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Principal Component Analyses of the Bayley Scales of Infant Development for a Sample of High-Risk Infants and Their Controls

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At 92 weeks postconceptual age, 192 high-risk infants with birth weights $\leq$ 1,500 grams and/or requiring ventilator support shortly after birth, and 85 full-term infants who were healthy newborns, were administered the Bayley Scales of Infant Development. A principal component analysis was performed separately for the high-risk and control infants. There was a reasonable degree of congruence between the first principal component for the high-risk infants and that of the controls, although the first principal component of the high-risk infants explained a greater number of heavily weighted items than for the control infants. The similarity was increased when differences in developmental levels were controlled for. There was considerable similarity between the results of analyses for high-risk infants and those for normal infants reported in the literature.

Infant scales have been developed to assess the behavioral level of infants. McCall has advocated the use of principal component analyses of infant scales to characterize empirically the structure of development (McCall, Hogarty, & Hurlburt, 1972; McCall, Eichorn, & Hogarty, 1977). He has used principal component analyses to define the abilities that are prominent and correlated at different ages in infancy. The results of these analyses are similar for both the Fels and Berkeley Growth data (McCall, et al., 1977) and for a sample of rural Guatemalan infants (Lasky, Klein, Yarbrough, & Kallio, 1981). The structure of behavioral development in infancy seems to be

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similar across a range of populations. Furthermore, McCall and colleagues have noted the similarity between their empirically determined characterization of the structure of development and Piaget's description of development (McCall et al., 1972, 1977).

There is less certainty that the development of normal and abnormal infants can be characterized in the same way. On the one hand, a Piagetian orientation stresses that all infants must go through the same developmental stages. On the other hand, Bayley (1969) cautions that using mental and motor ages may be misleading since, she argues, delayed infants are not merely infants whose behavior is appropriate for infants of a younger chronological age. In this report, we present the results of principal component analyses of performance on the Bayley Scales of Infant Development (Bayley, 1969) at 1-year corrected age (92 weeks postconception, regardless of the date of birth) for a sample of high-risk infants, and separately for their controls. We address the issue of whether the structure of development as defined by principal component analyses of the Bayley Scale is similar in high-risk control infants at 1 year of age. The high-risk infants sampled were infants weighing 1,500 grams or less at birth and/or requiring ventilator assistance for survival shortly after birth. Only a few years ago, before the establishment of neonatal intensive care units, these infants would have had a poor prognosis for survival. These infants are at risk for neurological and behavioral delay (Dweck, 1977; Fitzhardinge & Ramsey, 1973; Rothberg, Maisels, Bagnato, Murphy, Gifford, McKinley, & Vannucci, 1981; Stewart, Turcan, Rawlings, & Reynolds, 1977).

METHODS

Subjects

The sample included all infants who (a) weighed $\leq$ 1,500 grams at birth and/or required ventilator assistance shortly after birth; (b) were born at Parkland Memorial Hospital between September 1, 1977 and December 7, 1979; and (c) kept a follow-up appointment when they were 92 weeks conceptual age. The Parkland population is from the lower socioeconomic class, extremely transient, often unaware of the importance of health care, and somewhat suspicious of hospital-related personnel (the families of these infants incur large and often unpaid hospital bills). For these reasons, we administered interpretable Bayley examinations to 192 of the 369 infants who were scheduled to attend the follow-up clinic (for five infants, the Bayley was not interpretable). In addition, 85 control infants were assessed who were similar to the high-risk infants with respect to sex, maternal marital status, maternal age, stage during pregnancy when prenatal health care was first sought, number of siblings, and financial status, but who had experienced a normal gestation, delivery, and newborn period.

Procedure

A caregiver, generally the mother, brought the infant, at 1-year corrected age, to our follow-up clinic at Callier Center for Communication Disorders (a 10-minute walk from Parkland Memorial Hospital). Anthropometric, physical, neurologic, and Bayley examinations, as well as surveys of socioeconomic status and health, were administered during the clinic visit. (A clinic lasted 2 to 3 hours, on the average.) The Bayley Scale was administered first, in order that the infants would be well rested and alert during the examination. The Bayley Scale examiners were not told whether the infant they were to examine was a high-risk or a control infant. They knew nothing about the infant other than the infant's name, sex, and age (1-year corrected age).

RESULTS

Principal component analyses were computed separately for the high-risk and control samples. Following McCall et al. (1977), dependent items were grouped into a single variable and only items or grouped items for which more than 10% of the infants in each sample either passed or failed that item were included in the analyses. The final item pool consisted of 23 items. The results of these analyses are presented in Table 1 for the high-risk sample and Table 2 for the controls. Only items with factor loadings $\geq \pm .40$ for one of the first five factors are included in the tables. The most striking difference between the high-risk and control infants can be appreciated from the first principal component. For the high-risk infants the first principal component accounted for 26.9% of the total variance; 16 of the 23 items had factor loadings greater than $\pm .40$. In contrast, for the controls, the first principal component accounted for only 16.1% of the total variance and only nine of the 23 items had loadings of $\pm .40$ or greater. All but one ("spontaneous scribble") of the items with a loading greater than $\pm .40$ that defined the first principal component for the control infants also had a loading greater than $\pm .40$ for the high-risk infants. Thus, walking and gross movement skills, putting cubes and beads in containers, and scribbling characterized the first principal component of both samples of

TABLE 1. High-Risk Infants' Factor Loadings

Bayley Items:	*Factors* *I*	*II*	*III*	*IV*	*V*
Walking (5 items)	.79		−.41		
Pulls to upright position (5 items)	.67				
Searches box for hidden object (2 items)	.65				
Imitates scribble (3 items)	.64				
Walks alone	.64		−.46		
Pulls string and dangles ring (3 items)	.62				
Puts cube in a cup (3 items)	.60				
Midline skills (2 items)	.58				
Stands up (2 items)	.58			.44	
Manipulates bell (2 items)	.56	.45			
Responds to verbal requests	.55				
Uses gestures to make wants known	.51		.47		
Walks sideways and backwards (2 items)	.48			.52	
Puts beads in box	.48		.50		
Throws ball	.48	−.45			
Unwraps cube	.42				
Says "da-da" or equivalent		.65			
Jabbers expressively		.54			
Imitates words				.43	
Says two words					.56
Spontaneous scribble (2 items)					.40
Percentage of total variance	26.9	8.7	7.5	5.9	5.3

infants. Whereas a number of other behaviors (manipulating the bell, responding to verbal requests and using gestures, throwing a ball, and midline skills, pulling upright, and unwrapping a cube), are highly correlated with these behaviors for the high-risk infants, they are not for the controls and, in fact, define other factors.

The most likely interpretation of the differences between the first principal component of the high-risk and control infants concerns the marked behavioral delay for the high-risk infants. For both the Fels and Berkeley data, the first principal component is defined by fewer items (i.e, those with loadings greater than ±.40) with in-

TABLE 2. Control Infants' Factor Loadings

Bayley Items:	*Factors* I	II	III	IV	V
Stands up (2 items)	.70				
Walking (5 items)	.67	−.51			
Walks alone	.66	−.52			
Walks sideways and backwards	.65				
Puts cubes in cup (3 items)	.52				
Uses gestures to make wants known	.47				
Imitates scribble (3 items)	.44				
Puts beads in box	.43		.54		
Spontaneous scribble (2 items)	.42				
Manipulates bell (2 items)		.56			
Responds to verbal request		.53			
Says "da-da" or equivalent		.51			
Searches box for hidden object (2 items)		.40	.46		
Matches forms appropriately (2 items)		.40	.47		
Imitates words		−.54			.44
Jabbers expressively		−.49			
Pulls to upright position (5 items)				−.64	
Midline skills (2 items)				−.51	
Says two words					.74
Throws ball					−.41
Pulls string and dangles ring (3 items)					
Percentage of total variance	16.1	10.4	9.9	7.3	6.4

creasing age from at least 6 to 12 months. Whether that is due to the makeup of the infant scales used or the process of increasing differentiation in development, such as hypothesized by Werner (1948), is unclear. However, the high-risk infants' responses do seem somewhat more correlated than the controls and behaviorally the high-risk infants are delayed (their mean mental and motor ages as defined by Bayley (1969) were 10.8 and 11.1 months, respectively, in contrast to 12.4 and 13.4 months for the controls).

In order to quantify the degree of similarity among the principal component loadings, congruence coefficients (Harman, 1976, p. 344) were calculated. This was only done for the first principal component for two reasons. The first principal component was the best overall summary of performance. Second, if all of the factors for each sample were included, the number of significant positive correlations between factors in the different samples would have been quite large. Due to the large number of factors involved and the probable lack of reproducibiltiy of many factors, those correlations would be difficult to interpret. The congruence coefficient for the first principal component of the control and high-risk infants was .75, indicating a reasonable degree of similarity.

Principal component analyses were recomputed separately for the high-risk infants with a mental age of 10 months or less ($n = 76$) and for high-risk infants with mental ages of 11 months or greater ($n = 116$) in order to determine whether equating for developmental age increases the similarity of the analysis in the two samples of infants. Only one control infant had a mental age of 10 months or less. The first principal component for the 76 high-risk infants with mental ages 10 months or less explained 22.5% of the total variance and had 13 items with loadings of $\pm.40$ or better. In contrast, the first principal component for the high-risk and control infants whose mental ages were 11 months or greater explained, respectively, 15.3% and 15.5% of the total variance. For each of these two groups of infants, nine items had loadings of $\pm.40$ or greater.

The congruence coefficients for the first principal component for the high-risk infants with mental ages $\leq$ 10 months and those with mental ages $\geq$ 11 months was .83; for the high-risk infants with mental ages $\leq$ 10 months and control infants with mental ages $\geq$ 11 months it was .75; and for the high-risk and control infants with mental ages $\geq$ 11 months it was .84. These results suggest that the first principal component for the control infants was somewhat more similar to that of the high-risk infants when significantly delayed high-risk infants were excluded from the analysis.

DISCUSSION

The first principal component of the high-risk and control infants was similar. This similarity increased when the high-risk infants who were significantly delayed were excluded from the analysis. Accounting for the differences in items and developmental level, there is general agreement between the item composition of the first principal component for controls, normal, and delayed high-risk infants, and for those infants reported by McCall et al. (1972, 1977) and Lasky et al. (1981) on other samples. It is necessary to use the same instrument and examiners as was done in this study and to equate the developmental ages of the high-risk and control infants and their conceptional ages in order to make more definitive statements concerning principal component differences as a function of risk category. Such research is important in determining whether behavioral development can be characterized similarly for all infants or whether some infants may develop differently than others. However, our results suggest that the high-risk infant is similar to normal infants in this respect, especially when differences in developmental level are accounted for.

REFERENCES

BAYLEY, N. *Manual for the Bayley scales of infant development.* New York: Psychological Corp., 1969.

DWECK, H. S. The tiny baby: Past, present and future, *Clinics in Perinatology*, 1977, *42*, 425–430.

FITZHARDINGE, P. M., & RAMSEY, M. The improving outlook for the small prematurely born infant. *Developmental Medicine and Child Neurology*, 1973, *15*, 447–459.

HARMON, H. *Modern factor analyses.* Chicago: University of Chicago Press, 1976.

LASKY, R. E., KLEIN, R. E., YARBROUGH, C. Y., & KALLIO, K. D. The predictive validity of infant assessments in rural Guatemala. *Child Development*, 1981, *52*, 847–856.

McCALL, R., EICHORN, D., & HOGARTY, P. Transitions in early mental development. *Monographs of the Society for Research in Child Development*, 1977, *42*, (3, Serial No. 171).

McCALL, R., HOGARTY, P., & HURLBURT, N. Transitions in infant sensorimotor development and the prediction of childhood IQ. *American Psychologist*, 1972, *27*, 728–748.

ROTHBERG, A. D., MAISELS, J., BAGNATO, S., MURPHY, J., GIFFORD, K., McKINLEY, K., PALMER, E. A., & VANNUCCI, P. D. Outcome for survivors of mechanical ventilation weighing less than 1,250 gm at birth. *Journal of Pediatrics*, 1981, *98*, 106–111.

STEWART, A. L., TURCAN, D. M., RAWLINGS, G., & REYNOLDS, E. O. R. Prognosis for infants weighing 1000 g or less at birth. *Archives of Diseases in Childhood*, 1977, *52*, 97.

WERNER, H. *Comparative psychology of mental development.* New York: International Universities Press, 1948.