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# Assessment of Preterm Infants' Behavior (APIB): Confirmatory Factor Analysis of Behavioral Constructs

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Confirmatory analysis was used to specify behavioral domains from results of the Assessment for Preterm Infants' Behavior (APIB). The APIB measures both task performance and quality of performance, which theoretically improves the possibility of discriminating infant functional capacity beyond that obtained by measuring task performance exclusively. We hypothesized that the APIB measures six behavioral domains, including overall modulation of behavior, availability for examination, motor competency, sociability, habituation, and reactivity. The subjects were a medically heterogeneous group of 145 infants who required neonatal intensive care. Data from 157 behavioral and 41 reflex items, out of a possible 280 items, were used.

The model was highly acceptable by several practical indices of fit (Bentler-Bonett Normed Fit Index = .994; Bentler-Bonett Nonnormed Fit Index = .999; Comparative Fit Index = .999). The six behavioral constructs are clinically understandable and parsimonious with respect to the behavioral measures included. The results suggest that prerequisites for social interaction of infants requiring neonatal intensive care include both overall modulation and availability, which are unique and distinct from each other and from motor competency and habituation.

prematurity neonatal development APIB behavioral constructs

The Assessment for Preterm Infants' Behavior (APIB) is a detailed neurobehavioral assessment tool which was developed for use with preterm and ill full-term newborn infants to identify both neurobehavioral competencies and threshold to stress (Als, Lester, Tronick, & Brazelton, 1982). The APIB includes all items from the first edition of the Neonatal Behavioral Assessment Scale (NBAS; Brazelton, 1973). In turn, the NBAS (Brazelton, 1984) has incorporated a number of the APIB items. Both the NBAS and the APIB strive to obtain the infant's best behavioral performance. The APIB has additional features to identify threshold to stress and self-regulatory ability. One feature is that items are organized in groups called packages which are administered in order of increasing difficulty for the infant. Package I assesses response decrement, or habituation, to distal stimuli (light, rattle, bell) during sleep. Package II involves uncovering and then placing the infant into a supine position. Packages III, IV, and V include various reflex maneuvers, ranging from tactile manipulations on the bed surface (Package III) to handling the infant away from the bed surface (Package IV) and adding vestibular stimulation (Package V). Package VI involves presentation of both animate and inanimate objects when the infant is awake and alert, either spontaneously or brought there with gentle stimulation. A second feature of the APIB is that order of package administration is governed by the infant's tolerance of challenge, as defined by the level of self-organization in terms of autonomic, motor, state, attention, and self-regulation systems. A third feature is that the need for and response to examiner support is evaluated throughout the examination.

The NBAS, first edition, contains 56 items, of which 27 are behavioral responses and 20 are reflex items. The APIB has 280 items, which subsume 28 behavioral items of the NBAS and includes all NBAS reflex items. Among the challenges in using these scales is formulation of a parsimonious and clinically practical method for data reduction. Ideally, behavioral constructs should be both pragmatic and reliable predictors of an infant's future neurodevelopmental status. Als devised one method for the APIB (Als & Moir, 1984). It provides instructions for recording and grouping of the individual behavioral and reflex items into 31 summary variables. These are operationally independent and are thought to be conceptually distinct. Six of the summary variables are called system scores; they have 1 as

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the best score and 9 as the worst score. These variables measure an infant's stress threshold in terms of physiologic, motor, state, attentional, and self-regulatory systems of functioning. They also measure the degree of examiner facilitation needed for optimal performance. All other APIB behavioral items are recoded to be linear with 9 as the best score and 1 as the worst score. The reflex summary variable is the percent of abnormal reflexes of the total number administered. Three studies using the six system scores have shown that preterm infants are less well organized in terms of all six parameters than full-term newborn infants (Als, Duffy, & McAnulty, 1988a, 1988b; Duffy, Als, & McAnulty, 1990). Another study using all six system scores also showed that healthy preterm infants had poorer performance than full-term infants (Wilcox, 1993). Two studies to test effectiveness of individualized developmental care in the neonatal intensive care unit (NICU) showed better modulation in the physiologic, motoric, and self-regulatory systems of very low-birthweight infants who received the intervention compared to those who did not (Als, et al., 1986, 1994).

The purpose of this report is to use confirmatory factor analysis in verification of seven hypothesized behavioral domains derived from the APIB. These domains include overall modulation of behavior, motor competencies, availability, sociability, habituation during sleep, autonomic competency, and reactivity. Confirmatory procedures evaluate the utility of causal hypotheses by testing the fit between a theoretical model and empirical data. If the theoretical model has a good fit with the data, the model is supported. If the model does not have a good fit, the model is disconfirmed (James, Mulaik, & Brett, 1987).

## METHOD

### Subjects

One hundred and forty-five infants were selected from a larger group who received an APIB evaluation before discharge from the NICU. Consent to use data was obtained in accordance with institutional guidelines when parents returned to follow-up clinic. The infants were cared for between 1985 and 1989 in one of two Tucson NICUs, prior to formally introducing developmental intervention into nursery care practices. The infants were heterogeneous with respect to their medical problems, gestational age at birth, and birthweight. Table 1 gives the birthweight and gestational age at birth information, and Table 2 provides additional perinatal information for 138 of the subjects.

**TABLE 1**
**Subject Weight and Gestational Age at Birth**

| Variable | *N* of Subjects | % | Cumulative % |
|---|---|---|---|
| Birthweight (gms) | | | |
| <750 | 11 | 7.6 | 7.6 |
| 751–1000 | 22 | 15.2 | 22.8 |
| 1000–1250 | 23 | 15.9 | 38.7 |
| 1250–1500 | 22 | 15.2 | 53.9 |
| 1500–2000 | 24 | 16.6 | 70.5 |
| 2000–2500 | 13 | 9.0 | 79.5 |
| 2500–3000 | 8 | 5.5 | 85.0 |
| >3000 | 15 | 10.3 | 95.3 |
| not known | 7 | 4.7 | 100.0 |
| Gestational Age at Birth (weeks) | | | |
| 24–25 | 10 | 6.9 | 6.9 |
| 26–27 | 14 | 9.7 | 16.6 |
| 28–29 | 23 | 15.9 | 32.5 |
| 30–31 | 24 | 16.6 | 49.1 |
| 32–33 | 33 | 22.8 | 71.9 |
| 34–35 | 6 | 4.1 | 76.0 |
| 36–37 | 13 | 9.0 | 85.0 |
| 38–42 | 15 | 10.3 | 95.3 |
| not known | 7 | 4.7 | 100.0 |

**TABLE 2**
**Perinatal Information of Subjects**

| Variable | *M* | *SD* |
|---|---|---|
| Apgar Score at 1 Min ($n$ = 135)[a] | 5.36 | 2.49 |
| Apgar Score at 5 Min ($n$ = 134) | 7.09 | 2.13 |
| Days on Respirator ($n$ = 96) | 21.50 | 24.60 |
| Days on Oxygen ($n$ = 107) | 35.70 | 38.85 |
| Days on Phototherapy ($n$ = 101) | 4.81 | 2.92 |
| Number of Red Blood Cell Transfusions ($n$ = 90) | 7.58 | 7.43 |
| Days Hospitalized ($n$ = 145) | 54.57 | 31.64 |
| Maternal Age ($n$ = 136) | 25.90 | 6.06 |

[a]Number of subjects reflects numbers for whom information was known for Apgar scores and maternal age or who required the procedure or treatment.

There were 79 males (57.2%) and 59 females (42.8%); 86.2% were average for gestational age. Of the 102 mothers whose ethnicity was known, 61.8% were Caucasian, 27.5% were Hispanic, 4.9% were African American, and 5.9% were other/mixed. The sample of infants included (a) 58.7% inborn from the hospital perinatal population, (b) 20.3% inborn after maternal transport, and (c) 21.0% transported after birth elsewhere. Neonatal medical problems were proven sepsis in 28 (20.3%); intraventricular hemorrhage Grade I in 15 (12.7%), Grade II in 4 (3.4%), Grade III in 2 (1.7%), and Grade IV in 6 (5.1%) (Papile, Burstein,

Burstein, & Koffler, 1978); respiratory distress syndrome in 78 (56.5%); retinopathy of prematurity in 56 infants of 95 tested, with Stage 1 in 16.7%, Stage 2 in 18.1%, and Stage 3 in 21.7%; bronchopulmonary dysplasia in 45 (32.6%).

## APIB

Reliability in administration and scoring of the APIB by two examiners was reassessed every year with the originator of the APIB. The mean age at administration of the APIB was 38.9 weeks ($SD$ = 3.3, range = 33–50 weeks). All APIBs were administered before discharge home. The APIB was scored according to Als et al. (1982). A letter score was assigned to an APIB item that could not be administered or scored meaningfully due to an infant's level of disorganization (Als & Moir, 1984). Later, the letter score was converted to a predesignated numerical score to permit quantitative analysis.

An item was scored on both the APIB and NBAS, if possible. The NBAS items were subsumed by the APIB definition only when the NBAS definition was insufficient or inappropriate to describe the infant's performance. In accordance with APIB instructions, the consequence of this procedure is that a letter rather than a number is assigned to the NBAS item, thus resulting in a missing NBAS data point.

## Statistical Analysis

*Structural Equations Modeling.* The data from the APIB were subjected to a multivariate causal analysis by factor-analytic structural equations modeling (Bentler, 1989). The two predominant components of this analysis are measurement and structural models. For this article, only the former was used. The measurement model is a confirmatory factor analysis, where several measured variables are related to a smaller set of hypothetical constructs called latent variables. It is believed that the latent variables are underlying the correlations among the measured variables. The theoretically specified latent constructs are generated as a priori hypotheses to be tested against the correlational data. There is exclusive prior assignment of each indicator (i.e., measured behavior) to the theoretically specified hypothetical constructs. Thus, confirmatory factor analysis reduces the number of factor loadings needed, which enhances the efficiency of parameter estimation. A requisite of this procedure is that each subject have a complete data set for all measured variables.

*Formulation of Latent Factors for the Model.* Our experience with the APIB and the a priori method for data reduction (Als & Moir, 1984) led us to hypothesize the following domains of behavioral functioning, or latent factors: overall modulation of behavior, availability for examination, motor competency, sociability, habituation, autonomic stability and reactivity. Selection of measured variables for inclusion in the analysis was based on a perceived contribution to one of the behavioral domains. Some variables were not included because scores were not available on all subjects. Altogether, 157 behavioral and 41 reflex items out of 280 total items on the APIB were examined for inclusion in our model. The reflex items were condensed into one summary variable, namely, the percentage of abnormal reflexes. Twenty-nine behavioral items, 13 of which are from the NBAS, were used individually; 128 behavioral items were combined into 15 summary variables as proposed in the Als model (Als & Moir, 1984). The summary variables and individual items used in the model are listed in the appendix for purposes of clarification. It should be noted that the six system summary variables, referred to previously, were placed together into the overall modulation of behavior factor. The summary reflex score and 13 behavioral items (i.e., general tone, defensive maneuver, cuddliness, motor maturity, alertness, five orientation items, tremors, startles, and peak of excitement) originate with the NBAS. However, not all of those items were scored numerically because the item was either not administrable or was unscorable using the NBAS definition. Thus, they were scored according to APIB criteria in the recoding process and for that reason cannot be considered truly NBAS items. Although administration of the three habituation items is identical on both scales, shutdown is defined differently, and therefore the scoring is not identical between NBAS and APIB. We used the APIB scoring for habituation items.

*Data Analysis.* An item covariance matrix was computed with output by SAS (SAS Institute, 1989). Then a confirmatory factor analysis was performed using the covariance matrices with EQS, which is a structural equation program (Bentler, 1989). Generalized least squares solutions were used to estimate the model parameters. The fit of the models was assessed with chi-square and goodness-of-fit indices (Bentler-Bonett Normed Fit Index [NFI], Nonnormed Fit Index [NNFI], and Comparative Fit Index [CFI]). Measurement equations with test statistics and standardized regression coefficients were obtained. Both chi-square and goodness-of-fit indices indicate whether the specified model is a good model. The chi-square statistic indicates how well the covariance matrix was reproduced by the model. If the hypothetical model does not accurately reproduce the original covariance matrix, the chi-square statistic will be large and significantly different from zero. However, Bentler and Bonett (1980) have shown that chi-square is oversensitive to large sample sizes, rejecting almost any model tested because even the smallest residuals are rarely equal to zero. Therefore, more importance is given to the goodness-of-fit indices, which indicate the percentage of variance explained by the covariance matrix and are less sensitive to sample size and distribution.

The measurement equation tests the significance of each relationship which is specified by a model, namely, how well each of the observed variables is represented by the hypothesized latent factor. Significant estimates are considered good representations by the latent factor, whereas nonsignificant estimates indicate that the relationship between the observed variable and latent factor is very weak or nonexistent. The standardized regression coefficients, or factor loadings, are estimates of the amount of variance in the measured variable that is accounted for by the latent factor.

When the model was tested initially, high covariances were noted among several observed variables, suggesting that they shared common features, either as behavioral characteristics or as methodologies. This possibility was tested with the confirmatory factor-analytic multitrait-multimethod approach to construct validity described by Ferketich, Figueredo, and Knapp (1991) and Figueredo, Ferketich, and Knapp (1991). The multitrait-multimethod approach consists of creating additional latent factors to statistically control for methodologic or behavioral characteristic variance associated with the different measured variables. Several behavioral traits were tested and were

not significant. Four potential methodological factors were considered because each contained behavioral measures that shared similar features. The first method factor was activity, because both spontaneous and elicited are scored identically, with the difference being whether the activity occurred spontaneously or after handling. The remaining three method factors were adjustments for the complexity of orientation stimulus, that is, visual and auditory together, visual alone, and auditory alone. Structural equations modeling requires at least three measures in a latent factor. Because each methodological factor had only two significant measures, their residual correlations were substituted in the models.

Two models were run. The inclusive model contained all behavioral and reflex items. The restrictive model contained only the items with significant factor loadings in the final calculations.

## RESULTS

Table 3 shows the statistical comparison between the inclusive model, which was defined as including all variables with pathways to the seven factors, and the restricted model, which was defined as including only significant variables and their respective pathways to six factors. The difference between the two models was not significant which indicates statistical acceptability of eliminating the nonsignificant measured variables from the restricted model.

We attempted to test a model with NBAS data as described by Lester (1983). However, that was unsuccessful because the number of subjects with a completely scored NBAS was too low for analysis with a structural equations model.

The restricted model is presented in Figure 1. Heavy arrows with numbers which are factor loadings (i.e., regression coefficients) indicate significant items, and lighter arrows with no numbers indicate nonsignificant items. The chi-square statistic for the restricted model was significant, $\chi^2$ (number of subjects = 145; degrees of freedom = 921) = 1085.69, $p < .001$. Although the model could be considered statistically rejectable with this chi-square value, it is quite acceptable given the fit indices, which are quite large. These results indicate that the covariances among the measured behavioral variables were adequately explained by the factor model. The APIB measures exclusively loaded on three factors, namely, overall modulation of behavior, availability for examination, and habituation. Both APIB and NBAS measures contributed to motor competency, sociability, and reactivity, albeit with some NBAS items having a high percentage of recoded scores (see appendix).

Significant pathways in the overall modulation of behavior factor (see Figure 1) include Als' physiology, motor, state, and regulatory system summary variables, which are considered indicators of an infant's internal organization or self-regulation (Als & Moir, 1984). Examiner facilitation, an Als system summary variable, is another significant pathway. It indicates the amount of examiner facilitation necessary to bring out the infant's best performance and to help the infant reorganize. Specific attentional signals and autonomic stress signals were also significant. Nonsignificant measures were the overall attention system, specific motor system signals, and cost of orientation. It should be recalled that the best score of system summary variables is a 1 and the worst score is a 9, whereas scale direction is reversed for all other variables. That explains the negative factor loading of the system variables as compared with the positive loading of all other significant variables. The factor loadings for overall modulation of behavior suggest that modulation is the ability to maintain organization in terms of physiological, motoric, and state organization and in terms of self-regulatory capacity, while simultaneously needing less support from the examiner.

Significant pathways for the availability for examination factor (see Figure 1) include measures of robustness, state improvement with facilitation, state-related signals, and the degree

**TABLE 3**
**Statistical Comparison of Inclusive and Restrictive Models**

| Model | $\chi^2$ | *df* | *p* | NNFI | NFI | CFI |
|---|---|---|---|---|---|---|
| Inclusive | 1101.76 | 941 | .001 | .994 | .999 | .999 |
| Restricted | 1085.69 | 921 | .001 | .994 | .999 | .999 |
| Difference | 16.07 | 20 | .712 | .000 | .000 | .000 |

*Note.* NNFI = Nonnormed Fit Index; NFI = Normed Fit Index; CFI = Comparative Fit Index.

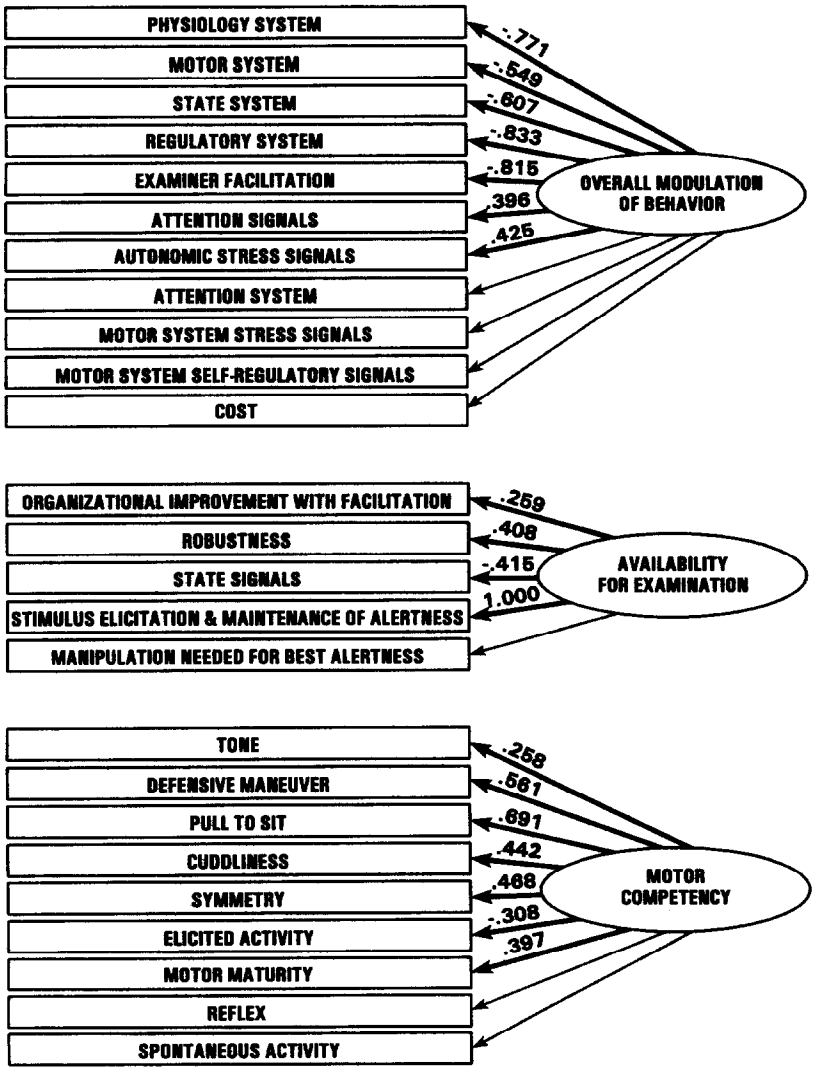


**Figure 1. Model factors of overall modulation of behavior, availability for examination, and motor competency. (Numbers are restricted model regression coefficients.)**

to which an orientation item elicited and maintained alertness. The predominant measure of this factor is the degree to which orientation stimuli bring out and maintain alertness for an infant. Robustness measures an infant's energy resources and endurance throughout the examination. Organizational improvement with examiner help is an indicator of effective utilization of examiner help during the examination. Finally, state-related signals may be considered stress indicators, which accounts for the negative factor loading of this variable. Thus, an infant who is more available for examination demonstrates more robustness, a greater awareness of and responsiveness to stimuli as well as use of the examiner's support, and has fewer state stress indicators.

Motor competency is comprised predominantly of NBAS items, with recoding of nonnumeric scores as previously described. All variable factor loadings were positive except for elicited activity. Spontaneous activity was elim-

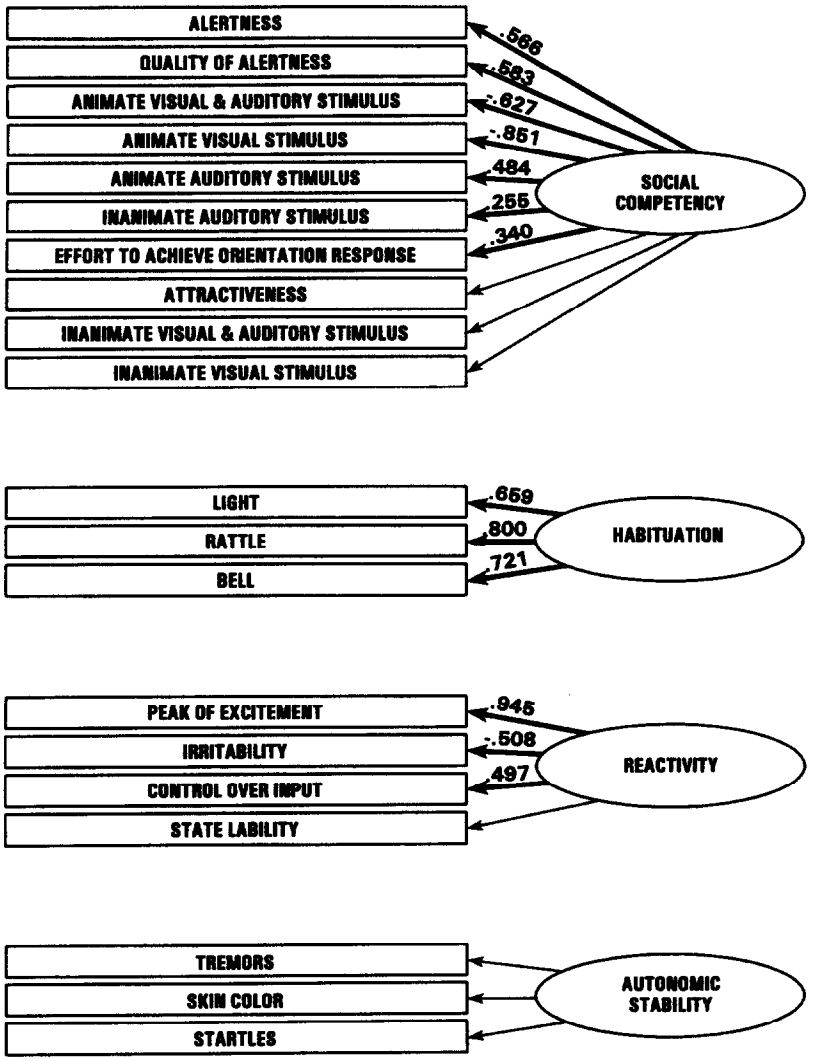


**Figure 2. Model factors of social competency, habituation, reactivity, and autonomic stability. (Numbers are restricted model regression coefficients.)**

inated from the model when controlled for by the methodologic activity factor. With the exception of elicited activity, the results suggest that a higher level of motor competency was associated with better performance on tone, the defensive maneuver, pull to sit, cuddliness, symmetry, and motor maturity. A low elicited activity score is not consistent with good motor performance; it means either very little or continuous and difficult to control activity. So, the negative factor loading for elicited activity is puzzling. Perhaps the recoding procedure is not the best, and another approach would give more readily interpretable results.

The sociability factor is comprised of significant pathways for alertness, effort on the infant's part to achieve the orientation response, quality of alertness when attending to stimuli, and the responses to all three animate and the inanimate auditory stimuli. Interestingly, there were negative factor loadings with the two animate stimuli having a visual component, yet a positive factor loading for the two auditory stimuli. Thus, more sociability encompassed

more alertness, better quality of alertness, better responses to auditory stimuli, and greater effort to attend to the stimuli, yet poorer response when there is only an animate visual component to the stimuli presented. Statistical control for each of three potential methodologic variables involving different sensory input (i.e., visual alone, auditory alone, and a combination of visual and auditory) eliminated the two items with an inanimate visual stimulus.

Significant pathways for all three habituation stimuli exist with the habituation factor. Habituation measures the response to and the ability to shut out repeated light, rattle, or bell stimuli during sleep. The APIB scores were used for this factor as previously described.

The reactivity factor has significant pathways for peak of excitement, irritability as defined by the APIB, and control over input. The factor loadings were positive for control over input, which means greater control on the infant's part over incoming stimuli, and for peak of excitment, which means the ability to achieve a higher state (e.g., crying) at some point during the examination. The factor loading for APIB irritability was negative, which indicates the extreme sensitivity of these infants, as irritability is manifest by minor motor signals such as grimaces or increasing motor activity in response to handling. The vast majority of infants had scores indicative of a high level of irritability ($M = 2.53$, $SD = 1.74$).

A seventh latent factor, autonomic stability, was patterned after Lester's (1983) autonomic cluster. There were no significant measured variables among the four tested.

Table 4 shows intercorrelations among the six factors in the restricted model. All but two were not significantly different from zero, indicating good differentiation among the behavioral constructs represented by the latent, factors. Significant factor correlations may mean that the factors are not discriminable from each other, or that they are conceptually distinct yet necessary for each other. One possible explanation for the relationship between habituation and overall modulation of behavior ($r = .714$) is that an infant with better modulation will also demonstrate better shutdown to (i.e., tuning out of) light and sound stimuli during sleep. The association between social and motor competencies ($r = -.622$) is more complex because there was a mixture of negative and positive factor loadings for the variables on these two factors. One possible explanation is that a specific degree of motor tone and control over activity coincide with more capable social interactiveness, which is well known to be a very demanding task for infants at this stage of development.

## DISCUSSION

Behavior of a heterogeneous group of infants who received neonatal intensive care was measured with the APIB. Confirmatory factor analysis of the behavioral measures identified six behavioral constructs which we called overall modulation of behavior, availability for examination, motor competency, sociability, habituation, and reactivity. These behavioral constructs measure both task performance and the quality with which tasks are accomplished.

These findings have several important implications. First, the behavioral constructs and their correlational relationships are clinically understandable. For example, an infant who has considerable difficulty with modulating basic functions such as breathing and maintaining tone is unlikely to be awake or available for social

**TABLE 4**
**Intercorrelations Among Latent Factors in the Restricted Model**

| | Factor | | | | |
|---|---|---|---|---|---|
| **Factor** | **Modulation** | **Availability** | **Motor** | **Sociability** | **Habituation** |
| Modulation | — | | | | |
| Availability | .054 | — | | | |
| Motor | −.079 | −.158 | — | | |
| Sociability | −.116 | .139 | −.622* | — | |
| Habituation | .714* | −.025 | .142 | .106 | — |
| Reactivity | .069 | .063 | −.052 | −.116 | .114 |

*$p < .05$.

interactions. In contrast, an infant will be socially engaging when able to modulate physiologic, motor, and state functions. Another example would be an infant who cannot diminish response to light or sound stimuli while asleep. Such behavior is considered very disorganized.

A second ramification is the theoretical possibility of improved discrimination of infant functional capacity beyond that obtained when only task performance is measured. Let us take, for example, response to the animate auditory stimulus. The sociability factor measures the actual response; it can range from no response at all, to stilling, to eye searching for the stimulus, to repeatedly turning head and eyes together toward the stimulus, which is considered the very best response. Simultaneously, the modulation and the availability factors provide insight into the quality of responding to the auditory stimulus. The infant's self-regulation while listening, response to examiner facilitation if needed, robustness, and use of the voice for staying alert are assessed. Thus, it is possible to learn about the amount of internal modulation and availability that accompany a particular level of responsiveness to an orientation object.

Others have shown the utility of measuring disorganization threshold with the six individual system summary variables in differentiating between healthy preterm and full-term infants (Als et al., 1988a, 1988b; Wilcox, 1993) and in showing the effectiveness of NICU developmental intervention in very-low-birthweight infants (Als et al., 1986, 1994). This report demonstrates the potential for an even more detailed and informative picture of behavioral functioning in previously ill newborn infants by using many more of the APIB items. Altogether, 157 behavioral and 41 reflex items out of 280 total items on the APIB were examined for inclusion in our model. The reflex items were condensed into 1 summary variable, namely, the percentage of abnormal reflexes. Twenty-nine behavioral items, 13 of which are from the NBAS scale, were used individually; 128 behavioral items were combined into 15 summary variables (Als & Moir, 1984). Each item or summary variable was related to one of six discrete domains of behavioral functioning. Greater parsimony exists with these six behavioral constructs than with Als's 31 summary variables or with the very large number of individual items on the APIB.

The restricted model was obtained with the multitrait-multimethod procedure to adjust for potential methodologic confounds in several factors. Elimination of the spontaneous activity item seems practical based on clinical experience. There is usually little time available to observe spontaneous activity which is the amount of activity when an infant is not being handled. Generally, the infants had continuous activity in response to handling, which necessitated examiner facilitation. Adjusting for the potential methodologic confounds of complexity of orientation stimuli caused removal of stimuli with an inanimate visual component from the sociability factor. A possible explanation is that in ancestral environments in which humans evolved, inanimate objects rarely moved or made sounds. Thus, infants might not be as biologically prepared to respond to inanimate objects as to humans.

Within the social competency factor, the factor loadings were negative for stimuli with an animate visual component, but positive for the two auditory stimuli. One plausible explanation comes from clinical observation that social interaction is a very demanding process for these highly sensitive infants. Another possibility is that the auditory sensory pathway matures earlier than the visual sensory system. Perhaps both circumstances are relevant.

Six measures in motor competency had positive factor loadings, whereas the one for elicited activity was negative. Activity is U shaped after initial scoring, so that scores of both 1 and 9 represent poor performance. Best performance is represented by the mid-range of scores. We followed Als's methodology for recoding activity, which results in a scale of 1 (*worst*) to 9 (*best*). The negative factor loading for elicited activity could mean that this rescoring method does not yield a linear scale. A second consideration is that a large proportion of three behavioral items with positive coefficients on the motor competency factor were rescored. This was done in 36.8% for general tone, in 51.4% for defensive maneuver, and in 34.8% for motor maturity. The only available rescoring methodology for a letter score was described by Als and Moir (1984) to generate the summary variables. The logic was that a letter score be given when the degree of behavioral disorganization was so great that an infant either could not perform the task or would have performed very

poorly had the item been given. It seemed inappropriate for us to suggest another methodology. Thus, rescoring converts a letter score to the worst possible numerical score (Als & Moir, 1984; H. Als, personal communication, July, 1993). This issue will benefit from additional clarification of the examination conditions and infant performance, which should lead to scoring a letter or a number for some of the motor items.

Our model should be tested to determine if the hypothetically devised behavioral constructs are of practical use. The subjects were relatively heterogeneous with respect to medical problems, birthweight, and gestational age, leading to the expectation that the findings of this study could be generalized to the population of neonatal intensive care infants. It is unknown if identical behavioral constructs would be obtained if a more homogeneous group of subjects were studied, for example, extremely low-birthweight or very ill infants.

In summary, the results of latent factor structural modeling of behavioral characteristics derived from the APIB gave a parsimonious and clinically interpretable model with six discriminable behavioral constructs. The next step will be to investigate the clinical utility of these models to differentiate among infants in the neonatal period and to predict their developmental outcome. The excellent fit of the measured variables in the model suggests that it may be possible to simplify scoring of the APIB by reducing the total number of scored items. However, based on the clinical experience of our examiners, we would not recommend altering how the APIB is administered or how examiners are trained to reliability in the APIB. Otherwise, one would lose very valuable information about an infant's modulation and availability for social interaction and endurance, which in turn would preclude correct scoring of the behavioral measures that are validated in the model.

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APPENDIX

Origin of Measured Variables in Model and Percentage Rescored From a Nonnumeric Value if Greater Than 5%

| Fact and Behavioral Item | NBAS or APIB | Percentage Rescored |
|---|---|---|
| *Overall Modulation of Behavior Factor* | | |
| Physiology system[a] | APIB | 31% Package 1 & 2 |
| Motor system[a] | APIB | 31% Package 1 & 2 |
| State system[a] | APIB | 31% Package 1 & 2 |
| Attention system[a] | APIB | |
| Regulatory system[a] | APIB | 31% Package 1 & 2 |
| Examiner facilitation[a] | APIB | 31% Package 1 & 2 |
| Attention signals[a] | APIB | |
| Autonomic stress signals[a] | APIB | |
| Motor stress signals[a] | APIB | |
| Motor self-regulatory signals[a] | APIB | |
| Cost of attending to orientation items[a] | APIB | |
| *Availability for Examination Factor* | | |
| Amount of manipulation for best alertness | APIB | |
| Organizational improvement with facilitation | APIB | |
| Robustness | APIB | |
| State-related signals[a] | APIB | |
| Stimulus elicitation and maintenance of alertness[a] | APIB | |
| *Motor Competency Factor* | | |
| General tone | NBAS | 30.8% |
| Abnormal reflexes[a] | NBAS | 9.0%–37.5% for Package III<br>50.0%–54.9% for Package IV |
| Defensive maneuver | NBAS | 51.4% |
| Pull to sit[a] | APIB | 56.2% |
| Cuddliness | NBAS | |
| Symmetry | APIB | 5.6% |
| Spontaneous activity | APIB | 7.0% |
| Elicited activity | APIB | 6.3% |
| Motor maturity | NBAS | 34.8% |
| *Social Competency Factor* | | |
| Alertness | NBAS | |
| Quality of alertness | APIB | |
| Animate visual and auditory stimulus | NBAS | |
| Animate visual stimulus | NBAS | |
| Animate auditory stimulus | NBAS | |
| Inanimate visual and auditory stimulus | APIB | |
| Inanimate visual stimulus | NBAS | |
| Inanimate auditory stimulus | NBAS | |
| Effort to respond to and/or stop responding to orientation items[a] | APIB | |
| Attractiveness | APIB | |
| *Habituation Factor* | | |
| Habituation to light | APIB | |
| Habituation to rattle | APIB | 10.4% |
| Habituation to bell | APIB | 47.9% |
| *Reactivity Factor* | | |
| Peak of excitement | NBAS | |

| Fact and Behavioral Item | NBAS or APIB | Percentage Rescored |
|---|---|---|
| Irritability, APIB | NBAS | |
| Control over input | APIB | |
| State lability | APIB | |
| *Autonomic Stability Factor* | | |
| Tremors | NBAS | 6.3% |
| Skin color | APIB | |
| Startles | NBAS | 21.5% |

[a]These behaviors are composites of individual APIB items known as Als's summary variables:
Physiology, motor, state, and regulatory systems—each is an average of 18 items.
Attention system is an average of 3 items.
Examiner facilitation is an average of 6 items.
Autonomic signals is an average of 7 items
Cost of attending to orientation, elicitation and maintenance of alertness, effort to respond to and/or stop responding to orientation stimuli are each an average of 6 items.
Motor stress signals is an average of 6 items.
Motor self-regulatory signals is an average of 12 items.
State-related signals is an average of 4 items.
Package I and II systems were rescored using the same guidelines for scoring Als's summary variables HABIM1 and CAPAM1.