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ABSTRACT

Based on findings that report differences between cries of normal and clinically abnormal infants, this study examined the relationship between birthweight and behavioral and acoustic features of neonatal cry because of the long-standing association between birthweight, perinatal trauma, and subsequent development. Subjects were 88 neonates between 12 and 36 hours old. The sample included 37 low birthweight, 25 premature, and 19 small for gestational age infants. Cries were elicited by snapping the soles of the babies' feet with a rubber band. Four dependent variables, two acoustic and two behavioral, were extracted from each infant's cry episode. Because other independent variables such as gestational age, sex, and race might confound the prediction of crying from birthweight, a multiple regression analysis was done on the data. A separate regression analysis was computed for each of the four dependent variables, in which the independent variables were birthweight, gestational age, sex, and race. Results indicate that birthweight and gestational age were relatively equal in predicting the pitch of the cry; but that birthweight, and not gestational age, was related to the latency of the cry. The predicting of abnormal conditions from cry properties is discussed. (Author/SB)

Spectrum Analysis of Low and Full Birthweight Newborn Cries[1]

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Spectrum Analysis of Low and Full Birthweight Newborn Cries

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Crying is a behavioral response to stimulation produced by the expulsion of air through the vocal cords into the pharynx and mouth. Crying also has acoustic features and we can distiguish between the cry act and the cry sound. The cry act is the behavioral component and is a complex motor phenomenon. The cry sound refers to acoustic properties and is of a different physical nature than the cry act. The nature of the cry sound will depend upon factors such as the intensity of air expelled, the tension in the vocal cords and the shape of the resonating chambers.

Clinical significance is often attributed to the cry. The cry is an integral part of the pediatric examination of the newborn and is used as an aid in the diagnosis of some forms of brain damage (Illingworth 1955; Parmelee 1962). Theoretically, this assumes that the nature of the cry reflects the integrity of the newborn's physiological state. From a psychobiological point of view this makes a lot of sense if we consider the adaptive function of variations in infant cry patterns. For example, unnerving, high pitched cries may be part of a built-in warning system; a biological siren, if you will, designed to signal a caregiver that the infant is in trouble.

In fact, a number of investigators have reported both behavioral and acoustic differences between the cries of normal and clinically abnormal infants. The chilling, high pitched cry of the infant suffering from Cri du Chat (Wasz-Hockert, Lind, Vuorenkoski, Partanen & Valanne 1968), which means cry of the cat, and the long latency to the onset of the cry in Down's syndrome (Fisichelli & Karelitz 1963) are some cases in point. In my own work, I have reported high pitched cries highly correlated with low level cardiac orienting responses in one-year-old malnourished infants (Lester 1976).

If these notions about the adaptive significance of the cry are justified we would expect neonates suffering from less severe forms of insult than, say, Cri du Chat or Down's syndrome to show cry properties different from full term healthy babies. In this first study we decided to look at the relation between birthweight and behavioral and acoustic features of the newborn cry because of the long standing association between birthweight, perinatal trauma and subsequent development.

Method

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insert Table 1 here

The sample consisted of 88 neonates between 12 and 36 hours of age. Table 1 shows the number of babies by birthweight, gestational age, sex and race. The sample included 37 low birth-weight, 25 premature and 19 small for gestational age infants. All of the infants were clinically healthy and were born of relatively uncomplicated pregnancies and deliveries.

The procedure began with the infant in a supine position and in an awake, non-fussy state. The cry was elicited by snapping the sole of the babies's foot with a rubber band. The cry was tape recorded with a microphone held approximately 20 cm from the infant's mouth.

Four dependent variables, two acoustic and two behavioral were extracted from each infant's cry episode. The acoustic measures were taken by passing the cry signal through a Spectrum Analyzer which produces a visual display as well as a digital readout of the frequency and amplitude of the signal along the selected bandwidth. The acoustic measures were the fundamental frequency or dominant pitch of the cry and the amplitude of the fundamental frequency or the intensity of the cry.

The two behavioral measures, that is, measures of the cry act were made with the aid of an Iconix digital clock. Cry latency was defined as the time from the offset of the rubber band snap to the onset of the cry. The length of the initial cry sound was the time from the onset of the initial cry to the first inspiration.

Results

Although our primary hypothesis involved the relation between birthweight and crying we were also aware that other independent variables such as gestational age, sex and race might confound the prediction of crying from birthweight alone. Since our sample included both premature and small for gestational age infants we were particularly interested in the differential effects of birthweight and gestational age. In order to look at the combined effects of a number of independent variables we used stepwise multiple regression analysis. A seperate regression analysis was computed for each of the four dependent variables. The independent variables in the regressions were birthweight, gestational age, sex and race. The order of inclusion was determined by the respective contribution of each independent variable to the explained variance.

insert Table 2 here

Table 2 shows a summary of the regression analysis of the fundamental frequency or pitch of the cry. As you can see, birthweight was the most powerful predictor of cry pitch yielding a significant correlation of .45 which accounts for 21% of the variance. The second variable entered into the regression equation was gestational age. The obtained multiple correlation of .51 indicates that 26% of the variation in infant cry pitch is explained by birthweight and gestational age operating jointly. The remaining independent variables did not meet the minimum *F* value for inclusion in the regression.

The last, and probably most important data to note in this table are the Beta weights or standardized regression coefficients which enable us to evaluate the contribution of each independent variable with the influence of the other independent variable controlled. The Beta weight for birthweight without controlling for gestational age is .45. When gestational age is controlled, the contribution of birthweight drops to .30 with the relative contribution of gestational age alomost the same. Also, the *F* values for these Beta weights show that both birthweight and gestational age account for significant and independent portions of the variation in infant cry pitch. In other words, high pitched cries are associated with both premature and small for gestational age babies.

insert Table 3 here

Table 3 shows a summary of the regression analysis of the amplitude of the fundamental frequency or intensity of the cry. The variables that were entered into this regression were race and birthweight, respectively. The F ratios of the Beta weights show that the effects of birthweight were not significant when the effects due to the race of the infant were controlled. The 6% of the variance explained by race was due to a tendancy for white babies to cry louder than black babies.

insert Table 4 here

Of the two behavioral measures only cry latency was predictable from any of the independent variables. Table 4 shows the regression of cry latency. First birthweight then race were entered into this regression equation. The F test of the Beta weights indicates that only the relative contribution of birthweight was significant. The 5% of the variance explained by birthweight was due to a longer latency to the onset of the cry associated with low birthweight.

Discussion

The results from this study lend support to the idea that acoustic and behavioral parameters of the cry may be used to help mirror the pediatric and perhaps risk status of the newborn.

The finding that the relative contributions of birthweight and gestational age in predicting the pitch of the cry were almost the same is particularly interesting. Since the sample included both premature and small for gestational age infants we were, in fact, dealing with two etiologically distinct populations. Yet both seem to use the same mechanism, the high pitched cry, to signify their need for special attention.

On the other hand, birthweight and not gestational age was related to the latency of the cry. This might suggest that particular constellations of cry features may be sensitive to specific conditions in the infant. Previous findings with damaged infants where investigators have looked at other measures of the cry would indicate some degree of specificity to certain anomalies. Behavioral measures such as the length of the first cry signal and the pause between first and second cry sounds were reported to be of value in the diagnosis of brain damage in one study (Lind, Wasz-Hockert, Vuorenkoski, Partanen, Theorell & Valanne 1966) and were found in malnourished infants in another study (Lester 1976 In other work, infants suffering from Down's syndrome required more stimuli to elicit the cry than normal infants (Karelitz & Fisichelli 1962). Studies using acoustic measures have focused on the pitch of the cry although other properties such as the quality of th melody form and the occurrence of tenseness and shifts in pitch have also been used in attempts to present a profile of pathognomic cry patterns (Wasz-Hockert et al. 1968).

However, one would be hard put, at least at this point, to distiguish one syndrome from the next on the basis of the cry alone.

In fact, given the variability in these measures, it is unclear whether one could distinguish normal from abnormal infants on the basis of the cry alone. For example, in our study, the standard error in the regression equation used to predict cry pitch was 272. This means that I would be off by an average of 272 Hz if I tried to predict the pitch of an individual infant's cry soley from the infant's birthweight!

There are several likely explanations for this lack of precision. One simply has to do with the normal variability in infant cry pitch and normative data is very scarce. An additional source of variation is the extent to which factors other than birthweight could contribute to the prediction of infant cry pitch. For example, the combination of birthweight and gestational age in this study dropped the standard error to 265.

Our hope is that with additional and more precise estimates of the pediatric status of the neonate we will come to a firm understanding of the adaptive significance of both behavioral and acoustic features of the cry. Through follow-up studies we may then be better able to determine, with the aid of neonatal cry analysis, <u>who</u> is the infant at risk.

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TABLE 1

FREQUENCY DISTRIBUTION OF INFANTS BY BIRTHWEIGHT, GESTATIONAL AGE, SEX AND RACE

		Low Birthweight (<2501 grams)		Full Birthweight (>2500 grams)		
		Male	Female	Male	Female	Total
Premature	White	8	5	1	0	14
(<37 weeks)	Black	6	3	1	1	11
Full Term	White	4	6	19	16	45
(>36 weeks)	Black	1	4	8	5	18
	Total	19	18	29	22	N=88

TABLE 2

SUMMARY OF STEPWISE REGRESSION ANALYSIS ON INFANT CRY PITCH (Hz)

Variable 1: Birthweight

		df	F	p
Multiple R	.45	1,86	22.31	<.001
R Square	.21			
Standard Error	271.75			
Beta	-.45			

Variable 2: Gestational Age

		df	F	p
Multiple R	.51	2,85	14.64	<.001
R Square	.26			
Standard Error	264.57			
	Beta			
Birthweight	-.30	1,85	7.01	<.01
Gestational Age	-.27	1,85	5.73	<.025

TABLE 3

SUMMARY OF STEPWISE REGRESSION ANALYSIS ON INFANT CRY INTENSITY (dB)

Variable 1: Race

		df	F	p
Multiple R	.25	1,86	5.62	<.025
R Square	.06			
Standard Error	81.06			
Beta	.25			

Variable 2: Birthweight

		df	F	p
Multiple R	.29	2,85	3.83	<.05
R Square	.08			
Standard Error	80.61			
	Beta			
Race	.24	1,85	5.28	<.025
Birthweight	-.14	1,85	1.97	N.S.

TABLE 4
SUMMARY OF STEPWISE REGRESSION ANALYSIS
ON INFANT CRY LATENCY (sec)

Variable 1: Birthweight

		df	F	p
Multiple R	.23	1,86	5.02	<.05
R Square	.06			
Standard Error	1807.97			
Beta	-.23			

Variable 2: Race

		df	F	p
Multiple R	.28	2,85	3.75	<.05
R Square	.08			
Standard Error	1793.35			
	Beta			
Birthweight	-.22	1,85	4.68	<.05
Race	.15	1,85	2.41	N.S.