

content emphasis of the scales from 3 to 24 months. Utilizing exploratory factor analytic procedures the author's results provide empirical evidence for Bayley's hypothesis that different constructs define development at different ages and that there is little evidence for accurate prediction of a child's later performance in a particular domain from his or her earlier performance. The authors discuss these findings and their significance when using the child's Bayley performance to predict his or her later performance.

The third paper, by Gyurke, Lynch, LaGasse, and Lipsitt, uses an item analysis procedure to examine the relationship between the child's speed of performance on various timed items on the BSID Mental Scale and the child's overall performance on this scale. Many infant tests rely on speed of performance as a means of establishing a child's ability to perform that task. The assumption that speed is correlated with developmental maturity is well established for school-age children, but relatively untested in preschoolers. This research finding, that speed of performance may not be as reliable an indicator for young children as for older children, can be used by clinicians who prefer to interpret the child's performance beyond the scale level.

The final paper, by Siegel, is an empirical assessment of the commonly held belief that there are continuities in development and commonalities among diverse behaviors that underlie cognitive development. Using an alternative scoring procedure for the BSID Mental Scale, Siegel attempted to predict later performance in a number of academic and cognitive areas. The results of this study point to the fact that the predictive validity of the BSID is improved when one approaches it from a domain specific perspective.

Integrative comments for these papers are provided by a distinguished developmental psychologist, Lewis P. Lipsitt, who has spent many years as the director of a large longitudinal study which used the BSID. Dr. Lipsitt's comments draw attention to the historical purposes of infant assessment as determining current level of functioning and predicting future functioning. He further points out that repeated examinations of the predictive power of the Bayley Mental or Motor Scales will continue to produce consistently unremarkable results.

Dr. Lipsitt continues his discussion by pointing out the merits of investigating the psychometric properties of the Bayley as alternative means to addressing issues relating to assessment of current functioning. His integration of the present collection of papers provides the reader with a multifaceted and yet coherent view of the methodologies currently available to answer questions about the reliability and validity of infant scales.

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## ESTABLISHING THE "CEILING" ON THE BAYLEY SCALES OF INFANT DEVELOPMENT AT 25 MONTHS\*

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## I. INTRODUCTION

The Bayley Scales of Infant Development (BSID) are used widely in clinical and research contexts to assess the developmental functioning of infants. Norms are provided by the publisher for infants and toddlers from 2 months through 30 months of age (Bayley, 1969). Longitudinal and comparative research studies of full-term and preterm infants often include the BSID as the primary assessment instrument through 24 months.

As with most individually administered developmental and intelligence tests, the BSID employs "discontinue criteria" for the examiner to use in determining the examinee's "ceiling" level, that is, determining when to stop administering items. A ceiling is defined for the BSID as the item representing the most difficult success for that examinee. The ceiling item is identified by means of a discontinue criterion. For the Mental Scale, the recommended discontinue criterion (*BSID Manual*, 1969, p. 29) is the lowest 10 consecutive failed items. That is, the item just below this series of 10 consecutive failures is, by definition, the ceiling item. For the Motor Scale, the recommended discontinue criterion is six consecutive failed items. According to the manual, "these levels must be carefully established to ensure that the infant's full range of successful functioning has been tested" (1969, p. 29). The use of this type of discontinue criterion is based on two assumptions: first, that the items are sequentially ordered by difficulty level; and second, that after the specified number of failures the infant would be unlikely to achieve any more correct responses.

Clinical experience suggests that many 24-month-olds are able to pass one or more of the last 10 items on the Mental Scale—thus effectively precluding the establishment of an empirical ceiling according to Bayley's recommended criterion for discontinuation. For at least some of these infants, it is possible that the test has not adequately sampled their behavior (that is, the infant's "full range of successful functioning" has not been tested). The extent of this problem and the functioning range of the infants most likely to be affected are not known.

This study examines the extent to which the full range of successful functioning of 24-month-olds is adequately sampled by the BSID. More specifically, the degree to which the discontinuation criteria are not met can be seen as the degree to which the BSID does not adequately sample the full range of successful functioning for 24-month-olds. This poses the possibility that the BSID may not fully delineate the full range of individual differences among 24-month-olds. To investigate this issue, the current study employs a highly standardized research administration of the BSID to a large multi-site sample of 24-month corrected-age low-birthweight (LBW) preterm infants. Because preterm and LBW infants typically function below the level of their full-term counterparts (see Pape, Buncie, Ashby, & Fitzhardinge, 1978; Field, Dempsey, & Shuman, 1979; Teberg et al., 1982; Eckerman, Sturm, & Gross, 1985; Rose & Wallace, 1985;

Ford et al., 1986), the sample assessed here should provide a conservative overall estimate of problems in meeting the ten-failure discontinue criterion on the Mental Scale.

## II. METHOD

### A. Subjects

The data reported here were collected as part of the Infant Health and Development Program (IHDP; The Infant Health and Development Program, 1990). This study was a multi-site randomized controlled trial to evaluate the efficacy of combining early child development and family support services with high quality pediatric follow-up for LBW premature infants. (See the Appendix for participating institutions and principal investigators.) One-third of the IHDP infants received the full array of services; the other two-thirds received the pediatric follow-up component only.

In the trial, a total of 4451 inborn LBW children born between January 1 and September 7, 1985 were screened for eligibility. After being screened for eligibility and giving informed consent to participate in the three-year study, 985 families were enrolled. Baseline data about neonatal health and selected socio-demographic variables were collected prior to newborn nursery discharge. Extensive data were gathered about the children's development, health, and behavior, and about family background and maternal characteristics. These data were collected through structured hospital clinic visits at 40 weeks gestation, and at 4, 8, 12, 18, 24, 30, and 36 months corrected age. Ages were corrected for weeks of prematurity based on clinical estimates of gestational age at birth using the Ballard assessment (Ballard, Novak, & Driver, 1979) as modified by Constantine et al. (1987). All subsequent references to age should be interpreted as "corrected age."

Of the 985 children in the IHDP sample, 811 were tested with the BSID within two weeks of their 24-month corrected birthday; of these, 807 were administered both the Mental and Motor Scales. These 807 constitute the sample reported here.

Approximately one-third of these infants were participating in the intensive early intervention program, and at the time of testing had been exposed to approximately two years of a home visiting program and one year of daily attendance at an IHDP Child Development Center. A structured, developmentally oriented curriculum emphasizing cognitive, language, and social development was implemented in both program components (Sparling, Lewis, & Neuwirth, in press; Sparling & Lewis, 1984).

Two features of this study are especially noteworthy. First, this is the largest sample to date to report 24-month BSID scores ( $N = 807$ ). Second, all examiners in this multisite study participated in a highly structured training program. The

examiners' abilities to maintain the standardized test administration were certified prior to testing the study children and monitored throughout the study.

## B. Procedures

All children were administered the BSID between January and October 1987. This was the first procedure administered in the scheduled 24-month hospital clinic visit. Site staff were instructed to schedule the clinic visit within two weeks of the infant's 24-month corrected birthday. A second clinic visit was scheduled within one week of the original visit to complete any test that was terminated due to irritability, fatigue, or other behavior that interfered with obtaining optimal performance.

The coordinating center for the trial was designated the National Study Office (NSO). The NSO employed special procedures to insure that the BSID was administered in a uniform and standardized manner at all eight sites. These procedures included: careful selection of qualified examiners and site supervisors; detailed training for each BSID item; and regular surveillance of assessments, including written critiques of videotaped BSID administrations by each examiner.

At each site, a Ph.D. or Master's level psychologist with substantial experience in infant testing provided training and supervision to two or three local examiners. The BSID examiners were required to have prior infant testing experience, to participate in a highly structured training program, and to be certified on their performance by the supervisor from the NSO prior to the testing of study children.

The training was conducted in two parts. First, the supervisors participated in a two-day national training meeting conducted by the NSO. At the meeting, the BSID was reviewed item by item, and videotapes of BSID tests of 24-month-old children were critiqued. The standard BSID manuals (Bayley, 1969; Rhodes, Bayley, & Yow, 1984) and an additional manual detailing specific procedures for the IHDP also were reviewed, with special emphasis on maintaining a uniform testing protocol and standard procedures for training the examiners. This included discussion of procedures for handling different types of infant behavior (e.g., fatigue, irritability, wariness, negativistic behavior, restlessness).

In the second phase of training, the on-site supervisors trained the examiners. There were 28 examiners at eight sites. This consisted of participating in a series of prescribed instructional sessions, viewing and scoring videotapes of BSID exams (provided by the NSO), and conducting a minimum of five practice test sessions with 24-month-old children. These practice sessions were observed, co-scored, and critiqued for each examiner by the on-site supervisors. One of these practice test sessions (or an additional sixth session) was videotaped by the supervisor, and the tape was shipped to the NSO supervisor for review, written critique, and approval. A form was developed to provide written feedback to the

site staff. The feedback included specific comments on the procedure for administering each item as well as comments on general testing issues, such as establishing and maintaining rapport with the child and mother, pacing, and organization of the entire test session. In this way, every effort was made to ensure that each examiner uniformly administered the BSID according to standard protocol.

During the 10 months in which study infants were tested, a monitoring system was established to ensure that the research protocol of standardized test administration was maintained. Each on-site supervisor conducted 10 periodic observations of the examiners' testing of study children at intervals mandated by the NSO. Halfway through the testing of study children, another videotape of each examiner's testing was made and sent to the NSO for review, written critique, and approval.

If an examiner's testing was judged to fall below the established standards at any time during the initial training or during the testing of study children, that examiner was temporarily prohibited from testing additional study children, and further training was instituted until a satisfactory level of performance could be reestablished. This occurred with two examiners during the initial training and with one examiner during the period of testing. All other examiners demonstrated a high level of standardized and uniform test performance during the initial training period and throughout the months during which study children were tested.

Examiners were instructed to attempt to maintain the infant in an optimal behavioral state for the test session. If the infant became restless, fatigued, or negativistic, testing was discontinued and a second test session was scheduled to occur within one week of the first session.

## III. RESULTS

Table 1 shows baseline descriptive statistics for the sample, as well as means, standard deviations, and ranges for the 24-month Bayley Mental Developmental Indices (MDI) and Psychomotor Developmental Indices (PDI).

A tabulation of children by MDI intervals and whether they met the discontinuance criterion of 10 consecutive failed items is presented in Table 2. The MDI intervals are in standard deviation increments, representing groups commonly used to define developmental ranges. Table 2 shows that 72.6% of the sample failed to meet the criteria for establishing a ceiling. In every MDI interval, except the interval of more than three standard deviations below the mean (under 52), there are some infants who did not meet the 10-failure criterion. The problem becomes more pronounced at higher MDI ranges. Of the 494 infants in mid-range (MDI 84-116), 421 (85.2%) passed at least one of the last 10 items. All but four of the 333 infants with an MDI greater than 99 passed at least one of the last 10 items.

TABLE 1  
Sample Characteristics

Variable	Mean	Standard deviation	Range
Birth weight (grams)	1797.8	454.7	540-2500
Gestational age (weeks)	33.0	2.7	25-38
Number of days in newborn nursery	25.3	23.3	1-144
Maternal age (years)	24.9	6.1	14-43
24-Month BSID MDI <sup>1</sup>	97.8	18.9	50-150
24-Month BSID PDI <sup>2</sup>	96.1	14.7	50-141
Variable	N	(%)	
Gender:			
Male	399	49.4	
Female	408	50.6	
Neonatal health indicators:			
On ventilator	255	31.6	
RDS <sup>3</sup>	324	40.1	
BPD <sup>4</sup>	43	5.3	
PDA <sup>5</sup>	90	11.1	
Maternal education:			
< 9th Grade	29	3.6	
Some high school	286	35.4	
High school graduate	222	27.5	
Some college	159	19.7	
College degree or more	111	13.7	
Maternal race:			
Black	421	52.2	
White	274	33.9	
Hispanic	88	10.9	
Asian	13	1.6	
Other	11	1.4	
Marital status:			
Married	380	47.1	
Single	367	45.5	
Divorced/Separated/Widowed	60	7.4	

<sup>1</sup> BSID MDI = Bayley Scales of Infant Development Mental Developmental Index

<sup>2</sup> BSID PDI = Bayley Scales of Infant Development Psychomotor Developmental Index

<sup>3</sup> RDS = Respiratory Distress Syndrome

<sup>4</sup> BPD = Bronchopulmonary Dysplasia

<sup>5</sup> PDA = Patent Ductus Arteriosus

Tables 3 and 4 further illustrate the extent and nature of the criterion failure problem in our sample. Table 3 presents a cross-tabulation of MDI interval by the number of passes achieved in the last 10 items. Infants with higher MDI scores are more likely to pass more of the last 10 items, but in the mid-range (84-116), many infants passed several items out of the last 10 items. Table 4 presents a similar tabulation for the number of passes achieved in the last five items. Even

TABLE 2  
Discontinue Criterion Status on Mental Scale for IHDP Sample

MDI Score	Met criterion <sup>1</sup>		Did not meet criterion <sup>1</sup>		Total	
	Row %	(N)	Row %	(N)	Column %	(N)
Under 52	100.0	(15)	0	(0)	1.9	(15)
52-67	94.7	(18)	5.3	(1)	2.3	(19)
68-83	72.3	(115)	27.7	(44)	19.7	(159)
84-99	24.6	(69)	75.4	(212)	34.8	(281)
100-116	1.9	(4)	98.1	(209)	26.4	(213)
117-132	0	(0)	100.0	(81)	10.0	(81)
Over 132	0	(0)	100.0	(39)	4.8	(39)
TOTAL	27.4	(221)	72.6	(586)	100.0	(807)

<sup>1</sup> Criterion is ten consecutive failed times.

at this most upper end of the test, 50.2% of this sample passed one or more of the last five items.

Table 5 presents information on discontinue criterion status for the Motor Scale, parallel to the Mental Scale information presented in Table 2. These data indicate a much less prevalent ceiling problem. Overall, only 5% of the infants passed any of the last six items, and this only occurred with infants who obtained a PDI of at least 84. However, for infants with a PDI above 116 ( $N=68$ ), 33.8% ( $N=23$ ) passed at least one of the last six items. It appears that the criterion problem on the Motor Scale primarily affects infants performing in the higher ranges of motor functioning, and that the problem is not as pervasive as that found on the Mental Scale.

Although the BSID manual reports that the items are arranged in order of difficulty, the proportion of infants in the standardization sample who passed each item are not reported in the manual (Bayley, 1969). These data<sup>1</sup> were obtained and are presented in Table 6 for the last 10 Mental Scale items for the standardization sample and for the IHDP sample.

Table 6 shows that in the standardization sample these last 10 items depart slightly from sequential order of difficulty, and in the IHDP sample they depart more substantially. Each item except the last two was passed by a substantial percentage of 24-month-old infants in both samples. For the IHDP sample the most frequently passed item was item number 155 (Blue Board: Completes in 150 Seconds)—passed by 58% of the sample; for the standardization sample the most frequently passed item was item number 156 (Pegs Placed in 22 Seconds)—passed by 37% of the sample. It is notable that the IHDP sample showed relatively better performance on perceptual-motor and timed items (e.g., Blue Board; Builds Tower of Eight Cubes) compared to the standardization sample.

<sup>1</sup> These data were obtained from Janet Hunt, Ph.D. Institute of Human Development, University of California, Berkeley.

TABLE 3  
Number of Passes in Last Ten Items by MDI Interval (Items 154-163)

Number of passes in last ten items	MDI Scores							Total
	Under 52	52-67	68-83	84-99	100-116	117-132	Over 132	
0 Passes:								
N	15	18	115	69	4	0	0	221
%*	100.0	94.7	72.3	24.6	1.9	0.0	0.0	27.4
1 Pass:								
N		0	29	68	25	0	0	122
%		0.0	18.2	24.2	11.7	0.0	0.0	15.1
2 Passes:								
N		1	12	46	35	1	0	95
%		5.3	7.5	16.4	16.4	1.2	0.0	11.8
3 Passes:								
N			2	48	35	5	0	90
%			1.3	17.1	16.4	6.2	0.0	11.1
4 Passes:								
N			1	39	47	19	0	106
%			0.6	13.9	22.1	23.5	0.0	13.1
5 Passes:								
N				9	35	16	2	62
%				3.2	16.4	19.7	5.1	7.7
6 Passes:								
N					2	26	27	64
%					0.7	12.2	33.3	7.9
7 Passes:								
N					6	12	12	30
%					2.8	14.8	30.8	3.7
8 Passes:								
N						1	12	13
%						1.2	30.8	1.6
9 Passes:								
N							3	3
%							7.7	0.4
10 Passes:								
N							1	1
%							2.6	0.1

\* This is the percentage of the column N.

#### IV. DISCUSSION

Almost three-fourths of our sample (588 out of 807) did not meet the recommended discontinue criterion of 10 consecutive incorrect items on the BSID Mental Scale; and half of the sample (406 out of 807) obtained one or more passes among the last five items. The problem on the Motor Scale was less evident, with all but 5% of the sample meeting the recommended six-item criterion. Examination of the item data from the BSID standardization sample

TABLE 4  
Number of Passes in Last Five Items by MDI Interval (Items 159-163)

Number of passes in last five items	MDI Scores							Total
	Under 52	52-67	68-83	84-99	100-116	117-132	Over 132	
0 Passes:								
N	15	18	146	169	52	2	0	402
%*	100.0	94.7	91.8	60.1	24.4	2.5	0.0	49.8
1 Pass:								
N		1	11	52	47	9	0	120
%		5.3	6.9	18.5	22.1	11.1	0.0	14.9
2 Passes:								
N			2	54	75	32	6	169
%			1.3	19.2	35.2	39.5	15.4	20.9
3 Passes:								
N				6	35	33	17	91
%				2.1	16.4	40.7	43.6	11.3
4 Passes:								
N					4	5	14	23
%					1.9	6.2	35.9	2.9
5 Passes:								
N							2	2
%							5.1	0.3

\* This is the percentage of the column N.

suggests that this problem with the discontinue criterion also occurred to some lesser degree with the standardization sample.

The findings show that the BSID Mental Scale may not capture the true range of developmental variability for 24-month-olds and older infants of even below average developmental functioning. More specifically, the BSID does not appear to adequately sample the full range of successful functioning for the

TABLE 5  
Discontinue Criterion Status on Motor Scale for IHDP Sample

PDI Scores	Met criterion <sup>1</sup>		Did not meet criterion <sup>1</sup>		Total	
	Row %	(N)	Row %	(N)	Column %	(N)
Under 52	100.0	(21)	0	(0)	2.6	(21)
52-67	100.0	(36)	0	(0)	4.5	(36)
68-83	100.0	(99)	0	(0)	12.3	(99)
84-99	98.4	(370)	1.3	(5)	46.7	(376)
100-116	94.2	(195)	5.8	(12)	25.7	(207)
117-132	72.6	(45)	27.4	(17)	7.7	(62)
Over 132	0	(0)	100.0	(6)	0.7	(6)
TOTAL	95.0	(766)	5.0	(40)		(806) <sup>2</sup>

<sup>1</sup> Criterion is six consecutive failed items.

<sup>2</sup> One subject is not included because ceiling status was unknown due to an assessor error.

TABLE 6  
Proportion Passed for the Last 10 Items on the Mental Scale:  
Comparison of Samples of 24-Month-Olds

Item no.	Item name	Standardization <sup>1</sup>	IHDP <sup>2</sup> sample
		sample	IHDP <sup>2</sup> sample
		Proportion pass	Proportion pass
154	Train of cubes	.36	.26
155	Blue board: completes in 150 seconds	.29	.58
156	Pegs placed in 22 seconds	.37	.47
157	Folds paper	.20	.21
158	Understands 2 prepositions	.21	.23
159	Blue board: completes in 90 seconds	.21	.49
160	Blue board: completes in 60 seconds	.14	.37
161	Builds tower of 8 cubes	.09	.25
162	Concept of one	.04	.07
163	Understands 3 prepositions	.07	.09

<sup>1</sup> These data were provided by the Institute of Human Development, University of California, Berkeley.  $N = 90$ .

<sup>2</sup> IHDP = Infant Health and Development Program.  $N = 807$ .

overwhelming majority of 24-month-olds in our sample. Our findings also suggest that the useful upper age limit of the BSID Mental Scale may be lower than the minimal top of the test at 30 months.

It is puzzling that this discontinue criterion problem has not been reported before. It may be that many BSID examiners do not adhere to the recommended 10-successive-item discontinue criterion for the Mental Scale, and routinely discontinue testing after a smaller number of successive failed items. The nature of data collection protocols in many clinical research studies may also help explain why this problem has not been widely reported; some studies are actually reports of clinical efforts, without rigid, standardized research protocols. Developmental assessment data for preterms may be gathered as part of routine follow-up clinic visits over an extended period of time, without methodical attention to the consistency of a standardized research protocol (see review article by Kopp, 1983).

Because of the rich history and extensive previous use of the BSID and because the authors know of no better alternative at the 24-month age level, it is not recommended here that the use of the BSID at this age be limited. Instead, the authors make the following recommendations regarding the BSID Mental Scale:

1. Examiners should report whether or not the suggested discontinue criterion was employed, and if not, what criterion was used.
2. Researchers should report the proportion of their sample who do not meet the recommended discontinue criterion.

3. Readers should exercise caution in interpreting results whenever it is known that the discontinue criteria have not been met, or when it has not been reported that they have been met. This is especially true for, but not limited to, infants 24–30 months of age with MDI scores in the average range or above.
4. The next restandardization effort should consider adding more items at the upper end of the test or, as a less desirable alternative, reducing the nominal “top” of the test to a lower age.

## V. APPENDIX: INFANT HEALTH AND DEVELOPMENT PROGRAM

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# ADVANCES IN INFANCY RESEARCH

## VOLUME 7

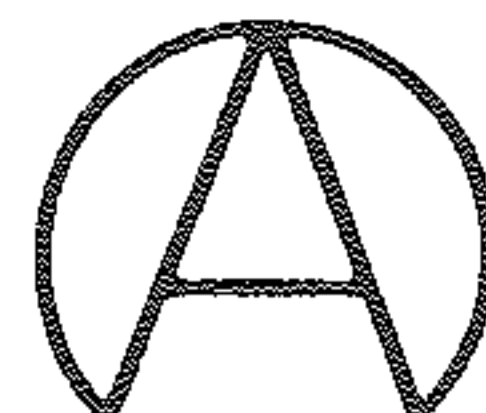
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