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BREAST FEEDING AND CHILDREN'S INTELLIGENCE[1]

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Summary.—Breast feeding was reported in 1992 by Lucas, *et al.* to provide advantages for the development of intelligence in children of low birth weight, possibly through nutrients or other biological factors found in human breast milk but not cow's milk. Research on breast feeding and intelligence in children of normal birth weight has yielded mixed results, probably because measurement of environmental influences has not been thorough and the range of intelligence components measured has been limited. Our research with 204 3-year-old children of normal birth weight included control measures for the environment and maternal intelligence (Hollingshead socioeconomic status, Home Observation for the Measured Environment, Shipley) and two measures of childhood intelligence (Stanford-Binet Fourth Edition and Peabody Picture Vocabulary Test–Revised). Controlling for environmental variables and maternal intelligence, initiation of breast feeding predicted scores on intelligence tests at age three. Breast feeding was associated with 4.6-point higher mean in children's intelligence.

The possibility that mother's milk may provide infants with nutrients or other factors which foster intellectual development has been considered for many years. The report by Lucas, Morley, Cole, Lister, and Leeson-Payne (1992) of an association between breast milk and intelligence in premature infants has refueled interest. Interpretation of such an association is complicated because a mother's choice to feed her infant breast milk is highly associated with social class. In the United States, women who choose breast feeding are more likely to be of higher socioeconomic status and to engage in healthier behaviors (Pollock, 1989). Researchers typically have controlled for social class as indicated by parental occupational status or education (Pollock, 1994; Rodgers, 1978; Taylor & Wadsworth, 1984) and report significant differences between breast-fed and nonbreast-fed children on measures of intelligence. Morley, Cole, Power, and Lucas (1988) found similar differences for a sample of low birth weight at 18 months, and Morrow-Tlucak, Haude, and Ernhart (1988) reported significant correlations of breast feed-

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ing with Bayley scores at ages one and two. However, Silva, Buckfield, and Spears (1978) studied infants of normal birth weight with a broader range of environmental controls than other researchers and did not find significant advantages for breast milk. A subsequent study by Ferguson, Beautrais, and Silva (1982) of children ages 5 and 7 yielded significant differences in intelligence between breast- and bottle-fed children measured at age 5 with the Stanford-Binet and at age 7 with the Wechsler Intelligence Scale for Children (Ferguson, Beautrais, & Silva, 1982). The report by Lucas, *et al.* (1992) has been criticized for not taking into account the genetics of intelligence by using parental intelligence as a control variable (Houghton, 1992; Wright & Deary, 1992).

Our research on breast feeding and intelligence differs from prior work by providing a more complete assessment of environmental influences and a measure of maternal intelligence and by using a wider range of measures of childhood intelligence.

METHOD

Subjects

Children were participants in a longitudinal study of cognition and language in normal children from birth to age 3. Families were recruited for the study at the time of the child's birth; they lived on Galveston Island or in Galveston County communities within a 30-mile radius. Exclusion criteria for the sample included birthweight under 2.5 kg, prematurity, Apgar score under 6, bilirubin over 15, or need for intensive neonatal care. To facilitate comparison with prior research children of Euro-American families only were selected ($N=211$). The number of children available for some analyses was slightly smaller than for others because some children did not complete all intelligence subtests. Background characteristics of the subjects are shown in Table 1. As may be seen, the sample was quite heterogeneous and, compared with data collected for other purposes, was representative of Euro-American families with infants in the Galveston, Texas area.

This research was approved by Institutional Review Boards at the Uni-

TABLE 1
MEANS, STANDARD DEVIATIONS, AND RANGES FOR CHARACTERISTICS OF SAMPLE

Score	*M*	*SD*	Range
Socioeconomic Status	42.3	12.2	12–66
Home	41.0	3.6	17–45
Shipley	102.3	10.7	55–120
Child Intelligence			
Stanford-Binet IV Composite	105.0	11.7	73–135
Peabody Picture Vocabulary Test–Revised	98 5	15.6	59–127

versity of Texas Medical Branch–Galveston and the University of Houston. Informed consent was obtained from all parents.

Procedure

Information on breast feeding was gathered shortly after the infant's birth and biweekly thereafter for two years. Trained technicians entered the home and inquired about infant feeding, among other things. A checklist was used to record type of feeding: exclusive breast feeding, breast feeding mixed with formula or other foods, or formula feeding. These data were likely to be quite reliable because the frequent home visits minimized the likelihood of mothers' memory lapses and allowed mothers and technicians to form close relationships. When subjects were two years of age, data on background environmental information were collected and maternal intelligence was assessed in the home.

Children were tested for intelligence within 4 weeks of their third birthday in a single session at the Department of Pediatrics, University of Texas Medical Branch, Galveston, Texas. The examiners were three female graduate students in psychology who were specially trained to administer the intelligence tests and were blind to the subjects' infant-feeding status. Children were tested only when they were judged by the examiners to be comfortable in the testing situation. Mothers were not present but were nearby during the assessment.

Measurements

Intelligence.—The Stanford-Binet Fourth Edition scores were the Composite, Verbal Comprehension Factor, Nonverbal Reasoning/Visualization Factor, and eight subtests of Vocabulary, Comprehension, Absurdities, Pattern Analysis, Copying, Quantitative, Memory for Sentences, and Bead Memory (Thorndike, Hagen, & Sattler, 1986). The Peabody Picture Vocabulary Test–Revised (PPVTR), a measure of receptive vocabulary knowledge, has a single score (Dunn & Dunn, 1981). The Shipley Institute of Living Scales was used to measure intelligence of the mother. The Total score was converted to Wechsler Adult Intelligence Scale equivalent scores (Zachary, 1987).

Environmental measures.—Socioeconomic status of the family was estimated with the Hollingshead Four-factor Index of Social Status. This measure is based on the mothers' and fathers' years of education and occupational ranking (Hollingshead, 1975). Home Observation of the Measured Environment (HOME) combines observation of the home environment with interview questions about the home and assesses how educationally stimulating is the home environment. We used the three factor scores of HOME which reflect the quality of maternal affect: Responsiveness, Absence of Punishment, and Involvement (Caldwell & Bradley, 1984).

Infant feeding.—The dates of the start and cessation of breast feeding, formula feeding, and feeding of other foods were recorded at regular home visits. A dichotomous variable "initiation of breast feeding" was created and coded "yes" for mothers who breast fed for any length of time. The "duration of breast feeding" variable was continuous and reflected breast feeding of any length of time regardless of whether it was combined with or exclusive of formula and other foods. A second continuous variable was created for breast feeding exclusive of formula or other foods ("duration of breast feeding alone"). The value of zero was entered for infants who were never breast fed.

Results

The purpose of the analysis was to estimate the relation of initiation or duration of breast feeding to intelligence while controlling for a number of potential confounding variables including socioeconomic status, HOME scores, mother's intelligence, mother's smoking behavior, and gender, and birth order of the child. First, a model including the control variables predicting the measures of cognitive ability was analyzed. Then, whether the mother breast fed her infant was added to the model to see if it added significantly to the prediction of the cognitive variables. Thirdly, duration of breast feeding was added to the control variables to see if it added more or less than whether the mother breast fed at all. Finally, the duration of breast feeding alone (subtracting the time the mother both breast and bottle fed) was used.

An issue for this analysis was what to do about duration of breast feeding for mothers who did not breast feed. If these mothers' data are omitted, the sample size of reduced and the power of the test is reduced. In addition, a direct comparison of breast feeding versus duration cannot be made and, thus, it does not give an adequate test of whether duration of breast feeding is important. We decided that this comparison was most important to answering our research question. Thus, when duration of breast feeding or duration of breast feeding alone was used, mothers who never breast fed were given a value of zero. While this makes the distribution of breast feeding durations even more skewed, in a fixed-effects model there are no distributional assumptions for the predictor variables.

Of the 204 Euro-American mothers for whose children data on IQ were available, 159 reported breast feeding for any length of time. The range of duration was from 3 days to 42 months with an average duration of 7.1 months. The data were positively skewed with a median duration of 4 mo. and a semi-interquartile (SIQR) range of 3.75 mo. When all mothers were included, specifying a duration of zero for mothers who never breast fed, the mean duration was 5.0 mo., with a standard deviation of 6.8 mo. ($Mdn = 2$, SIQR = 3.1).

Table 2 gives the sample sizes for each variable in the analysis with R^2 for each of the original models, the first consisting of control variables only, the second adding whether the mothers breast fed to the control variables, the third adding duration of breast feeding to the control variables, and the fourth adding duration of breast feeding alone to the controls. As can be seen from the table, the control variables predicted from 8% to 27% of the variability in the cognitive scores with the greatest prediction for the Peabody Vocabulary Test, the Composite IQ, and the Verbal Comprehension factor. The biggest predictor tended to be socioeconomic status, followed by mother's IQ for most of the variables.

TABLE 2
VARIANCE IN CHILDREN'S INTELLIGENCE ACCOUNTED FOR (R^2) BY CONTROL VARIABLES‡

Intelligence Measure	N	Model				
		1	2	3	4	5
Stanford-Binet IV Composite	195	.24	.26*	.25	.25	.27*
Verbal Comprehension Factor	195	.23	.26*	.24	.23	.27†
Nonverbal Reasoning/Visualization Factor	195	.18	.19	.19	.19	.20
Vocabulary	193	.22	.24*	.23*	.23	.25*
Comprehension	193	.20	.21*	.20	.20	.22*
Absurdities	172	.23	.27*	.24	.23	.27†
Sentence Memory	181	.12	.13*	.12	.12	.15*
Pattern Analysis	190	.13	.14	.14	.14	.14
Copying	180	.08	.09	.09	.09	.10
Bead Memory	179	.13	.13	.13	.13	.13
Quantitative	165	.17	.17	.18	.18	.18
Peabody Picture Vocabulary Test–Revised	190	.27	.29*	.28	.28	.28

‡Control variables: (1), Control Plus Breast Feeding (2), Control Plus Duration of Breast Feeding (3), Control Plus Duration of Breast Feeding Alone (4), and Control Plus Duration and Duration Squared (5).
*$p < .05$. †$p < .01$.

Table 2 shows that breast feeding added significantly to the prediction of the Composite IQ, Verbal Comprehension factor, Vocabulary, Absurdities, Memory for Sentences, and Peabody Picture Vocabulary Test–Revised. The relations were positive, that is, initiation of breast feeding was associated with higher scores on these cognitive measures. On the Stanford-Binet Composite IQ breast-fed children had a mean score of 100.1 and nonbreast-fed children had a mean score of 95.1 (95% confidence interval: 0.3–9.5). Comparable Peabody means were 106.3 and 101.7 (95% confidence interval: 0.7–8.5). However, duration of breast feeding only added significantly to the prediction of Vocabulary scores and the duration of breast feeding alone did not add significantly to any of the measures.

Thus, while initiation of breast feeding is positively related to cognitive variables, the duration of breast feeding, for the most part, is not. This sug-

gests that the relation of duration of breast feeding to intelligence must have a more complicated relation. For this reason, we chose to include a quadratic term for duration of the model. This analysis yielded a significant improvement in prediction for the Composite IQ, the Verbal Comprehension factor, Vocabulary, Comprehension, Absurdities, and Memory for Sentences. The nature of the relation is reflected in the parameter estimates for the squared term which were negative. This indicates that as the duration of breast feeding increases, the magnitude of the relation decreases. This would reflect a model of gradually diminishing returns. After 18 months or so of breast feeding, further increases in duration have little additional relation.

To place these results into perspective, it might be helpful to consider effect sizes. Initiation of breast feeding increased the R^2 for the Composite IQ by 2%, which does not sound like a great deal; however, the group of children who were breast fed would be predicted to have IQs 4.6 points higher than those who were not. In addition, initiation of breast feeding contributed more to the predictability of the Composite IQ than any of the other variables except socioeconomic status, which contributed 8% unique variance above and beyond the other variables. Adding mother's intelligence to the equation accounted for 2% of the predictive variance. When the quadratic model for curvature was fitted, duration predicted in excess of 3% of the variance. The model would predict that children who were breast fed for 10 mo. would have IQs approximately 5 points higher than those who were not breast fed.

Discussion

Lucas, *et al.* (1992) have reported substantial enhancement of intelligence (8.3 points) for children of low birth weight who were fed human milk. Four other studies using several environmental controls have found higher intelligence in children of normal birth weight who were breast fed (Ferguson, *et al.*, 1982; Pollock, 1994; Rodgers, 1978; Taylor & Wadsworth, 1984), but one controlled study (Silva, *et al.*, 1978) did not confirm those results. Our results are in accord with those of Pollock (1989), Rodgers (1978), Ferguson, *et al.* (1982) Taylor and Wadsworth (1984) and in suggesting that the intelligence of full-term infants also benefits from breast feeding, not only that of infants low in birth weight, as suggested by Lucas, *et al.* (1992). Children in our sample who were breast fed scored higher on intelligence than those fed formula: 4.6 points on the Stanford-Binet IV and 7.3 points on the Peabody Picture Vocabulary Test–Revised.

Maternal intelligence was a significant predictor of child intelligence over and above socioeconomic status on the Stanford-Binet IV Vocabulary subtest, the two factor scores, the Composite IQ, and the Peabody vocabulary score. This result suggests that the critics of the study by Lucas, *et al.*

(1992) may have a valid point and that parental intelligence should be included in analyses of breast-feeding effects. For a full evaluation of possible genetic effects, we should, of course, have also had an intelligence score for fathers. It should also be noted that the maternal intelligence score reflects both environmental and genetic factors, since the mother's intelligence undoubtedly influences her management of her child's environment.

The significant findings in our study were for verbal measures of intelligence. This was also the case in Pollock's (1994) research, but Taylor and Wadsworth (1984) found a nonverbal measure, copying, was also significantly related, albeit at a lower level than their verbal measure. These results, which emphasize effects for verbal more than nonverbal measures, raise questions about sources of the influence. One question is whether breast feeding might enhance the social interaction of mother and infant and set in motion a series of interactions such as more conversations which have positive influences on a child's intelligence. Our data do not permit a direct investigation of that possibility.

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