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ABSTRACT

To find predictive relations between measures taken in infancy and later scores on intelligence tests, a study was made that measured in the infant those cognitive processes examined later in life. Operant conditioning tasks were employed which required 3-, 7-, and 11-month-old infants to execute some response to produce an environmental consequence. At each age, infants recieved 2 days of training separated by 24 hours and a retention test session 7 or 14 days later. Measures of retention were based upon the number of responses emitted during specific nonreinforcement phases. Subjects were 41 full-term middle class Caucasian infants who were tested with the Bayley Mental and Motor Scales of Infant Development approximately 1 week following retention test sessions and the Bayley Scales and the Stanford-Binet Intelligence Test at 27 months of age. The two measures of retention were correlated at all four ages, but they were not correlated with Bayley Scale scores. Retention measures were significantly correlated between 3 and 7 and 7 and 11 months. Significant positive correlations were obtained between retention measures at each age and Stanford-Binet and Bayley Mental scores at 27 months, with one exception. Findings suggested that infant memory is a relatively stable component of infant cognition that is related to later intelligence. (RH)

Infant Long-Term Memory for a Conditioned Response and Intelligence Test Performance at 2 Years of Age

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For many years, psychologists have been attempting to relate scores obtained on standardized tests administered during infancy to measures of intelligence obtained later in life. The assumption underlying much of this research has been that intelligence is a finite, unchangeable potential which is present at birth and gradually unfolds as the child develops. Several reviews of the literature, however, have all arrived at the conclusion that scores obtained on standardized tests such as the Bayley Scales of Infant Development, the Gesell Developmental Schedules, and Cattell's Infant Intelligence Scale have little predictive validity (e.g., Bayley, 1970; Lewis & McGurk, 1972; McCall, 1976, 1979a; McCall, Hogarty, & Hurlburt, 1972).

Faced with the lack of prediction, several psychologists have put forth two alternative propositions. First, the doctrine of intelligence as a constant and general trait may be incorrect. Bayley (1970) exemplified this position when she wrote that each stage of infant development is composed of a set of age-specific abilities that are unrelated to those of a succeeding stage. Second, some investigators have pointed a finger at the infant tests themselves claiming either that these tests are unreliable or that they are measuring the wrong behaviors. As McCall (McCall et al., 1972) has pointed out, however, the standard infant tests are quite reliable and therefore it is unlikely that reliability is a significant factor in the failure to obtain predictions from infancy to childhood. We agree with others (e.g., Fagan, 1979) who have proposed that some of the poor predictive validity can be traced to the type of behaviors assessed by the standardized tests. By and large, the infant scales are composed of items designed to assess simple sensory and motor skills. Childhood intelligence tests, on the other hand, measure the child's ability to reason, as well as his or her skill in such areas of intellectual competence as learning and remembering. In other words, while the infant tests focus on such skills as "sits alone steadily" or "reaches for a cube," those of childhood focus more on broader cognitive processes. Thus, it seems that in order to find predictive relations, we need to measure in the infant those cognitive processes that will later be examined as the child develops. In short, while the behavioral expression of intelligence may change from one age to another, its underlying processes should remain invariant. As McCall (1979b) wrote:

> Consistency is more likely to be found in the biological function of mental behavior (i.e., its adaptive significance for the organism and species) than its specific behavioral manifestations....One function is the <u>acquisition of information</u>, its intake storage, and retrieval. A second but corollary function is <u>to influence the environment</u>, both animate and inanimate. (p. 191)

In recent years, a few investigators have been successful in uncovering relations between measures of infant visual attention and later intelligence test scores. Most notable has been the work of Joseph Fagan (1979, 1981, 1984, 1985) who familiarized 4- to 7-month-old infants with one visual target and then exposed these infants to the familiar target paired with a novel one. Immediate recognition memory for the familiar target was inferred from the percent of total fixation time that was allocated to the novel stimulus. At 3, 4, 5, or 7 years of age, moderate but significant correlations ranging from .37 to .57 were obtained between the "percent novelty" scores and scores on the Peabody Picture Vocabulary Test.

Studies by other researchers have also implicated the infants' response-to-novelty as a reliable predictor of some underlying cognitive competence.

Yarrow and his associates (Yarrow, Klein, Lomonaco, and Morgan, 1975) permitted a group of 6-month-old infants to manipulate a toy bell for 10 minutes. Following this familiarization period, each infant was observed when the bell was paired with each of 10 novel objects. Responsiveness to novelty as measured by the amount of time the infant spent handling or mouthing the novel object was found to be significantly related to Stanford-Binet IQ at 3 years (r = .35). Lewis and Brooks-Gunn (1981) presented 3-month-old infants with six 30-second presentations of a slide followed by one 30-second exposure to a novel stimulus. They found that the magnitude of recovery of the fixation response to the novel stimulus was correlated with scores on the Bayley Scales at 24 months with a median correlation across the two samples that they used of .46. Rose and Wallace (1985) reported correlations of .66 and .45 between preterm infants' novelty preference at 6 months and their Stanford-Binet IQ at 34 and 40 months, respectively. They also found a correlation of .56 between 6-month percent novelty scores and IQ at 6 years as measured by the WISC-R. Finally, Bornstein and Sigman (1986) conducted a meta-analysis using 11 studies that compared the response to novelty in infancy with various measures of mental development between 2 and 7.5 years. This analysis indicated that these infancy and childhood measures share 22% of common variance.

Our laboratory has taken a procedurally different approach to the question of predictability; one that does not rely on the infant's response to novelty. Instead, we use various operant conditioning tasks, each of which requires the infant to execute some response in order to produce a visual consequence. By placing infants in settings where they produce changes in the environment, we can measure how well an infant learns a task and how long, and under what conditions, he or she retains it. As summarized by Horowitz and Dunn (1978):

> After all, it is quite possible that our most fruitful approach to understanding infant development and the prevention of developmental delay lies in an analysis that views the infant as a processor of environmental information who, in the exercise of processing strategies, functionally affects the amount, kind, duration, and timing of stimulus information made available to him or her. (p. 32)

At 3 months of age our infants learned to produce movement in an overhead crib mobile by means of a ribbon connected between the infant's foot and an overhead mobile stand. At 7 months of age infants were placed in a highchair and learned to activate a musical toy and a bank of 10 lights via an arm-pulling response. At 11 months, a bar-press response was used to activate this toy in a different enclosure containing a red and a green light.

The general procedure is illustrated in Figure 1. At each age, infants received 2 days of training separated by 24 hours and a retention test session 7 or 14 days later. Once assigned to a particular retention interval, an infant was tested at that interval at each age. Each session began and ended with a nonreinforcement phase (Phases 1 and 3) that lasted 3 minutes at 3 months and 1 minute at 7 and 11 months. At 3 months, nonreinforcement meant that the mobile was in view but was not responsive to the infant's kicking because it hung from a stand to which the ribbon was not attached. At 7 and 11 months, nonreinforcement entailed turning off the toy and the lights so that the infant's arm-pulling or panel-press responses did not produce any contingent visual reinforcement. Phase 2 represents reinforcement or acquisition which at 3 months involved suspending the mobile from the stand to which the ribbon was attached for 15 minutes so that footkicks produced mobile movement in a conjugate manner. At 7 and 11 months, each response during each daily 6-minute reinforcement phase was immediately followed by a 1.5-second activation of the toy and lights.

This paradigm yields two measures of retention at each age, both of which are based upon the number of responses emitted during specific nonreinforcement phases. The first, called the Retention Ratio, is calculated by dividing each infant's number of responses during the nonreinforcement phase at the outset of the retention test session (a long-term retention test) by that infant's number of responses during the procedurally identical nonreinforcement phase at the end of the second training day (an immediate retention test). Ratios greater than or equal to 1.00 indicate no change in performance and therefore no forgetting of the conditioned response over the retention interval; ratios less than 1.00 reflect the particular fraction of conditioned responding that persisted after the retention interval. The second measure, called the Baseline Ratio, is computed by dividing each infants number of responses during the nonreinforcement phase at the outset of the retention test session (the long-term retention test) by that infant's pretraining baseline or operant level of responding as assessed during the first nonreinforcement phase on the first training day. With this measure ratios of 1.00 merely reflect performance that has returned to baseline while ratios greater than 1.00 reflect the extent to which performance has remained above baseline following the retention interval.

The data presented in this paper represent that for 41 full-term Caucasian infants who have been given the Stanford-Binet Intelligence Test and Bayley Scales of Infant Development at 27 months of age. These infants were also tested with the Bayley Scales approximately 1 week following the retention test session at 3, 7, and 11 months of age. All subjects were recruited from middle class communities in Nassau County, New York.

Table 1 presents the within-age correlations obtained both during the three infancy observations and at 27 months. At each age, the two measures of retention obtained from the various operant conditioning tasks were correlated. This is not unexpected given that they have the same numerator. Also at each age, the correlation between the two Bayley scales was significant although the relation between the two did decline with age and, in fact, was gone by 27 months where the Bayley mental scale was correlated with the Stanford-Binet. Finally, and most importantly, the two measures of retention were not correlated with the infants' scores on either of the Bayley scales.

Table 2 presents the age-to-age correlations for the two retention measures and the Bayley Scales for the three infancy assessments. The two retention measures were significantly correlated between 3 and 7 and 7 and 11 months but not between 3 and 11 months where only one of the correlations was significant. In addition, the retention measures were about as stable from age to age as were those obtained from the Bayley Scales.

Finally, Table 3 presents the correlations between the infant measures and the 27-month measures. The most important data in this table are the significant positive correlations between both retention measures at each age and the 27-month Stanford-Binet and Bayley Mental scores with one exception, that for the 11-month baseline ratio and the 27-month Bayley Mental Development Index. The lack of correlation between the retention measures and the 27-month Bayley Psychomotor Development Index is not unexpected although the large significant negative correlation between the 3-month baseline ratio and the 27-month Bayley motor score is unexplainable.

Figure 2 presents a summary of the correlations obtained in this study. The average correlation of .40 is consistent with that reported by other researchers using the infants' response-to-novelty as their dependent measure. For example, Fagan (1985) reported that the mean predictive validity coefficient based on his samples as well as those of Lewis and Brooks-Gunn (1981) and Yarrow et al. (1975) was .44.

These data have both theoretical and practical implications for understanding and measuring intellectual functioning and its development. Theoretically, they suggest that infant memory is a relatively stable component of infant cognition that is related to later intelligence. On a practical level, they suggest that measures of infant memory should be incorporated into any new attempts to develop screening devices for infants at risk for retarded mental development.

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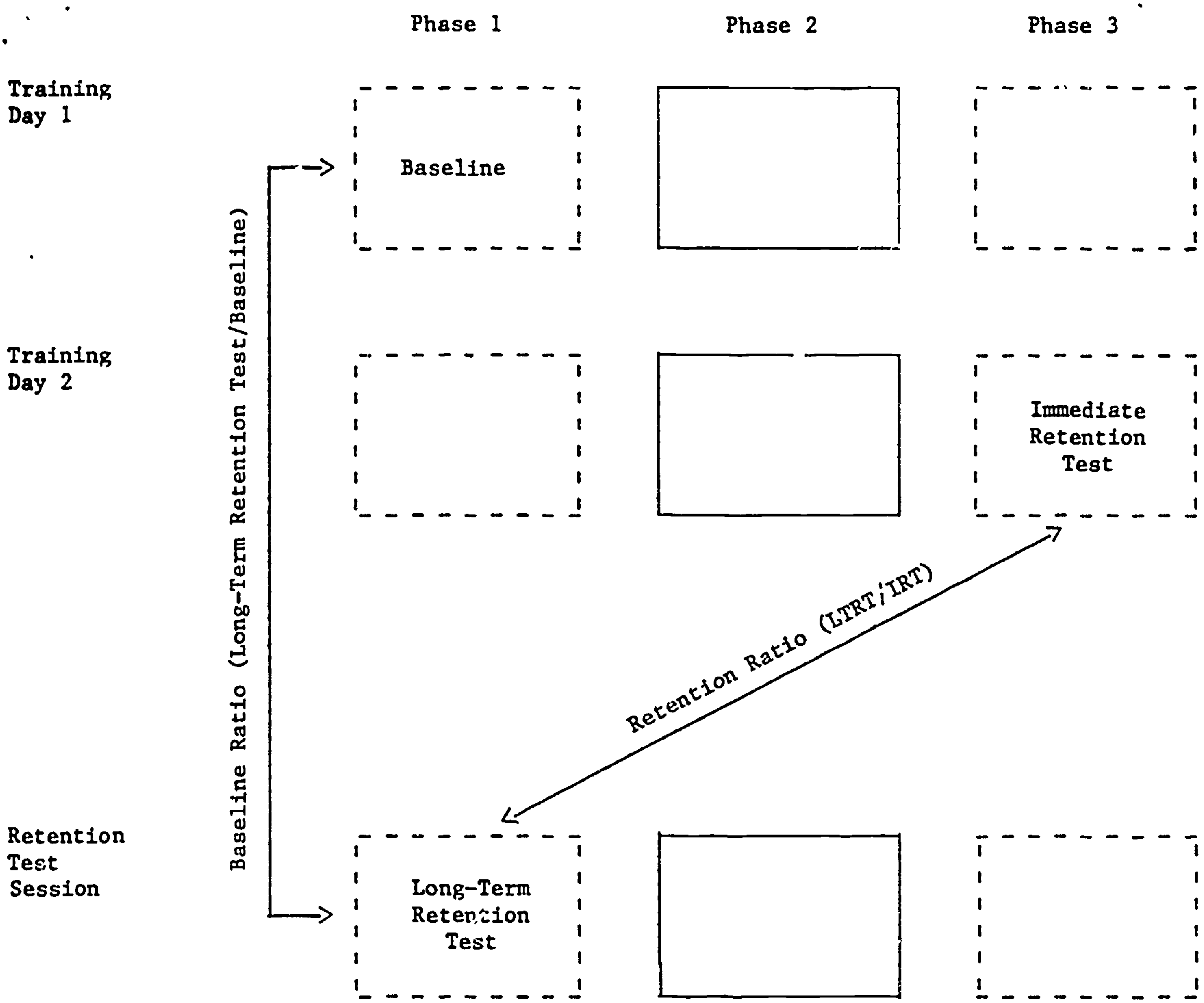

Phase 1
Phase 2
Phase 3
Training Day 1
Baseline
Training Day 2
Immediate Retention Test
Baseline Ratio (Long-Term Retention Test/Baseline)
Retention Ratio (LTRT/IRT)
Retention Test Session
Long-Term Retention Test

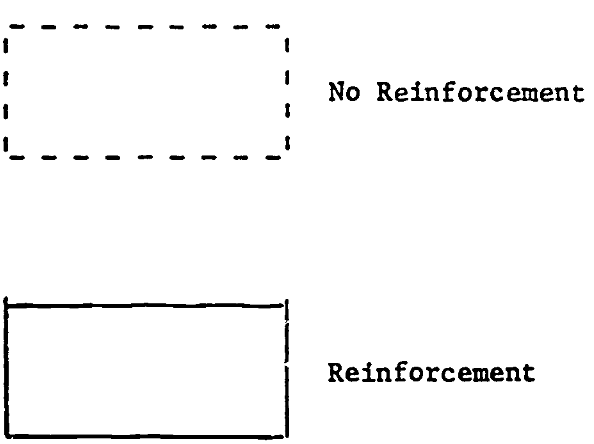

No Reinforcement
Reinforcement

Table 1

Within-Age Correlations

Measure	Retention Ratio	Bayley Mental	Bayley Motor
	3 Months		
Baseline Ratio	.63*	.01	.15
Retention Ratio	-	.16	.14
Bayley Mental		-	.70*
	7 Months		
Baseline Ratio	.53*	-.05	.09
Retention Ratio	-	-.03	.02
Bayley Mental		-	.58*
	11 Months		
Baseline Ratio	.44*	-.08	.01
Retention Ratio	-	-.19	-.17
		-	.40*
	27 Months		
Bayley Mental	-	-	.21
Stanford-Binet	-	.62*	.18

Note. Correlations with baseline and retention ratios are pooled within-cell correlations adjusted for retention interval.

*$p < .01$

Table 2

Stability Correlations for Infancy Measures

	Ages (months)		
Measure	3 to 7	7 to 11	3 to 11
Retention Ratio	.35*	.42**	.17
Baseline Ratio	.44**	.51**	.31*
Bayley Mental	.34*	.30*	.35*
Bayley Motor	.32*	.54**	.23

Note. Correlations for retention and baseline ratios are pooled within-cell correlations adjusted for retention interval.

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

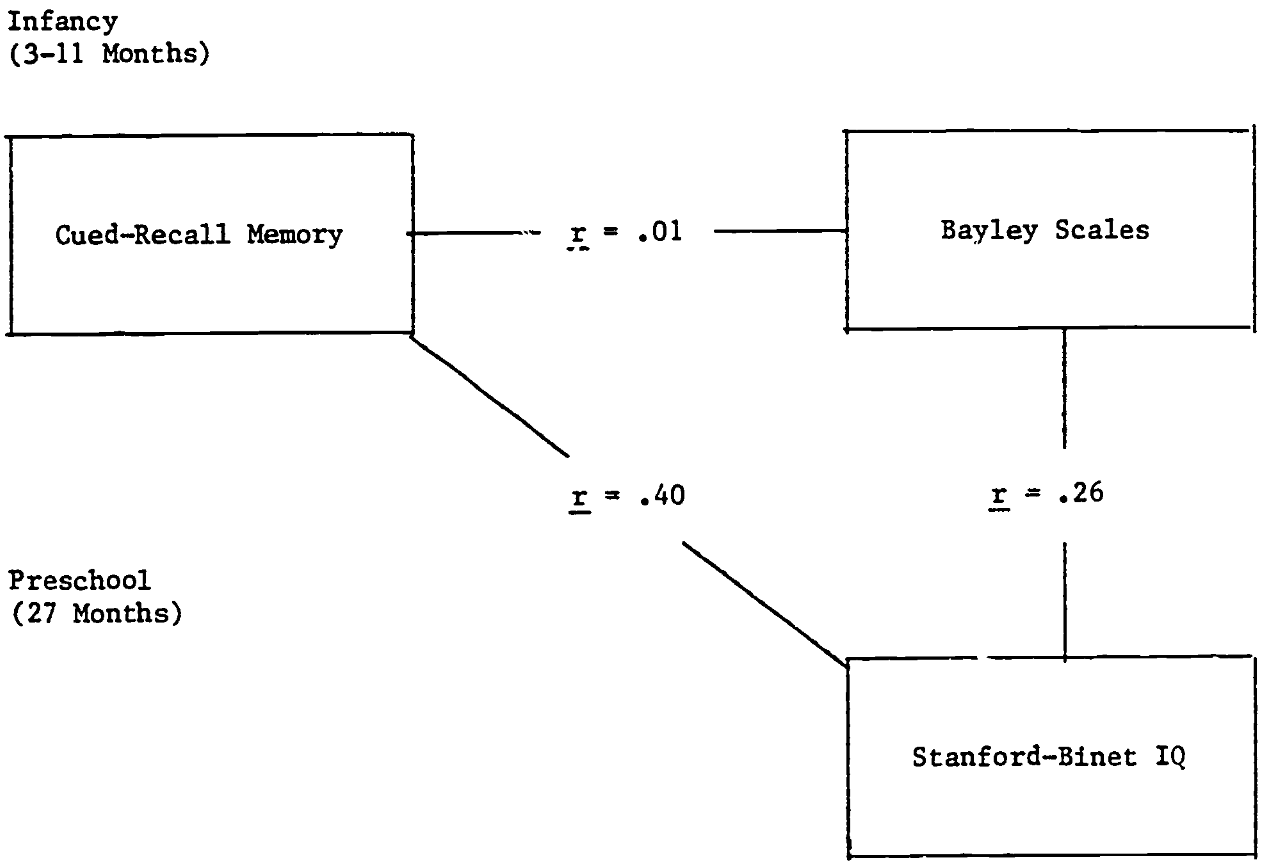
Table 3

Correlations Between Infant Measures and 27-Month Test Scores

	27-Month Scores		
Infant Measures	Stanford Binet	Bayley Mental	Bayley Motor
3 Months			
Retention Ratio	.42**	.39**	.15
Baseline Ratio	.31*	.26*	-.58**
Bayley Mental	.36**	.45**	.39**
Bayley Motor	.24	.37**	.18
7 Months			
Retention Ratio	.51**	.54**	.22
Baseline Ratio	.39**	.29*	-.05
Bayley Mental	.33*	.30*	.30*
Bayley Motor	.25	.23	.38**
11 Months			
Retention Ratio	.46**	.32*	.14
Baseline Ratio	.28*	.18	.09
Bayley Mental	.24	.40**	.11
Bayley Motor	.13	.15	.58**

Note. Correlations with baseline and retention ratios are pooled within-cell correlations adjusted for retention interval.

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


Infancy
(3-11 Months)
Cued-Recall Memory
r = .01
Bayley Scales
r = .40
r = .26
Preschool
(27 Months)
Stanford-Binet IQ