(s) have yet to be fully and adequately examined as antecedents to the lateral head turning phenomena. For example, is there a relationship between the breast which the mother employs for the initial feeding periods, the shoulder which she prefers to hold the baby on, the side of the baby's body which she strokes, and the observed lateral phenomena? In examining possible environmental influences on the expression of the neonatal lateral phenomena, consistencies in different caretaker-neonate holding preferences would seem to be an important variable to consider.

WHAT ARE THE CONSEQUENCES OF THE PHENOMENA?

Given the evidence from both level one and level two studies, what is the relationship of neonatal lateralization with the development of later lateral organization and behavior? Does a relationship exist and, if so, can causality be addressed? Initial data on the assumed consequences of lateral behaviors in infancy was provided by Gesell (1938; Gesell & Ames, 1947). He posited that infant lateral behavior such as the ATNR and the head turning bias influenced the development of dominant hand use. To Gesell, the presence of a rightward bias facilitated visualization of and experience with the right hand more than the left hand in the majority of infants and vice versa for the small proportion of infants who manifested leftward-biased behavior. A recent study by Liederman & Coryell (1980), however, questions the facilitory influence of the ATNR in the visualization and experience of the right hand as posited by Gesell and as obtained in an earlier study by Coryell (Coryell & Henderson, 1979). Liederman and Coryell report that movements were less reflex-bound (i.e., ATNR-bound) during either rightward head positioning or experimental placement of the head rightward than were movements during leftward positioning or placement. They speculated that

greater inhibition of the ATNR during rightward head rotation might be advantageous to the infant in that he would thus be able to look at his hand without the ATNR interfering with volitional positioning and movement of the hand and limb.

Hand use. Hand use in infancy is an extremely variable phenomenon, as Gesell and Ames (1947) have shown in their careful analysis of the development of hand preference. At different points in infancy and early childhood, the individual may predominantly employ his right hand, left hand, or both hands. Additionally, the demands of the task and the testing methods employed may easily influence which hand is employed and is dominant. While such variability should not dissuade interested researchers from examining the issue of handedness, the researcher and the reader of the researcher's work need display a good deal of caution in generalizing results across studies that differ in design and sample attributes. The hypothesis that neonatal head turning lateral phenomena per se are related to later handedness is both implicitly and explicitly prevalent in the head turning literature. Two direct examinations of the relationship between the level one lateral bias and infant handedness are provided by Coryell & Michel (1978) and Michel (1980).

In Coryell & Michel's study, eight male and eight female healthy infants were examined on seven occasions from birth to 12 weeks of age. Spontaneous head and limb movements while supine-positioned were recorded on all occasions; visually-elicited reaching tasks were performed on six sessions, excluding the first.

The occurence of a lateral ATNR was highly correlated with the position to which the infant turned his head; hence, an infant who tended to keep his head to one side of body midline generally only exhibited the ATNR on that side. As stated previously, 12 infants maintained a typically rightward position while two maintained leftward positions. The prevalance of both a laterally-rightward turned head and the ATNR placed the infant's ipsilateral (right) hand within its visual fields more often than the contralateral hand (however, refer to Liederman & Coryell, 1980, regarding criticisms of this method).

Three variables (head turning lateral bias, ATNR, and hand visualization) were subjected, as predictor variables, to a multiple regression analysis using differential hand activation on the reaching tasks as the criterion. A multiple R of .61 (i.e., 37% variance overlap) was found. Concerns arising from the statistical

problems of both a sub-minimal subject-to-variable ratio and from not adjusting the multiple R to estimate generalizability to another sample are not addressed by the authors. The criterion variable, hand activation, reached statistically significant differences between left and right hands on the final, twelfth week observation, the right hand being more active than the left.

Michel (1980) has presented the results of a 22-week follow-up of twenty subjects who were selected from a larger sample of neonates because of their extreme level one bias either rightward or leftward. Subjects were tested at 3, 6, 8, 12, 16, and 22 weeks on a visually-elicited reaching task. Michel reports a significant association between the level one bias and hand use preference on the task: as a group, left-biased neonates employed their left hands while the right-biased neonates employed their right hands more as infants during the task.

Viviani, Turkewitz and Karp (1978) have reported a seven year follow-up of a subsample of subjects originally tested as neonates (in Turkewitz, Moreau and Birch, 1968). Of the 69 infants in the original study of the level two

asymmetry subsample, 22 were located and available for testing at seven years. However, these 22 subjects had significantly higher neonatal laterality index scores than the unavailable group, creating serious inferential limitations due to biased sampling at follow-up. At follow-up, an assessment of hand and eye preferences was performed.

A significant correlation between the neonatal laterality index and an ''index of consistency'' of right-left hand and eye use on a variety of tasks was obtained. Unfortunately, as only one of the 22 subjects was left-handed, the consistency index reflected variations only in the lateral consistency of right-handers.

The importance of this study is difficult to assess due to the limits imposed by the less-than-adequate sampling and the presence of only one left-hander. At the moment, however, it remains the sole long-term follow-up study.

Dichotic listening performance. Viviani, Turkewitz, & Karp also examined the relationship between their neonatal level two asymmetry and performance on a dichotic digits listening task at age seven. No relationship between the neonatal lateral index and dichotic test performance was observed.

Maternal holding preference. Ginzburg et al (1979) examined the possible interdependent influences of a lateral bias in neonatal head turning and a lateral bias in maternal holding preferences over either the right or left shoulder. The level one lateral bias was assessed following a brief midline restriction. They report the results of two experiments which indicate that infants who are rightward-biased were more likely to be held over their mother's left shoulder while leftward-biased infants were more likely to be held over their mother's right shoulder. While the authors maintain that the holding preference is a consequence of the lateral turning bias, this assumption is by no means proven by their data. In fact, the generalization of supine-positioned head turning biases to biases manifested in other positions may not be tenable. For example, Michel & Goodwin (1979) have shown that the supine lateral bias is absent when the infant is tested while in a prone position. However, the authors have identified one of many possible environmental biases that need to be seriously examined.

In sum, the available data, rather than providing unequivocal evidence bearing on the relationship between neonatal lateralization and later phemonena such as manual preference, present initial evidence that will be useful

for future hypothesis generation. Michel's work, for example, provides a firm base which can be extended from early infancy to later time periods and from one type of manual preference task to others to determine developmental consistencies and task influences, respectively.

WHAT IS THE NEUROPSYCHOLOGICAL SIGNIFICANCE OF THE PHENOMENA?

Describing and understanding the mechanisms of the lateral cerebral organization and manifestation of specific functions has been a primary goal of empirical investigation in neuropsychology. Interest in the ontogenetic aspects of lateralization has been of very recent origin relative to classic neuropsychological interest in adult language functioning and handedness. However, ontogenetic interest in lateralization has centered nearly exclusively upon children (see Witelson, 1977), perhaps due to the methodological difficulties in examining behavior during infancy. Considering the importance of the first two years of life for the development of both language use and motor sophistication, the recent and growing interest in the study of infant

lateralization is, most likely, a necessary step for a fuller understanding of the development of adult-relevant lateralization of cerebral organization and behavior. The head turning laterality literature, along with work dealing with fetal and neonatal neuroanatomic asymmetries (e.g., Wada, Clarke & Hamm, 1975; Witelson & Pallie, 1973), neonatal and infant electrophysiological asymmetries (e.g., Molfese, 1977; Molfese & Molfese, 1979), asymmetrical responsive behavior by infants on speech-relevant auditory perception tasks (e.g., Entus, 1977; Glanville, Best & Levenson, 1977; Vargha-Khadem & Corballis, 1979) and manual and pedal performance asymmetries in infants (e.g., Coob, Goodwin, & Saelens, 1966; Caplan & Kinsbourne, 1977; Peters & Petrie, 1979) compose the available body of evidence on the status of lateral organization and behavior in infants under two years of age.

There are several possible neuropsychological conceptualizations into which one might attempt to fit the head turning literature. However, before one can attempt to supportively view the neonatal laterality as either a manifestation of asymmetric cortical organization at birth, or as evidence of asymmetric cortical maturity, as evidence for a neonatal precursor to the later adult-

relevant lateralizations, non-neuropsychological alternative explanantions need to be eliminated. For example, Gesell (1938) stated anecdotally that a rounder head would turn more easily than a flatter head. Clearly non-neuropsychological explanations such as skeletalure or unsystematic lateral biases in the testing environment need to be eliminated by a carefully-conceptualized research design. Other less-tangible potential causes such as early life asymmetries in maternal holding or mechanical influences such as intra-uterine head position need to be addressed and, if possible, eliminated as alternative explanations. Even if the causes of the neonatal lateralization were non-neuropsychological in nature, the possibility that there are neuropsychological consequences of the neonatal lateralization remains a distinct subject of investigation.

The head turning literature may also be of interest to applied neuropsychological researchers. The clinical neuropsychological utility of the assessment of lateral bias in newborn infants has been speculated upon by several authors who view the neonatal asymmetry potentially being a sensitive index of newborn neurobehavioral organization (Turkewitz, Moreau, & Birch, 1968; Turkewitz & Birch, 1971; Young, 1977). The search

for neonatal risk-indicators of later neurological and neuropsychological dysfunctions has been an on-going process with little reported success (Turkewitz & Birch, 1971). It might initially be considered paradoxical to propose that the absence of a lateralized response could be a sign of aberrance in light of the opposite being a much more common indicator in standard newborn neurological examinations. Such was indeed the case, however, in Turkewitz, Moreau, & Birch's (1968) finding that low Apgar infants were less laterally biased on their level two asymmetry task than either intermediate or high Apgar infants. Given the truly barren state of our current knowledge about possible early life antecedents and predictors of later developmental neuropsychological dysfunctions, the clinical usefulness of the lateral head turning phenomena might well be worthy of future prospective developmental investigation. Until then, unfortunately, the validity of employing measures of neonatal lateralization in a clinical setting remains untested.

CONCLUSIONS

The preceding review of the available literature dealing with, perhaps, the most systematically studied aspect of neonatal lateralization indicates that two types of lateral head position behaviors are observable in the normal newborn infant. The first - asymmetric attainment and maintenance of a rightward head position (level one) - has been reliably observed in several investigations employing either a spontaneous observation or an experimental restriction design. A rightward lateral head maintenance is first seen during the 35th gestational week in premature infants, developing in degree over time. The normal newborn infant maintains a predominant rightward head position very soon after birth. The attainment of a rightward head position has been found to be less resistent to elimination subsequent to a period of time in a non-lateral head position in very young (i.e., under 12 hours of age) neonates. A smaller percentage of newborn infants manifest a consistent leftward lateral bias. A very small percentage of healthy neonates do not manifest a consistent lateral bias rightward or leftward.

Rightward ipsilateral responsiveness to stimulation (level two) has also been generally observed in studies

examining lateral responsiveness to stimulation. The newborn infant responds to right-sided stimulation with an ipsilateral head turn more frequently than to left-sided stimulation. Ipsilateral turning to right-sided stimuli is more resistent to habituation than to left-sided stimuli.

The causal mechanisms of level one and level two asymmetries remain inadequately understood. The mechanisms underlying level two responsive biases have been the subject of more extensive study than those underlying the level one lateral bias, but neither set of investigations have produced a sufficiently clear-cut understanding of the mechanisms of neonatal lateralization. Possible antecedents and consequences are just beginning to be seriously examined.

Regardless of the direction of the lateral bias, a great majority of newborn infants show a relatively consistent pattern of this behavioral asymmetry. A single study exists in the literature which suggests that many of those few infants who do not show a consistent level two responsive asymmetry have undergone some degree of stress during pregnancy or during delivery as indexed by the Apgar score (Turkewitz, Moreau, & Birch, 1968). Two

relevant clinical questions are raised by this finding. First, does the absence of the lateral phemonenon signal an aberrance in neonatal neuropsychological status? Second, does the absence of the neonatal lateral phenomenon indicate a possible precursor to later-life neuropsychological aberrance? These questions have yet to be adequately addressed. Hopefully, an awareness of our naivete in understanding the neonate and developmental precursors of later neuropsychological aberrance will act to stimulate such work.

This literature may also have potential value for neuropsychological theoreticians concerned with the development of adult-relevant lateral organization and behavior. Fitting the literature into any of the several current neuropsychological conceptualizations remains problematic until the existence of alternative non-neuropsychological explanations of the phenomena are empirically eliminated. Solid empirical evidence for the existence of a cortically-based lateralization in the normal newborn infant would certainly be a sizable addition to our current knowledge about the ontogeny of cerebral lateralization.

Although quite a few studies have been criticized in this review along conceptual and methodological lines, the available literature remains an excellent base from which to generate further thought and work. Recognition of basic parameters which need to be under the control of the investigator and communicated in reported studies along with a well-conceptualized research design can only lead to a more refined and adequate examination of these behaviors of interest in both normal and clinical samples.

PURPOSE OF PRESENT INVESTIGATION

The present investigation attempts an in-depth evaluation of the basic level one lateral bias which is manifested by the attainment and maintenance of a typically-rightward head position in normal, healthy newborn infants. Unlike previous level one lateral bias studies, lateralization along three dimensions will be examined: consistency in the direction of the initial head turn following midline restriction (attainment of head posture); consistencies in the direction of all the head turns made during a trial and in the total amount of time spent with head rightward, leftward, or in midline (maintenance of head posture).

The initial goal of this investigation is to assess the hypothesized oft-observed consistency (typically rightward) in newborn head turning behavior along all three dimensions of lateral bias. That is, most of the infants in the current sample are hypothesized to show a typical unilateral bias in head posture upon repeated examination of head position subsequent to non-lateral midline head restriction. It is hypothesized that the majority of these infants will be rightward biased.

Contingent upon obtaining this lateral consistency in head turning behavior, independent of possible artifactual relationships with either gross environmental lateralities which were deliberately minimized during testing or with the length of time that the infant's head was held in midline, as well as being independent of changes over time, individual performance along these three lateral dimensions will be defined by three lateral indices. The relationship of these indices to potentially-relevant early life variables will be examined. These attribute variables include those previously identified in the literature as relevant to either level one or level two lateralization and other variables included in an exploratory fashion. The stated goals are to observe if previously-identified level one antecedents (i.e., spontaneous head position prior to testing, uterine head position) are replicable, if reported level two antecedents (i.e., parental handedness, Apgar status at birth) are also related to level one lateral biases, and to explore potential relations between the lateral bias and variables that have not been previously examined (i.e., maternal age, maternal medication during delivery). Variables that have shown to not be consistently related to the level one lateral bias (i.e., sex, age at testing, state, and type of delivery) are also re-examined.

METHODS

Subjects. The potential subject pool consisted of the newborn offspring of admissions to the Maternity Ward at the Royal Jubilee Hospital in Victoria, British Columbia, Canada, during the spring and summer months of 1980. Newborn infants were excluded from this pool for any of the following experimental or practical reasons: pre-term delivery, term forceps delivery, term breech delivery, multiple birth, low birth weight (i.e., under 2500 grams), medical unfitness (e.g., infants undergoing medication or bilirubin phototherapy), circumcision, rooming in an excessively noisy area of the ward, and maternal tiredness/depression. Deliveries via cesarean section were excluded if the indication for section was based upon the present pregnancy (e.g., placenta privea) but were included if the section was only indicated by a previous history of cesarean deliveries.

These initial restrictions resulted in a pool of healthy males and females (with cooperative mothers) who were considered to be acceptable candidates by both the head nurse and the investigator. Several mother-infant

dyads were subsequently excluded from consideration as it was determined that the mother did not possess an adequate comprehension of the English language to understand the testing instructions. Approximately 95% (68 of 71) of the acceptable mothers who were approached were receptive to testing and gave written consent to be tested (see Appendix A).

The following information was gathered from available medical records for subjects: head position during delivery and/or at birth as assessed by standard obstetric procedures (e.g., see Pritchard & MacDonald, 1976), one-minute Apgar score (Apgar & James, 1962), record of medication administered during the delivery period, sex, time of birth, birthweight, and maternal age. Information on parental handedness (i.e., writing hand) was assessed by a self-report questionnaire (see Appendix B).

It was not possible to systematically vary any aspect of the subject's experience prior to the testing session: for example, feeding periods at the hospital which are 'on demand', access to and duration of time spent with mother by infant, extent of time spent outside of the bassinet, and placement of the bassinet in the nursery by staff.

Subjects were tested in whichever state they presented in to allow state to be included as a variable of interest. Therefore, sleeping babies were not deliberately awakened nor were crying babies calmed. It should be noted that Brackbill, Douthill & West (1973) have reported that supine-positioned newborn infants cry more and sleep less relative to prone-positioned newborn infants. The authors, however, were unable to conclude which position was actually representative of natural quiescent neonatal behavior. State was determined behaviorally and labelled on a five-point scale: asleep, drowsy, awake, cranky, and crying. Determination of state was assessed during each trial of the test session. These five descriptive states correspond loosely to the five identified by Prechtl (1974). Although adequate for the purposes of the current study, they fall short of Prechtl's criteria as they are based on one minute rather than three minute behavioral consistencies and their assessment does not include either regularity of respiration or physiological measurement.

In this study, an ''asleep'' neonate was one which made little or no movement during the majority of a trial as well as having his eyes closed for the majority of a trial.

A ''drowsy'' neonate was so rated when the baby either made several alternations from a sleeping to a mildly awake state during a trial or when the baby made some movement, slowly opened and closed his eyes several times, or yawned repeatedly.

An ''awake'' neonate attended to his environment for the majority of a trial, keeping his eyes open and uttering an occasional sound or brief cry.

A ''cranky'' neonate alternated repeatedly between periods of silence and periods of crying, as well as showing a good deal of limb flailing and body movement.

A ''crying'' neonate spent the majority of a trial crying and/or screaming as well as making wild flailing limb movements and body movements.

Of the 68 subjects who met all criteria and were scheduled for testing, 55 were videotaped. Of the 55 that were videotaped, 50 (27 males and 23 females) were used in data analyses. Table One indicates the frequencies of relevant subject attributes listed above. The 18 subjects were excluded for reasons that will be mentioned below (e.g., loud unexpected noises during testing).

Procedures. All mothers were initially informed that the study was designed to examine ''baby behaviors'' such as head turning and arm movements (see Appendix C). A more detailed discussion regarding the study occurred at the conclusion of testing. As the mother played an active role during the test session, it was important to minimize any possible biases in handling the baby by keeping the mother uninformed about the lateral component of head turning. Employing individual mothers rather than a single tester may have added a small degree of unwanted variance into the design of the study, however, it conformed to hospital regulations.

All testing occurred in semi-private patient rooms on the maternity floor of the hospital. Care was taken to avoid excessively noisy areas of the ward and to eliminate traffic into the room by nurses, visitors, etc. during the test session. A partition separated the participating mother-child dyad from the neighboring, non-participating mother. On many occasions, the participating mother was not sharing the room with another patient at the time of testing. However, when a non-participating mother was present in the room, she was requested to be quiet and to turn off all electrical appliances for the duration of testing. Windows, window shades, and doors were closed to

minimize potentially lateral sounds, lighting, and air drafts. Room lights were turned off, dimming the room to minimize potential hue differences. The baby's bassinet was located in one of four positions, each position approximately equidistant between the partition and a wall. One room position had the partition on the baby's left and the windowed-wall on the right. A second position had the partition on the baby's right and the door-wall on the baby's left. The other two room positions were opposite to these two, i.e., partition right with windowed-wall left or partition left with door-wall right.

Testing occured between 10:00 a.m. and noon, a period of relative calm on the ward following the conclusion of breakfast and the average baby's morning feeding period and before the mother's lunch and the visiting time period. Testing was delayed if the baby was being fed, about to be bathed, or for several reasons of maternal inconvenience such as tiredness or bathing.

The infant's blanket and shirt were removed and the infant was wrapped in a lighter blanket posteriorly from the nipple area to allow a relatively stable ambient temperature while still allowing for free movement of the head and the upper extremeties. The subject was then

placed on his back in the bassinet and given several minutes to acclimate, during which time the mother was given instructions for testing (see Appendix D).

The testing session began with an approximately one-minute-long recording of spontaneous behavior in the bassinet. During this time (and at all other times when the mother was not required during the session) the mother stood quietly behind the head-end of the bassinet, out of view by the baby and without touching the baby.

Following this period, the mother was signalled to initiate the first of multiple (usually six) identical trials by orienting the baby's head to a body midline position until feeling no lateral pressure from the baby to turn his head to the right or to the left. When no lateral pressure was felt, the mother removed her two hands simultaneously and moved back out of the baby's potential view. The average testing session lasted approximately eight minutes.

All subjects were scheduled for a six-trial session. However, sessions were terminated once in progress for a variety of unexpected reasons such as prolonged loud noises or the entrance into the room of persons who had inadvertently not complied with the posted request not to

enter. On these occasions, data were excluded from further analysis if less than four trials had been completed at the time of termination. Those subjects with four (4), five (9), or six (37) completed trials were retained for data analysis, termination excluding either the fifth and/or the sixth trial.

All test sessions were videotaped using a Sony-matic Portable Videocorder videotape device onto black-and-white video magnetic tape. The camera (equipped with a zoom lens) and taping equipment were located approximately four feet from the foot-end of the bassinet within an extended plane created by the baby's midline axis. The investigator was located behind the equipment, also within the extended plane. Videotapes were subsequently replayed and scored on a nine-inch Sony solid-state black-and-white television monitor. All tapes were viewed at least two times for scoring purposes by the investigator.

A subsample of six subjects was scored by a second person naive to the purpose of the research to determine the inter-rater reliability of the various measures of lateral bias and state. There was 100% agreement by the two raters on the direction of the initial head turn (36 observations), 94% agreement on time spent leftward and

rightward (72 observations), and 93% agreement on the total number of right and left head turns (72 observations). State ratings were less consistent. There was 66% agreement within one-half a state level and 94% agreement within one state rating, with particular disagreement on the difference between the asleep and drowsy state ratings.

Data Reduction. Two sets of analyses were conducted. The first analysis examines the level one lateral bias per se. The second analysis examines deals with potential relationships between the lateral bias and various early life phenomena. For this second analysis, the lateral bias data is reduced to form three specific laterality indices: (1) An index based upon the initial head turn following midline release on each trial (i.e., the number of trials on which the initial head turn was rightward minus the number of trials on which the initial head turn was leftward, all divided by the total number of trials). (2) An index based upon the relative amount of time spent rightward and leftward on each trial (i.e., the number of trials during which the subjects spent most of the time rightward minus the number of trials during which the subject spent most of the time leftward, all divided by the total number of trials). (3) An index based upon the

relative total number of right and left head turns on each trial (i.e., the number of trials during which the majority of turns were rightward minus the number of trials during which the majority of turns were leftward, all divided by the total number of trials). On this final index, if there was an equal number of right and left turns on a particular trial following midline release then the trial was scored ''0''. The scores on all three indices ranged from +1.00 (entirely rightward) to -1.00 (entirely leftward). Given Colbourn's (1978) research caveat that, given the current status of empirically-verifiable knowledge in neuropsychology, one should not fall victim to assuming that the degree of a measured lateral phenomenon corresponds to and assesses the degree of the cerebral lateralization of that phenomenon, these three indices are reduced to the following basic categories: right-sided bias, no bias, left-sided bias.

Chi-square analyses were employed in the second analysis to examine distributional relations. When a particular set of data failed to meet suggested minimum requirements for the chi-square statistic (Siegel, 1956), data were collapsed along conceptually-relevant catagories.

All results were tested at the $p < .05$ level of significance.

SPSS (Nie et al, 1975) control card information and raw data are supplied in Appendix E.

RESULTS

LEVEL ONE LATERAL BIAS

The initial observation period allowed an attempt to assess spontaneous head posture prior to the initiation of the midline-restricted trials. Thirty-eight of the 50 subjects (76%) spent the majority of this period with their heads rightward while only 10 (20%) spent the period with heads leftward; two subjects (4%) spent equivalent periods both rightward and leftward ($\chi^2 = 42.88$, df = 2, $p < .00001$).

All three measures of lateral behavior subsequent to midline restrictions were significantly rightward-biased in nature:

First, as indicated in Table Two, on each trial of the testing period, the majority of infants made initial turns to the right of their body midline subsequent to release from a midline head restriction. Overall, in 283 trials, 179 (63.2%) were rightward and 103 (36.4%) were leftward ($\chi^2 = 20.482$, df = 1, $p < .001$), while a single trial (0.3%) was completed without a head turn. This single trial was removed from further analysis. Hence, 63.5% of trials were rightward, 36.5% leftward. A comparison of the first and second halves of the overall session

revealed no significant change in this rightward bias over time (χ^2 = .02, df = 1, p = .89).

Second, over the course of the session it was very common for subjects to make additional head turns during the observation period. Turns opposite the initial head turn direction as well as turns between the midline and the initially-turned-toward direction were common. The mean number of head turns per trial was 1.67 rightward and 1.02 leftward. Subjects turned rightward more so than leftward during the time subsequent to midline release on 175 (62.1%) of all 282 trials (Table Three). More turning leftward than rightward was seen on 66 (23.4%) of the trials; there were an equal number of turns in both directions on 41 (14.5%) of the trials (χ^2 = 108.021, df = 2, p < .00001). An analysis of the first and second halves of the test session revealed no significant differences over time (χ^2 = .98, df = 2, p = .61).

Finally, the relative amount of time spent rightward and leftward on a given trial was determined and each trial was scored as either majority of time spent rightward, majority of time spent leftward, or equal time in both directions. Table Four indicates that 206 (73%) of all trials were rightward biased, i.e., the subject spent the majority of the trial time right of the body

midline, while 76 (27%) of the trials were leftward-biased (χ^2 = 59.929, df = 1, p < .00001). Again, no significant changes over time were observed between the first and second halves (χ^2 = .58, df = 1, p = .45). The average percentage of time per trial spent rightward was 66.98%, leftward 24.19%, and 9.13% of the time was spent in midline.

Neither the position of the bassinet in the ward relative to the partition and the wall nor the length of time the mother held the subject's head in the midline restriction were significantly related to the obtained lateral biases (see Table Five). These influences did not significantly differ over the first and second halves of the session. Artifactual relations did not exist between the lateral behaviors and: room position (which indexed the influence of any possible lateral environmental component which escaped control), the length of the midline hold, and changes over time. Therefore, each subject's performance was indexed on the three lateral bias indices described above: (i) lateral consistency in direction of initial head turn (Table Six), (ii) lateral consistency in direction of all head turns (Table Seven), and (iii) lateral consistency in relative trial time (Table Eight).

In examining how the lateral bias is distributed in individual subjects it must be remembered that not all of the subjects were examined over six trials. To determine whether the data were artifactually influenced by subjects who only completed four or five trials, the analysis for the full sample of 50 subjects was followed by an analysis of the subsample of 37 infants who completed all six trials. Significant deviations between this subsample and the full sample would argue for discarding data collected from those infants who only completed four or five trials. As seen below, there were no significant differences between the full sample and the subsample.

Figure One indicates the catagorized distribution of the first index, consistency in the direction of the initial head turn: 58% of the newborn infants were right-biased, 24% were left-biased, and 18% of the sample failed to show a consistent bias. In the subsample of subjects with six completed trials, 56.8% were right-biased, 24.3% were left-biased, and 18.9% failed to show a consistent bias.

Figure Two indicates the catagorized distribution of the second index, consistency in the direction of all head turns: 74% of the subjects were right-biased, 22% were left-biased, and 4% failed to show a consistent bias. In

the subsample of subjects with six completed trials, 73% were right-biased, 21.6% were left-biased, and 5.4% failed to show a consistent bias.

Figure Three indicates the catagorized distribution of the third index, consistency in relative time,: 74% of the subjects showed a right-bias, 22% a left-bias, and 4% failed to show a consistent bias. In the subsample of subjects with six completed trials, 70.3% were right-biased, 24.3% were left-biased, and 5.4% failed to show a consistent bias.

For the first index, 18% of the subjects were entirely right-biased while 4% were entirely left-biased. On the second index, 20% were entirely right-biased while 4% were entirely left-biased. On the third index, 38% were entirely right-biased while 6% were entirely left-biased.

Table Nine indicates that the three indices were significantly concordant. If subjects were right-biased on one index, they were highly likely to be right-biased on the other two indices; the same for left-biased subjects.

RELATION BETWEEN LEVEL ONE LATERAL BIAS AND ATTRIBUTE VARIABLES

Uterine head position. Twenty-two of the 50 newborn infants were evaluated by the attending physician as to occiput position during the process of delivery while 35 were evaluated at the time of birth. Seven of the infants who were not assessed during this period were delivered via cesarean section; the remainder were either unscorable or were rated only for general presentation (e.g., vertex) but not specific occiput position. The relative percentage of left and right presentations approximated normal population values (see Pritchard & McDonald, 1976). Given the small number of infants presenting either LOT/ROT or LOP/ROP, only LOA/ROA infants were included in the current analysis. Table Ten indicates that no relation between head position recorded during the delivery process but does indicate a significant relation between head position recorded at birth and the direction of the initial head turn. As this finding was not observed for head position rated during delivery nor was it observed for the other two lateral indices, it most likely represents chance variation.

Parental handedness. Overall chi-square analysis between parental handedness as assessed by self-report and

each of the lateral indices were not significant (Table Eleven).

Modal state. An analysis of the potential relationship between modal state and the lateral indices was precluded by the very small number of infants in the asleep, drowsy, and cranky states (refer to Table One). Contingency tables are provided in Table Twelve.

Sex. No significant relationship between sex of infant and the laterality indices was found (Table Thirteen).

Spontaneous head position. All three laterality indices were significantly related to the direction of the baby's spontaneous head position prior to testing (Table Fourteen).

Age at testing. No consistent relationship between age at testing (i.e., day since birth) and the lateral indices emerged (Table Fifteen). However, very young neonates were absent from the current sample.

Apgar status at birth. Eight of the healthy infants had 'questionable' Apgar scores at birth; i.e., Apgar score less than eight. No significant difference was found for any of the indices relative to Apgar status (Table Sixteen).

Maternal medication. The presence or absence of maternal medication during the delivery period as charted by the attending physician was not related to any of the lateral indices (Table Seventeen).

Maternal age. Maternal age was arbitrarily grouped into four catagories: 18-22 years of age, 23-27 years, 28-32 years, and 33-37 years. No relationship between maternal age and the lateral indices was evidenced (Table Eighteen).

Cesarean section. No significant relationship between type of delivery; i.e., cesarean section versus vaginal delivery, and the lateral indices was noted (Table Nineteen).

DISCUSSION

The results of the current study provide additional evidence for the presence of a distinct level one lateral head turning bias in the normal, full-term newborn infant. Lateralization was observed to be very consistent both within individual subjects and across the sample as a whole: the majority of newborn infants in the sample typically oriented their heads rightward of the cephalo-caudal midline body axis both spontaneously and when their heads were released from the non-lateralized midline position. Three indices of lateral behavior: consistency in the direction of the initial head turn subsequent to midline release, consistency in the direction of all head turns from the midline, and consistency in time spent rightward and leftward, concordantly indicate the predominant rightward lateral bias.

These results provide further independent evidence for the presence of a level one lateral bias among healthy neonates which has been observed in several research settings over the past fifteen years. Given the inadequate attention paid to the assessment of the influence of the neonate's environment between birth and the time of testing in these studies (the current study included) the occurrence of a very consistent lateral

behavior in divergent settings lends a good deal of reliability to the literature.

However, it must be remembered that although this phenomenon is seemingly independent of early life setting, the role of a specific environment on neonates has yet to be adequately addressed. The sole attempt at examining the influence of a neonate's early experience on testing is Liederman & Kinsbourne (1980a, Exp. II). Yet, even this study did not attempt a multi-dimensional analysis of lateral components in the neonate's early surround.

The current study extends the assessment of the level one lateral bias to include consistencies in relative time spent rightward and leftward as well as relative differences in the total number of head turns. The results strongly suggest that, in newborn babies, not only is the attainment of a lateral bias predominantly rightward but, also, the continued maintenance of a head position subsequent to the initial head turn from the midline is also consistently rightward. In spite of a good deal of head turning in both directions over a period of observation, most infants spend the majority of time turning right of midline and maintaining a rightward orientation. Thus, these findings concordantly integrate Michel's findings dealing with head position over time and

Turkewitz' findings dealing with initial head turning.

One suggestive post hoc finding, the significance of which cannot be determined in this study but awaits future work, is that the group of infants tested while they were awake were bimodally left and right dominant on all three indices while those infants who were tested while they were crying were uniformly right dominant (see Table Twelve). If replicable, such a finding could generate a hypothesis that the rightward bias is most potent when the neonate is not attending to its environment nor is maintaining voluntary motor control but is attenuated when the neonate does maintain attention and voluntary motor control, allowing either a leftward or a rightward bias to be manifested.

The value of the second analysis is of an intermediate nature. Obviously, the adequate test of the relative importance of these attribute variables must await a multi-dimensional research strategy employing a large enough sample of infants to allow a sizable sample of those attribute variables which have low probabilities of occurrence (e.g., infants who are left-biased). Neither the current study nor previous attempts have satisfied both criteria. Until that point in time, however, the available evidence may have heuristic value. The current

findings suggest that the only attribute variable consistently related to the head turning phenomenon is the infant's head position immediately prior to testing. While this finding is congruent with the previous work described in the review of the literature, non-congruent findings were obtained for relationships between the phenomenon and uterine head posture. The relationship between parental handedness and the level two lateral bias shown by Liederman and Kinsbourne (1980c) was not obtained for the level one lateral bias.

To conclude, the current study provides extended information about the basic level one lateral bias per se while also providing further intermediate information regarding a set of possible antecedents of the lateral bias. Expanding our knowledge about the level one lateral bias in normal newborn infants is necessary if clinical samples are to be examined and, given the relationship between it and the level two responsive asymmetry, prerequisite to a fuller understanding of the level two responsive asymmetry in both normal and clinical samples. The literature dealing with neonatal lateralization is relatively fresh, consistent, and beginning to incorporate changing neuropsychological, developmental, and pediatric neurological conceptualizations of the newborn infant. However, individual studies have usually been directed at

single aspects of the phenomenon. Further, multi-dimensional design studies, incorporating both identified factors and also environmental factors (which have yet to be adequately addressed) will be necessary to critically examine the relative roles of antecedents to the lateral phenomenon. Determining both the theoretical and clinical viability of neonatal lateralization in neuropsychology must await such work; perhaps realization of the need to have this information will be a sufficient impetus to generate such work.

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Parent Consent Form

I understand the purpose and procedures of this study and give permission for my child _____ to be a member of this study's sample. I have been informed that this study has been accepted by Dr. J.R. LeHuquet, the Medical Director of Royal Jubilee Hospital. I also understand that, for the purposes of this study, my child's identity will be protected; consecutive subject numbers will be assigned to children and will be employed in the analysis of the videotape.

Signature_____ Date_____

Home Address_____

_____

_____

Witnessing signature_____
(investigator or head nurse)

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Neonatal Study

HANDEDNESS QUESTIONNAIRE

1. Which hand (Right, Left, or Ambidextrous) do you use...
   ...to write legibly?_____
   ...to throw a ball to hit a tagret?_____
   ...to cut with scissors?_____
   ...to draw a picture?_____
   ...to hold a toothbrush while cleaning your teeth?_____

2. Which hand (Right, Left, or Ambidextrous) does your husband use...
   ...to write legibly?_____
   ...to throw a ball to hit a target?_____
   ...to cut with scissors?_____
   ...to draw a picture?_____
   ...to hold a toothbrush while cleaning his teeth?_____

3. List the handedness for each of your following relations:
   Mother_____ Father_____ Brother 1_____ Brother 2_____ Brother 3_____
   Sister 1_____ Sister 2_____ Sister 3_____

4. List the handedness for each of your husband's relations:
   Mother_____ Father_____ Brother 1_____ Brother 2_____ Brother 3_____
   Sister 1_____ Sister 2_____ Sister 3_____

5. Further Comments. For example, has your handedness or your husband's changed over time?

_____

_____

_____

NAME_____ DATE_____

Appendix C

Hi. I'm from the Psychology Department at U.Vic. I'm doing a study looking at baby behaviors. I'm looking at actions like head turning and arm movements while babies are in their bassinets.

Would you be interested in being part of the study?

It will take about ten minutes of your time once we get started. I'll be videotaping the baby here in your room.

Please fill out this consent to be tested and this short questionnaire on your and your husband's handedness. I'll get the video equipment. Thank you.

Appendix D

For most of this session, I'd like you to stand back behind the baby's bassinet, without touching or speaking to the baby. Do not stand to either side of the baby and do not try to get the baby's attention.

When I signal to you, I'd like you to come up to the baby and orient his/her head so that his/her head and nose are facing straight up toward the ceiling (hand gesture) and not off to either side. I'd like you to hold the baby's head in that position until you feel no pressure from the baby to turn his/her head to either side. When you feel no pressure from the baby to turn his/her head to either side, release your two hands simultaneously and step back out of view.

Do you understand what I would like you to do? Do you have any questions before we start taping?

Appendix E

• • • CONTROL CARD AND DATA LISTING • • •

```
                                                    COLUMN NUMBERS
CARD
NUMBER  1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
                                                                                          .
     1  .PRINT BACK       NO                                                              .
     2  .COMMENT                                                                          .
     3  .                                                                                 .
     4  .                                                                                 .
     5  .                                                                                 .
     6  .                                                                                 .
     7  .                                                                                 .
     8  .                  RISSER NEONATAL LATERALITY/M.A. THESIS/CONTROL AND DATA CARDS   .
     9  .                                                                                 .
    10  .                                                                                 .
    11  .                                                                                 .
    12  .                                                                                 .
    13  .                                                                                 .
    14  .RUN NAME          NEOLAT   RISSER NEONATAL LATERALITY                            .
    15  .VARIABLE LIST      SUBJECT, SEX,AGE,PARHAND,DELHEAD,BIRHEAD,APGAR,               .
    16  .                   MAIMED,SMP,MI1 TO MI6, ST1 TO ST6, RHI1 TO RHI6,              .
    17  .                   LHI1 TO LHI6,S2,LAT1 TO LAT6,RTIME1 TO RTIME6,                .
    18  .                   MTIME1 TO MTIME6, LTIME1 TO LTIME6,                           .
    19  .                  S3,AVEHI,IHTDOM,TIMEDOM,THTDOM,STATE,CESAR,                    .
    20  .                  S4,BIRWT,BED,HOLD1 TO HOLD6,                                   .
    21  .                   S5,MATAGE,AGEMM,NEOHEAD                                       .
    22  .INPUT FORMAT       FIXED(F2.0,5F1.0,F2.0,2F1.0,1X,6F1.0,1X,                      .
    23  .                   6F1.0,1X,6F2.0,1X,6F2.0/                                      .
    24  .                   F2.0,1X,6F2.0,1X,6F3.1,1X,6F3.1,1X,6F3.1/                     .
    25  .                  F2.0,1X,F3.1,1X,F4.2,1X,F4.2,1X,F4.2,1X,F1.0,1X,F1.0/          .
    26  .                  F2.0,1X,F4.0,1X,F1.0,1X,6F2.0/                                 .
    27  .                   F2.0,1X,F2.0,1X,F3.0,1X,F1.0)                                 .
    28  .N OF CASES                    50                                                .
    29  .INPUT MEDIUM      .CARD                                                         .
    30  .COMMENT                                                                         .
    31  .                                                                                .
    32  .                                                                                .
    33  .                                                                                .
    34  .                                                                                .
    35  .                                                                                .
    36  .VAR LABELS        AGE, AGE IN DAYS POST-DELIVERY/                               .
    37  .                  PARHAND, PARENTAL HANDEDNESS AS ASSESSED BY                   .
    38  .                  QUESTIONNNIAME/                                               .
    39  .                  DELHEAD, THE POSITION OF THE NEONATE'S HEAD DURING            .
    40  .                  DELIVERY/                                                     .
    41  .                  BIRHEAD, THE POSITION OF THE NEONATE'S HEAD AT BIRTH/          .
    42  .                  APGAR, ONE-MINUTE APGAR STATUS/                               .
    43  .                  MAIMED, MATERNAL MEDICATION DURING DELIVERY/                   .
    44  .                  SMP, SPONTANEOUS HEAD POSITION PRIOR TO TESTING/              .
    45  .                  MI1 TO MI6, INITIAL HEAD TURN FOR EACH OF SIX TRIALS/         .
    46  .                  ST1 TO ST6, NEONATAL STATE FOR EACH TRIAL/                     .
    47  .                  RHI1 TO RHI6, NUMBER OF RIGHT HEAD TURNS DURING TRIAL/        .
    48  .                  LHI1 TO LHI6, NUMBER OF LEFT HEAD TURNS DURING TRIAL/         .
    49  .                  LAT1 TO LAT6, LATENCY FOR INITIAL HEAD TURN FOR EACH TRIAL/   .
    50  .                 RTIME1 TO RTIME6, PERCENT OF TRIAL WITH HEAD RIGHT/            .
    51  .                  MTIME1 TO MTIME6, PERCENT OF TIME WITH HEAD MIDLINE/          .
    52  .                  LTIME1 TO LTIME6, PERCENT OF TIME WITH HEAD LEFT/             .
    53  .                    AVEHI, AVERAGE NUMBER OF LEFT AND RIGHT HEAD TURNS DURING   .
    54  .                  TESTING/                                                      .
    55  .                  IHTDOM, INITIAL HEAD TURN DOMINANCE SCORE/                    .
    56  .                  TIMEDOM, LATERAL TIME DOMINANCE SCORE/                        .
    57  .                  THTDOM, TOTAL NUMBER HEAD TURNS DOMINANCE SCORE/              .
    58  .                  STATE, MODE STATE DURING SESSION/                             .
    59  .                  CESAR, CESAREAN SECTION/                                      .
    60  .                  BIRWT, BIRTHWEIGHT/                                           .
    61  .                  BED, SIDE OF ROOM/                                            .
    62  .                  HOLD1 TO HOLD6, LENGTH OF MIDLINE HOLD/                       .
    63  .                   MATAGE, MATERNAL AGE/                                        .
    64  .                   AGEMM, AGE IN MOURS/                                         .
    65  .                   NEOHEAD, DELHEAD PLUS BIRHEAD/                               .
    66  .COMMENT                                                                         .
    67  .                                                                                .
    68  .                                                                                .
    69  .                                                                                .
    70  .                                                                                .
    71  .                                                                                .
    72  .VALUE LABELS        SEX (1)MALE (2) FEMALE/                                     .
    73  .                   PARHAND (1)RIGHT-RIGHT (2)RIGHT-NONRIGHT (3)LEFT-LEFT/       .
    74  .                  DELHEAD (1) RIGHT (2) LEFT/                                   .
    75  .                  BIRHEAD (1)RIGHT (2)LEFT/                                     .
    76  .                  MAIMED (1) YES (2)NO /                                        .
    77  .                  SMP TO MI6 (1)RIGHT (2)LEFT (3) NO BIAS /                     .
    78  .                   ST1 TO ST6 (1)ASLEEP (2)DROWSY BUT AWAKE (3)AWAKE            .
    79  .                  (4)CRANKY (5)CRYING/                                          .
    80  .                  STATE (1) ASLEEP (2)DROWSY (3)AWAKE (4)CRANKY (5)CRYING/      .
    81  .                  CESAR (1)YES (2)NO/                                           .
    82  .                   NEOHEAD (1) RIGHT (2) LEFT/                                  .
    83  .MISSING VALUES     LAT1 TO LAT6 (99)/                                           .
    84  .                    SEX (0)/                                                    .
    85  .                    STATE (0)/                                                  .
    86  .                   BIRWT (0000)/                                                .
    87  .                   BED (0)/                                                     .
    88  .                    TIMEDOM (99.99)/                                            .
    89  .                    RTIME1 TO RTIME6 (99.9)/                                    .
    90  .                    MTIME1 TO MTIME6 (99.9)/                                    .
    91  .                    LTIME1 TO LTIME6 (99.9)/                                    .
    92  .                  AGE,PARHAND,MI1 TO MI6,APGAR,MAIMED,DELHEAD,BIRHEAD,          .
    93  .                  ST1 TO ST6 (0) /                                              .
    94  .                  RHI1 TO RHI6,LHI1 TO LHI6 (99)/                               .
    95  .                  HOLD1 TO HOLD6 (99)/                                          .
    96  .                   MATAGE (00)/                                                 .
    97  .                   AGEMM (000)/                                                 .
    98  .                   NEOHEAD (0)/                                                 .
    99  .RECODE                RTIME1 TO LTIME6 (99.6=100.0)                            .
   100  .RECODE               HOLD1 TO HOLD6 (BLANK=99)                                 .
        .1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
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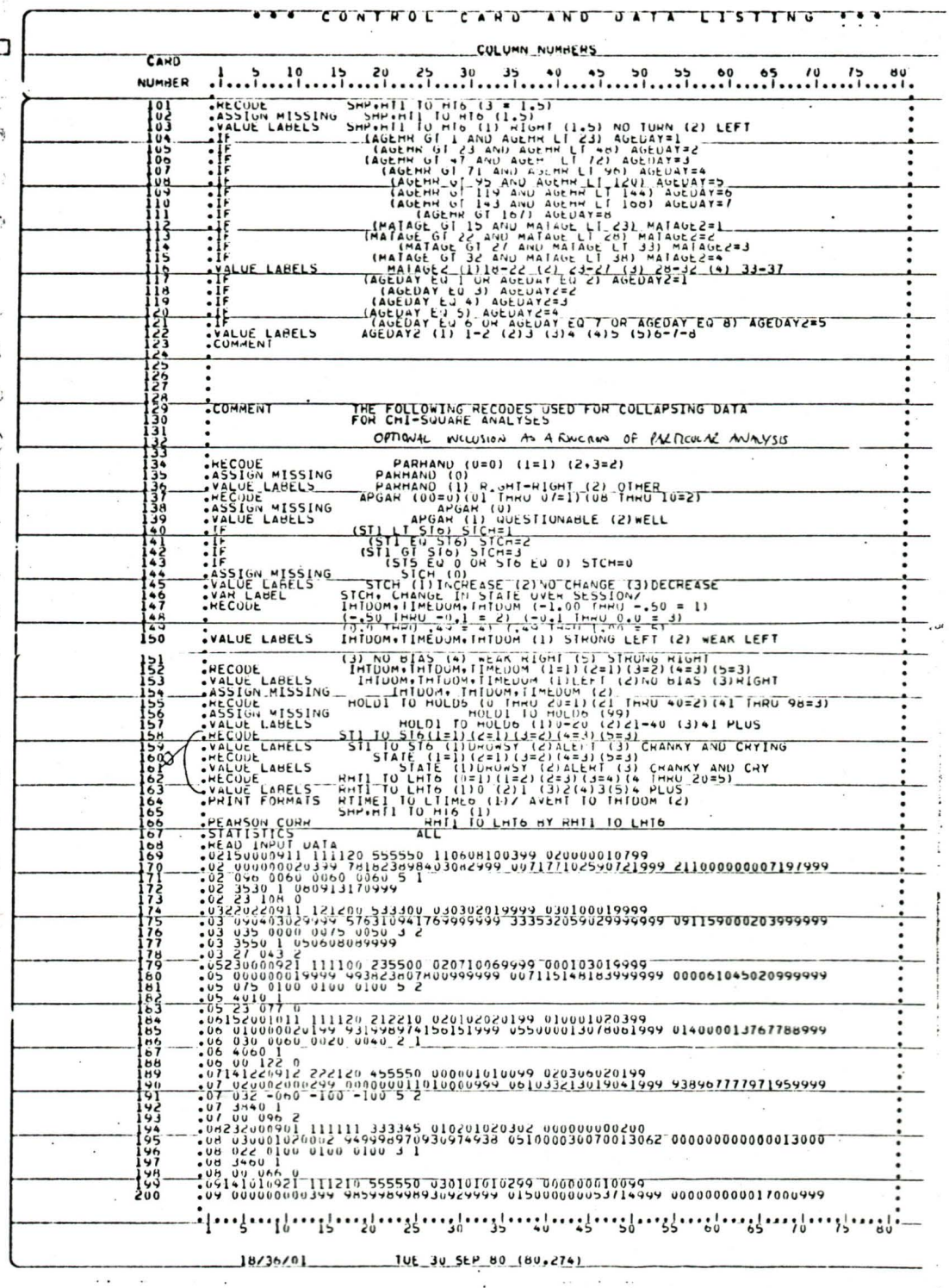
18/36/01 TUE 30 SEP 80 (80.274) PAGE



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                    • • •  C O N T R O L  C A R D  A N D  D A T A  L I S T I N G  • • •

                                                    COLUMN NUMBERS
CARD
NUMBER   1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
.....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
  101  .RECODE          SMP•MT1 TO MT6 (3 = 1.5)
  102  .ASSIGN MISSING   SMP•MT1 TO MT6 (1.5)
  103  .VALUE LABELS    SMP•MT1 TO MT6 (1) RIGHT (1.5) NO TOWN (2) LEFT
  104  .IF                (AGEMR GT 1 AND AGEMR LT 23) AGEDAY=1
  105  .IF                (AGEMR GT 23 AND AGEMR LT 48) AGEDAY=2
  106  .IF               (AGEMR GT 47 AND AGEM  LT 72) AGEDAY=3
  107  .IF                (AGEMR GT 71 AND AGEMR LT 96) AGEDAY=4
  108  .IF                 (AGEMR GT 95 AND AGEMR LT 120) AGEDAY=5
  109  .IF                 (AGEMR GT 119 AND AGEMR LT 144) AGEDAY=6
  110  .IF                 (AGEMR GT 143 AND AGEMR LT 168) AGEDAY=7
  111  .IF                  (AGEMR GT 167) AGEDAY=8
  112  .IF                (MATAGE GT 15 AND MATAGE LT 23) MATAGE2=1
  113  .IF               (MATAGE GT 22 AND MATAGE LT 28) MATAGE2=2
  114  .IF                 (MATAGE GT 27 AND MATAGE LT 33) MATAGE2=3
  115  .IF                (MATAGE GT 32 AND MATAGE LT 38) MATAGE2=4
  116  .VALUE LABELS       MATAGE2 (1)16-22 (2) 23-27 (3) 28-32 (4) 33-37
  117  .IF               (AGEDAY EQ 1 OR AGEDAY EQ 2) AGEDAY2=1
  118  .IF                 (AGEDAY EQ 3) AGEDAY2=2
  119  .IF                (AGEDAY EQ 4) AGEDAY2=3
  120  .IF                (AGEDAY EQ 5) AGEDAY2=4
  121  .IF                 (AGEDAY EQ 6 OR AGEDAY EQ 7 OR AGEDAY EQ 8) AGEDAY2=5
  122  .VALUE LABELS      AGEDAY2 (1) 1-2 (2)3 (3)4 (4)5 (5)6-7-8
  123  .COMMENT
  124  .
  125  .
  126  .
  127  .
  128  .
  129  .COMMENT           THE FOLLOWING RECODES USED FOR COLLAPSING DATA
  130  .                  FOR CHI-SQUARE ANALYSES
  131  .                    OPTIONAL INCLUSION AS A PROGRAM OF PARTICULAR ANALYSIS
  132  .
  133  .
  134  .RECODE                PARHAND (0=0) (1=1) (2,3=2)
  135  .ASSIGN MISSING      PARHAND (0)
  136  .VALUE LABELS        PARHAND (1) R.HT-RIGHT (2) OTHER
  137  .RECODE             APGAR (00=0)(01 THRU 07=1)(08 THRU 10=2)
  138  .ASSIGN MISSING          APGAR (0)
  139  .VALUE LABELS          APGAR (1) QUESTIONABLE (2)WELL
  140  .IF                (ST1 LT ST6) STCH=1
  141  .IF                 (ST1 EQ ST6) STCH=2
  142  .IF                (ST1 GT ST6) STCH=3
  143  .IF                   (ST5 EQ 0 OR ST6 EQ 0) STCH=0
  144  .ASSIGN MISSING          STCH (0)
  145  .VALUE LABELS       STCH (1)INCREASE (2)NO CHANGE (3)DECREASE
  146  .VAR LABEL         STCH• CHANGE IN STATE OVER SESSIONS
  147  .RECODE            IMTDOM•TIMEDOM•IMTDOM (-1.00 THRU -.50 = 1)
  148  .                  (-.50 THRU -0.1 = 2) (-0.1 THRU 0.0 = 3)
  149  .                  (0.0 THRU .49 = 4) (.49 THRU 1.00 = 5)
  150  .VALUE LABELS      IMTDOM•TIMEDOM•IMTDOM (1) STRONG LEFT (2) WEAK LEFT
  151  .                  (3) NO BIAS (4) WEAK RIGHT (5) STRONG RIGHT
  152  .RECODE             IMTDOM•IMTDOM•TIMEDOM (1=1)(2=1)(3=2)(4=3)(5=3)
  153  .VALUE LABELS       IMTDOM•IMTDOM•TIMEDOM (1)LEFT (2)NO BIAS (3)RIGHT
  154  .ASSIGN MISSING        IMTDOM• IMTDOM•TIMEDOM (2)
  155  .RECODE           HOLD1 TO HOLD5 (0 THRU 20=1)(21 THRU 40=2)(41 THRU 98=3)
  156  .ASSIGN MISSING          HOLD1 TO HOLD6 (99)
  157  .VALUE LABELS          HOLD1 TO HOLD6 (1)0-20 (2)21-40 (3)41 PLUS
  158  .RECODE           ST1 TO ST6(1=1)(2=1)(3=2)(4=3)(5=3)
  159  .VALUE LABELS     ST1 TO ST6 (1)DROWSY (2)ALERT (3) CRANKY AND CRYING
  160  .RECODE              STATE (1=1)(2=1)(3=2)(4=3)(5=3)
  161  .VALUE LABELS          STATE (1)DROWSY (2)ALERT (3) CRANKY AND CRY
  162  .RECODE           RMT1 TO LMT6 (0=1)(1=2)(2=3)(3=4)(4 THRU 20=5)
  163  .VALUE LABELS     RMT1 TO LMT6 (1)0 (2)1 (3)2(4)3(5)4 PLUS
  164  .PRINT FORMATS    RTIME1 TO LTIME6 (1)7 AVEMT TO IMTDOM (2)
  165  .                 SMP•MT1 TO MT6 (1)
  166  .PEARSON CORR              RMT1 TO LMT6 BY RMT1 TO LMT6
  167  .STATISTICS                ALL
  168  .READ INPUT DATA
  169  .02150000911 111120 555550 110608100399 020000010799
  170  .02 000000020399 781823898403082999 007177102590721999 211000000007197999
  171  .02 096 0060 0060 0060 5 1
  172  .02 3530 1 0809131709999
  173  .02 23 104 0
  174  .03220220911 121200 533300 030302019999 030100019999
  175  .03 090403029999 576310941769999999 333532059029999999 091159000203999999
  176  .03 035 0000 0075 0050 3 2
  177  .03 3550 1 050608089999
  178  .03 27 043 2
  179  .05230000921 111100 235500 020710069999 000103019999
  180  .05 000000019999 993823807000999999 007115148183999999 000061045020999999
  181  .05 075 0100 0100 0100 5 2
  182  .05 4010 1
  183  .05 23 077 0
  184  .06152001011 111120 212210 020102020199 010001020399
  185  .06 010000020199 931598974156151999 055000013078061999 014000013767788999
  186  .06 030 0060 0020 0040 2 1
  187  .06 4060 1
  188  .06 00 122 0
  189  .07141220912 222120 455550 000001010099 020306020199
  190  .07 020002000299 000000011010000999 061033213019041999 938967777971959999
  191  .07 032 -060 -100 -100 5 2
  192  .07 3540 1
  193  .07 00 096 2
  194  .08232000901 111111 333345 010201020302 000000000200
  195  .08 030001020002 949998970930974938 051000030070013062 000000000000013000
  196  .08 022 0100 0100 0100 3 1
  197  .08 3460 1
  198  .08 00 066 0
  199  .09141010921 111210 555550 030101010299 000000010099
  200  .09 000000000399 985998998930929999 015000000053714999 000000000017000999
       .
       .|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|....|
       1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80

                18/36/01          TUE 30 SEP 80 (80.274)
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• • • CONTROL CARD AND DATA LISTING • • •

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    202 .09 3490 2
    203 .09 00 097 1
    204 .10162110812 222120 333330 000101010099 0201010000199
    205 .10 0002000001199 0006919849980000999 0080210000000017999 9922870360009839999
    206 .10 016 -060 0060 -020 3 2
    207 .10 3590 1
    208 .10 00 151 1
    209 .11141220811 112100 133300 010101019999 0000010099999
    210 .11 0203023849999 9715924256009999999 0290480954009999999 0000000100009999999
    211 .11 012 0050 0100 0075 3 2
    212 .11 4030 1
    213 .11 00 093 2
    214 .12162000721 221100 355500 030403049999 0202000049999
    215 .12 0100000009999 8737088955149999999 0632361050699999999 0630550004449999999
    216 .12 055 0000 0100 0075 5 2
    217 .12 3120 2
    218 .12 00 141 0
    219 .13231110821 111121 555434 010101010101 0000000000100
    220 .13 0700220940212 8969988999899429786 1040003011380382149 0000000000000019000
    221 .13 012 0067 0100 0083 5 2
    222 .13 3765 0
    223 .13 00 072 1
    224 .14231200311 111121 433333 010102010103 0000010000100
    225 .14 0000000000000 9989989909995992990 0000000000000000010 0000000100000080000
    226 .14 018 0067 0100 0083 3 2
    227 .14 3700 1
    228 .14 00 079 2
    229 .15241020811 112212 555555 010202040404 0000030303002
    230 .15 0101010204002 9809394704003314459 0200612273435673240 0000030325411821 6
    231 .15 047 0000 0067 0067 5 2
    232 .15 3940 2
    233 .15 00 103 2
    234 .16171000721 111110 555550 010301030299 0000000000099
    235 .16 0303000000099 9399369989898998999 0610640000000000999 0000000000000000999
    236 .16 020 0100 0100 0100 5 1
    237 .16 3400 2
    238 .16 00 168 0
    239 .17261000421 222222 334333 0001000000100 0101010103
    240 .17 0000020000202 0009750000003220000 0000000460230510175 9980259539776279251
    241 .17 018 -100 -067 -083 3 1
    242 .17 3420 1 2315111140508
    243 .17 00 146 0
    244 .19242010421 112111 555555 010102010201 0000002000000
    245 .19 0101000000000 9829859069989978998 0180150350000220000 0000000570000000000
    246 .19 017 0067 0100 0083 5 2
    247 .19 3740 1 251157151930
    248 .19 19 088 1
    249 .20121220811 111110 332320 020101020199 0000000000099
    250 .20 0000030000299 9859989989998950999 0170000000000050999 0000000000000000999
    251 .20 014 0100 0100 0100 3 2
    252 .20 3280 1 152411152199
    253 .20 25 052 2
    254 .21211110911 111111 332333 010101010101 0000000060000
    255 .21 4513000203033 3758099989729569652 6251910000280440480 0000000000000000000
    256 .21 010 0100 0083 0100 3 2
    257 .21 3920 2 351522121331
    258 .21 32 068 1
    259 .22241010912 222221 333332 0000000000101 0101010103000
    260 .22 0100000000000 0000000000000233998 9820000000000017000 0189989989987500000
    261 .22 015 -067 -067 -067 3 2
    262 .22 2880 2 13291107050 6
    263 .22 29 066 1
    264 .23140020911 111111 311111 010101010101 0000000000000
    265 .23 0200000000001 9679989989998998985 0330000000000000015 0000000000000000000
    266 .23 010 0100 0100 0100 1 2
    267 .23 4040 2 111114090711
    268 .23 27 084 2
    269 .24121010821 111121 333333 020101010001 0000000000200
    270 .24 0601010000201 8549779719980000977 1460230290000360923 0000000000000964000
    271 .24 013 0067 0067 0067 3 2
    272 .24 3670 2 301115110516
    273 .24 20 047 1
    274 .25121220411 211211 322212 010104010101 0200000010000
    275 .26 0203010200501 2694339981776900974 5580670191381000026 1730000000860000000
    276 .26 020 0033 0083 0050 2 2
    277 .26 3440 1 0605271209113
    278 .26 25 047 2
    279 .27141220811 121110 333330 030101010199 0101000000099
    280 .27 0802000000099 8429439989989998999 1400380000000000994 0180190000000000999
    281 .27 018 0060 0100 0080 3 2
    282 .27 3490 1 191214151099
    283 .27 00 104 2
    284 .28121220811 111112 433333 010101010101 0000000000001
    285 .28 0101000690100 9839861998862978926 0170190001380220000 0000000000000000074
    286 .28 012 0067 0100 0100 3 2
    287 .28 4250 1 361529151223
    288 .28 20 041 2
    289 .29151020923 123111 222222 0100000010302 0103000000101
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                18/36/01          TUE 30 SEP 80 (80.274)
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*** CONTROL CARD AND DATA LISTING ***

COLUMN NUMBERS

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CARD
NUMBER   1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
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301  .31 028 0100 0100 0100 4 2
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305  .32 010402000003 30693596229498952 1450650380740000048 5480000006320000000
306  .32 020 0067 0033 0033 3 2
307  .32 4210 2 151109061909
308  .32 21 057 2
309  .33121000811 222120 333330 030201050099 04010-030599
310  .33 010002010099 8878440853390000999 1040311492150629Y9 2091257664469389999
311  .33 050 -060 -060 -020 3 2
312  .33 2950 1 212010131099
313  .33 22 060 0
314  .34231010921 111122 555544 040305080203 010502040103
315  .34 100201000000 77800467756591762S 2063021451940500Z1 016094177242033304
316  .34 068 0033 0100 0050 5 2
317  .34 3010 2 090921130605
318  .34 34 078 1
319  .35131000921 111211 222122 040201010302 000200010000
320  .35 010103050000 9200539374929509988 0800530630775050000 0008950004310000000
321  .35 020 0083 0067 0067 2 2
322  .35 4110 1 5194968081915
323  .35 28 064 0
324  .36142020811 212211 354543 010102020101 020001010000
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327  .36 2780 1 2916231522I9
328  .36 24 065 2
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331  .37 010 -100 -100 -100 3 2
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338  .38 32 098 2
339  .39122221011 212211 343344 020100010201 010001010000
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341  .39 016 0000 0033 0050 2
342  .39 4550 1 441812131711
343  .39 32 057 2
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345  .40 000120000322 351000000944610240 0000160160000051035 6399844984000339719
346  .40 014 0000 -033 0000 2 2
347  .40 3940 2 060512042410
348  .40 28 058 2
349  .41252000921 111211 333333 020205010102 000001010000
350  .41 000000000000 9989829879498998998 0000180170000000000 0000000170000000000
351  .41 025 0067 0100 0083 3 1
352  .41 3270 1 2009141009I2
353  .41 32 120 0
354  .42221220912 211222 345534 040904030001 060301060204
355  .42 000000060000 143820915240000018 2380330868771100368 619147017377900614
356  .42 072 -033 -017 -033 4 2
357  .42 3610 1 121606122107
358  .42 32 055 2
359  .43122010922 122212 334434 020000010200 010101020001
360  .43 010219000401 233000000548825000 4830363330321759I8 2839646674190009820
361  .43 014 -033 -033 -033 3 2
362  .43 4260 1 151024121009
363  .43 24 051 1
364  .44111010421 111121 334333 010301020201 000200010100
365  .44 010001030001 977178978816872978 0230220221020640220 0008000000820640000
366  .44 022 0067 0067 0100 3 2
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368  .44 00 011 1
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382  .47 3200 2 9629014131421
383  .47 00 079 2
384  .48253100912 212122 333333 000400030002 010201030103
385  .48 000001010503 0004420008150000339 0000770220551060051 998481978130894610
386  .48 033 -033 -067 -050 3 2
387  .48 3090 1 1904110708I5
388  .48 00 098 1
389  .49261020421 221221 333333 000101010101 010100010100
390  .49 000003020201 0009809448497716980 0000000560710300Z0 9980200000A9254000
391  .49 015 -033 0067 0017 3 2
392  .49 3030 1 2911111611I6
393  .49 31 110M 2
394  .50131020412 222122 333334 000001020100 010202010201
395  .50 010301000106 0000000892750000000 0220540106059999120 97894689366799988O
396  .50 022 -067 -100 -067 3 2
397  .50 2980 1 271619171110
398  .50 25 054 2
399  .51251110811 121111 434555 040403030401 040102020100
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     1    5    10   15   20   25   30   35   40   45   50   55   60   65   70   75   80
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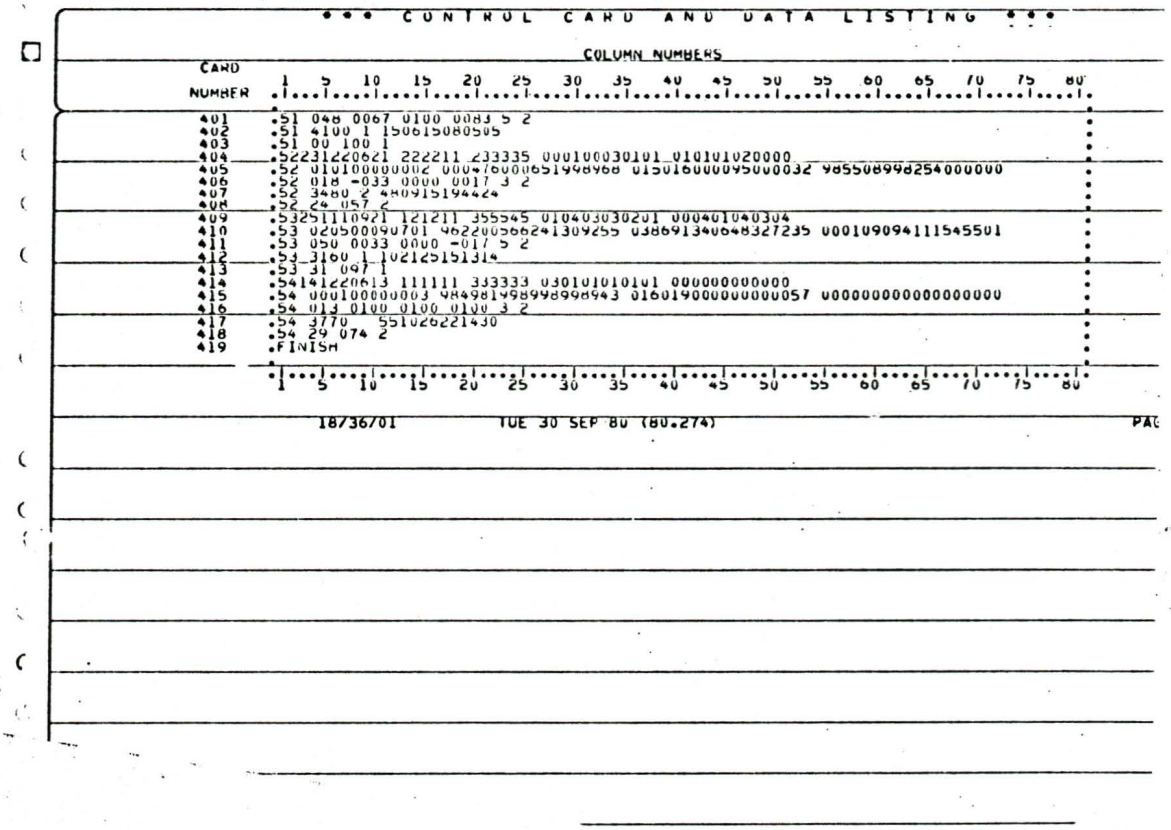
1794



*** CONTROL CARD AND DATA LISTING ***

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402	.51 4100 1 150615080505
403	.51 00 100 1
404	.522312220621 222211 233335 000100030101 010101020000
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408	.52 24 057 4
409	.53251110921 121211 355545 010403030201 000401040304
410	.53 020500090701 9622005668241309255 038691340648327235 000109094111545501
411	.53 050 0033 0000 -017 5 2
412	.53 3100 1 102125151314
413	.53 31 097 1
414	.5414122206l3 111111 333333 030101010101 000000000000
415	.54 000100000003 9849814988998998943 0160190000000000057 0000000000000000000
416	.54 013 0100 0100 0100 3 2
417	.54 3770 5510262214l0
418	.54 29 074 2
419	.FINISH

1 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80

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TABLE ONE

SAMPLE CHARACTERISTICS

Sex	Male	27
	Female	23
Age (days)	1-2	5
	3	17
	4	10
	5	11
	6-8	7
Parental Handedness	Right-right	36
	Other	10
	Not coded	4
Apgar Score	Questionable (1-7)	8
	Well (8-10)	42
Maternal Medication	Present	27
	Absent	22
	not available	1
Delivery	Vaginal	43
	Cesarean	7
Modal State	Asleep	1
	Drowsy	6
	Awake	25
	Cranky	3
	Crying	13
	Bimodal	2
Birthweight	Mean	3638.5 g
	s.d.	414.9 g
	Range	2780 g - 4550 g
Age (hrs.)	mean	82.7 hrs.
	s.d.	31.5 hrs.
	Range	11 hrs.- 168 hrs.
Maternal Age	Mean	26.0 yrs.
	s.d.	4.5 yrs.
	Range	18 yrs. - 34 yrs.

TABLE TWO

DIRECTION OF THE INITIAL HEAD TURN SUBSEQUENT TO RELEASE FROM THE MIDLINE

	Right (n)	Left (n)
Trial One	32	18
Trial Two	31	19
Trial Three	31	18
Trial Four	33	17
Trial Five	27	19
Trial Six	25	12
Total	179	103
	63.5 %	36.5%

$\chi^2 = 20.48$ df = 1 p = .89

First Half	94	55
Second Half	85	48
Total	179	103

$\chi^2 = .02$ df = 1 p = .89

TABLE THREE

DIRECTION OF THE MAJORITY OF THE TOTAL NUMBER OF HEAD TURNS PER TRIAL SUBSEQUENT TO MIDLINE RELEASE

	Majority Rightward (n)	No Majority (n)	Majority Leftward (n)
Trial One	28	7	15
Trial Two	33	8	9
Trial Three	32	4	13
Trial Four	30	12	8
Trial Five	27	5	14
Trial Six	25	5	7
Total	175	41	66
	62.1%	14.5%	23.4%

$\chi^2 = 108.2$ df = 2 $p < .00001$

First Half	93	19	37
Second Half	82	22	29
Total	175	41	66

$\chi^2 = .98$ df = 2 $p = .61$

TABLE FOUR

DIRECTION SPENT FOR THE MAJORITY OF TRIAL TIME SUBSEQUENT TO MIDLINE RELEASE PER TRIAL

	Majority Rightward (n)	Majority Leftward (n)
Trial One	32	18
Trial Two	37	13
Trial Three	37	12
Trial Four	39	11
Trial Five	32	14
Trial Six	29	8
Total	206	76
	73.0%	27.0%

$\chi^2 = 59.93$ df = 1 $p < .00001$

First Half	106	43
Second Half	100	33
Total	206	76

$\chi^2 = .58$ df = 1 $p = .45$

TABLE FIVE

RESULTS OF CHI-SQUARE ANALYSES EXAMINING POTENTIALLY-ARTIFACTUAL RELATIONS

(i) Room Position

Analysis	χ^2	df	p
Room Position by Trial One	1.18	3	.76
Room Position by Trial Two	5.89	3	.12
Room Position by Trial Three	5.01	3	.17
Room Position by Trial Four	2.38	3	.50
Room Position by Trial Five	4.35	3	.23
Room Position by Trial Six	1.99	3	.57

(ii) Length of Midline Restriction

Analysis	χ^2	df	p
Length by Trial One	1.59	2	.45
Length by Trial Two	0.26	2	.88
Length by Trial Three	0.25	2	.88
Length by Trial Four	2.34	2	.31
Length by Trial Five	2.28	2	.32
Length by Trial Six	0.56	2	.75

TABLE SIX .

FREQUENCY DISTRIBUTION OF AN INDEX OF LATERAL CONSISTENCY IN THE DIRECTION OF INITIAL HEAD. TURNS SUBSEQUENT TO MIDLINE RELEASES

Score	Frequency (n)	Frequency (%)
-1.00	2	4
-0.67	2	4
-0.60	3	6
-0.33	5	10
0.00	9	18
0.33	4	8
0.50	2	4
0.60	4	8
0.67	9	18
0.83	1	2
1.00	9	18
Total	50	100

TABLE SEVEN

FREQUENCY DISTRIBUTION OF AN INDEX OF LATERAL CONSISTENCY IN THE DIRECTION OF THE MAJORITY OF HEAD TURNS PER TRIAL SUBSEQUENT TO MIDLINE RELEASE OVER THE COURSE OF THE OBSERVATION PERIOD

Score	Frequency (n)	Frequency (%)
-1.00	2	4
-0.83	1	2
-0.67	2	4
-0.50	1	2
-0.33	2	4
-0.20	2	4
-0.17	1	2
0.00	2	4
0.17	2	4
0.33	3	6
0.40	1	2
0.50	7	14
0.60	1	2
0.67	4	8
0.75	2	4
0.80	2	4
0.83	5	10
1.00	10	20
Total	50	100

TABLE EIGHT

FREQUENCY DISTRIBUTION OF AN INDEX OF LATERAL CONSISTENCY IN THE DIRECTION SPENT FOR THE MAJORITY OF A TRIAL SUBSEQUENT TO MIDLINE RELEASE OVER THE COURSE OF THE OBSERVATION PERIOD

Score	Frequency (n)	Frequency (%)
-1.00	3	6
-0.67	3	6
-0.60	1	2
-0.33	3	6
-0.17	1	2
0.00	2	4
0.20	1	2
0.33	4	8
0.60	2	4
0.67	8	16
0.75	1	2
0.83	2	4
1.00	19	38
Total	50	100

TABLE NINE

CONCORDANCE AMONG THE THREE INDICES OF LATERAL CONSISTENCY

(i)

Consistency in Direction of Initial Turn	Consistency in the Direction of All Turns: Right	No Bias	Left
Right	28	0	1
No Bias	7	2	0
Left	2	0	10

$\chi^2 = 43.49$ $df = 4$ $p < .00001$

(ii)

Consistency in Direction of Majority Time	Consistency in the Direction of All Turns: Right	No Bias	Left
Right	36	0	1
No Bias	1	0	1
Left	0	2	9

$\chi^2 = 42.97$ $df = 4$ $p < .00001$

(iii)

Consistency in Direction of Majority Time	Consistency in the Direction of Initial Turn: Right	No Bias	Left
Right	28	7	2
No Bias	1	0	1
Left	0	2	9

$\chi^2 = 29.99$ $df = 4$ $p < .00001$

TABLE TEN

CONTINGENCY TABLES FOR UTERINE HEAD POSITION BY THE THREE LATERAL INDICES OF LATERAL CONSISTENCY: (A) DURING DELIVERY PROCESS (B) AT BIRTH

(A)

		During Delivery Process	
		ROA	LOA
Consistency in Direction of Initial Turn	Left	1	2
	No Bias	0	2
	Right	3	5 [a]
Consistency in Direction of All Turns	Left	2	1
	No Bias	0	1
	Right	2	7 [b]
Consistency in Direction of Majority Time	Left	0	2
	No Bias	1	1
	Right	3	6 [c]

(B)

		At Birth	
		ROA	LOA
Consistency in Direction of Initial Turn	Left	4	4
	No Bias	0	7
	Right	11	8 [d]
Consistency in Direction of All Turns	Left	5	2
	No Bias	0	2
	Right	10	15 [e]
Consistency in Direction of Majority Time	Left	3	4
	No Bias	1	1
	Right	11	14 [f]

a. $\chi^2 = 1.07$ df = 2 p = .59
b. $\chi^2 = 2.57$ df = 2 p = .28
c. $\chi^2 = 1.26$ df = 2 p = .53
d. $\chi^2 = 7.10$ df = 2 p = .03
e. $\chi^2 = 3.87$ df = 2 p = .14
f. $\chi^2 = 0.03$ df = 2 p = .98

TABLE ELEVEN

CONTINGENCY TABLES FOR PARENTAL HANDEDNESS BY THE THREE INDICES OF LATERAL CONSISTENCY

		Parental Handedness	
		Right-Right	Other
Consistency in Direction of Initial Turn	Left	9	3
	No Bias	4	3
	Right	22	4 [a]
Consistency in Direction of All Turns	Left	8	3
	No Bias	2	0
	Right	25	7 [b]
Consistency in Direction of Majority Time	Left	8	2
	No Bias	2	0
	Right	24	8 [c]

a. $\chi^2 = 2.48$ df = 2 p = .29
b. $\chi^2 = 0.74$ df = 2 p = .69
c. $\chi^2 = 0.72$ df = 2 p = .69

TABLE TWELVE

CONTINGENCY TABLES FOR MODAL STATE BY THE THREE INDICES OF LATERAL CONSISTENCY

		Modal State				
		Asleep	Drowsy	Awake	Cranky	Crying
Consistency in Direction of Initial Turn	Left	0	0	10	1	1
	No Bias	0	2	2	1	2
	Right	1	4	13	1	10 [a]
Consistency in Direction of All Turns	Left	0	0	8	1	2
	No Bias	0	1	1	0	0
	Right	1	5	16	2	11 [b]
Consistency in Direction of Majority Time	Left	0	1	7	1	1
	No Bias	0	0	1	0	1
	Right	1	5	16	2	11 [c]

a. $\chi^2 = 10.25$ df = 8 p = .25
b. $\chi^2 = 6.65$ df = 8 p = .57
c. $\chi^2 = 3.64$ df = 8 p = .89

TABLE THIRTEEN

CONTINGENCY TABLES FOR SEX BY THE THREE INDICES OF LATERAL CONSISTENCY

		Sex		
		Male	Female	
Consistency in Direction of Initial Turn	Left	6	6	
	No Bias	4	5	
	Right	17	12	a
Consistency in Direction of All Turns	Left	6	5	
	No Bias	0	2	
	Right	21	16	b
Consistency in Direction of Majority Time	Left	4	6	
	No Bias	0	2	
	Right	22	15	c

a. $\chi^2 = 0.66$ df = 2 p = .72
b. $\chi^2 = 2.46$ df = 2 p = .29
c. $\chi^2 = 3.55$ df = 2 p = .17

TABLE FOURTEEN

CONTINGENCY TABLES FOR SPONTANEOUS HEAD POSITION IMMEDIATELY PRIOR TO TESTING BY THE THREE INDICES OF LATERAL CONSISTENCY

		Spontaneous head position		
		Right	Equally right & left	Left
Consistency in Direction of Initial Turn	Left	4	0	8
	No Bias	8	0	1
	Right	26	2	1 [a]
Consistency in Direction of All Turns	Left	3	0	8
	No Bias	1	0	1
	Right	34	2	1 [b]
Consistency in Direction of Majority Time	Left	3	0	7
	No Bias	2	0	0
	Right	33	2	2 [c]

a. $\chi^2 = 22.63$ df = 4 p = .0002
b. $\chi^2 = 27.27$ df = 4 p < .00001
c. $\chi^2 = 22.61$ df = 4 p = .0002

TABLE FIFTEEN

CONTINGENCY TABLES FOR AGE AT TESTING (DAYS) BY THE THREE INDICES OF LATERAL CONSISTENCY

		Age at testing				
		1 & 2	3	4	5	6,7 & 8
Consistency in Direction of Initial Turn	Left	0	7	0	3	2
	No Bias	1	5	0	2	1
	Right	4	5	10	6	4 [a]
Consistency in Direction of All Turns	Left	0	6	0	3	2
	No Bias	0	2	0	0	0
	Right	5	9	10	8	5 [b]
Consistency in Direction of Majority Time	Left	0	7	0	2	1
	No Bias	0	1	0	1	0
	Right	5	8	10	8	6 [c]

a. $\chi^2 = 14.77$ df = 8 p = .06
b. $\chi^2 = 11.22$ df = 8 p = .19
c. $\chi^2 = 11.92$ df = 8 p = .15

TABLE SIXTEEN

CONTINGENCY TABLES FOR APGAR SCORE BY THE THREE INDICES OF LATERAL CONSISTENCY

		Apgar Score	
		Questionable	Well
Consistency in Direction of Initial Turn	Left	2	10
	No Bias	2	7
	Right	4	25 [a]
Consistency in Direction of All Turns	Left	1	10
	No Bias	1	1
	Right	6	31 [b]
Consistency in Direction of Majority Time	Left	1	9
	No Bias	1	1
	Right	5	32 [c]

a. $\chi^2 = 0.37$ df = 2 p = .83
b. $\chi^2 = 2.11$ df = 2 p = .35
c. $\chi^2 = 2.25$ df = 2 p = .32

TABLE SEVENTEEN

CONTINGENCY TABLES FOR MATERNAL MEDICATION BY THE THREE INDICES OF LATERAL CONSISTENCY

		Maternal Medication	
		Present	Absent
Consistency in Direction of Initial Turn	Left	8	4
	No Bias	5	4
	Right	14	14 [a]
Consistency in Direction of All Turns	Left	8	3
	No Bias	1	1
	Right	18	18 [b]
Consistency in Direction of Majority Time	Left	7	3
	No Bias	0	2
	Right	19	17 [c]

a. $\chi^2 = 0.94$ df = 2 p = .62
b. $\chi^2 = 1.78$ df = 2 p = .41
c. $\chi^2 = 3.40$ df = 2 p = .18

TABLE EIGHTEEN

CONTINGENCY TABLES FOR MATERNAL AGE BY THE THREE INDICES OF LATERAL CONSISTENCY

		Maternal Age			
		18-22	23-27	28-32	33-37
Consistency in Direction of Initial Turn	Left	2	3	3	0
	No Bias	1	2	3	0
	Right	5	6	5	1 [a]
Consistency in Direction of Total Turns	Left	2	3	3	0
	No Bias	1	0	1	0
	Right	5	9	7	1 [b]
Consistency in Direction of Majority Time	Left	3	1	3	0
	No Bias	0	1	1	0
	Right	5	8	7	1 [c]

a. $\chi^2 = 1.66$ df = 6 p = .95
b. $\chi^2 = 2.26$ df = 6 p = .89
c. $\chi^2 = 3.02$ df = 6 p = .81

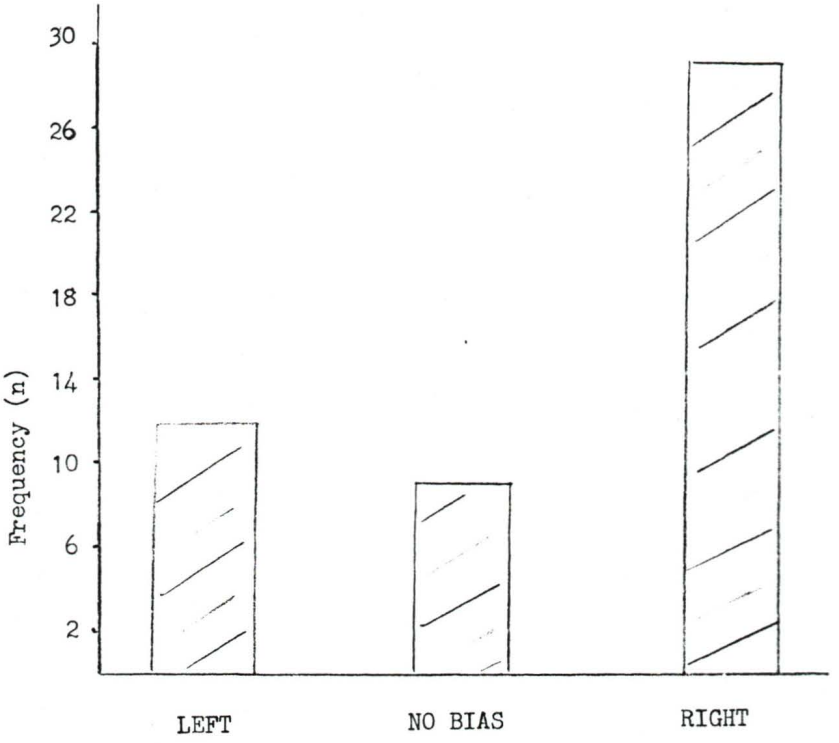
TABLE NINETEEN

CONTINGENCY TABLES FOR TYPE OF DELIVERY BY THE THREE INDICES OF LATERAL CONSISTENCY

		Type of Delivery	
		Cesarean	Vaginal
Consistency in Direction of Initial Turn	Left	1	11
	No Bias	0	9
	Right	6	23 [a]
Consistency in Direction of All Turns	Left	1	10
	No Bias	0	2
	Right	6	31 [b]
Consistency in Direction of Majority Time	Left	1	10
	No Bias	0	2
	Right	6	31 [c]

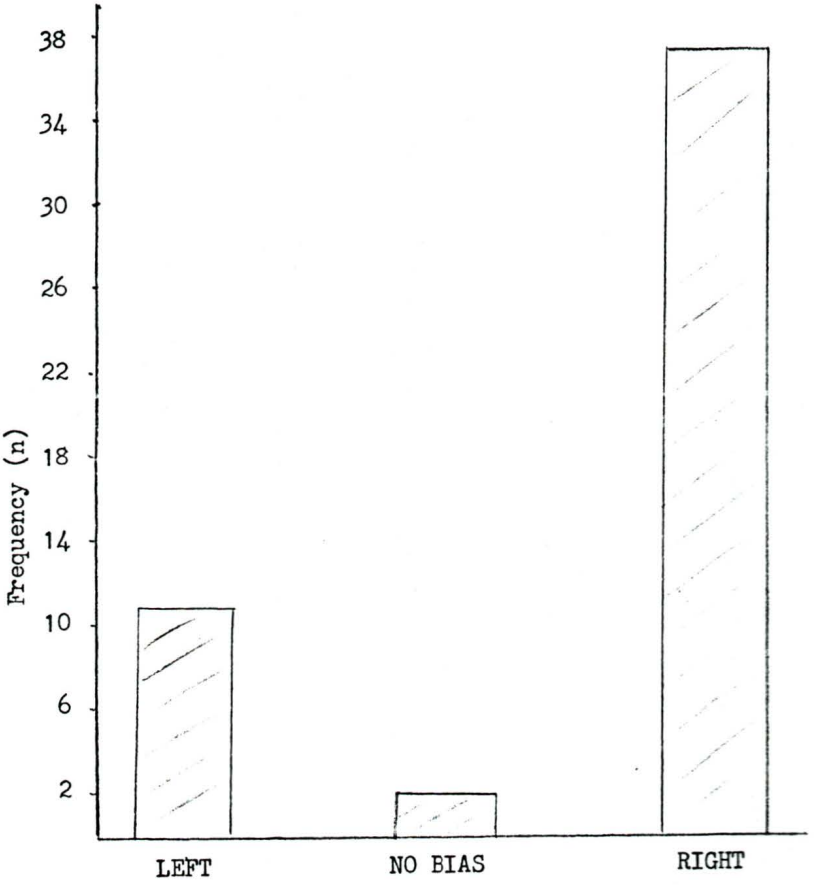
a. $\chi^2 = 2.86$ df = 2 p = .24
b. $\chi^2 = 0.70$ df = 2 p = .70
c. $\chi^2 = 0.70$ df = 2 p = .70

FIGURE ONE



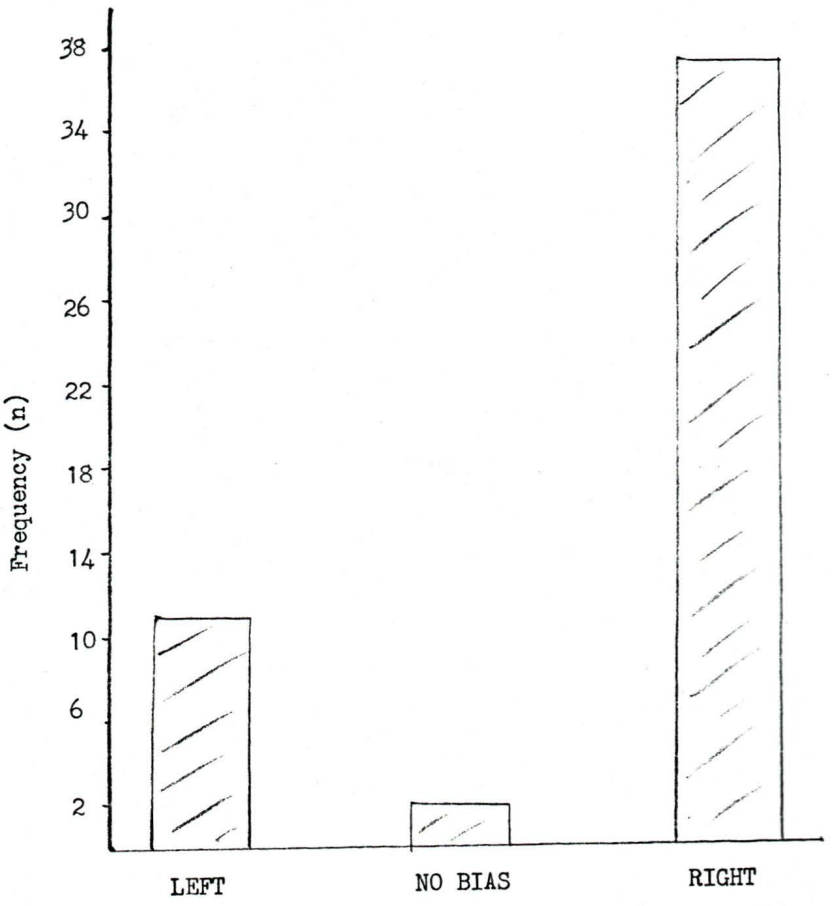
CONSISTENCY IN DIRECTION OF INITIAL HEAD TURN

FIGURE TWO



CONSISTENCY IN THE DIRECTION OF ALL HEAD TURNS

FIGURE THREE



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Spreen, O. & Risser, A.H. Assessment of aphasia. In: Acquired Aphasia. M. Taylor-Sarno (ed.). New York: Academic Press, 1981.

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