

# How infant and mother jointly contribute to developing cognitive competence in the child

(infancy/parenting/cognition/development)

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**ABSTRACT** Infants who processed visual information more efficiently and had mothers who more frequently encouraged them to attend to properties, objects, and events in the home environment in the first 6 months of life excelled in verbal development during their second year and scored higher on a conventional psychometric assessment of intelligence at 4 years. These results, confirmed over several studies, support the idea of continuity in mental development from infancy and begin to specify parental didactic activities that may most efficaciously promote cognitive achievement in young children of different ages.

The study of mental development in infancy has been motivated by three compelling questions. Can reliable and valid indexes of cognitive abilities be identified early in life? Do cognitive measures in infancy predict intellectual development in childhood? And, can mental growth in young children be enhanced by external influence? Here, I report findings of a series of interconnected prospective studies—longitudinal, observational, and experimental—that were designed to address these central questions of human development. Cognitive abilities in infants and didactic characteristics of maternal interaction patterns with children were selected on the basis of theory and pretests and then assessed and traced over time in several cohorts. This report elucidates some ways by which infant cognitive abilities and maternal interaction patterns contribute to mental development in the child.\*

The main study was longitudinal. Children were seen with their mothers three times, initially as babies 4 months after birth, again when they celebrated their first birthday, and finally when they turned 4 years old and were about to enter preschool. Fourteen dyads participated; the eight girls and six boys were healthy and term at birth, and their parents were of middle- to upper-socioeconomic status. Although individual intelligence test scores may fluctuate over the life cycle, at about 4 years, test performance is beginning to stabilize at its mature level (1, 2).

At 4 months, infants were observed both in the laboratory and at home. In the laboratory, babies participated in a study of visual habituation (3, 4). Habituation quantifies infants' declining interest in a repeatedly presented stimulus. Infants saw a red, 26°, 4.5-cycle, vertical, square-wave grating over fifteen 10-s trials, and the decrement in their attention was calculated as the percent decline in their looking from the mean of trials 1 and 2 to the mean of trials 14 and 15. This attention decrement is believed to reflect infants' acquisition of stimulus information and is hypothesized to involve the construction of a mental representation of the stimulus and

the subsequent comparison of successive stimulation with that representation (4, 5). Greater habituation decrement, given equivalent stimulus exposure, is interpreted as more efficient habituation. In the home, babies were observed in naturalistic interactions with their mothers. Observers followed a standard frequency time-sampling procedure over 1-min intervals for a typical half-hour of the baby's home routine (6). Thus during 30 s of each min, observers tallied the occurrence or nonoccurrence of several selected infant and maternal activities. Specifically, observers recorded when mothers didactically, physically or verbally, encouraged their infants' attention to properties, objects, and events in the environment—to illustrate, maternal encouraging attention included handing the baby a toy, pointing to a picture, or naming an object. At 1 year, observers returned to record home activities of the mothers and their children, focusing on productive vocabulary development in the toddlers and again on maternal didactics (7).† At 4 years, children were tested both on the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) (8) and on a nonverbal discrimination-learning task (9). At each observation, mothers completed questionnaires concerning their own educational attainment and socioeconomic status, as well as their children's physical, cognitive, and social development. Observations of mothers and children and the administration of tasks and tests were always conducted by experimentally blind, reliable, trained personnel.

Table 1 provides the zero-order correlations among key variables measured over these three formative time periods in early childhood. Maternal education and familial socioeconomic status were not significant factors in these comparisons.

Three sets of results are noteworthy. First, habituation performance—i.e., information processing—in early infancy was a moderately good predictor of toddlers' productive vocabulary size over the short term and children's intelligence test performance over the long term. The 4-month infants who habituated more efficiently by showing greater decrement in attention tended to possess larger expressive vocabularies at 1 year and to score higher on the standardized intelligence test at 4 years.

Two cross-validation studies with different samples have confirmed this predictive finding. In one exact replication with 10 children, habituation efficiency at 4 months correlated with productive vocabulary size at 1 year ( $r = 0.66$ ,  $P < 0.025$ ). In a second study with 18 children, habituation efficiency at 5 months correlated with children's performance

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Abbreviation: WPPSI, Wechsler Preschool and Primary Scale of Intelligence.

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†Independent records of infant word use correlated with maternal reports ( $r = 0.47$ ,  $P < 0.05$ ).

Table 1. Zero-order correlations among variables assessed to predict cognitive development between infancy and childhood

Variable	Variable				
	1	2	3	4	5
1. 4-month infant habituation	—				
2. 4-month maternal encouraging attention	0.55*	—			
3. 1-year toddler productive vocabulary	0.56*	0.61*	—		
4. 1-year maternal encouraging attention	0.67*	0.43	0.24	—	
5. 4-year child intelligence	0.54*	0.51 <sup>†</sup>	0.19	0.36	—

\* $P < 0.025$ .<sup>†</sup> $P < 0.05$ .

on the Reynell (10) Developmental Language Scales at 2 years ( $r = 0.55$ ,  $P < 0.01$ ).<sup>‡</sup>

The second noteworthy result of the main longitudinal study is that the amount of maternal encouragement given to young infants to attend to properties, objects, and events in the environment—i.e., caretaker didactics—was a moderately good predictor of toddlers' language development over the short term as well as children's intellectual attainment over the long term. The 4-month infants whose mothers prompted them more consistently tended to possess larger expressive vocabularies at 1 year and to score higher on the WPPSI at 4 years. Interindividual variability and intraindividual consistency apparently characterize many maternal activities. Some mothers stimulate their infants often, and some mothers respond more efficiently and in ways more sensitive to their infants' needs, but, whatever the activity, a mother's style seems to be reasonably stable during the course of her offspring's earliest development.

Two cross-validation studies with different samples have confirmed and further refined the role that specific didactic stimulation may play in fostering children's intellectual development. The first study replicated the original longitudinal observation with a sample of 10 twin pairs and their mothers. Twins constitute a natural experiment in which the economics of didactics (among other things) is taxed through necessary maternal time sharing. At 4 months and at 1 year, mothers of twins stimulated each of their infants at less than half the rate that mothers of singletons in the original longitudinal study stimulated their infants ( $t = 2.88$  and  $2.08$ ,  $P < 0.05$ ); at 1 year, the twins possessed less than half the productive vocabulary of singletons ( $t = 2.18$ ,  $P < 0.05$ ), and at 4 years, the twins scored lower on the WPPSI ( $t = 6.00$ ,  $P < 0.01$ ). Twins are widely acknowledged to perform consistently less well than singletons on mass-scale international psychometric assessments of language development, verbal reasoning, and intelligence (11), except perhaps when they are reared as singletons (12). Amidst the plethora of biological and experiential factors that eventuate in this twin disadvantage, these data suggest that twins' relative deprivation in maternal didactics may play a contributory role (13). The second study observed 23 mothers concurrently with their 13-month children and employed refined categories of maternal didactics. At this age, mothers encouraging their toddlers' to attend to a new property, object, or event in the environment, as opposed to elaborating on whatever was already under the child's purview, correlated with the child's

developing verbal comprehension as measured by the Reynell scales ( $r = 0.67$ ,  $P < 0.01$ ).

Cumulatively, the results of these studies suggest some important ways by which infants and their caretakers jointly contribute to children's eventual cognitive achievements. An unrestricted path analysis (14) of data from the main longitudinal study illustrates this point (Fig. 1). In this model, the infant information-processing capacity measured at 4 months postpartum constitutes the strongest single influence on intelligence test scores at 4 years, with a  $\beta$  weight of 0.58. General maternal didactic activity with young infants shows nearly equivalent and independent predictive power, with a  $\beta$  weight of 0.48. Together these two 4-month variables compose the major direct causal influences in the model.<sup>§</sup> By contrast, the 1-year measures behave like suppressors, whose zero-order correlations with the 4-month predictors are high but with the 4-year criterion low (15); it may be that general encouraging of attention is of relatively less practical significance in later infancy. Clearly, deploying different caretaker strategies, solicitous versus didactic for example, at different times in infancy may influence different outcomes.

This analysis illuminates two direct influences, from infant and mother, on children's developing cognitive competences over the long term. In addition to these patterns, it is important to underscore a third main conclusion, that the infant and mother also mutually influence one another during development through their continuing transactions. For example, a significant concurrent association obtains between infant habituation and maternal encouraging attention at 4 months, or, more clearly, infant attention style at 4 months influences maternal didactics measured 8 months later.

The findings in this paper suggest that specific information-processing skills and experiences assessed in the same sample of infants in the first 6 months of life contribute, both independently and in mutual interaction, to young children's performance on standard psychometric measures of intelligence and language proficiency (16). In recent years, the literature in developmental psychology has progressed toward increased specification and operationalization of interactional activities that may effectively promote cognitive development (17, 18). This report continues that tradition in its efforts to identify didactic strategies that meaningfully and efficaciously facilitate mental growth in children at different ages. Perhaps the determination of effective early experience will help to explain why otherwise disadvantaged infants adopted into advantaged families before their 6-month birthday score higher on tests of intelligence and achieve better in school than do children adopted after infancy (19); perhaps, too, caretaker activities such as those that are the focus of this report will help to explain the general well-known association between maternal intelligence and the

<sup>‡</sup>Habituation efficiency was measured in terms of the mean of the infant's first two looks (baseline), the percent decline from baseline to a criterion of two successive looks each less than 50% of baseline, and the slope of the linear regression of that decline; at 2 years, language was measured both by expression and by comprehension subscales of the Reynell scales. Strength of association between the three 5-month variables and the two 2-year variables was then evaluated through structural modeling in a simultaneous latent variable solution. Each variable satisfied requirements of this structural modeling equation, absolute factor loadings = 0.54–0.96.

<sup>§</sup>This model was evaluated for goodness-of-fit by  $\chi^2$  analysis, whose obtained value,  $\chi^2(1) = 0.98$ ,  $P = 0.32$ , indicated an adequate fit to the observed data.

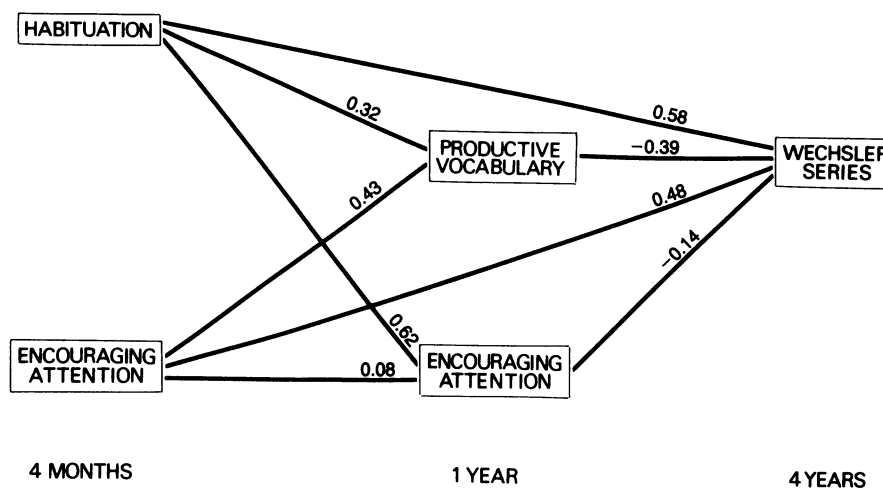


FIG. 1. Unrestricted path model (and  $\beta$  weights) among variables assessed to predict cognitive development between infancy and childhood.

intelligence of adopted children (20, 21). In this light, further exploration into caretaker activities with babies promises to illuminate causal mechanisms of early cognitive growth and to enhance early remediation efforts with infants born at risk for developmental delay.

Notwithstanding the strength of observed relations in these experiments, the specific infant and maternal associations studied here may represent only the lower bounds of actual longitudinal prediction, since imprecise measurement attenuates correlation. More sensitive and sophisticated measures of infant abilities and maternal activities will doubtlessly enhance future assessments of predictive validity. Following standard psychometric theory, for example, it is possible, albeit with extreme caution, to estimate true predictive relations among these pairs of constructs by correcting for attenuation of reliability (22). Given observed quantitative reliabilities of habituation (16) and of maternal didactics in infancy and of the WPPSI at 4 years (8), the resultant attenuation-corrected 4-year correlations to IQ for both infant habituation and maternal didactics showed significant increments in predictive power. Further, the kinds of intelligence assessed here as outcomes are admittedly circumscribed (23, 24), but they are of recognized cultural value for their associations with literacy, communication, academic achievement, and social attunement. By contrast neither infant nor maternal variables predicted children's discrimination learning at 4 years, although WPPSI scores and discrimination-learning rate in childhood intercorrelated ( $r = -0.48$ ,  $P < 0.05$ ). Habituation and maternal didactics in infancy seem therefore to link to verbal intelligence in particular, rather than to predict children's general problem-solving abilities.

Anatole France once characterized infants as *génies méconnus*. These findings document significant continuity in mental development beginning in infancy and extending into early childhood. Further, they open to question the origins, causes, and mechanisms by which individual differences arise in infant information processing and in adult caretaking. The present data do not imply that infant capacity or caretaker style fix cognitive ability over the lifespan; these studies have only examined infancy through early childhood. Many factors undoubtedly contribute to the growth of intelligence in childhood, just as many developments after childhood account for large proportions of the variance in mature intelligence. The present data do not support advocacy that one or another infant measure or caretaker activity determines cognitive growth in the child, rather, these studies are intended to stimulate new investigations aimed at defining with greater precision meaningful developmental transactions between infant cognitive abilities and the timing and

styles of adult caretaking. How children fare in terms of their mental growth is informed by their abilities in complex continuing interplay with the early experiences they provoke and those they encounter. Infancy is a starting point of life. This research signifies that infancy constitutes one of life's critical setting points as well.

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