Some Considerations in the Measurement of the Effects of Food Supplementation on Intellectual Development and Social Adequacy

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The problem of malnutrition commands increasing interest in today's world. Understandably, the initial concern focuses on the obvious relationship of malnutrition to health. Even the relatively casual observer appreciates that malnourished children are more likely to become sick and to die prematurely than their well-nourished counterparts. The resulting research gave much information on the physiological and biochemical aspects of malnutrition and about the relationship of malnutrition to infectious diseases.

A recent interest, more difficult to assess, arises from the concern that certain forms of malnutrition, especially protein-calorie malnutrition, might seriously restrict optimal intellectual development. This growing speculation about a relationship between malnutrition and intellectual development has led to a number of transversal studies of malnourished subjects. These studies, although still inconclusive and difficult to interpret, have served the useful purpose of probing means to assess a possible causal connection between what a child eats and how he thinks. In addition, interest in the relationship between malnutrition and mental development is responsible for the four longitudinal studies currently underway: one in Mexico, two in Colombia, and one in Guatemala. These long-range studies, in various stages of progress, are designed to probe a variety of environmental factors in their search for the effects of malnutrition on mental development.

Experimental Design Considerations

The procedures in setting up and operating these long-range studies are unusually complicated, the time and effort required are great, and yet for a number of reasons the objectives sought are to be attained in no other way.

Much of the difficulty of evaluating a relationship between nutrition and intellective development in these long-term studies arises because mental and social development are not single but multidetermined processes. That is to say, a child's social and intellective development takes place within a complex environmental context, and the course of that development is affected both adversely and favorably by countless

varying factors. Thus, it follows that malnutrition is but one of a variety of adverse environmental forces that affect a child's intellective social development. Examples of other adverse factors affecting that development are the mother's health and nutritional status, birth injury, and prenatal and postnatal infections, and the complex social and psychological deprivations inherent in the miserable living conditions where malnutrition abounds.

Granted this group of factors, each affecting the child's mental development, the next task facing the investigator in a prospective field study is that of constructing an adequate experimental design — one that will allow the effects of malnutrition to be estimated apart from, or as they interact with, the other factors which contribute to the child's mental development.

Being able to estimate the impact of malnutrition apart from the other factors affecting development is contingent on two endeavors: finding an adequate control group and measuring the entire range of environmental phenomena theoretically related to intellectual development. This brings us to the next problem to be faced in a longitudinal investigation. That problem phrased in a question is, with what group of well nourished children should the malnourished be compared?

Supplementary Feeding

Ideally, the children in the control group and those in the experimental group should be matched on all important variables with the exception, of course, of nutrition. The best, if not the only approach to that ideal, is through some type of supplementary feeding program. This, of course, is the crucial difference between an observational and an experimental study. Only with the aid of a supplementary feeding program will the experimentor be able to match the control and experimental groups on the important variables, nutrition excepted.

This is not to say that the supplementary feeding of the experimental group will automatically insure that that group will be ultimately comparable to the control group. There is a pitfall here, namely that the supplementary feeding program itself may have important social side effects. All here is dependent on how the supplement is dispensed. For example, if, as is the case in the INCAP investigation in Guatemala,[1] the children are brought together and provided a wholesome food supplement by members of the research team in a socially stimulating atmosphere, we must assume that this very experience will affect his subsequent response to tests of intellectual and social development resulting in improved performance. The positive feelings and

responses developed toward the food supplement personnel subsequently generalize to the psychological tester and to the testing situation. Clearly, such a program of food supplementation makes for a departure from the normal family routine of eating. What this means to the investigator is that when he notes that the family routine is changed appreciably, he must institute some type of control for the attendant effects.

However, there is a way around this problem. If nutritional supplementation can be incorporated within the normal dietary pattern, the attendant side effects are negligible. An example of this latter kind of study is the Tufts University—Universidad de Antioquia project directed by Dr. Joseph Vitale. In this study the nutritional supplementation is added to panela (brown sugar), and food is dispensed without initiating a specialized routine. In this way, nutritional supplementation is achieved without significantly altering the economic, dietary, or social patterns of daily life.

In whatever way the investigator solves the problem of providing food supplementation, the nutritional properties of the supplement must be demonstrated to be adequate with regard to the nutritional deficiencies displayed by the target population. Moreover, it is also incumbent on the investigator to demonstrate both that the nutritional supplement is reaching the subjects in the target population and the degree to which the nutritional status of the subjects in the target population is improved with the ingestion of the nutritional supplement. In the case of the INCAP study, the quantity of supplement consumed each morning and afternoon is recorded.

The actual composition of the nutritional supplement was determined by the findings from investigations that analyzed the diets of the subjects in the population and identified the limiting nutrients in the usual village diets. A nutritional supplement was then developed which would theoretically correct these nutritional deficiencies.

Prior to testing the nutritional supplement in humans, its efficacy was demonstrated in animal studies (unpublished INCAP data). Once demonstrated effective with animals, the supplement was shown to have a beneficial nutritional effect on the age groups most at risk of protein-calorie malnutrition (unpublished INCAP data).

Chronological Ages to be Studied

The next problem of the longitudinal study remains fixed, that is; the problem, what age children should be included in the study? The answer is, the younger the better. Data on brain development[2] suggest that the

central nervous system may be particularly susceptible to the effects of severe protein-calorie malnutrition during the last trimester of pregnancy and the first 6 months of life. In addition, other investigators have reported that the effects of malnutrition seem to vary inversely with the age at onset of malnutrition and directly with its duration and severity.[3,4] These results then argue strongly that effective nutritional supplementation must start early (preferably at or before conception). These findings also suggest that an adequate operational definition of nutritional status requires knowledge of the mother's nutritional status during pregnancy as well as measures of the nutritional status of the child from birth onward.

The final factor that militates for studying children from birth onwards evolves from the injuries other than malnutritional that infants invariably suffer — particularly those living in impoverished conditions. Thus, if the investigator is to avoid confounding the effects of nutritional insult with central nervous system damage due to factors such as perinatal injuries and infectious diseases, it is imperative that he initiate his testing program at the time of the subject's birth,

Selection of Assessment Measures

The next problem facing the investigator in a longitudinal study is the selection of the battery of tests designed to assess the effects of malnutrition on intellective and social development. The assessment of child development is a complicated problem under ideal conditions. It becomes much more complicated when it is attempted under field conditions, and, as is often the case, in a culture for which few if any measures of intellectual and social development exist.

There are obviously no simple answers to the question of which tests to use. Even if there were a substantial body of tests that would serve our purposes today, they would not necessarily serve tomorrow. For example, in a study of malnourished children who were nutritionally rehabilitated and compared with children who had no clinical history of malnutrition, the previously malnourished children performed more poorly than their well nourished counterparts (unpublished INCAP data). These investigators suggest that the differences between these two groups seemed to be related to attentional and motivational factors rather than differences in intellectual ability. Concepts about how malnutrition affects children are changing and as the concepts change, so must the tests. Thus, as more is learned about the effects of nutri-

tional insult on child development, new hypotheses will emerge, and new instruments will be required to test these hypotheses.

However, in the midst of this great flexibility of test selection there are some fairly predictable problems the investigator will face and there are some guidelines on how to solve at least some of them. Birch[5] helps us here. He argues that tests be selected on theoretical grounds which reflect both the investigator's framework for conceptualizing the effects of nutritional insult on intellective development and his theoretical point of view regarding the nature of cognitive development. Without a coherent research orientation in which the measuring instruments are employed to test specific hypotheses, the interpretation of data becomes exceedingly speculative.

Although this is clearly the only way in which sustained scientific progress can be made, many experimentors select tests largely on the basis of their availability, rather than on theoretical relevance. The almost universal use of sensory-motor development scales to assess mental development in infancy is an illustration. Sensory-motor development and coordination are important aspects of instrumental adaptive behavior, and the investigator profits from knowing as much as he can about this area of behavior. However, the assumption that the child's level of sensory-motor development is a valid and reliable index of infant intelligence is unsupported.

As alternatives to infant development scales the investigator can find a variety of useful techniques in the rapidly growing body of experimental studies of infant cognitive development. An example of such a technique appears in a longitudinal investigation by Jerome Kagan and his collaborators. In this unpublished study, the investigators measured both overt (e.g., smiling visual fixation, vocalization, and activity level) and covert (e.g., heart rate) behaviors of infants in response to experimental transformation of human faces. These are models of human faces wherein certain features are either absent or rearranged. The existence of cognitive structures are then inferred on the basis of the infant's responses to transformations of previously habituated stimuli. Using measures of attention as indices of cognitive development, Kagan and his associates have demonstrated reliable social class differences in the distribution of attention by 12 months of age.

This information that there are social class differences in cognitive development by 1 year of age is of tremendous importance to the study of malnutrition and cognitive development. What this information demonstrates is that working-class mothers systematically treat their

children in ways different from middle class mothers, and further, that differences in intellectual development associated with dissimilar styles of child rearing can be detected in early infancy.

These findings then reinforce the suggestions made by other investigators,[6] that the study of the mother-child diad is of crucial importance in studies of the effect of malnutrition on mental development. Specifically, apathy and listlessness are common symptoms of malnutrition and these behavioral characteristics could be expected to depress or otherwise interrupt the mother's response to the child and conversely — reciprocally — his response to her. The results of such a cycle, it is predicted, would demonstrably change the course of the child's intellectual development (see Pollitt[6] for a complete discussion of this point).

The Kagan study demonstrates the usefulness of tests other than sensory-motor in appraising infant intelligence. But the fact remains that investigators of the relationship between malnutrition and intellective development continue to select tests on bases other than their theoretical immediacy and applicability. A case in point is their continued use of standard IQ tests to measure the intelligence of preschool and school-age children. The concept of "intelligence" as measured by standard IQ tests is of little use in explicating the relations between malnutrition and mental development. The intelligence quotient is a global score that is based on a wide variety of test items. As a result, traditional IQ tests tell us little about problem solving, response style, linguistic competence, perception, and memory, processes commonly subsumed under the rubric of cognitive activity. What is called for instead of gross standard IQ tests are tests that measure discrete aspects of cognitive development.

Furthermore, studies of malnutrition and mental development are typically conducted in underdeveloped countries. These are countries that are culturally and linguistically dissimilar to those countries where the bulk of psychological research and test development has been carried out. This means that most existing measures of intellectual development are inappropriate for use in underdeveloped countries. The investigator then must develop suitable tests himself. The process of test development is long and exacting. Members of the Division of Human Development at INCAP have invested 3 years in the development of tests for use in a longitudinal study of malnutrition and mental and social development.

A detailed discussion of the theoretical rationale behind the tests in the INCAP battery and the psychometric criteria such as reliability and

validity which useful tests must meet are beyond the scope of this discussion. Instead, I have selected for detailed discussion two issues which have not been dealt with in detail elsewhere. These are the problems of the cultural relevance in tests of intellectual and social development and the measurement of sociocultural variables for the purpose of identifying family differences related to differences in performance of preschool children.

When we discuss the cultural relevance of a test we are referring to the harmony between both the core of experience and expectations of the child on the one hand and to the actual test stimuli and the demands placed on the child in the testing situation on the other. Put another way, when a test is appropriate or relevant to a particular culture, the subject is not put at a disadvantage because of his typical or normal culturally determined experiences, relationships, and expectations.

Of all the tests used in Guatemala, infant testing presents the least problem with respect to cultural appropriateness. The standard infant sensory-motor development tests require little adaptation for use in rural Guatemala. Likewise, no serious problems have been encountered with measures of infant cognitive development. The only problem with infant tests in Guatemala obtains for other cultures as well: namely, the mother's interest and cooperation must be enlisted. Specifically, we have found it useful to discuss the tests with the mothers of the infants in our sample prior to testing their children and give them a general idea of what the tests are like.

For preschool age children, however, the process of adapting and developing culturally relevant tests is considerably more involved. Our criteria in the development of the preschool age test battery were the following: (a) the tests should require simple and when possible nonverbal responses; (b) they should be interesting and "game-like," and they should greatly interest and involve the subject; (c) the tests should measure important cognitive processes; and (d) the tests should meet generally accepted test criteria for reliability and validity.

Our procedure in the development of the preschool test battery, and whatever success we have subsequently enjoyed, involved close collaboration with the cultural anthropologist and the Guatemalan psychologists on our staff. Initially, when we began work on each of the tests for the preschoolers, we discussed in detail with our anthropologist the theoretical rationale behind the test and our ideas of how to measure the phenomenon that concerned us. The anthropologist and

his staff again collaborated with us in the selection of test stimuli and the development of the test instructions.

In this collaborative fashion a preliminary form of each test was developed and pretested on a small sample. The performance of the children on the preliminary forms of the tests were discussed in detail with the anthropologist and the Guatemalan psychologists who administered the tests.

Thus, we move back and forth between the children and their performance on the one hand and the ideas, observations, and suggestions of the anthropologist and the Guatemalan psychologists on the other hand, tailoring—if you will—the cognitive tests to the population to be studied in our longitudinal investigation.

Our procedure for developing a test of social competence was similar in some respects to the procedures employed in the development of the cognitive tests. Here again, we worked hand in glove with the cultural anthropologist in developing a measure of social competence. It was the anthropologist indeed who identified the culturally important, sex-appropriate behaviors which children are expected to display and the tasks they are expected to master. He also identified the ages by which parents and others believe the children should display these behaviors and master these tasks.

The data on age and sex-appropriate behavior of the children in our sample were obtained through detailed observations of children in naturalistic situations and through parent interviews. Using the information gathered by the anthropologist, we then devised measures for a variety of social behaviors. We are currently using these measures to establish norms for role performance and social competence. The social development of the children in our sample will be evaluated in terms of these norms.

Related to the issue of social competence is the more general question of the relationship between measures of intellectual development and the naive or indigenous conception of intelligence prevalent among the adults in a peasant culture. There are both theoretical and practical reasons for attempting to measure these aspects of intellectual performance which seem to be important for successful role performance in a traditional society where our subjects will presumably live out their adult lives. Put in another way, intellectual test performance differences should ideally have logical as well as statistical significance for dimensions of role performance expected of the subjects.

To investigate the relationships between psychological test performance and the conception of intelligence in a rural village, we tested ten 7-year-old boys on a variety of psychological tests and we also took photographs of the subjects. We showed fifty adult villagers pairs of photos so that each adult viewed all possible pairs of the ten photos. The adults were asked to indicate which of the two children in each pair was the "smartest." The results indicate that the adults' ratings were highly consistent. A clear order of "smartness" emerged for the ten children. Moreover, performance for five of ten psychology tests, including measures of response latency, perceptual development, verbal analogies, and memory for visual designs, were found to correlate significantly with the adults' estimate of children's "smartness."

In addition to measuring the intellectual and social development of the children in our longitudinal study, we are also studying the children's families. These investigations take two forms. In the first type, careful observational measures are taken of specific maternal caretaking behaviors as well as various aspects of the infant's environment. This type of study is designed to search out the child rearing correlates of early intellectual and social development.

In the second type of family investigation, much broader and more varied characteristics are measured. In these studies, for example, parent interviews and home visits are conducted in order to get information on demographic, economic, and social variables. This information is used to construct social class indices. The rationale for the use of a social class index is as follows: We know that child-rearing practices are powerful determinants of intellectual and social development. We cannot identify all the critical dimensions of child rearing that affect intellectual and social development. Thus, a social class index allows us, for statistical purposes, to create groups by combining families who are similar. This makes it possible to account for a portion of the variance encountered in our measures of intellectual and social development which presumably is due to child rearing factors.

A demonstration of the utility of this technique is afforded by the results of a study we conducted recently in which we investigated the family correlates of psychological test performance of children in an isolated rural Guatemalan village. Social class indices reflecting living conditions and family structure were developed and were compared with measures of psychological test performance. For a group of thirty 3-year-old children, these social class indices accounted for 24 percent

of the variance in the number of correct responses on a test of perceptual development, called embedded figures, ($F = 3.23$; $df = 2, 30$: $P < 0.03$). Similarly, these same social class indices accounted for 13 percent of the variance in measures of language development for the entire sample of 183 children ranging from 3 to 7 years of age ($F = 14.03$; $df = 2, 183$; $P < 0.001$).

Summary

Nutrition and mental and social development are the focus of this paper. Six important factors to be considered in the design in prosecution of longitudinal studies of this topic are discussed in detail. First, there is the problem of finding an adequate control group. A variety of potentially confounding factors threaten to confuse the investigator unless he can eliminate them by appropriate between-group comparisons. Second, some form of nutritional supplementation program is essential, for without such a program, the investigator cannot hope to assemble an adequately nourished experimental group. Third, and in direct relation with the last procedure, the supplementation program itself should be carefully instituted to avoid generating unnecessary variance in the test results. Fourth, for many reasons, these longitudinal investigations should begin to study mothers from the time of conception and children from the time of the child's birth. What is at stake in the early initiation of examinations is an adequate definition of nutritional status and the elimination of nonnutritional factors, such as infectious diseases and birth injuries, as possible explanations for retarded intellectual and social development. The fifth issue is that of test appropriateness. The choice of tests must ultimately be determined by two criteria: They should be theoretically relevant to the basic scientific question and they should also be culturally appropriate for the subjects in the study. Sixth, the investigator should concern himself with the measurement of family characteristics associated with intellectual and social development, for family differences related to child-rearing practices are likely to be important sources of variance in the measurement of the intellectual and social development.

If these procedures are adhered to, the longitudinal study of effects of malnutrition on intellectual and social development has a good chance of providing definite answers to questions regarding the relations between malnutrition and intellectual and social development.

Acknowledgments

This research was supported by Contract #PH43-65-640 for the National Institute of Child Health and Human Development. This paper was prepared by the author during his tenure as a Belding Fellow, Association for Aid to Crippled Children.

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