Research support. The National Heart, Lung, and Blood Institute supports the entire spectrum of research on hypertension. Research activities can be divided roughly into three areas: knowledge acquisition, knowledge validation, and knowledge transfer.

Acquisition embraces basic and applied research. Validation attempts to provide persuasive, if not conclusive, evidence regarding an hypothesis. And transfer includes demonstration and education.

Generally, NHLBI allocates 85 percent of its budget for acquisition, 10 percent for validation, and 5 percent for transfer. In the case of hypertension, however, 15 percent is allocated for transfer. All blood pressure activities in Fiscal Year 1983 totalled $73.8 million. In FY 1985 that was expected to increase by $10 million.

One example of a major research effort is a long-term clinical trial of systolic hypertension control in the elderly being conducted jointly by NHLBI and the National Institute on Aging. Encouraged by a pilot study, these agencies have made awards to 17 clinical centers throughout the United States and one coordinating center. The trial will determine the morbidity and mortality benefits of lowering isolated systolic hypertension in the elderly.

While the cause of 95 percent of the cases of hypertension remains unknown, data regarding cardiac, nervous system, renal, humoral, genetic, and environmental factors are growing. There is increased knowledge of the roles of the autonomic nervous system, the central nervous system, the renin angiotension system, and vascular smooth muscle and cell membranes in the regulation of blood pressure.

This increased understanding is reflected in the many and continuing advances in the development of antihypertensive agents that have played a major role in the successful effort to control blood pressure. This area of basic research is not often considered prevention, and yet the ultimate prevention of hypertension most likely will be found in this area of investigation.

References

1. The public and high blood pressure: a survey. DHEW Publication No. 77-356, Washington, DC, 1973.
2. The public and high blood pressure: a six-year follow-up survey of public knowledge and reported behavior. DHHS Publication No. (NIH) 81-2118, Washington, DC, 1981.
3. Admire, J. B., Roccella, E. J., and Haines, C. M.: Hypertension control: meeting the 1990 objectives for the nation. Public Health Rep 99: 300–309, May-June 1984.
4. The 1984 Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. Department of Health and Human Services, NIH Publication No. 84-1088, June 1984.
5. Moser, M., Rafter, J., and Gajewski, J.: Insurance premium reductions, a motivating factor in long term hypertensive treatment. JAMA, 251: 6, 765–757, Feb. 10, 1984.

Cognitive Measure Stability in Siblings Following Early Nutritional Supplementation

LOU E. HICKS, PhD
ROSE A. LANGHAM, DrPH

Dr. Hicks is a Psychologist and Dr. Langham was formerly Head Nutritionist with the Louisiana Department of Health and Human Resources, Office of Preventive and Public Health Services. Dr. Hicks is also a Research Affiliate at Tulane University.

This investigation was supported by the U.S. Department of Agriculture, Special Supplemental Food Program for Women, Infants, and Children. The data were analyzed at the Tulane University computer center.

Tearsheet requests to Dr. Hicks, Rm. 606, P.O. Box 60630, New Orleans, LA 70160.

Synopsis

Cognitive data were obtained on 19 of the 21 pairs of siblings who had been in the authors' earlier study of behavioral outcomes associated with participation in the Special Supplemental Food Program for Women, Infants, and Children (WIC). The timing of WIC participation differed for the members of the sibling pairs, beginning in the perinatal period for one sibling and after 1 year of age for the other. The perinatally supplemented siblings received WIC services for an average of 22 months longer than the siblings whose supplementation began at 1 year of age.

The present study determined that enhancements in IQ scores proved stable on blind retesting 32

months after the original study, with those siblings who were supplemented perinatally (and for a longer duration) continuing to exhibit higher scores. The group differences in school grade point averages were in the expected direction at followup, but fell short of statistical significance.

THE PRESENT INVESTIGATION SOUGHT to provide a longitudinal examination of the impact of a perinatal supplemental food program on cognitive functioning during later school years. The portion of the perinatal period during which supplementation occurred corresponded to the brain's growth spurt in the final trimester of pregnancy and a postnatal period of roughly 6–12 months (*1–5*). Brain development during this period includes rapid dendritic arborization, myelination, some neurogenesis, and elaboration of a capillary network.

The group of children we studied participated in the national Special Supplemental Food Program for Women, Infants, and Children (WIC). Available to low-income pregnant women and preschool-age children, WIC provides food supplements, nutritional counseling, and health monitoring. Infants under 1 year of age received iron-fortified formula, iron-fortified cereal, and vitamin C-rich fruit juice; 1–5-year-olds and pregnant women received milk, eggs, cheese, iron-fortified cereal, and vitamin C-rich juices.

Participants in the study sample all became eligible for WIC services in 1974, when WIC eligibility was based on population nutritional risk factors (*6*), not individual risk factors. However, all participants in the study group (*7*) met one or more of the individual risk criteria later developed as a basis for eligibility for the program (*6*). For children, these criteria included a history of anemia or low weight for height; criteria for pregnant women included frequent pregnancy, young or old maternal age, anemia, or high weight for height.

In our original study (*8*), we described significant behavioral differences between sibling pairs who differed in the timing and duration of their WIC participation. The group that received supplementation perinatally (the early supplement group) typically excelled in a variety of cognitive measures, compared with their siblings who received supplementation after 1 year of age (late supplement group). The sample size was modest; modest samples characterize the sibling control design (*9–11*). This design does, however, control fairly precisely for the host of familial variables known to be correlated with children's cognitive development, making it possible to detect reliable nutritional correlates even with small samples.

Because the cognitive differences reported in the original study (*8*) were striking and obtained from a supplemented group drawn from a population at nutritional risk rather than a clinically malnourished one, the report drew attention and spirited methodological debate (*7,8,12,13*). In our original study, some of the cognitive measures, including the IQ assessments, were not obtained blindly, and issues relating to score stability were unresolved. The present report describes blindly obtained cognitive data that permit an estimate of the stability of the major cognitive measures used in the original report.

Methods

Original study sample. The original sample (*8*) consisted of all located sibling pairs meeting study criteria who had participated in the WIC Program since it had been instituted in three rural Louisiana parishes (counties). A sibling pair was selected if both siblings in the potential sample had received WIC services, but one member was at least 1 year old when he or she began the supplemental feeding programs (late supplement). The paired and as yet unborn sibling began to receive supplements at least by the third trimester of pregnancy, continuing through at least the first year of life (early supplement).

Because no within-family exclusions were made when the program was instituted, the selection procedure introduced an age difference between the early and late supplement groups, with the late supplement sibling always the older member of the pair. Because age and birth-order differences were thereby introduced, an effort was made to minimize other sources of environmental variability by choosing only stable, rural parishes in Louisiana, where no new educational or stimulative programs had appeared to which the two siblings might have been differentially exposed. The only preschool program available at any of the sites was Head Start; equal numbers of children in both supplement groups had participated in this program.

Other requirements for pair selection were that there be an approximately 2-year separation between the members of the sibling pairs (to reduce variability in supplementation duration) and that both members of the pairs have some school experience. Only full siblings were included; twins were excluded. A total of 27 pairs in the three locales met all study criteria; 21 pairs could be located. All located children participated in the original study.

Followup sample. Of the 21 sibling pairs in the original study (*8*), 19 pairs were located at followup 32 months later; two pairs had moved out-of-State. The parents of all located children agreed to participate. The average age at followup of the early supplement group was 107.5 months, and for the late supplement group it was 138.5 months. Nineteen children were black males, 15 were black females, two were white males, and two were white females. There were 8 different-sex and 11 same-sex pairs.

The average duration of supplementation was 52.6 months (*SD*, 11.6) for the early supplement group and 30.47 months (*SD*, 10.6) for the late supplement group. The content, monthly amount, and sequence of the nutritional supplements were the same for the two groups.

No quantitative data are available to compare the health status of the mother during the pregnancies with the studied siblings, although it would be reasonable to expect (*14–16*) that third-trimester supplements might enhance her health. If so, the health enhancement is not reflected in different Apgar ratings for the two supplement groups; mean Apgar ratings at 1 and 5 minutes after birth for the supplement groups do not reliably differ. Average birth weights for the two groups were also similar—3,119.35 grams for the early supplement group and 3,064.07 grams for the late supplement group, a nonsignificant difference.

Data obtained at the time of the original study (*8*) from Mercer's Sociocultural Scales (*17*) indicated that the sample did not differ markedly from the U.S. low-income population except for urban acculturation scores, which were quite low. The families of about half of the participants had received welfare from Aid to Families with Dependent Children at one time or another. The average maternal education in the present followup sample was 10.9 years. None of these educational or sociocultural measures differ between the sibling supplement groups.

Information on parity (birth order) was obtained from birth certificates. In three pairs, the siblings were not of adjacent parity; in the remaining pairs, parity was adjacent. Average parity was 4.0 in the early supplement group and 2.6 in the late supplement group, with a parity range of 1–15. The sample contained 10 first-born (all late supplement), 11 second-born, and 8 third-son children, with the remainder of higher parity.

Cognitive measurement. Three psychologists administered the complete Wechsler Intelligence Scale for Children-Revised (WISC–R) (*18*) to each of the 38 children, using the child's school as the testing site. The psychologists were unfamiliar with the children's nutritional histories or with the study's hypotheses. Employed in the private sector and hired by contract, the psychologists were told they would be testing siblings, but not which sibling was expected to score higher or whether they were expected to score differently. The same psychologist assessed both siblings of a pair, usually on different days. Members of participating agency staff were cautioned against sharing the children's charts with the assessors. After the data were gathered, all testers stated that they had remained unaware of the hypothesis of the study. Staff from the agency executing the study obtained the children's school grades in reading, writing, and spelling. Each grade was converted to grade point averages (GPAs), with A = 4, B = 3, C = 2, D = 1, and F = 0 points.

Mercer's Sociocultural Scales (*17*), which had been administered to parents in the original study, were not readministered at the followup. Hence, the Estimated Learning Potential, a popular corrected estimate of intellectual level reported in the original study, could not be calculated.

Results and Discussion

The table presents the mean WISC–R scores and GPAs of the full sample of 42 siblings in the original study (*8*), the results from the original investigation of the 38 siblings who were located later for followup (original study results for followup sample), and the new data obtained 32 months later in the present followup. No significant differences were found in the means or standard deviations in any measures between the original study and its subsample (item 1 versus item 2 in the table).

Comparison of the data from the followup results (table item 3) with those of the original study subsample (item 2) indicates that trends in supplement group differences are generally replicated at followup. However, the contrast between the GPAs of the two nutritional supplement groups at followup is not now significant ($F = 3.68$). The contrasts between the three summary IQ scores remain significant at followup, indicating that stable cognitive differences continue to exist between the two nutritional supplement groups under blind assessment conditions. The F-test results for the Verbal, Performance, and Full-Scale IQ supplement group contrasts at followup are 6.23, 5.90, and 7.56, respectively. When raw data were examined for the

Cognitive achievement of early and late supplement groups in original and followup assessments of siblings given nutritional supplementation through the WIC Program

		Wechsler Intelligence Scale for Children-Revised											
		Verbal IQ			*Performance IQ*			*Full-scale IQ*[1]			*GPA*[2,3]		
Study group	*Number, sibling pairs*	*F test P level*	*Mean*	*SD*	*F test P level*	*Mean*	*SD*	*F test P level*	*Mean*	*SD*	*F test P level*	*Mean*	*SD*
1. Original study (*8*):													
Early supplement	21	0.00002	89.9	9.2	0.002	85.1	8.3	0.00002	86.4	7.3	0.0006	2.6	0.9
Late supplement	21		76.0	11.5		74.8	11.5		73.4	11.9		1.7	1.2
2. Original study results for followup sample:													
Early supplement	19	0.001	90.2	9.7	0.004	85.4	8.7	0.0004	87.3	7.6	0.010	2.7	1.0
Late supplement	19		78.1	11.1		75.2	11.4		74.8	11.5		1.7	1.2
3. Followup results:													
Early supplement	19	0.017	88.5	8.7	0.020	88.8	8.7	0.009	87.8	8.5	[4]0.063	2.5	0.8
Late supplement	19		79.7	11.6		80.4	12.4		78.5	12.0		2.0	0.9

[1]Verbal, Performance, and Full-scale IQ scores are separately scaled; the last is not the average of the first two scores.
[2]Age-matched grade point average.
[3]For the original study and original results of followup sample results, grade point average means are based on grades from the first 3 years of school.
[4]Not significant.

sibling pairs, the early supplement member displayed the higher IQ in 17 of the 19 comparisons.

The pattern of group differences on the 10 subtests of the WISC–R was examined. Group differences were generally somewhat larger on the verbal-area subtests than the performance-area subtests, as suggested by the means in the table. The early supplement group was consistently superior on all 10 subtests; the subtest in the performance area in which the groups had performed similarly in the original study (*8*, p. 1113) no longer yielded similar performance. The average performance of the early supplement group was consistently superior to that of the late supplement group on all cognitive factors tapped by the WISC–R.

When interpreting this apparent cognitive difference between the two supplement groups, one must consider possible correlates that might selectively influence one of the two groups to produce the IQ differences. The most obvious candidates for such consideration are the age and parity differences between the two supplement groups. Generally, the research reports relating parity or age to ability measures have indicated that, except for only children, early-born children or older children score slightly higher on ability measures, on the average, than later born or younger children (*19–26*). The effect is a joint function of parity and family size; the relationship is slight, but now fairly reliably established: if IQ correlates to parity, it tends to correlate negatively.

The present results are a reversal of this typical finding. Here, as in the original study (*8*), higher parity, younger (early supplement) children score significantly higher on the IQ test than their lower parity, older (late supplement) siblings. Thus, age or parity differences between the supplement groups would not seem to be an adequate explanation for the significantly different WISC–R scores for the two supplement groups, either in the original study or the followup.

It should, however, be emphasized that occasional sources of evidence have reported (*27–29*) that the usual relationship between parity or age and IQ is obscured and even reversed in extremely poor environments. To take account of this phenomenon, the "cumulative deficit" hypothesis was developed. It proposes that the usual parity and age effects hold only for beneficent environments and that a reversed relationship of parity and age to IQ is to be expected with sustained exposure to deprived environments.

The hypothesis, as formulated by Jensen (*30*), has descriptive and explanatory portions. First, the occasionally noted increasing test score decrements over time of disadvantaged groups compared with advantaged groups are described. Second, the hypothesis seeks to explain any cumulative decrement in terms of the cumulative effects of a deprived environment. It is primarily the second portion of the hypothesis that is relevant to our present discussion.

The hypothesis has sometimes been supported (*30,31*) and sometimes not (*32–35*). Jensen (*30–31*) did obtain some evidence of a small cumulative deficit in his methodologically sound investigations employing sibling comparisons in deprived and less deprived school children. Therefore, it is important to consider the possibility that the results of the present sibling control study could be explained in terms of an environmental deficit suffered for a longer period by the older, late supplement siblings, rather than a specific perinatal nutritional deficit.

The present followup investigation was designed (*7*) in part to investigate the cumulative deficit hypothesis as an alternative explanation (*12*) to the nutritional enhancement interpretation offered to explain the results of the original investigation (*8*). If environmental deprivation operated over time to produce a cumulative development lag so that older siblings score below younger siblings, then an added time interval would magnify this discrepancy. Examination of the table indicates, however, that the followup study revealed a reduced discrepancy between the two supplement (age) groups, not a magnified difference; the 13-point group difference in a Full-scale WISC–R scores in the original study became a 9.3-point difference in the pairs located at followup. Further, if the same 19 pairs of siblings are followed from the original study to the present followup, both groups actually increased their Full-scale WISC–R scores over time. The early supplement group's score increased by 0.5 point, and the late supplement group's score increased by 3.7 points; neither group decreased over time. Thus, it seems reasonably clear that age or birth-order correlates, from either deprived or nondeprived populations, are inadequate explanations for the present data.

Data from the original study subsample and the followup assessments were compared to check the possibility that the score changes over time were actually significant. Duncan's Multiple Range Tests indicated that the differences between the original study subsample and followup assessments were not statistically significant for Verbal, Performance, or Full-scale IQs within the early or late supplement group. The only significant contrasts were those between the two supplement groups at each of the two assessment times.

Although the IQ scores did not change appreciably over the 32-month interval between assessments, one might consider the processes that may have led to the consistent trend, over time, toward reduction of the contrast between nutritional groups on each of the cognitive measures. Several distinct possibilities should be noted. First, it is certain that the convergence of the means of the two supplement groups over time represents, at least in part, simple statistical regression to the mean. Any study like the present one that uses two imperfectly correlated variables (IQ and supplement group) will, of mathematical necessity, display regression toward the population mean if cases are studied that are extreme on one of the variables (*36,37*). In the present instance, both supplement groups have IQ scores that are distinctly below national and ethnic group norms. Regression effects are indicated by regression toward the population norms on the second testing occasion.

Cohen and Cohen (*36*, pp. 45–46) observed "Because regression toward the mean always occurs in the presence of a nonperfect linear relationship, it is observed when the variables consist of the same market taken at two points in time. In this circumstance, the extreme cases at Time 1 subsample will be less extreme at Time 2." The present followup data exhibit this expected regression effect: the late supplement group, which had the more extremely low WISC–R values at the time of the original study subsample, is the group that shows the larger score increase at followup, attenuating the supplement group difference at followup. It is possible that these regression effects obliterated the potential cumulative deficit effects previously discussed, as well as attenuating followup supplement group differences.

The fact that regression effects are displayed in a data set is not evidence of a methodological flaw; such effects inevitably appear when repeated measures are taken on imperfectly correlated variables, in which some scores were extreme on the first measurement occasion (*36–38*). To avoid regression effects, one would be required to avoid many areas of scientific investigation. Statisticians do, however, counsel that caution be used when making substantive interpretations about posited operative factors when such factors would have operated in the same direction (here, score convergence at followup) as the regression effect (*37–38*).

One may then cautiously note two substantive factors that might have operated in the present data set, along with regression effects, to produce some score convergence over time. It is possible that the greater objectivity of blind assessments at the present followup, as opposed to the original study, contributes to the phenomenon. There is further possibility that the adverse effects correlated with perinatal nutritional risk diminish somewhat over time, and other environmental stimuli assume greater importance. This finding has been previously reported (*39,40*).

The failure of the nutritional groups to display significant differences in GPA at followup is partly to be expected from regression of deviant GPAs at followup. A possible substantive factor that might also have operated is related to an educational tradition in elementary schools. As a child becomes older in Western cultures he is less likely to be retained in a grade as a result of failing grades because of a general belief that a child should be with his approximate age peers. There is evidence that this tendency operated here by the fact that of the 14 retentions-in-grade (5 in early supplement group, 9 in late supplement group), 8 occurred in the first grade. As the table indicates, the age-matched GPA comparisons in the original study and its subsample were made on the first grade data only, when failing grades were awarded more freely than in later years. The followup GPA data are based on 3 years of schooling, when teachers are more inclined to truncate the GPA scale by avoiding the lowest value. This truncation would inevitably tend to move the GPA means for the two supplement groups into greater proximity. One should, however, note that the trend of the GPA contrast that was reported in the original study is replicated in the table.

Having considered possible reasons for the reduction in magnitude of the nutritional group's differences at followup, one might consider the fact that the group differences in WISC–R IQ scores remain significant and stable despite inevitable regression effects. Because the study design required that supplement groups' differences counter the regression effect, the fact that these differences are nevertheless significant at followup suggests a stable, substantial correlate of early nutritional supplementation.

It is probably important that this study, like some other published studies (*39,41,42*), used a validated ability test as a measure of cognitive outcome rather than an early developmental test. As many authors have observed (*7,37,43–45*), early developmental measures of reflexes and sensorimotor alertness that can be given to infants and children under 2 years of age assess completely different behavioral factors than the measures of reasoning, abstraction, and problem solving that can be assessed in older children. Because these latter cognitive factors are tapped by IQ and other ability tests, early developmental tests correlate negligibly with IQ tests in school years and not at all with traditional adolescent and adult measures of ability (*37,43–45*). Because the outcome measures used in our study are qualitatively different from early developmental tests, comparisons with the many nutritional studies that used the latter measures must be made with great caution, if at all. This report provides additional support for the hypothesis that early nutritional supplementation facilitates cognitive development; the results are in concert with investigations (*39,41,42*) that used IQ or similar cognitive outcomes rather than early measures of sensorimotor development.

It has been posited that the critical variable was the timing of the nutritional supplementation, which coincided with the brain growth spurt for the early supplement group. The two groups also differ, however, in duration of supplementation, with the early group receiving supplements for an average of 22 months longer than the late group. Recent supplementation studies with clinically malnourished samples have suggested that duration of supplementation, rather than timing, is the critical factor related to cognitive performance. Waber and coworkers (*41*) detected this duration effect with cognitive measures. The association is statistically significant overall for the serial assessments of their supplemented groups, but appears to be strongest for the second and third year appraisals, when school-relevant complex cognitive skills begin to be measurable. It is possible that the cognitive differences detected in the present study derive from differences in supplement duration or timing or both. Associated components of the WIC Program, such as nutritional counseling and medical services, may also contribute to relationships with cognitive outcomes.

The association of preschool nutritional and medical intervention with enhancements in performance on standard ability measures should not be interpreted to discount the potential impact of social and educational intervention. Zeskind and Ramey (*39*) have reported that a supportive educational environment in early childhood tends to ameliorate the effects of poor early nutrition. Those children who were adequately nourished, however, profited far more from educational intervention than those with a history of poor perinatal nutrition. The present findings are compatible with those of Zeskind and Ramey and underline the need for precise investigations linking nutritional services with social and educational influences.

References

1. Dobbing, J., and Sands, J.: The quantitative growth and development of the human brain. Arch Dis Child 48: 757–767 (1973).
2. Cragg, B. G.: The development of cortical synapses during starvation in the rat. Brain 95: 143–150 (1972).

3. Balazs, R., Lewis, P. D., and Patel, A. J.: Nutritional deficiencies and brain development. *In* Human growth, neurobiology and nutrition—III, edited by F. Falkner and J. M. Tanner. Plenum, New York, 1979, pp. 415–511.
4. Davison, A. N.: The biochemistry of brain development and mental retardation. Br J Psychiatry 131: 565–574 (1977).
5. Dhopeshwarkar, G. A.: Nutrition and brain development. Plenum, New York, 1983.
6. Rush, D.: Is WIC worthwhile? [Editorial.] Am J Public Health 72: 1101–1103 (1982).
7. Hicks, L. E., Langham, R. A., and Takenaka, J.: Interpretation of behavioral findings in studies of nutritional supplementation. Different views. Am J Public Health 73: 695–697 (1983).
8. Hicks, L. E., Langham, R. A., and Takenaka, J.: Cognitive and health measures following early nutritional supplementation: a sibling study. Am J Public Health 72: 1110–1118 (1982).
9. Hertzig, M. F, Birch, H. G., Richardson, S. A., and Tizard, J.: Intellectual levels of school children severely malnourished during the first two years of life. Pediatrics 49: 814–824 (1972).
10. Birch, H. G., et al.: Relation of kwashiorkor in early childhood and intelligence at school age. Pediatrics Res 5: 579–585 (1971).
11. Evans, D. E., Moodie, A. D., and Hansen, J. D.: Kwashiorkor and intellectual development. S Afr Med J 45: 1413–1426 (1971).
12. Pollitt, E., and Lorimor, R.: Effects of WIC on cognitive development. Different views. Am J Public Health 73: 698–700 (1983).
13. Rush, D.: In response to Hicks et al. Different views. Am J Public Health 73: 700–701 (1983).
14. Edozien, J. C., Switzer, B. R., and Bryan, R. B.: Medical evaluations of the Special Supplemental Food Program for Women, Infants, and Children. Am J Clin Nutr 32: 677–692 (1979).
15. Kennedy, E. T., Gershoff, S., Reed, R., and Austin, J. E.: Evaluation of the effect of WIC supplemental feeding on birth weight. J Am Diet Assoc 80: 220–227 (1982).
16. Kotelchuck, M., Schwartz, J. B., Anderka, M. T., and Finison, K. S.: WIC participation and pregnancy outcomes: Massachusetts statewide evaluation project. Am J Public Health 74: 1086–1092 (1984).
17. Mercer, J. R.: System of multicultural pluralistic assessment technical manual. The Psychological Corporation, New York, 1979.
18. Wechsler, D.: Manual for the Wechsler Intelligence Scale for Children—Revised. The Psychological Corporation, New York, 1974.
19. Belmont, L., and Marolla, F. A.: Birth order, family size, and intelligence. Science 182: 1096–1101, Dec. 14, 1973.
20. Bradley, R. W.: Birth order and school-related behavior: a heuristic review. Psychol Bull 70: 45–51 (1968).
21. Breland, H. M.: Birth order, family size, and intelligence. Science 184: 114, Apr. 12, 1974.
22. Burton, C.: Birth order and intelligence. J Soc Psychol 76: 199–206 (1968).
23. Koch, H. L.: The relation of primary mental abilities in five- and six-year-olds to sex of child and characteristics of his siblings. Child Devel 25: 209 (1954).
24. Lunneborg, P. W.: Birth order, aptitude, and achievement. J Consult Clin Psychol 32: 101 (1968).
25. Record, R. G., McKeown, T., and Dewards, J. H.: The relation of measured intelligence to birth order and maternal age. Ann Hum Genet 33: 61–69 (1969).
26. Zajonc, R. B., and Markus, G. B.: Birth order and intellectual development. Psychol Rev 82: 74–88 (1975).
27. Garber, H. L.: Intervention in infancy: a development approach. *In* The mentally retarded and society: a social science perspective, edited by J. J. Begab and S. W. Richardson. University Park Press, Baltimore, 1975.
28. Gordon, H.: Mental and scholastic tests among retarded children. Education Pamphlet 44. H.S.M.O., Board of Education, London, 1923.
29. Wheeler, L. R.: A comparative study of the intelligence of East Tennessee mountain children. J Educ Psychol 33: 331–334 (1942).
30. Jensen, A. R.: Cumulative deficit: a testable hypothesis? Devel Psychol 10: 996–1019 (1974).
31. Jensen, A. R.: Cumulative deficit of blacks in the rural south. Devel Psychol 13: 184–191 (1977).
32. Coleman, J. S., et al.: Equality of educational opportunity. U.S. Office of Education, Washington, DC, 1966.
33. Harris, A. J., and Lovinger, R. J.: Longitudinal measures of the intelligence of disadvantaged negro adolescents. School Rev 76: 60–66 (1968).
34. Kennedy, W. A., Van De Riet, V., and White, J. C., Jr.: A normative sample of intelligence and achievement of negro elementary school children in the Southeastern United States. Monogr Soc Res Child Devel 28 (6), Serial No. 90, 1963.
35. Osborne, R. T.: Racial differences in mental growth and school achievement: a longitudinal study. Psychol Rep 7: 233–239 (1960).
36. Cohen, J., and Cohen, C.: Applied multiple regression/correlation analysis for the behavioral sciences. Ed. 2. Lawrence Erlbaum, Hillsdale, NJ, 1983.
37. Jensen, A. R.: Bias in mental testing. Macmillan Co., New York, 1980, ch. 7.
38. Webster, H., and Bereiter, C.: The reliability of changes measured by mental test scores. *In* Problems in measuring change, edited by C. W. Harris. University of Wisconsin Press, Madison, 1962.
39. Zeskind, P. S., and Ramey, C. T.: Preventing intellectual and interactional sequelae of fetal malnutrition: a longitudinal, transactional, and synergistic approach to development. Child Devel 52: 213–228 (1981).
40. Mora, J. O., et al.: Nutrition, health and social factors related to intellectual performance. World Rev Nutr Diet 19: 205–236 (1974).
41. Waber, D. P., et al.: Nutritional supplementation, maternal education, and cognitive development of infants at risk of malnutrition. Am J Clin Nutr 34: 807–813 (1981).
42. Balderston, J. B., et al.: Malnourished children of the rural poor. Auburn House, Boston 1981.
43. Bayley, N., and Schaefer, E. S.: Correlations of maternal and child behaviors with the development of mental abilities: data from the Berkeley Growth Study. Mongr Soc Res Child Devel 28 (6), Whole No. 97, 1964.
44. Cronbach, L. J.: Essentials of psychological testing. Ed. 3. Harper and Row, New York, 1970, pp. 257–266.
45. Goffeney, B., Henderson, N. B., and Butler, B. V.: Negro-white, male-female eight-month developmental scores compared with seven-year WISC and Bender test scores. Child Devel 42: 595–604 (1971).