Neonatal Behavioral Organization and Visual Processing at Three Months

Madelyn Moss, John Colombo, D. Wayne Mitchell, and Frances Degen Horowitz

University of Kansas

MOSS, MADELYN; COLOMBO, JOHN; MITCHELL, D. WAYNE; and HOROWITZ, FRANCES DEGEN. *Neonatal Behavioral Organization and Visual Processing at Three Months.* CHILD DEVELOPMENT, 1988, **59**, 1211–1220. In 2 studies, the Range of State cluster derived from infants' scores on the Neonatal Behavioral Assessment Scale with Kansas Supplements (NBAS-K) was found to correlate significantly with visual discrimination performance at 3 months of age. Contrary to the expectation that NBAS-K orientation scores would predict visual discrimination at 3 months, it was neonatal behavioral state organization that related to later cognitive functioning in infancy.

Since the 1950s, there has been a concerted effort to develop assessments of the neonate and young infant that might be useful in quantifying and qualifying the behavioral organization of both healthy infants and infants at risk for abnormal development (Horowitz, Sullivan, & Linn, 1978; St. Clair, 1978). The instruments developed over this period include neonatal screening tools (Apgar, 1953; Ballard, Novak, & Driver, 1979; Dubowitz, Dubowitz, & Goldberg, 1970) primarily intended for clinical use, neurological assessments (Prechtl & Beintema, 1965), and assessments of the overall behavioral organization and/or physiological condition of the neonate and older infant (Bayley, 1969; Brazelton, 1973; Rosenblith, 1979; see Self & Horowitz, 1979, for a comprehensive review).

Of the neonatal assessments, the Neonatal Behavioral Assessment Scale (NBAS; Brazelton, 1973) is the most comprehensive and most widely used instrument for research on individual characteristics of neonates. However, the predictive value of the NBAS as well as other neonatal assessments has been somewhat disappointing (Fagan & Singer, 1983; Sameroff, 1978). Various investigators have suggested that the lack of significant correlations between the assessments for neonates and very young infants and later measures of intelligence may be due in part to the emphasis on simple reflexive responses and/or motor ability of the infants in the initial assessment rather than the more complex sensory processes (Zelazo, 1979).

The search for early predictive measures of later intelligence has involved attention to novelty using paired-comparison visual recognition paradigms (e.g., Fagan & Singer, 1983) and discrimination using the habituation-dishabituation techniques (e.g., Sigman, Cohen, Beckwith, & Parmelee, 1985). Studies using these procedures (Fagan & Singer, 1983; Lewis & Brooks-Gunn, 1981; O'Connor, Cohen, & Parmelee, 1984; Sigman et al., 1985; Slater, 1985) have shown moderate but significant correlations between infants' performance and later intelligence. The infant's ability to encode, retain, and discriminate among stimuli in the environment may therefore be related to information-processing functions that are components of mature cognitive abilities (Bornstein & Sigman, 1986; Fagan & Singer, 1983; O'Connor et al., 1984).

Although there have been numerous studies using the NBAS and many using habituation/dishabituation paradigms and paired-comparison tasks, few investigators have compared individual NBAS performance with performance on concurrent or

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Please address correspondence and request for reprints to Madelyn Moss, Infant Study Center, Department of Human Development, University of Kansas, Lawrence, KS 66045.

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subsequent cognitive tasks. Dubowitz, Dubowitz, Morante, and Verghote (1980) administered the orientation items of the NBAS and a neurological examination to a group of premature infants varying in gestational age from 28 to 34 weeks and also tested the infants' performance on a paired-comparison visual recognition task. Measures were made concurrently as soon after birth as possible and twice weekly thereafter depending on the wellness of the infants. They reported no significant correlations between infants' NBAS orientation scores and their novelty preferences. Frankel, Shapira, Arbel, Shapira, and Ayal (1982) compared NBAS scores at 2, 17, and 21 days of age with performance on a fixed-trial habituation task at 4 months of age in a group of small-for-gestational-age and normal term infants. Again, no significant correlations emerged between a priori NBAS dimensions and rate of habituation or dishabituation to a novel stimulus within the two groups.

In spite of the low predictive utility of the NBAS to date, it is still presumed that the NBAS measures neonatal behaviors that relate in some systematic way to later behaviors (Ulvund, 1984). We hypothesized that there would be a correlation between NBAS orientation behavior and later performance on a visual habituation/dishabituation task. To test this hypothesis, we administered the Neonatal Behavioral Assessment Scale with Kansas Supplements (NBAS-K: Horowitz et al., 1978) to healthy 2–3-day-old neonates prior to hospital dismissal. The examination was administered in the usual manner with the exception of the orientation items, which were standardized to insure attainment of a standard measure of individual performance. When the infants were 3 months of age, they were tested in a laboratory infant-controlled habituation/dishabituation visual discrimination task (Horowitz, Paden, Bhana, & Self, 1972). The results of this first study (Study 1) were somewhat unexpected and prompted a replication attempt (Study 2) several months later.

Study 1

Method

Subjects

Forty healthy neonates were recruited at Lawrence Memorial Hospital, Lawrence, Kansas, in the Spring of 1984. All of the subjects were considered normal according to pediatric examination, and all of the subjects met specific criteria for the study (gestational age 37–42 weeks, birthweight >2,500 grams, APGAR >7 at 5 min, age at test >23 hours; see Table 1 for sample characteristics). Three neonates were delivered by planned Caesarean section, two were delivered by Caesarean section due to breech position of the baby, and one Caesarean section was due to cephalopelvic disproportion. Fetal distress was not reported in any of the neonates. Of the 40 subjects recruited, 10 did not participate in the 3-month follow-up cognitive assessment due to subsequent scheduling problems, and one infant was excluded from the final analysis due to fussiness on the 3-month task, leaving a final sample of 29 (17 F, 12 M). One infant was black, one was Hispanic, and the other 27 infants were Caucasian.

Procedure

Neonatal Behavioral Assessment Scale with Kansas Supplements (NBAS-K).—The NBAS-K (Horowitz et al., 1978) was administered to the neonates on the second or third day of life by examiners with at least 2 years of testing experience and 90% criterion of reliability. The examination was administered in the standard manner, with the exception of the orientation items. In the typical NBAS-K examination, the presentation of orientation items is not standardized. In this study, however, these items were standardized to insure that each infant received the same protocol (Moss, 1985). Stimuli were presented to each subject in a fixed order, beginning with the inanimate auditory item, followed by inanimate visual, inanimate visual-auditory, animate auditory, animate visual, and animate visual-auditory. Five presentation trials were allotted for each item, and once an item had been attempted it was not repeated. The items were usually presented after the baby had been placed in the prone position and then redressed, as babies are commonly in an alert state at this point in the examination. However, the items could be presented anytime during the examination depending on the examiner's judgment of the baby's optimal state. The examiner could facilitate alertness by using vestibular stimulation, brief time-out, or swaddling in addition to the stimulus inherent to the item being presented. If there were no alert periods during the examination, the orientation items would, of course, have been omitted and scored N.A.; however, all of the babies in Study 1 and Study 2 completed the orientation items with scoreable responses.

Auditory items were administered by shaking the rattle or speaking several words a maximum of three times at approximately 5-sec intervals (i.e., present stimulus, wait 5 sec,

TABLE 1

SAMPLE DESCRIPTION FOR STUDIES 1 AND 2: PERINATAL AND DEMOGRAPHIC VARIABLES

	STUDY 1 (N = 29)		STUDY 2 (N = 31)	
	Mean	SD	Mean	SD
Gestational age (range in weeks)	37–42		37–42	
Weight (grams)	3,572	519.2	3,463	360.4
APGAR, 1 min	8.1	1.2	8.2	.7
APGAR, 5 min	9.3	.6	9.4	.6
Age at test (hours)	54.4	14.8	43.1	13.7
Mother's age (years)	26.9	3.7	27.5	4.8
Mother's education (college)	3.2	1.1	3.5	1.1
Father's age	28.3	4.2	29.3	5.4
Father's education (college)	3.6	1.2	3.6	1.3

present stimulus, wait 5 sec and present stimulus, wait 5 sec) beginning at the baby's right side. This same presentation was made to the baby's left side. A total of five trials was given for each auditory item: three trials to the baby's right side and two trials to the left side. The score for each trial was based on the baby's best response within the allotted time, which was 15 sec. Visual and visual-auditory items were presented beginning at midline and moving to the baby's right side. If the baby followed the stimulus with smooth continuous head and eye movement for 60°, the baby was given an opportunity to follow the stimulus from the right side past midline to the baby's left side for a 120° arc. If the baby lost the stimulus before 60°, that portion of trial was ended and the response noted. The stimulus was returned to midline and moved vertically and in a circle as long as the baby continued to follow the stimulus. The stimulus was then moved to the baby's left side for the beginning of the second trial. There were three trials to the baby's right side and two trials to the left side for each visual and visual-auditory item. While this standardized presentation was made to try to limit the influence of examiner variables on infants' performance, it is important to note that this procedure did not yield orientation scores that were appreciably different from those reported elsewhere (R. E. Culp & J. D. Osofsky, personal communication, August 26, 1987; Lancioni, Horowitz, & Sullivan, 1980; Murray, in press; Schwartz, Horowitz, & Mitchell, 1985).

Three-month habituation-dishabituation task.—At 3 months of age, infants were tested in an infant-controlled habituation-dishabituation task in the laboratory. The visual stimuli were a black-and-white bull's-eye and a black-and-white 24 × 24 checkerboard. Mitchell and Steiner (1984) have shown with appropriate control groups that these stimuli are discriminable by 3-month-old infants.

Infants were observed in a darkened 1 × 1.5-m testing booth. The front of the booth contained a translucent screen on which stimuli were rear-projected, subtending a visual arc of 23°. Observers viewed infants through 15-mm peep holes on either side of the screen. The experimenter and equipment (Kodak projector model 350H and Rockwell Aim 65 microcomputer) were located in an adjacent room. A video camera mounted at the top of the experiment booth allowed the experimenter to monitor the infant's behavior during the session. Observers recorded infants' visual fixations (corneal reflections) via switches interfaced with a microprocessor. The microprocessor monitored fixations, calculated the habituation criterion, and prompted the experimenter for stimulus presentations.

Infants were positioned in a car seat .5 m in front of the screen. Parents were allowed in the testing room with their infants. However, they were instructed to remain out of visual range of the infants and not to interact with the infants at any time during the testing procedure; in all cases, they followed these instructions.

The testing session began with projection of the bull's-eye onto the translucent screen. Valid fixations began when the infant looked at the bull's-eye for 1 sec or more. The fixation was terminated when the infant looked away from the target for at least 1 sec (Colombo & Horowitz, 1985). This in turn signaled a 2-sec offset of the stimulus, followed by presentation of the stimulus for the next visual fixation. The criterion for habituation to the bull's-eye was two consecutive fixations below 50% of the mean of the two previous longest fixations. Following habituation, infants were shown four presentations of a novel stimulus, the black-and-white checkerboard.

This procedure allowed us to measure several variables that have served as a focal point in various past research reports on the topic of visual habituation/dishabituation. The variables were:

1. Total looking time: The sum of the duration of all fixations to the habituation stimulus (bull's-eye), including criterion fixations.

2. Total interlook interval: In the infant-control procedure, the stimulus is turned off for 2 sec when a fixation is terminated and then re-presented for the next fixation. The total interlook interval is the sum of the time infants spend looking away from the stimulus between fixations during the habituation sequence.

3. Peak look: The length of the longest fixation during the habituation sequence.

4. Location of peak look: The ordinal value of the peak fixation during the habituation sequence (e.g., first = 1, second = 2).

5. Criterion fixation: The final fixation of the habituation sequence (i.e., at 50% decrement from initial fixation levels).

6. Dishabituation: Fixation time to the first presentation of the novel stimulus (checkerboard).

Colombo, Mitchell, O'Brien, and Horowitz (1987) have very recently provided detailed rationales for the habituation measures elsewhere. For the measurement of dishabituation, difference scores (i.e., posthabituation fixation–criterion fixation) are often used. Because difference scores are considered problematic in correlational analyses (see Applebaum & McCall, 1983), they were not used. Instead, the habituation criterion look and the first posthabituation fixation measures were each correlated with the NBAS cluster scores.

Results and Discussion

The NBAS-K scores were clustered according to a method proposed by Lester, Als, and Brazelton (1982).[1] Means and standard deviations for infants' NBAS-K clusters are presented in Table 2, and for infants' habituation and dishabituation performance in Table 3.

Since infant data are often quite variable, the distribution of scores was tested for normality, and residuals analyses were employed for each bivariate distribution to identify outliers whose data would disproportionately affect individual correlations. Subjects were to be excluded from correlational analyses if the residuals within the bivariate distribution were 3.0 or greater (Cohen & Cohen, 1983), but no infants in this study met that criterion. There were no significant correlations between infants' habituation variables and their dishabituation to the novel stimulus. Furthermore, there were no significant correlations between any of the NBAS-K clusters and any of the habituation measures analyzed (i.e., total looking time, total interlook interval, peak look, and location of peak look).

We next examined correlations between the NBAS-K and dishabituation measures. The criterion look was not correlated with any of the NBAS-K clusters. However, as shown in the first column of Table 4, correlational analyses between the NBAS-K cluster scores and the first posthabituation fixation revealed a significant correlation with the Range of State cluster scores ($r = +.49$, $p < .01$). The Motor Maturity cluster was also significantly related to the first posthabituation fixation ($r = +.39$, $p < .05$).

The correlations reported here reflect the relation between NBAS-K Range of State scores and degree of dishabituation. The degree of dishabituation does not necessarily reflect discrimination performance, however. Discrimination is determined by whether infants' fixations actually recovered to the novel stimulus following habituation. In order to examine the actual discrimination performance of infants on the basis of their neonatal range of state, we split the Range of State cluster

[1] There were two exceptions made to the Lester et al. (1982) system. First, data from the Reflex cluster are not reported in this article because examiners' scoring of the reflex items that comprise this cluster is not trained to reliability at the University of Kansas NBAS training center. Second, we report data from an interactive cluster in Tables 2 and 4 that consists of items from the Kansas Supplement to the NBAS: Quality of Responsivity, Examiner Persistence, General Irritability, and Reinforcement Value (see Horowitz et al., 1978).

TABLE 2

NBAS-K Cluster Means and Standard Deviations: Study 1 and Study 2

NBAS-K Cluster	Study 1 (N = 29) Mean	SD	Study 2 (N = 31) Mean	SD
Habituation	6.7	1.5	7.1	1.3
Orientation (best)	6.4	.9	6.5	.8
Orientation (modal)	5.4	1.1	5.1	1.3
Motor organization	5.3	.8	5.3	.5
Range of state	4.0	.7	4.0	.5
Regulation of state	5.5	1.4	4.6	1.5
Autonomic regulation	6.3	1.0	6.2	1.0
Interactive	5.6	1.3	5.5	1.4

TABLE 3

Visual Habituation-Dishabituation Means and Standard Deviations: Study 1 and Study 2

Habituation Measure	Study 1 (N = 29) Mean	SD	Study 2 (N = 31) Mean	SD
Total looking time	94.1	83.2	164.1	189.6
Total interlook interval	27.1	22.7	40.9	53.7
Peak look	45.2	49.4	66.5	48.0
Location of peak look	2.3	1.9	1.7	1.2
Final criterion look	5.6	8.0	6.1	4.9
First posthabituation look	22.3	32.7	13.8	14.6

TABLE 4

Correlations between NBAS-K Lester Clusters and Discrimination Scores

NBAS-K Cluster	First Posthabituation Look: Study 1 (N = 29)	Study 2 (N = 31)
Habituation	.30	.22
Orientation (best)	.12	.02
Orientation (modal)	.06	.15
Motor organization	.39*	.03
Range of state	.49**	.34*
Regulation of state	−.07	−.01
Autonomic regulation	.27	.17
Interactive	.07	.00

* $p < .05$.
** $p < .01$.

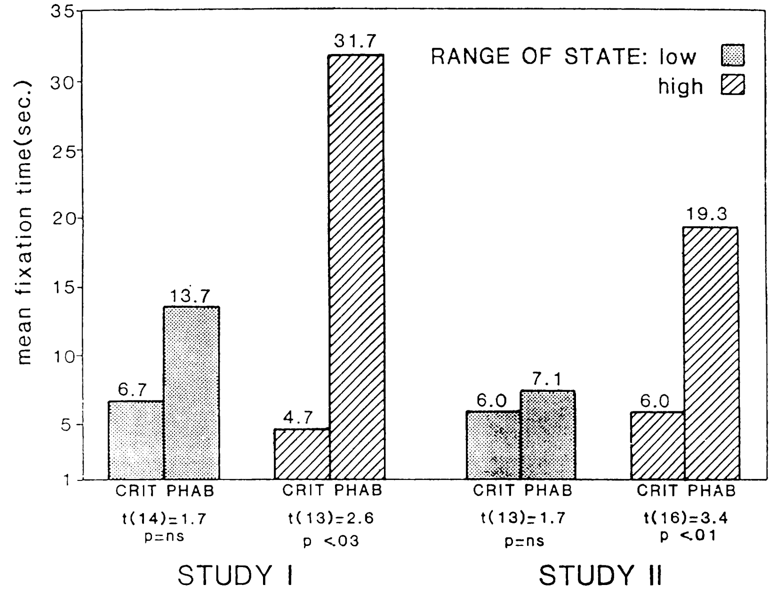

FIG. 1.—Means for 3-month-olds' habituation criterion fixations (CRIT) and posthabituation (PHAB) fixations as a function of their NBAS-K Range of State score.

score distribution at the median (4.0) and looked at recovery for the low and high groups separately using paired t tests. As can be seen in Figure 1, the neonates who scored greater than 4.0 on Range of State showed a significant increase in fixation time in response to the presentation of the novel stimulus following habituation, $t(13) = 2.6$, $p < .03$, while neonates scoring 4 or less did not, $t(14) = 1.7$, N.S. Thus, those neonates whose scores were higher on the Range of State cluster also demonstrated better performance on the discrimination task at 3 months of age than those neonates with lower Range of State scores.

The finding that NBAS-K orientation scores were not related to later visual habituation/dishabituation measures while the Range of State and Motor Maturity clusters were related to infant discrimination performance was unexpected. We therefore decided to try to replicate these results in a second study.

Study 2

METHOD

Subjects

Forty-six healthy neonates were recruited for Study 2 (see Table 1 for characteristics; there were no significant differences between samples on any of these measures). Of the 46 recruited infants, 35 participated in the habituation/dishabituation assessment at 3 months of age, and of these, three were excluded from the study due to fussiness. This left a final sample of 32 (19 F, 13 M). Fetal distress was not reported for any of these subjects. One infant was Hispanic and the other 31 infants were Caucasian.

Procedure

NBAS-K.—The procedure for administering the NBAS-K was the same for Study 2 as it was for Study 1.

Habituation/dishabituation paradigm.—The apparatus, presentation of stimuli, and procedures were the same as for Study 1, with the exception of three slightly different conditions. First, due to remodeling of the laboratory between studies, the testing room was slightly larger, approximately 1.5 × 2.5 m rather than the 1 × 1.5-m booth in Study 1. Second, the slide projector was placed in the testing room behind the screen instead of in the adjacent room as was done in Study 1. Third, the offset time of the stimulus was 3 sec in Study 2 instead of the 2-sec offset time in Study 1. However, the stimuli were presented the same as before (i.e., rear-projected), and again, controlled by a microcomputer that remained in the adjacent room.

RESULTS AND DISCUSSION

Preliminary multivariate analyses indicated that the replication study sample of subjects was indeed comparable to the sample of subjects from Study 1. There were no significant differences between the samples on

NBAS-K clusters reported in Table 2 (Wilks's lambda = 0.78; multivariate $F[8,38] = 1.37$, N.S.), or on the habituation (Wilks's lambda = 0.86; multivariate $F[5,54] = 1.78$, N.S.) or the dishabituation measures, $t(58) = 1.30$, N.S., reported in Table 3.[2]

The method of correlational analysis for Study 2 was the same as for Study 1. As in Study 1, bivariate distributions were tested for outliers with residuals analyses (Cohen & Cohen, 1983). One subject was excluded from the study because of a standardized residual within the Range of State–posthabituation distribution that was greater than 3.0, leaving a total of 31 subjects in the final analyses (18 F, 13 M).

While the correlation between neonates' Motor Maturity cluster and dishabituation observed in Study 1 did not replicate in Study 2, we did replicate a significant correlation between the NBAS-K Range of State cluster and the first posthabituation look at the novel stimulus ($r = +.34$, $p < .05$; see Table 4). As in Study 1, we further examined this correlation by performing a median split on infants' Range of State scores (median = 4.0). Again, infants whose scores were higher on the Range of State cluster were more likely to discriminate the visual stimuli during the habituation task at 3 months of age, $t(16) = 3.4$, $p < .01$, than those infants with lower scores on range of state, $t(13) = 1.7$, N.S.; Figure 1.

General Discussion

The purpose of Study 1 was to examine the predictive strength of the NBAS-K with respect to a later measure of infant development. The results of Study 1 were unexpected with respect to the apparent importance of Range of State and thus prompted a replication attempt, and we again found that individual differences in the organization of neonatal state measured by the NBAS-K predicted performance in a visual discrimination task at 3 months. Only one of 48 possible correlations between newborns' performance on the NBAS-K and cognitive function at 3 months of age emerged as statistically significant in both studies. Ordinarily, one would be wary of trusting one significant correlation out of 48, but the fact that this exact result replicated on an independent sample provides more confidence in the finding.

The results of these two studies did not support the original expectation that of the NBAS items, the orientation items would be most predictive of later performance on a visual discrimination task. The standardized presentation of orientation items in these studies does not appear to be responsible for this lack of correlation, since the standardized procedures yielded orientation scores that are virtually identical to other studies in this and other laboratories that administered orientation items as specified in the NBAS manual (R. E. Culp & J. D. Osofsky, personal communication, August 26, 1987; Lancioni et al., 1980; Murray, in press; Schwartz et al., 1985).

There are several possible theoretical explanations for the lack of correlation between the orientation items and the habituation paradigm. It is possible that the facilitation of infant orientation item performance that is typical in NBAS administrations (e.g., timeout, swaddling, and/or vestibular stimulation) may reduce the individual variation of responses on these items and therefore reduce their predictive power. Another explanation may be that orientation items are assessed under constrained state conditions (i.e., states 4 and/or 5 only). Alert, responsive states are among the least representative of newborn behavioral states (Wolff, 1966), and consideration of behavior under this constraint may limit the predictive power of the measure. Finally, the newborn's first task in life may be seen as the stabilization and maintenance of vital biological functions. Thus, orientation to external stimuli may be secondary to this task and, therefore, less predictive of later cognitive function than the establishment of a stable biobehavioral internal environment.

Of the eight NBAS-K clusters, only the Range of State cluster was significantly correlated in both studies with a measure derived from the habituation task at 3 months of age. The Range of State cluster consists of four items—Peak of Excitement, Rapidity of Build-up, Irritability, and Lability of State. The Peak of Excitement item is a measure of

[2] To compare the samples from Study 1 to Study 2, eight NBAS-K cluster scores (see Table 2) were entered into one multivariate analysis, and five 3-month visual habituation measures (total looking time, total interlook interval, peak look, location of peak look, and the final criterion look) were entered into another (the dishabituation measure was tested with a simple t test). The degrees of freedom in the numerator of the multivariate analyses reflect the number of variables entered into the analysis (eight NBAS clusters, or five visual habituation measures), while those for the denominator are obtained by using the formula $(N - k - 1)$, where N equals the total number of subjects in the two studies, and k equals the number of measures entered into the analysis.

the overall arousal level, from sleep through crying activity, of the neonate as observed by the examiner throughout the examination. It is also an indication of the neonate's ability to return to or maintain an alert responsive state. Rapidity of Build-up is a point in time during the examination when the neonate changes from a quiet to more agitated state. It is a measure of the neonate's tolerance or reactivity to increasingly aversive stimuli, as well as to the additive effects of these stimuli. The third item, Irritability, is a measure of the number of times the neonate is irritable as well as the kind of aversive stimuli that contribute to the neonate's irritability. Lability of State, the last item in the cluster, is an indication of the number of times the neonate changed states throughout the course of the examination. In creating the Range of State cluster, Lester et al. (1982) recoded the original NBAS items (Peak of Excitement, Rapidity of Build-up, Irritability, and Lability of State) so that the less optimal item scores at the extremes of the 1–9-point scale are collapsed, and the more optimal scores from the middle of the scale represent higher item scores in the cluster. The higher Range of State cluster scores represent neonates who could be aroused from sleep to a quiet alert state, who did not get upset early in the examination, who demonstrated moderate irritability, and who only changed states several times during the examination. The lower Range of State cluster scores represent those neonates who were seldom or never aroused (or were passive and flat if they could be aroused) and those neonates who were irritable and easily agitated throughout the examination and difficult to console.

The Range of State cluster is difficult to interpret without controversy. The individual items that comprise the cluster include the assessment of the newborn's arousability, variability of state changes across the examination, and reactivity. We propose that infants who score high on this cluster are infants who will react with appropriate state changes to both internal biological signals (e.g., cry when hungry, become drowsy when fatigued, etc.) and to external stimulation (e.g., become alert when handled, cry when aversive stimuli are administered). Infants who score low on this cluster do not react adaptively to such signals. For example, they might maintain sleepy or fussy states across a variety of environmental or internal conditions. In sum, those neonates whose state organization reflects a more adaptive manner of dealing with exogenous and endogenous signals also demonstrated better visual discrimination of a novel stimulus on the habituation task at 3 months of age than did those neonates who showed less adaptive state organization.

Such state organization during the neonatal period may therefore be indicative of early organization of the CNS, which in turn modulates early responses to external stimuli (Colombo & Horowitz, 1987; Thoman & Tynan, 1979; see also Posner & Rothbart, 1981). Similar positions have been offered in the past. For example, Korner (1972) argued for the value of state variables per se in infant research nearly 2 decades ago. Finally, Emde (1978) has suggested that a wide range of behavior might be especially adaptive during the newborn period, and that "consistently 'modal' " neonatal behavior patterns might in fact reflect vulnerability (p. 136). Our findings seem to fit clearly with these contentions.

In comparison with past research on the NBAS and later cognitive performance, our results support one previous study (Dubowitz et al., 1980), and differ with another (Frankel et al., 1982). Our results concur with the Dubowitz et al. (1980) study, since they also did not find relations between NBAS orientation items and infants' subsequent cognitive performance, and did not report state data. At least two factors may account for why the present study revealed significant relations between the NBAS-K Range of State cluster and later cognitive tasks while Frankel et al. (1982) did not. First, Frankel et al. (1982) used the a priori cluster method for data analyses (Als, Adamson, Tronick, & Brazelton, 1976), while the Lester et al. (1982) clustering system was used in the current research. Second, Frankel et al. (1982) used fixed-trial visual discrimination procedures, whereas the infant control procedure was used in the present research.

The NBAS is based on a model in which the neonate is considered as a dynamic system in active transaction with its environment. Using the NBAS as an evaluative tool is a way of briefly becoming a part of this system in order to draw inferences about that transaction, with the hope that such inferences will help us understand the infant's effect on the environment and in turn the effect of the environment on the infant (Gorski, Davison, & Brazelton, 1979; Lester, 1983). From the results of these two studies on homogeneous groups of normal infants, we may tentatively conclude that at least one of the measures derived from the NBAS-K may provide limited prediction of later cognitive functioning. The results of Studies 1 and 2 reported here, together with other recent studies (Horowitz, Linn, & Johns-Buddin, 1983; Linn & Horowitz, 1983; Tynan, 1986; Worobey, 1986) tend to support the notion that individual differences in neonatal state and in behavioral variability-stability are significant dimensions of neonatal responding and can thus contribute to increasing our understanding of later developmental outcome (Colombo & Horowitz, 1987; Horowitz, 1987a, 1987b).

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