Relations between Nutrition and Cognition In Rural Guatemala

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Abstract: The nutritional status of three and four year old children, as measured by height and head circumference, is related to cognitive performance in four rural Guatemalan villages. The relationships persist when social factors are taken into account.

Families in two of the villages participate in a voluntary, high protein-calorie supplementation program. In the other two villages, the families receive a vitamin and mineral supplement with about one-third of the calories. Although the longitudinal study still is ongoing, there is some evidence that the children who receive the higher calorie supplement (or whose mothers received it during pregnancy and lactation) are most likely to score high in cognitive performance. The results support other animal and human studies that report an association between nutrition and cognitive development. The findings, while not diminishing social environmental explanations of differences in cognitive function, suggest the worth of nutrition intervention programs in rural areas of lesser-developed countries. (Am. J. Public Health 67:233–239, 1977)

During the 1960s, a number of investigators studying children in various regions of the world reported an association between severe protein-calorie malnutrition and intellectual functioning.[1–5] Laboratory studies with animals in the 1960s and early 1970s also provided important findings of the profound effects of malnutrition on neurological development[6,7] and on learning patterns and other individual behaviors.[8,9] The demonstration of a linkage between severe protein-calorie malnourishment and cognitive performance of children, bolstered by the animal studies, received widespread attention since an estimated three per cent of the world's children experience one or more episodes of severe malnutrition before five years of age.[10]

In relation to the incidence of mild and moderate protein-calorie malnutrition, however, severe nutritional deficiencies are relatively unique events. It is estimated that fully one-half of the children in lesser developed nations are suffering from mild-to-moderate protein-calorie malnutrition,[11] as well as varying but critical numbers of children in low-income families in industrialized countries.[12] The finding that severe nutritional deficiencies of children appear to limit their mental development, when extrapolated to moderately and mildly malnourished children, has resulted in one of the important scientific and policy debates of the past decade. In part, the controversy centers around accepting a causal relationship on the basis of epidemiological data between measures of nutritional status and psychological test scores.[2,13] In part, it is the result of the efforts of well-intentioned policy makers and humanitarians who marshal all possible evidence to justify large-scale nutrition interventions.

The presumed causal link between malnutrition and intellectual development is challenged by the findings of numerous investigations of the influence of the social environment on the child's cognitive functioning. Evans and associates, for example, found that malnourished South African children and their healthier siblings *both* attain similar scores on cognitive tests.[5] The widely-known Coleman report as well as less ambitious but more rigorous investigations provide support for an association between aspects of the child's social environment and cognitive development.[14] Economically advantaged children obtain larger values on the anthropometric indicators commonly used to measure nutritional status. Thus, many have suggested the covariation between economic and nutritional indices accounts for the relation between mild malnutrition and poor cognitive functioning.[15]

The intentioned and unintentioned efforts of scientists and policy makers to downgrade the influence of either nutrition or the social milieu is understandable in terms of both the disciplinary orientations of investigators—biological and medical on the one hand, and social and psychological on the other—and the passions that come into play among policy makers competing for limited funds, particularly those provided by industrialized countries to less developed ones.

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By the mid-1960s, there was a widely acknowledged need to develop and implement investigations that took into account *both* nutritional and social determinants of cognitive development. The need to study both nutritional and social factors involves complex issues of conceptualization, design, and analysis. The number of variables that must be quantified and introduced into any reasonable design requires respectable sample sizes, extensive data collection and collation, and complex data analysis. Further, the immature state of the nutritional and behavioral sciences does not allow complete solutions to the major problems of method, including the operationalization and measurement of the several sets of key variables (see Klein, et al., for an expanded discussion of this point[15]).

The data reported here came from a long-term longitudinal investigation of nutrition and mental development being undertaken in Guatemala by the Institute of Nutrition of Central America and Panama (INCAP) and begun in 1968 (see McKay, et al. and Mora, et al. for discussions of related ongoing projects[16, 17]). The INCAP investigation, although still in its data collection phase, has resulted in a large number of papers on various substantive and methodological aspects of the project (see Klein, et al., for a recent review[18]). In a 1972 paper,[15] early data were reported that bear directly on the contributions of nutritional and social factors to cognitive functioning. The results of this analysis suggested that both domains of measures are related to cognitive development, and that the relative importance of nutritional and social factors depended on the particular cognitive dimension selected as the criterion variable; further, that the sex of the children must be taken into account. There were major sex differences in the amount of variance accounted for by the different social and nutritional measures included as independent variables. Given the limited robustness of the findings, the sample size at that time, and the inevitable methodological weaknesses of a complex field study, we were forced to conclude that, while the results hint at the importance of nutritional as well as social factors, the findings were insufficient to advocate wide-scale social action programs that are predicated on nutritional status being related to cognitive functioning.

In this paper, we summarize a considerably larger body of data from the INCAP study on the contributions of nutritional and social factors to cognitive development. It is still a progress report since much of the longitudinal analysis awaits some two additional years of data collection. But the information at hand allows for a more definitive examination of the competing viewpoints.

The INCAP Study

The study population consists of children from four small, Spanish-speaking Guatemalan villages. The families in them are poor with average incomes less than $300 per year, most cannot read or write, live without indoor sanitary facilities, and drink water contaminated with enteric bacteria. Corn and beans are the major diet and animal protein is less than 12 per cent of total protein intake.[19] Height and weight of both adults and children are strikingly low in comparison with standards for children in developed countries.

Study Design

The study can most properly be described as a quasi-experiment. In two of the villages, pregnant and lactating mothers and children are offered a protein-calorie supplement (11 gms. of protein per 180 ml. of supplement). In two other villages, a supplement that contains no protein is provided. The second supplement, a "Kool-aid" type drink, contains one-third of the calories of the protein-calorie supplement (59 total calories compared with 163 per 180 ml.).* Both preparations contain the vitamins, minerals, and fluorides possibly limited in the home diets. Attendance at the twice-daily supplementation program is voluntary, there are no restrictions on how much can be ingested, and a wide range of intake is observed in each village.

The supplementation of two of the four villages with a high-calorie diet, however, provides a study group that includes sufficient children and lactating mothers with an adequate calorie intake, even in families with minimal economic resources. The intervention is necessary because the proportion of poor families in rural Guatemalan villages with malnourished children is so large that it is not possible to examine thoroughly the relations between social-environmental variables, measures of nutritional status, and cognitive functioning. As reported elsewhere, the physical growth of young children in the set of villages receiving the high-calorie supplement is significantly higher than in the set receiving the low-calorie one.[20] In addition, preventive and curative medical care is provided in all villages by a physician-supervised resident nurse. Appropriate referrals are made to regional hospitals in cases of serious illness. Severe malnutrition is treated upon discovery in all four villages.

The Study Group

The longitudinal study group at the time of this report consisted of 1,083 children, 671 born alive since the field work started in 1969, and 412 alive and under three years of age when data collection commenced. The study group reported on here consists of those children from the 1,083 in the longitudinal panel who are old enough so that data are available at either age three (N = 573), age four (N = 536), or both ages. This point requires some amplification. When data are presented by age, the age designation refers to the information collected at a particular time-point; in other words, information reported for age three and then for age four includes many of the same children in the two analyses, but the data differ by time-point collected. The study group sizes are as follows:

3-year-old males	300
3-year-old females	273
4-year-old males	278
4-year-old females	258

*The protein-calorie supplement will be referred to as the "high calorie" supplement or diet in this paper.

Exact study group sizes for each analysis presented vary somewhat because of missing data. In general, the tables contain about 95 per cent of the subjects reported above.

Variables

The project has collected an unusually large corpus of data on health status and medical treatment, food consumption, nutritional supplementation, physical growth, and social environmental factors. Because of the pressure to implement the field study, early data collection included many measures later discarded as either irrelevant or unreliable. In this paper, selected measures from three domains of variables are employed.

1. Dependent Variables

The cognitive measures come from a specially designed "preschool" battery. As in the previous report,[15] we use three variables selected from this battery.

Language Facility. The score is based on the child's ability to name and recognize pictures of common objects and to note and state the relations among orally presented verbal concepts.

Short-term Memory for Numbers. The child's score is based on his recall of increasingly long strings of numbers read to him at the rate of one per second.

Perceptual Analysis. The child's score is based on his ability to locate hidden figures embedded in a complex picture or to detect which of several similar variations of an illustrated object was identical with a standard.

Test-retest reliabilities differ somewhat by age but are in the generally accepted range of .7 to .8 when the scores are obtained one month apart. Consistent with current thinking about cognitive performance, particularly the utility of Western-oriented tests to underdeveloped populations,[21] the general strategy has been to develop a set of measures that "sample" a domain of separate cognitive processes. For heuristic purposes, however, it also seemed useful to develop a single score reflecting the overall cognitive performance for each child. Since the earlier paper was published, a number of efforts based on theoretical considerations and factor analytic studies have been undertaken to develop a composite measure. The one that seems to satisfy both theoretical and psychometric requirements consists of 12 tests that represent the child's ability to memorize, recognize, perceive, infer, and verbalize. This measure, labeled *cognitive composite*, is included as a fourth dependent variable in the analysis. The test-retest reliability when the cognitive composite battery was administered the second time after one month was .88 for three-year old children.

2. Social Environmental Measures

These measures were developed from first administering a large number of items, inspecting intercorrelations between items, and identifying scales that correlate with psychological test scores. Reliability of the measures in many cases was found to be too low to continue their use. Although the villages are relatively "flat" in stratification, nevertheless there is evidence of structural and life-style variation. It was decided to continue using three measures and to obtain family data repeatedly on them. The measures are the following:

Quality of house: Rating based on the type of construction, interior design and condition of dwelling. (Test-retest reliability = .80.)

Mother's dress: Rating based on whether or not the mother possessed particular items of commercially manufactured clothing. (Test-retest reliability = .65.)

Task instruction: Rating based on family members' reports of teaching the child to perform household tasks and to travel to a nearby town. (Test-retest reliability = .50.)

The first measure, quality of house, is conceived as a social-economic stratification measure. The second, mother's dress, reflects modernity as well as income. The third, task instruction, is viewed as an indicator of the parents' efforts to provide adult modeling and purposeful learning opportunities. Reliability of the two stratification measures is reasonably high, particularly the quality of house measure. The task instruction measure's reliability is border-line. Reliability of measures is increased by pooling the scores, usually three in number, that are obtained in repeated annual interviews. In part of the analysis, these three variables are combined. The composite measure is referred to as the *social factor index*. The test-retest reliability of the social factor index is .85.

3. Nutritional Data

The child's head circumference and total height are used as indices of nutritional status. Both variables presumably reflect the child's history of protein-calorie intake, although genetic background and illness experience also influence head size and height. Height is generally the best indicator of extended nutritional deficiency; head circumference is most sensitive to malnourishment before the age of two years.[20] Extensive field trials conducted as part of the INCAP program argue for the utility of anthropometric measures as indicators of nutritional status.[20] In villages in which children receive an annual intake of more than 20 liters of the high calorie food supplement, children's physical growth velocities are similar to those recorded for children in the U.S. In villages receiving the low-calorie supplement, these velocities are significantly lower. In part of the analysis, these two measures (height and head circumference) are combined. The composite is referred to as the *nutrition index*.

4. Supplementation Data

Children and their mothers receive and drink the supplements under supervision and the amount is recorded for each visit. In this study, two separate measures are used. The first is the total caloric intake of mothers during their pregnancy and the period of their lactation. The second is the total calories consumed by the mothers and by the child directly.

In the two villages receiving the high calorie supplement, the mothers of the children tested at three years of age, during pregnancy and lactation, ingested approximately twice as many calories as mothers in the villages receiving the vitamin-mineral supplement (67,000 calories compared with 32,000). The mothers of the four year old children averaged 53,000 and 24,000 calories respectively. The children themselves at three years of age had consumed an average of 97,000 calories in the two high calorie supplement villages compared with 15,000 calories in the two low calorie supplement villages; at four years of age the comparable figures were 121,000 and 31,000 calories respectively.

Results

A multiple-regression analysis was employed. For each of the four cognitive measures, separate analyses were undertaken by age and sex with the data pooled for the four villages. A large number of repeated analyses were performed for three reasons. First, in order to estimate the independent and joint effects of variables reflecting the different domains of measures, the variables were "forced" into the analyses in different orders, e.g., the social factor measures first and then the nutritional measures. Second, analyses were undertaken with the individual measures and with the composite indices. The indices greatly reduce the number of variables, advantageous in conserving degrees of freedom and in simplifying the interpretation and presentation of findings. The measures in the composite indices are not highly correlated, however, and thus the amount of variance explained may be reduced. Third, analyses were undertaken with and without taking into account the interaction effects between variables. There were no interaction effects deemed useful to include in the data presented since the variance explained by them was small and outweighed by the loss of degrees of freedom. A further refinement was to adjust the correlations for the estimated reliability of these measures. Again, this procedure does not modify the results.

Nutrition and Cognitive Performance

In Table 1, the zero-order correlations of the two measures of nutritional status, the composite nutrition index, and the test-scores are presented. The R^2 values between these two variables and the psychological scores also are included.

In most cases, the correlations are statistically significant at the .05 or lower level. There are considerable variations in the magnitude of the correlations, by both psychological score and by age-sex group. Values are consistently lower for boys at age three than for the other groups, possibly related to age-sex maturation differences.

The variations in the correlations of height and head circumference to the test scores is difficult to explain. Both are conventional measures that reflect nutritional status. Perhaps age-sex maturation patterns account for the differences. In any event, consistent with epidemiological studies of nutritional status and intellectual development, and the findings reported in our previous paper, there is a reasonably clear association between nutritional status and cognitive measures.

Social Factors and Cognitive Performance

Social-environmental factors, as well as nutritional status, are related to cognitive scores. In Table 2, the zero-order correlations are reported for the three individual measures—quality of house, mother's dress, and task instruction—and for the social factor index. In addition, the R^2 values are presented when the three individual measures are regressed on the test scores.

The social variables are significantly related to the psychological scores at the $p < .05$ level or lower in a number of instances. Only a few of the correlations between quality of house measure and the test scores are statistically significant. This social measure was a much better predictor of cognitive scores in the data reported on earlier.[15] The general direction of the correlations, however, is consistent enough to argue for a link between social-environmental differences and psychological performance. The relationship is most clear for the language measure.

Independent and Joint Contributions of Nutrition and Social Factors

As reported in studies primarily focused on *either* nutrition *or* social-environmental factors as explanatory variables, the INCAP data suggest that both domains of variables are related to psychological test performance. The issue is whether any general statement can be made about the unique contributions of nutritional status and social factors to mental development. Put another way, do the nutrition measures predict cognitive functioning after all the variance attributed to the social variables has been acknowledged, and vice-versa?

TABLE 1—Correlations between Nutritional Status and Cognitive Scores

Nutritional Measures	Cognitive Measures															
	Language				Memory				Perception				Cognitive Composite			
	3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Nutritional Index	.20**	.34**	.29**	.30**	.05	.31**	.06	.14*	.14*	.25**	.09	.14*	.17**	.39**	.26**	.30**
Height	.24**	.26**	.29**	.27**	.11	.28**	.14*	.18*	.13*	.19*	.11	.14*	.20**	.30**	.28**	.29**
Head Circumference	.10	.31**	.19**	.25**	−.01	.26**	−.04	.09	.11	.24**	.05	.11	.09	.36**	.15*	.09
Multiple R^2	.06**	.12**	.09**	.10**	.02*	.10**	.02*	.03**	.02*	.07**	.01	.02*	.04**	.16**	.08**	.08**

*P < .05
**P < .01

TABLE 2—Correlations between Social Measures and Cognitive Scores

Social Measures	Cognitive Measures															
	Language				Memory				Perception				Cognitive Composite			
	3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Social Factor Index	.22**	.12*	.21**	.25**	.15*	.08	.10	.10	.16**	.04	.08	.08	.23**	.10	.18**	.23**
House Quality	.08	.11	.06	.23**	.04	−.01	.05	.15*	.02	.02	−.06	.05	.05	.04	.04	.19**
Mother's Dress	.18**	.07	.22**	.19**	.15*	.06	.11	.10	.12*	.00	.16*	.07	.18**	.06	.22**	.19**
Task Instruction	.20**	.05	.19**	.12**	.12*	.05	.10	−.06	.18**	.01	.10	.03	.22**	.03	.16*	.10
Multiple R^2	.06**	.01*	.07**	.07	.03	.00	.02	.04*	.04*	.00	.04*	.00	.07*	.00	.06*	.06*

*P < .05
**P < .01

Multiple regressions were undertaken in which the social variables were forced in first, followed by the nutritional terms and the interactions between these measures. Likewise, in other regressions, the measures and the height × head circumference interaction were forced in first, followed by the social variables. The analysis was undertaken by the composite indices as well as by the separate variables.

In Table 3, we show the proportion of variance explained when the composite nutrition and social factor indices are regressed on the psychological measures. The total amount of variance explained tends to be somewhat lower when the composite indices are used instead of the separate variables. The results are substantially the same, however, and the use of the indices economizes on degrees of freedom.

In one-half of the regressions, the amount of variance explained by the nutrition index is statistically significant even when the social factor effects are first taken into account. When the procedure is reversed, the social factor index sometimes continues to explain a significant amount of variance, but primarily in the case of the language measure. The amount of variance explained by the social factor index is generally less than the nutritional measures.

These findings are consistent with the results reported in the earlier report. Further, there are differences by both age-sex group and cognitive domain. The earlier analysis was undertaken with the first 342 cases in the study, data were available for the memory and perception tests on slightly more than 200 children. Here, the size of the study group—over 500 children—and scores at two age-points provide strong evidence for the contribution of nutrition measures to cognitive performance, especially to language.

Impact of Supplementation

The data previously discussed make a substantial case for the view that inadequate nutrition is associated with lower cognitive performance. Statements of a causal nature, however, are risky from epidemiological data. Fortunately, the nutrition intervention is far enough along to use its results as supporting evidence of the identified relationships. In Table 4, the findings on supplementation and cognitive performance are shown. The variable labeled supplementation is the sum of calories consumed during pregnancy and the lactation of the tested child by the mother, added to the calories consumed by the child up until each testing point. The analysis was also undertaken using only calories con-

TABLE 3—Proportion of Variance Explained by Nutrition and Social Factor Measures

Factors	Cognitive Measures															
	Language				Memory				Perception				Cognitive Composite			
	3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Nutrition Index Alone	.04**	.12**	.08**	.09**	.00	.09**	.00	.02*	.02*	.06**	.01	.02*	.03**	.15**	.07**	.09**
Social Factor Index Alone	.05**	.02*	.05**	.06**	.02*	.01	.01	.01	.03**	.00	.01	.01	.05**	.01	.03**	.05**
Nutrition and Social Indices Combined	.07**	.12**	.11**	.12**	.02*	.10**	.01	.03*	.04**	.06**	.01	.02	.06**	.15**	.08**	.11**
Nutrition Index with Social Factor Index First Removed	.02*	.11**	.06**	.06**	.00	.03*	.00	.02	.01	.00	.00	.00	.02	.05**	.05**	.06**
Social Factor Index with Nutrition Index First Removed	.03**	.00	.03**	.04**	.02	.00	.01	.01	.02*	.00	.00	.00	.03**	.00	.01	.02*

*P < .05
**P < .01

TABLE 4—Amount of Variance Explained by Supplementation, Social Factors, and Nutrition

Factors	Cognitive Measures															
	Language				Memory				Perception				Cognitive Composite			
	3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs		3 yrs		4 yrs	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Supplementation only	.02*	.01	.02*	.02*	.00	.03*	.00	.00	.01	.00	.00	.00	.00	.01	.01	.01
Supplementation with Social Factor Index Removed	.03**	.01	.03*	.03*	.00	.03*	.00	.00	.01	.00	.00	.01	.01	.01	.01	.01

*P < .05
**P < .01

sumed by the mother during pregnancy and lactation. Results are the same and this variable is not shown. As discussed elsewhere,[18] the INCAP results suggest that adequate nutrition of pregnant and lactating mothers, rather than the direct supplementation of children after weaning, may be the more important determinant of differences in young children's cognitive performance. Supplementation of young children, however, may be beneficial in terms of current and future health status and physical growth.

The data have their weaknesses. Ideally, it would be desirable to have measures of home diet-intake as well. Although home nutrition surveys are regularly undertaken, they are not precise enough by family members for use here. They do provide evidence that the interventions are "true supplementations" and do not substitute for food normally eaten by the children. Also, since over one-half of the children were born before the study started, many mothers in the study group were not exposed to the intervention while pregnant and lactating, and some one-quarter of the children were similarly unexposed to supplementation during early life.

Nevertheless, the results are encouraging from an intervention standpoint. Out of the 16 estimates of variance explained that are presented in the first line of Table 4, four are significant at the .05 level and five others are greater than zero. In all cases, the values are accounted for by direct relationships between nutritional status and test scores. The social factor index, however, is negatively related to the supplementation measure, although not always significantly. The direction of the relationships between the social factor index and the supplementation measure suggests that the "needier" children are benefiting most from the supplementation program. Removing the variance explained by the social factor index first, in some cases, raises the amount of variance explained by supplementation. With the social factor index removed first, 11 out of 16 times there are direct relationships between the amount of supplement ingested and cognitive test scores. These direct relationships account for all of the values greater than zero that are shown in the second line of Table 4.

In this analysis, the composite social and nutritional indices were employed to preserve degrees of freedom. Results are similar when the individual nutrition and social measures are employed. Although the amount of variance explained by the supplement is small, the findings lend support for the causal character of the relationship between nutrition and cognitive development.

Limitations of the Study

A number of criticisms can be addressed at this analysis. We are aware of the validity problems surrounding the variables selected. Even though there were strenuous efforts to develop reliable variables, some unreliability remains in both the social and psychological measures. As noted, however, adjusting the correlation coefficients by the estimated reliability of these measures does not substantially change the findings. We recognize that many of the measures are metrically inelegant and we have not met all of the statistical assumptions required for some of the analyses performed. Additional indices of either nutrition and growth of social characteristics could have been included and may have modified the findings. Moreover, the two nutrition variables are not sensitive indices of the severity, duration, or age at onset of nutritional insult. The nutritional heterogeneity of the groups may account for some of the irregularities of the findings. Finally, the association may not be sustained as children approach adulthood. Rather, nutritional condition may simply postpone cognitive development temporarily.

Nevertheless, the analysis suggests that supplementation of pregnant and lactating mothers and young children is related to the latters' pre-school cognitive performance, and it is reasonable to suggest that the relationship is causal. The amount of variance explained by the nutrition measures is not always substantial, but consistent with the magnitudes of findings of most social-epidemiological investigations. Indeed, it is a fair assertion that given more reliable measures, and ones with better metric properties, the variance explained might be larger. Further, although we present only the results for three psychological variables and a composite score, the findings are generally consistent when other cognitive test measures are used as the dependent variables.

Finally, it is puzzling that the effect of nutrition is greater for a nondynamic cognitive variable like size of vocabulary than it is for memory, which requires focused attention and cognitive strategies. Indeed, supplementation or the nutritional index, with social class removed, made a minimal contribution to memory or perceptual analysis. A child's vocabulary knowledge is the cognitive variable that consistently shows the highest correlation with social class of family—across cultures and time. It is also the best single correlate of the total IQ on intelligence tests which sample a variety of cognitive talents. Hence, the fact that vocabulary correlates best with nutrition indicates that vocabulary is either an extremely sensitive index of the quality of cognitive functioning or that social-cultural differences not captured by our social factor index, but nevertheless linked to cognitive performance, accounts for the high vocabulary score for the physically larger children.

Implications

The findings presented strongly suggest that calorie intake affects cognitive development as well as physical growth and general health status. There are a number of plausible explanations for the results. Either a lack of adequate total calories or a deficiency of protein may impede the development of the neurological system. Another hypothesis is that the poorly nourished child, pre- and post-partum, has insufficient energy to take advantage of opportunities for social contacts and learning. Finally, it may be that adults and older children treat the larger child as a more mature individual, which leads to increased social learning opportunities. Clearly, the state of knowledge, as Evans and associates have noted,[5] in neither the nutritional nor the social sciences is sufficient to suggest a single, primary explanation.

It bears emphasis that the findings do not diminish social environmental explanations of difference in cognitive functioning. The generally persistent correlations between the social factor variables and cognitive functioning support the reasonableness of various views on the consequences of deficient family milieux. Moreover, the fairly systematic findings on the amounts of variance explained by nutritional and social measures from one cognitive dimension to the next suggest that the social and nutritional inputs into a child's life have different magnitudes of importance in determining performance on various cognitive dimensions.

At the same time, it is important to note that at least in rural Guatemala nutrition intervention programs are relatively easy to implement in comparison to most other social action efforts. In terms of the human and economic resources required for broad-scale, sustained social milieu interventions, and the political and cultural barriers to their rapid implementation, there is sound reason to stress nutrition intervention efforts in the formulation of social and community development policies for rural Guatemala and perhaps for other lesser-developed countries as well.

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ACKNOWLEDGMENTS

The data for this study are drawn from the Guatemalan growth and development project by Contract N01-HD-5-0640 of the National Institute of Child Health and Human Development, N.I.H. This investigation is part of a program of collaborative research and Uniform Measures of Social Competence by H. E. Freeman, J. Kagan, R. E. Klein, and A. K. Romney and is supported by the National Science Foundation (Grant GS-33047) and the Grant Foundation.