NINETEENTH MEETING OF THE
PAHO ADVISORY COMMITTEE ON MEDICAL RESEARCH

San Jose, Costa Rica
9-13 June 1980

INDEXED

MALNUTRITION, MENTAL DEVELOPMENT, BEHAVIOR AND LEARNING

MALNUTRITION, MENTAL DEVELOPMENT, BEHAVIOR AND LEARNING

Joaquin Cravioto, M.D., M.P.H., D.Sc.
Professor and Scientific Director
National Institute of Child Health
Sciences and Technology - DIF
National System for the Comprehensive
Development of the Family

Through the creation of society and of culture and of the
concomitant development of technology, man who initially was only
a biological species has developed into a flexible and changing
social organism. Because of his capacity to learn and his ability
to think, man can act consciously and establish rules and laws of
behavior for protecting the social organism, even against forms
of behavior produced to satisfy the biological demands of some of
the individuals that make up society, if the need arises. The
ability of man to reason enables him to determine what to do with
himself and with the environment he lives in. In addition to his
physical and biological environment, man, as a social entity, has

---

a social environment that embraces all kinds of transactions, present or potential, that occur whenever a human being encounters, by chance or deliberately, another human being.

Within this social context man has become interested in the fate of his species. Specifically during the last half of the twentieth century, growing interest has been focused on the various ways in which the environment can affect man. Health has become a focus of attention for a steadily growing number of persons and institutions connected with the planning and implementation of economic, social and cultural development policies. A logical outcome of this behavior has been the thought given to the role that nutrition can play in the life of the individual from the time he is conceived until the time he dies, especially during the period of his growth and maturation.

In our time, all of us, both experts and laymen, agree that the consumption of a sufficient amount of good quality food is a crucial factor in the life of man and that, in that of the child, it is virtually a prerequisite for optimum growth and development. It is not too much to say that nutrition is perhaps the all-pervading factor that affects the health and well being of man.

Nevertheless, Jose Maria Bengoa in a study of nutritional conditions in 12 countries in Latin America, four in Asia, and eight in Africa, found that millions of children were suffering from various degrees of malnutrition. This expert in nutrition has also pointed out that we should realize that although, on first sight, nutrition is contingent upon factors in the physical environment such as climate, topography and geological structure, and the biological components of the human environment represented primarily by food chains, the all important determinant of the nutritional status of the population is the social milieu in which it develops. In the final analysis, nutrition, good or bad, is part and parcel of the total context of social, economic and cultural conditions.

It, therefore, follows that malnutrition at the community level is a problem created by man and is especially prevalent in those segments of the population that have little or no say in the decisions taken about economic, social and political matters. In these population strata, the present system, consciously or unconsciously, created malnourished individuals, generation after generation, through a number of mechanisms; foremost among them are limited access to goods and services, little social mobility and restricted opportunities to receive and use experiences in critical moments of their life. As a result, malnutrition is a

very common disease among the "vulnerable groups" made up of older

weaned   and preschool-age children and pregnant women or nursing

mothers, since, in addition, these groups need more nutrients and

energy foods.

In the control of malnutrition as in the control of any

other fatal disease, survival was the primary objective. A better

knowledge of the differences in the homeostatic responses to harmful

agents characteristic of malnourished individuals, as opposed to

well-nourished individuals, the detailed and quantitative descrip-

tion of the chemical pathology of the malnourished and the avail-

ability of better methods and techniques for early diagnosis and

the treatment of electrolytic disturbances and infection were cap-

able of reducing the case fatality rate in children suffering from

severe malnutrition; so that the probability of dying or surviving

which 20 years ago was 50% has, since 1962 to date, become less

than 5% for preschool-age children treated in pediatric wards.

Despite this spectacular breakthrough it must be borne in

mind that the problem of malnutrition in children does not end

when a low case-fatality rate has been achieved. It is precisely

the fact that most of the malnourished, even the severe malnourished,

do not die and that, in the pre-industrial world, millions of adults

have suffered at least one episode of malnutrition during their

childhood that makes it imperative to endeavour to investigate the consequences of early malnutrition for mental development, learning and behavior at later ages.

Approaches to the Problem

The strategies research workers have used to study the consequences of malnutrition have been derived from their conceptualization of malnutrition in man. One group considers malnutrition to be an acute disturbance that is rather well delimited in time. This concept led to the conduct of filed studies such as those of Hiernaux in Rwanda (1964), to experiments on human volunteers like the outstanding study of Keys et al (1950) and studies like those of Richardson in Jamaica (1976), which endeavour to quantify the contribution of malnutrition as acute symptoms. Another group considers malnutrition to be a chronic process that may or may not be acutely exacerbated both by physiological conditions and the social circumstances of the individual at risk (Dean 1950, Gopalan 1955).

Three additional approaches have been used to endeavour to clarify the causal factors and the consequences, both short and long term, of protein-calorie malnutrition. These three approaches have been used to study the organism at full development, since it has been demonstrated that, in the adult, the consequences of

malnutrition are transitory (Keys, et al, 1950) whereas the young

have proved to be very vulnerable and to suffer damage that may be

permanent (Jackson and Steward, 1920, Platt et al, 1964). With

this focus of attention, the three principal strategies developed

are as follows: 1) the deprivation model; 2) the intervention

model; and 3) the ecological or natural history model. The research

studies carried out with these strategies have included case

studies, comparison of populations, an analysis of special condi-

tions of risk, replacement and rehabilitation.

The deprivation model, used especially in experiments with

laboratory animals, has been extremely useful since it has made

it possible to examine the impact of malnutrition on various

biological structures by using controlled conditions that it would

be impossible or immoral to obtain in human beings. This strategy

has provided data on specific organs, systems and mechanisms of

biological organization exposed to the process of malnutrition.

Despite their very important contributions, studies on lab-

oratory animals do not provide a complete analogy with human

conditions. Laboratory animals lack the social substratum in

which the deprivation of man takes place and with which he inter-

acts. Furthermore, the impact of malnutrition on behavior must

be limited in the animal model to relatively simple types of be-
havioral adaptation that can be exhibited by the lower animal so
that the effects that malnutrition might have on social functions
and complex behavioral patterns cannot be reproduced in the
analogue which, although very useful, is a supplement and not a
substitute for the studies that should be made on human beings.

The approach based on intervention represents the other
face of the coin of deprivation; with this model a research worker
seeks to estimate the combined effects of nutrition, infection
and social and family circumstances by systematically changing
each one of the variables he considers important. In practice,
this has resulted in the differential application of food sup-
plements, control of infectious diseases, improvement of housing,
increase in the level of formal or specific education in health
and nutrition, economic subsidies to increase income, and an
increase in opportunities for social learning in communities or
population samples supposedly comparable in all the factors to
which they are not subject to intervention.

The principal attraction of the intervention model is its
attempt to separate the influential variables and to compare them
in a way similar to that used in laboratory experiments in physics
or chemistry. Unfortunately, it is extremely difficult to exactly

match groups and to prevent the dissemination of the effect when subsegments of one and the same population are handled differently. The assumed homogeneity even of small and relatively isolated populations is only an assumption (Cravioto et al, 1967) so that while the use of different communities reduces the dissemination of the effect, it increases the difficulty of comparability. In any event, to the foregoing we must add the fact that every time a variable is affected, there is danger of an ecological rearrangement, especially when the variable acted on is food, since we must not forget that food and nutrition are precisely central foci of human organization.

Although the intervention model raises problems of ethics; for example, when the intervention is food supplementation in which the principal problem is the recognition that that supplementation will, for most of the cases, end when the study period ends. The effect of this supplementation on the ecology of the food with undesirable consequences when its availability and consumption is ended is something that cannot be overlooked. Of course, it may be argued that these are moral considerations and not strictly methodological considerations and that if they are anticipated as part of the total design, the transition can be made without prejudice to the population involved.

The third model is the ecological approach. This is in fact a special form of the method known as the natural history method and is intended to determine the nature of the influential variables through the study of their interrelations in one and the same population. When this method is applied to the problem of malnutrition, the intention is to separate patterns of cause and effect by seeking the interrelations between nutrition, health and social factors over time.

Use of the ecological model over a sufficiently long period makes it possible to identify age-specific risk conditions, to relate causes and consequences in different periods of stages of development of the individual, and to set up scales of biological and social time. Levels of macro or micro-environment may be selected by the research worker to ascertain the interaction of his biological and social variables. The point to be recognized in this model is that the factor he is studying is precisely the uncontrolled variation; therefore, the basic requirement for its use is the existence of sufficient variability in the factors to be considered in the community it is intended to study.

The major problem of the ecological approach is the multiplicity of factors to be measured and the quantification of many of the family and social variables involved.

In this chapter through a review of selected investigations we have attempted to present, in summary from, the current status of our knowledge on the relationship between malnutrition and mental development and learning

I.- SOME OF THE PROBLEMS INVOLVED IN THE ASSESSMENT OF THE ROLE OF MALNUTRITION.

In attempting to assess the role that malnutrition may have on mental functioning of the human, it becomes essential to consider the meaning of food and feeding along at least three dimensions. The first one, is the physiological dimension which has as a unit of measurement the nutrient or the joule, and whose function is to provide chemical substances to the organism for pupuses of growth, maintenance and metabolic regulation.

The second dimension of food may be considered as psycho-physical. Its unit of measurement would be the foodstuff which through its organoleptic characteristics would provide the organism with a variety of stimuli (texture, color, aroma, taste, temperature, etc). In this context, a foodstuff presented at the table as two different kitchen preparations having the same nutrient and energy content would, in fact, behave as if two different foods were offered to the individual.

Finally, the third food dimension may be considered as psychosocial in nature. Its unit of measurement would be the

mealtime. The functions of food along this line are, on the one hand to aid in symbol formation through the value family and society attach to food, such as a form of reward or punishment, as an experience attached to a gratifying person, or as an identifying characteristic of an ethnic or subcultural group. On the other hand, the meal time provides opportunities to demostrate, clarify and practice role and status at the family and at the community level. Who is waited on first? Who sits at the place of honor at the table? Who receives the best part of a dish? Who moderates conversation at the table?, are some examples of the way in which this food dimension is expressed.

It seems easy to visualize that food deprivation in young children represents not only a shortage of nutrients necessary for the increase in mass of the infant, but also a deprivation of sensory stimuli and of social experiences.

The very fact that malnutrition at the community level can be considered as a man-made disorder characteristic of the underpriviledged members of society, particularly of the pre-industrial societies where the social system, consciously or unconsciously, produces malnourished individuals generation after generation through a series of social mechanisms among which limited access to goods and services, limited social mobility, and restricted opportunities for social stimuli and experiences at crucial times in life play a major

role, makes it difficult to determine the contribution which

malnutrition vis a vis all the other potential conditions of risk

for maldevelopment may be making to the inhibition of growth in

mental abilities. The problem increases its complexity because

of the varying degrees to which the central nervous system is

vulnerable to insult at different ages (Chase et al., 1967, Benton

et al., 1966, Davison and Dobbing, 1966, Dobbing, 1963). These

investigators have reported species differences in the age of most

rapid myelination, and for the species exposed to food restriction

have documented the relation of abnormal outcomes in central

nervous system structure and composition to the conjuction of

malnutrition and the time of most rapid growth and differentiation

of the nervous system. Accordingly, not only the presence of

malnutrition but the time of life at which it is experience must be

taken into account if the relation between exposure and mental

performance or learning adequacy is to be properly assessed.

The time factor has another important bearing on the problem

of malnutrition and development. The assessment of the developmental

consequences of malnutrition suffered during infancy or the preschool

years cannot be fully evaluated at the time of the insult. This is

particularly true when one wishes to quantify the effects of malnutrition

on such functions as intellectual abilities, school achievement, and

later social and economic competence. For the assessment of these

late effects, a considerable gap in time must elapse between the

period of exposure and the period in which the functions to be
evaluated can be examined meaningfully. It is apparent that this
gap in time allows the potential intervention of many which may
influence the course of the child's developing competence. Thus,
for the effect of the nutritional condition to be assessed, the
influence of these operating factors must be accounted for.

Nontheless, the gap in time between the exposure to
malnutrition and the assessment of complex nervous system activities
is an asset in itself. Clearly, the effect of malnutrition on the
developing nervous system is unlikely, except in rare cases, to be
fully manifested by changes in simple reflex and adaptive behaviors.
Many years ago, Lashley (1929) demonstrated that as much as 20
percent of the rat cerebral cortex could be extirpated without
demostrable consequences for simple maze learning. However, Maier
(1932) using the same species showed that as little as 3 percent of
destroyed tissue demonstrably affected more complex learning
performances. Thus lags in developmental differentiation or even
distributed lesions, produced in the nervous system by malnutrition
would be expected to manifest themselves at varying distances in
time from the age of the primary insult. At these latter ages, when
more complex demands for integration are made, opportunities for
increased sensitivity in the assessment of consequences exist. A
time gap in the assessment of consequences therefore is essential
if the full force of the potential insult is to be measured. However,

the existence of a time gap does make it necessary to know and to
account for the influence of social and other variables on the
course of development during the intervening period.

In dealing with the problem of protein-calorie malnutrition
in humans and its effects on mental function, investigators have
not tended to approach the issue neuro physiologically. Rather
than explore the question of the impairment of mechanisms of brain
functioning which may result from deficient nutritive intake they
have attempted to answer the practical question of whether the more
readily noted reductions in somatic growth and biochemical maturation
are associated with reduced mental performance. Further, they have
wished to know whether such mental lags, when they have been found,
represent permanent changes in functional effectiveness or are
merely transient phenomena which disappear with nutritional recovery.

II.- SENSORY-MOTOR DEVELOPMENT IN MALNOURISHED INFANTS.

In several regions of the world where malnutrition in early
infancy is highly prevalent a direct association between deficits
in height and weight of severely malnourished preschool children
and lags in psychomotor, adaptive, language and social-personal
behavior, as measured by the Gesell, Catell or Bayley methods, has
been reported by Geber and Dean (1956) in Uganda children, Robles
et al. (1959) and Cravioto and Robles (1962) in Mexican children,

and Barrera-Moncada (1963) in Venezuelan children.

Serial studies on sensory-motor development in kwashiorkor patients have shown that as recovery from malnutrition takes place, developmental quotients, which are extremely lower than those obtained in non-malnourished children of similar are and social class, increase in most patients and the gap between normal age expectation and the actual performance of the child progressively diminishes for all except infants whose age on admission for treatment is less than six months. When developmental quotients are plotted against days of hospitalization it is apparent that the rate of behavioral recovery varies in direct relation to age at which malnutrition occurred. The older the group the greater the value of the slope (Cravioto and Robles 1962, 1965).

Research conducted in infants recovering from nutritional marasmus has also disclosed that intelligence and psychomotor activity, as judged by the Bayley Scales, remain severely retarded despite a clear somatic recovery. (Pollit and Granoff 1967). The results of these studies in kwashiorkor and marasmic patients have been confirmed in South Africa by Stoch and Smythe (1963); in Chile by Monckeberg (1968) and Kardonsky et al. (1971) in Lebanon by Bothe-Antoun et al. (1968) and Yatkin and McLaren (1970), in the U.S.A. by Chase and Martin (1970), and in Brasil by Marcondes et al., (1969). All these reports point out the fact that children

affected with either marasmus or kwashiorkor exhibit marked
retardation in sensory-motor development which is still present
even after physical and biochemical rehabilitation have occurred.

Not only in general measures of mental development do
malnourished children show a poorer performance. Brockman and
Ricciuti (1971) have examined a more specific cognitive function,
categorization behavior, in relation to malnutrition in twenty
severe marasmic children and in 19 control children matched for age
and sex, without a history of malnutrition and with heights above
the tenth percentile of the Boston, U.S.A., norms. Using simple
sorting tasks it was found that the total test scores on categorization
behavior of the malnourished children were significantly lower than
those obtained in the control children. On retest after 12 weeks
of treatment the malnourished children showed no significant increase
in scores. Analysis of the ten individual sort tasks differences
disclosed not only lower performance levels for the malnourished
children than for the controls, but also appreciable less variation
among task differences. Children with a longer period of successful
treatment expressed as greater gain in body lenght and head
circunference, and with a higher clinical rating of nutritional
recovery tended to perform better on the cognitive tasks.

All the above-mentioned studies make it clear that even after
a period of several months children who had made a successful

nutritional recovery of severe malnutrition and are medically
considered as cured still show developmental lags not only in
psychomotor behavior but also in several other areas, including
hearing and speech, social-personal behavior, problem-solving
ability, eye-hand coordination, and categorization skills.

III.- EARLY MALNUTRITION AND INTELLIGENCE AT SCHOOL AGE.

Follow-up studies of children, who as infants have suffered
from severe malnutrition requiring hospitalization, constitute one
of the model systems through which research workers have assessed
the degree to which severe malnutrition in early life may affect
subsequent levels of intelligence. In order to minimize the
possibility that the period of hospitalization might itself have
continue to exert a depressing effect on performance, the assessment
of level of functioning must be conducted in survivors several years
after discharge from the hospital. Within this model two main
strategies have been used. The first one compares the intelligence
test performance of children with documented episodes of severe
malnutrition with the performance of children living in the same
community, but without antecedents of severe malnutrition. Since
malnutrition develops in environments conducive, in many ways, to
lower performance investigators have tried to match survivors of
early malnutrition with control children for those non-nutritional
variables considered as capable of playing and important role.

The second strategy involves the comparison of children who have experienced early severe malnutrition with their own sibs raised in the same family environment but not experiencing the same severity of nutritional insult. The assumption behind this strategy is that siblings as controls cancel out the majority of the demographic or macro-environmental variables leaving those related to the specific micro-environment of each child within his or her own family to be accounted for by other means or study.

Table 1 shows the main characteristics and results of the studies which have contrasted survivors of severe malnutrition and non-severely malnourished children drawn from the general population among which the cases of malnutrition have contemporaneously occurred. As may be seen these reports deal, in total, with children living in markedly different cultural settings, with geographical representations from Europe (Yugoslavia), Asia (India, Indonesia and the Philippines), Africa (Uganda), and Latin America (El Salvador). Survivors of malnutrition were tested several years after they were considered as cured. Intelligence test performance was assessed by a variety of tests either standarized for the country or specially designed for the particular study. The comparison groups were drawn from the population and risk. In the majority of the studies survivors and controls were only matched for age and general socioeconomic status at the time of retesting; two exceptions are the study of Champakan, Srikantia and Gopalan (1968) in which the

comparison group was matched for age, sex, religion, caste,

socioeconomic status, family size, birth order, and educational

background of parents with the survivors of severe malnutrition;

and the study of Hoorweg and Standfield (1972) in which the comparison

group was made up of children with records of good nutrition and

growth during their first two years of life.

Srikantia, Sastry and Naidu (1975) have reported on the follow-
up of the group of survivors of kwashiorkor whose mental performance

at school age had been previously described in 1968 by Champakan,

Srikantia and Gopalan (1968). Eleven years after discharge from

the hospital the means in the Wechsler test were 49.9 for the

experimental boys and 60.5 for the control boys; for girls the scores

were 35.7 and 50.0 respectively for experimental and control groups.

In the two year period that followed, the control boys had improved

their score by 17.5 ± 4.05 points while the experimental boys had

improved theirs by 22.0 ± 2.94 points. Similarly, control girls had

improved their performance by 14.2 ± 1.4 points and the experimental

by 18.1 ± 4.39 points. The differences in mean increment between

the groups were not statistically significant, although both at the

beginning and at the end of the observation time period the absolute

scores were higher in the control groups, and more markedly so in

boys. In other words, differences in I.Q. initially present in

survivors of kwashiorkor and in control children persisted after a

lapse of over 13 years, but the early episode of severe clinical

malnutrition did not alter significantly the subsequent rate of

growth in intellectual performance.

The results of the six reported studies show that the presence

of an episode of severe malnutrition occurring early in life and of

enough severity to force the family to take the child to a hospital

significantly increases the chances of survivors, years after

discharge, of scoring at values much lower than those obtained in

the children of the comparison groups.

Two studies on the effect of early malnutrition on intellectual

performance at later ages have used the sibling strategy. In the

first one, conducted in Mexico (Birch et al. 1971) measured intelligence

at school age was compared in thirty seven survivors of severe

malnutrition and in thirty seven of their siblings closest in age.

The malnourished children all had been hospitalized for severe chronic

malnutrition of the kwashiorkor type when they were between six and

thirty months of age. No cases of marasmus were included, and the

group was relatively homogeneous both for severity of illness and

for type. All children had been discharged to the family following

nutritional rehabilitation. The average time of hospitalization was

six weeks, with a range of one to two months. During the hospital

stay children were visited by their mothers for a three-to four-hour

period every other day. The ratio of nursing staff to children was

high, with one nurse available for every three children. Care in
hospital in general was good and considerate, but no special
stimulation procedures were applied.

No detailed data were available with respect to the quality
of the diets received by the children after their discharge from
the hospital. Although it would be appropriate to assume from
knowledge of the social circumstances in which the children lived
that such diets were suboptimal, in no cases were any of the children
ever readmitted to any hospital for severe malnutrition.

At follow-up the children were between five and thirteen
years of age. In all cases intellectual evaluation was carried out
at least three years after discharge from the hospital. The child
chosen as the control was the one in the surviving sibship nearest
in age to the index case and without any prior history of an incident
of severe malnutrition. The age distributions of the index cases
and of the sibling controls were very similar. This was the
consequence of the sibling closet in age tending to be randomly
older or younger than the index case. Sex distribution was somewhat
divergent with relatively more females in the control cases.
Difference in sex ratio, however, was no significant (chi-square=1.95;
p more than 0.10).

At follow-up each child was individually examined to determine

intellectual level. The test used was the Wechsler Intelligence
Scale for Children (WISC) in its Spanish adaptation. Although it
was recognized that this test lacks sensitivity for the youngest
children studied, it was judged desirable to use it for all children
rather than to substitute a different and probably noncomparable
test for the youngest age group.

Full scale WISC IQ of the index cases (sexes combined) was
68.5 and of the controls 81.5 Verbal and performance differences
were of similar magnitude and in the same direction. All mean IQ
differences were significant al less than the 5 percent level of
confidence. If an IQ score of below 70 is considered a customary
out-off point for the definition of mental retardation then twice
as many of the previously malnourished children as their siblings
functioned below this level; eighteen malnourished, compared with
nine of the control subjects, had and IQ below 70. Moreover, of
those with a low IQ, ten of the index cases were below 60, contrasted
with only two of the control subjects. At the other extreme of the
distribution, in the conventionally normal range, the reverse
picture obtains: ten of the control subjects, compated with four of
the index cases, had an IQ of 90 or higher. Differences in age
between the survivors of malnutrition and their siblings did not
affect the differences in intellectual test performance between the
two groups. No significant sex difference in IQ was found among the
rehabilitated children. The mean full scale IQ for boys and girls,

respectively, was 70.7 ± 14.08 and 68.6 ± 13.83.

The situation in the sibs group was different. In these children there was a significant difference between boys and girls, with the boys having significantly higher full scale and verbal IQ than the girls. When patients and control subjects were compare separately by sex it was found that the previously malnourished boys differed from the control boys significantly, with control subjects having a full scale IQ approximately 12 points higher than patients. Although control girls also had somewhat higher IQ than girls who were previously malnourished the size of the difference was insufficient to result in statistical significance. This pattern of finding was entirely the result of the depressed level of IQ in the girls in the control group. No reasons for this depression could be found in differing educational experience since there were no sex differences in school attendance. A depressed level of IQ in girls relative to boys, however, has been repeatedly found in children of school age in the social groups considered and probably derives from the far lower value attached to the education of girls in this particular subculture. (Cravioto, Lindoro, and Birch 1971).

When the scaled scores on the 11 subtest of the WISC obtained in the survivors of malnutrition were compared with the values found in the siblings, the analysis of the subtest profiles suggested a relative uniform depression of performance in the index cases with respect to a variety of cognitive demands.

In the second study using siblings, Hertzig, Birch, Richardson and Tizard (1972) decided to investigate the degree to which children malnourished before two years of age differ from their sibs and classmates in intellectual competence at school age. The index cases were 74 Jamaican boys who had been treated in a hospital for severe malnutrition before the age of two years. The three main clinical types of severe protein-calorie malnutrition-kwashiorkor, marasmic, and marasmic-kwashiorkor - were represented. Children on the average were hospitalized for a period of eight weeks. Follow-up visits in the homes by nurses were carried out for 2 years after discharge. At the time of the intelligence testing the children's age ranged from 6 to 10 years. This age range was selected in order to be far enough removed from the time of hospitalization, and for the children to be at an age where intelligence test performance has predictive value.

A sib and a classmate or yardmate were selected as controls for each index case. Two comparison groups were thus included, the first one made up of male sibs. For a sib to be selected he had to be between 6 and 12 years old, nearest in age to his malnourished brother and without a history of severe malnutrition. The second comparison group was made up of classmates or neighbors of the index cases. For index children attending school two male classmates closest in age to the index case were selected. If the first comparison child was not available for examination, the second comparison was used. Some of the index boys, though of school age,

were not going to school. For these cases, a comparison case was
chosen by finding the nearest neighboring child who was not a
relative and who was of an age within six months of the index case.
For some index cases at small schools no classmate was within six
months of age. For these cases neighbor children were also used
as comparisons. As would be expected from the method of selecting
comparison children, index and comparison children lived in the
same general neighborhood from which the school drew its pupuls.

Each child's intellectual level was individually evaluated
by means of the Wechsler Intelligence Scale for Children (WISC).
All children were examined without the examiners being aware of
the group to which the child belonged.

Results showed that mean Verbal, Performance, and Total
(Full Scale) Intellectual Quotients were lower in the survivors of
severe malnutrition, with sibs scoring at an intermediate level, and
classmates and yardmates having the mean highest scores.

Since the WISC Test has a floor of 46 points for both the
Full Scale and the Verbal Scale, and of 44 points for the performance
Scale, it is apparent that even if a child's responses were all wrong
his minimal intellectual quotient would be the floor value, and
therefore a comparison of mean IQ's would be inappropriate. With
this in mind, Hertzig et al. compared the number of survivors of
severe malnutrition and of control children who scored at the lowest

level of measurable performance.   Twenty-three percent of the

survivors against seven percent of the controls were at the floor

level for the Full Scale I.Q.   Similar results were obtained for

the Performance Scale with no significant difference in the Verbal

Scale.   This analysis clearly shows the very low levels of I.Q. present

in the survivors of severe malnutrition.   In interpreting the data,

it is of importance to note that no age trend for I.Q. was found in

the study groups; nor was ordinal position for sibs responsible for

the differences obtained.

The use of siblings as comparison subjects has certain

implications for the interpretation of findings.   Such comparisons

are of course advantageous in that children who are contrasted come

from the same families and tend to share a common experiential

ambience.   Demographic data, however, strongly points out that having

a child hospitalized for severe clinical malnutrition in fact

identifies a family in which all children are at risk for significant

mild-moderate malnutrition on a chronic basis.   Therefore, index cases

and sibs are similar in sharing a common exposure to subnutrition on a

life-long basis and differ, in this nutritional background, only in

that the index cases have a superimposed episode of acute exacerbation.

Consequently, the comparison of sibs and index children does not

provide a full picture of the overall effects of nutritional inadequacy

on intelligence performance.   Rather, it indicates the additional

consequence for maldevelopment which may attach to the superimposed

episode of acute exacerbation. The use of sibs as controls also

means that the children compared have shared a generally disadvantageous

social and family environment several features of which can in

themselves significantly contribute to the depression of the

intellectual performance levels. This factor, too, should result in

the minimizing of differences between survivors of severe malnutrition

and their sibs and provides further support to the significance of the

difference found on measured intelligence.

In spite of their limitations, all the reviewed studies clearly

show that the environment in which children at risk of malnutrition live

is highly negative in its effects on mental development. Irrespective

of the presence or absence of a previous admission to a hospital

because of severe malnutrition, children developing in this milieu

have a high probability of showing poor performance on intelligence

testing. The presence of a superimposed episode of malnutrition

occurring early in life, and of enough severity to force the child

into a hospital, increases the chance of scoring at values even lower

than those characteristic of the poor environment.

It must be emphasized that the finding of an association between

early malnutrition and lower mental development is by no means

evidence that the insufficient intake of nutrients and energy _per se_

affects intellectual competence in man.

IV.- EARLY MALNUTRITION AND INTERSENSORY ORGANIZATION.

Since data from comparative psychology (Maier and Schneirla
1935, Birch 1954) and evolutionary physiology (Voronin and
Guselmikov 1963) have suggested that the emergence of complex
adaptive capacities is underlain by the growth of increasing liason
and interdependence among the separate sense systems, and in
addition a variety of studies (Birch and Bitterman, 1949, 1951)
indicated that the basic mechanisms involved in primary learning
(i.e the formation of conditioned reflexes) is probably the
effective establishment and patterning of intersensory integration,
Cravioto et al. in Guatemala and Mexico (1966, 1967), Champakan,
Srikantia and Gopalan in India (1968), and Wray in Thailand (1975)
in trying further to explore the mental functioning of school-age
children who had been at various degrees of risk of malnutrition in
the preschool years, have measured the development of intersensory
integration in the kinesthetic-visual, kinesthetic-haptic, and
haptic-visual modalities. The selection of these intersensory
modalities was made on the basis of the work of Birch and Lefford
(1964) who found that in normal children between the ages of six
to 12 years the interrelations among three sense systems-touch,
vision, and kinesthesis - improved in an age-specific manner and
resulted in developmental curves that were as regular as those for
skeletal growth.

In the Indian study, children rehabilitated from kwashiorkor,

suffered between the ages of 18 to 36 months, were compared at the

age of 8 to 11 years with matched controls. Intersensory organization

was poorer in the index cases that in the control subjects with

differences highly significant. When these children were again

tested 5 years later, the differences between the two groups had

considerably decreased. Although the survivors of severe protein-

calorie malnutrition still committed more errors than the control

children the difference was not statistically significant. After

another period of follow-up of two years, the performance of both

groups of children war errorles.

The apparent catch-up of the nutrition rehabilitated group

has to be taken cautiously. When applying a test with a clearly

developmental course the point at which the asympotic performance

is reached might be the only difference between a group with normal

development and a group with a developmental lag. If a child has

already completed the maximal level of performance and another child

obtains that same level later in time, although both children have

now the same score it cannot properly be said that the second child

caught-up with the first. Moreover, in societies were the demands

are chronological-age specific the importance of a lag in development

might be fundamental for the future role and status of those affected

inspite of the fact that later in life, such as in adulthood, the

test performance of these individual may not differ at all from that

obtained in their more fortunate mates.

In the Mexican, Guatemalan and Thailand studies school-age

children aged 5 through 11 years tested. According to the physical

growth achievement at each age level the lower quartile of height

distribution (most stunted children) and the upper quartile of the

distribution (most fully grown children) were contrasted in their

intersensory abilities. Differences in neurointegrative skills

were manifested in all combinations of intersensory integrations

examined. Tall children, particularly in the younger age groups,

performed at a higher level of competence than stunted children,

Figures 1 to 3 illustrate the results of the Guatemalan study. Not

only were mean differences significant, individual variability in

performance also tended to be greater in the shorter children.

Obviously, when height is used as an index of risk of exposure to

prior malnutrition at least 3 contaminating variables must be

controlled in interpreting its association with levels of performance.

The first is that height differences should not merely be the

reflection of familial differences in stature; the second, that

short stature should not be just another manifestation of a general

developmental lag; and the third, that shorter children must not

come from familial environments at significantly lower socio-cultural

levels.

These non-nutritional factors were ruled out as main contributors

to the results obtained since: 1) height of parents and children were

not significantly correlated: 2) No significant association was
found between the height of the fathers and the level of intersensory
competence achieved by the child;   3) Tall and short children of the
same age in populations of children without antecedent conditions of
nutritional risk did not exhibit differences in their levels of
intersensory adequacy; and 4) by the lack of correlation between
height and income, occupation, housing, personal cleanliness, presence
of sanitary facilities in the home, and contact of parents with mass
comunication media. Educational level could not be eliminated as an
important intervening variable since mother's level of formal education
was significantly associated with her child's height. Accordingly,
The Guatemalan, Mexican and Thailand results could be interpreted in
the sense that the inadequacy in intersensory development could
represent the effects of earlier malnutrition in association with
more general subcultural differences between the tall and short
children.

A more detailed definition of the roles of malnutrition and
cultural factors obviously requires a prospective study of a
community of children with varying quantified risk of malnutrition
in infancy and during the preschool years.

More recently, we have had the opportunity of a preliminary
analysis of the visual-kinesthetic development in children with
known nutritional histories during their first seven years of life

(Cravioto et al. 1968). As may be seen in figure 4, the competence

level at 78 months of age in survivors of severe malnutrition

suffered before 3 years of age in markedly lower than performance

obtained in children from the same birth cohort who never had severe

malnutrition. When the survivors of malnutrition were matched with

non-malnourished for total stimulation available in the home, as

measured by the inventory of Bettye Caldwell (1967), figure 5 show

the persistance of the lower levels of competence in the children

with the previous history of severe malnutrition.

The reports of neurointegrative adequacy in 4 different

cultural settings (India, Guatemala, Thailand and Mexico) may be

significant because they suggest that functional lags could occur

at mild-moderate degrees of protein-calorie malnutrition, and may

not be limited to the extremely severe cases represented by

kwashiorkor and marasmus.

Trying to extend our inquiry to other types of cross-modal

integrations, two studies of auditory-visual equivalence were

carried out. The first one in the school children of a Mexican

rural area where malnutrition in early life is highly prevalent

(Cravioto, Gaona-Espinosa, and Birch 1967). All children aged

seven through twelve were weight and measured, and on the basis of

height achievement the lower quartile and the upper quartile of the

distribution at each age were compared in their auditory-visual
performance. The children's ability to integrate auditory and
visual stimuli was individually tested by a method of equivalence
in which the children were asked to identify visual dot patterns
corresponding to rythmic auditory patterns (Birch and Belmont
1964).

At each age level the mean performance of the taller group
was higher than that of the shorter. The difference was most
striking at age twelve, when 42 percent of the taller children were
making eight or more correct judgements, with 30 percent achiving
a perfect score of 10. In contrast, only 9 percent of the shorter
children in this age group achieved scores of eight or greater, with
none making a perfect score.

In the second study (Cravioto, 1971) the developmental course
of auditory visual equivalence was studied in 39 school-age children
who had suffered severe clinical malnutrition before the age of 30
months, and in 39 siblings of similar sex and age. When the
performance of siblings and index cases was contrasted, age by age
the survivors of severe malnutrition were well below their siblings
in auditory-visual competence.

Independently of whether intersensory organization is interfered

by malnutrition per se or through one or more of the variables which
produce or accompany malnutrition, neurointegrative development is
delayed in those children at nutritional risk who have grown poorly.
It is, therefore important to consider the potential significance of
this type of developmental lag in so primary a process as intersensory
organization for more complex psychological functioning. In this
connection it is of interest to consider two significant features:
learning-conditioned reflex formation and acquisition of academic
skills.

In most conditioning situations what is being demanded is the
integration between two stimuli, each of which belongs to a different
sensory modality. Thus, in classical salivary conditioning of a leg
withdrawal, a gustatory or a tactile stimulus is in effect being
linked to an auditory or visual one. The process of conditioning,
when effective, therefore involves the establishment of intimate
equivalence between initially nonequivalent stimuli in different
sensory modalities. If interrelations among sensory modalities are
inadequately established the posibility exists that conditioning
will either be delayed in its occurrence or that the pairing of
stimuli will be ineffective in producing conditioned reflexes.
Therefore, failure for intersensory integration to occur at normal
age-specific points can contribute to inadequate primary learning at
the given age level.

Evidence already exists that the lag in the development of
certain varieties of intersensory integrations have a high
correlation with backwardness in learning to read or to write. In
this respect, Birch and Belmont (1964, 1965) and Kahn (1965) have
data strongly suggestive that backwardness in reading is significantly
associated with inadequacy in auditory-visual integration. Data are
also available that point out the dependence of visual-motor control
in design-copying on visual-kinesthetic intersensory organization.
(Birch and Lefford 1967). Since the time of Baldwin (1897) it was
recognized that such visual-motor control is essential for learning
to write, therefore, the lag in intersensory organization can interfere
with a second primary educational skill - learning to write.

Thus, inadequacies of intersensory development can place the
child at risk of failing to establish an ordinary normal background
of conditionings in his preschool years and at the risk of failing
to profit from educational experience in the school years.

V.- VISUAL PERCEPTION.

An essential prerequisite for learning to read is the child's
ability to distinguish simple visually presented figures, and to
respond to more differentiated aspect of the figural percept such
as angular properties and spatial orientation. Failure to respond
to these aspects can result in the child confusing the letters which

in the Roman alphabet are identical in form but distinguishable by their spatial positioning. Lower case letters such as b, p, d, and q, or capital N and Z, W and M, all represent equivalent shapes with the distinction among them depending upon the child's ability to respond simultaneously to shape and to orientation in visual space.

Using the visual discrimination task developed by Birch and Lefford for their studies on voluntary motor control (1967) visual perception of forms was explored in 39 school children who had been treated for severe malnutrition at ages below 3 years, and in an equal number of their nearest age and same sex siblings. Age by age, the levels of performance of recognition of geometric forms although low for both groups of children were significantly lower for the survivors of severe malnutrition until age 9 years when both siblings and previously malnourished children achieved similar levels of competence, with the circumstance that this asymptotic performance level had been reached by the siblings since age 7 years.

When the children were tested for their ability to analyze geometric forms, the meen number of errors committed also decreased as age advanced. Once again a marked difference was found in favor of the siblings. Thus, survivors of severe malnutrition present a lag in readiness to read which is even lower than the low readiness characteristic of their low socioeconomic class (Cravioto, DeLicardie, Piñeiro, and Alcalde, 1969).

VI.- LANGUAGE DEVELOPMENT.

In the course of a longitudinal ecological study of a total cohort of children born during one calendar year in a rural village of central Mexico out of the 334 infants inducted 14 girls and 8 boys developed clinically severe protein-calorie malnutrition before the age of 5 years. Fifteen of the 22 patients developed kwashiorkor the other 7 marasmus. Ten children, 6 with kwashiorkor and 4 with marasmus, were treated at home, while 9 children with kwashiorkor and 3 with marasmus were treated in a pediatric hospital. No deaths occurred in the latter group, but 3 of the 10 children treated at home died.

These cases occurred despite the fact that all children in the cohort studied were medically examined on a biweekly basis. Children who failed to grow normally were indentified, their infectious illnesses were treated, and their parents were given advice (which they did not follow) on the appropriate feeding and management of children who failed to thrive. In contrast to its lack of influence on the incidence of clinically severe PCM, this medical attention decreased the infant mortality rate from a figure of 96 per thousand to 46, and reduced the preschool mortality of the cohort by one-half. Incidentally, these data point out, once more, that traditional medical care can strongly influence mortality with minimal or no effect on morbidity.

Since one of aspects being under investigation in the cohort

was language and communication, it was possible to analyse its

development prior, during, and after the episode of severe

malnutrition. In a first report, Cravioto and DeLicardie (1972)

have described language development and appearance of bipolar

concepts in the group of survivors of severe malnutrition in

comparison with a group of children selected from the same birth

cohorth who were never diagnosed as severely malnourished and who

were matched, case by case at birth, for sex, gestational age,

season of birth, body weight, body length, and performance on the

Gesell Test.

During the first three years of life language acquisition

was evaluated by means of a technique similar to the Gesell (Gesell

and Amatruda, 1947). Mean language development was very similar in

index cases and controls during the first year of life when only

one case of severe malnutrition had been diagnosed. As time

elapsed and more children became ill with severe malnutrition a

difference in language performance favorable to the matched controls

became evident. The difference was more pronounced at each

successive age tested. Not only were mean values significantly

lower in the index cases, the distribution of individual scores was

also markedly different. At 1080 days of life 11 of the 19 control

children had language scores above 1021 days-equivalent. As a

contrast, while none of the children in the malnourished group scored

above 960 days-equivalent, 12 of the 19 cases had values below 720

days, with 3 of these children exhibiting language development

inferior in more than six months to that observed in the control

children who had the lowest scores.

Since the emergence of the conception of opposites and with

it bipolar labeling represents an early and readily measured aspect

of the development of concepts in young children, and since concept

development and particularly the emergence of verbal conceptions,

have long being viewed as a basic factor in the development of

human intelligence, the natural acquisition of bipolar concepts was

assessed in the longitudinal cohort of children starting at 26

months of age.

Data obtained by Rojano (1970) in the total cohort of Mexican

children tested at succesive ages with the series of bipolar

concepts developed by Francis H. Palmer at the Institute for Child

Development and Experimental Education of the City University of

New York, U.S.A., for the systematic training and enrichment of

language experience, documented a clearly developmental course of

competence in response to tasks involving the utilization of such

bipolar concepts as a scale of progressive difficulty. The test

oculd be used with young children less than 3 years of age because

most of the items included only require the selection by the child

of an object representing a given pole (e.g. big-little: long-short:

in-out; black-white) from two objects differing only with respect

to their position on one of the concepts continua. The items are

grouped into two forms so that each form contains items covering

both poles of each concept. The forms differ only with respect to

the setting in which the concepts are placed. The score derived

from the test provides a measure of the child's knowledge of

various categories that are commonly used in organizing sensory

experience.

Since examination of bipolar concept aquisition were done in

the total cohort at twenty-six, thirty-one, thirty-four, thirty-eight,

forty-six, fifty-two, and fifty-eight months of age, it was possible

to compare the patterns of competence of this function in the group

of children who developed severe malnutrition and in their selected

controls, both at the time some of children were suffering from

severe malnutrition and after they had been nutritionally rehabilitated.

The mean number of bipolar concepts present in the children

with present or past severe malnutrition was significantly lower

than the mean number of concepts shown by the control group. The

differences at all ages but age thirty-one months were statistically

significant. Not only were mean values significantly higher in the

control children, the proportion of better performens was also higher.

Thus, for example, at 26 months of age while almost one-half of the

control children had 5 or 6 concepts, none of the malnourished

subjects had attained this level of competence. On the other hand, one out of every three malnourished children had a maximun of one concept while seven out of every ten controls are at the level of two or more concepts. Even after nutritional rehabilitation the survivors continued to lag behind the controls. Thus, at age 58 months four out of every ten survivors had not more than 17 concepts while the minimun number shown by the control children was 18 concepts. Similarly, none of the previously malnourished children had more than 20 concepts while two out of every ten controls were above this level. A study of increments at succesive ages showed that between ages 26 and 38 months, the period in which the last cases of severe malnutrition appeared, increments in the control group were far greater than those in the malnourished group. During rehabilitation the survivors of severe malnutrition had an increment twice as big as that of controls: unfortunately, at later ages the increments tended to be lower, and there was not enough time for the previously malnourished children to catch-up. In other words, the lag in language development present when the children were actually malnourished continued to persist after clinical recovery had taken place.

Since the group of malnourished children had significantly lower scores in home stimulation than the control children, in an attempt to separate the possible influences of stimuli deprivation from those of malnutrition an analysis of the interrelations among these two variables and the number of bipolar concepts was carried out. As a first approach to this issue a technique of partial correlation was employed in order to estimate the degree of association

between two of the variables "holding constant" the influence of

third variable. Since the number of severe clinical malnutrition

is rather small, it was decided to test for the interrelations

in the total birth cohort assuming that body height is a good

indicator in the community under study, of the risk of chronic

malnutrition.

The coefficients of correlation product x moment among home

stimulation scores, total body height, and number of bipolar concepts

present at 46 months of age in the total cohort were all significant

at no less than 0.05. When the relation between home stimulation and

number of bipolar concepts was partialed out for body height the

coefficient of correlation dropped from 0.20 to 0.15. When the

relation between body height and number of bipolar concepts was

partialed out for home stimulation the coefficient changed from 0.26

to 0.23; finally when the number of bipolar concepts was "heald

constant" the coefficient of correlation between home stimulation

and body height changed from 0.23 to 0.19.

These results suggest that the association between home

stimulation and number of bipolar concepts is mediated, to a good

extent, through body height which in turn holds a significant degree

of association with the number of bipolar concepts independently, to

a large extent, of home stimulation. Within the limits of the

probabilities given by the magnitude of the coefficients, home

stimulation contributes relatively more to body height than to

number of bipolar concepts while body height contributes more than home

stimulation to the variance of bipolar concepts.

VII.- STYLES OF RESPONSE TO COGNITIVE DEMANDS.

Since the studies on the possible effects of malnutrition on

mental development and learning in humans have, for the most part,

focused on achievement without considering behavioral style, DeLicardie

and Cravioto (1973) decided to analyze, as a part of their longitudinal

study on the effects of environment on mental development, the

modification that an episode of severe malnutrition might make on

the behavioral style of lower class children. In other words, they

were concerned not with how well but with how the children with

antecedents of severe malnutrition behaved. To answer this question

the strategy for the analysis focused on the comparison of

responsiveness to cognitive demands in 14 survivors of severe clinical

malnutrition suffered before thirty-eight months of age, and in two

groups of children selected from the same birth cohort who never

showed signs or symptomes of severe malnutrition and who were matched,

case by case, with the survivors. In one comparison group the

matching was done for sex, gestational age, season of birth, body

weight, total body length, and organization of the central nervous

system as determined by the Gesell method. The second comparison

group included fourteen children, full-term and healthy at delivery

who were matched for sex and IQ (WPPSI) at five years of age with the survivors of severe malnutrition.

At the age of 5 years, all children were individually examined using an adapted version of the Wechsler Preschool Primary Scale of Intelligence (WPPSI). The tasks of this test were used to obtain behavioral information on response style to a standardly presented set of cognitive demands. During the administration of the test a detailed protocol of the child's behavior and verbalization was recorded by an independent observer.

The analysis of response styles followed the logic tree developed by Hertzig et al. (1968). When confronted with a demand, a child can respond either by working or not working. This initial choice can be expressed through either verbalization or motoric action. If the choice was to work, whether verbally or non-verbally, the response can involve an expression of spontaneous ideational extension or it could be delimited and restricted to the defined requirements of the task. In relation to non-work responses the different styles can be expressed as simple negation, substitutive behavior, request for assistance, or as a rationalization with respect to competence when the starting point is verbal. If the non-work response is nonverbal the subdivisions are simple negation, substitutive behavior, request for assistance, or passive unresponsibeness. All categories, in terms of which response styles to cognitive demands are classified, are objective generalizations about observed behavior.

As Hertzig and co-workers have emphasized, the categories are not, nor are they intended to be, inferences about the underlying reasons for the expression of the observed behavioral patterns.

Since the logic classification of styles is done mainly through a series of dichotomies, the way for identifying individual differences in the responsiveness to cognitive demands consisted in ascribing a child to a particular style when his proportion of responses of that style was equal to or greater than 0.75. Table 2, shows the main style of response in survivors of malnutrition and controls.

It is apparent that while survivors and controls for IQ. and sex tend to be similar in their styles of response the children in the group of controls matched at birth showed a different style. Verbal behavior predominated among this letter group, and the children who were classified as of the not-work type had verbal competence as their main style of response. Conversely, among the survivors and the controls matched for IQ and sex all the not-work children were of the not-work-nonverbal type, unresponsiveness being the typical behavior of these not-work children. Moreover, controls for size at birth when they give not-work verbal responses these are mainly expressed in terms of competence rationalizations.

In the presence of these findings, one might tend to consider

that the differences in patterns of response between the controls

matched at birth and the survivors of severe malnutrition could

be explained on the basis of differences in intellectual performance.

The observation of similar behavioral patterns in children with

and without antecedents of severe malnutrition but with equal low

intellectual performance would be in favor of this explanation.

Moreover, Hertzig et al. (1968), in their study of middle-class

American and working-class Puerto Rican children, found that

differences in IQ affected the proportion of demands that was met

by a work response, the proportion of total responses that were

verbally expressed, and the style of verbal not-work. However, the

difference in styles observed between middle-class and Puerto Rican

children persisted at all IQ levels. Lugo (1971) in a study of

urban Mexican children of three different social classes, also

found a quantitative difference in responsiveness as a function of

IQ level, but the differences in response style persisted across

the socioeconomic levels in the presence of a common IQ range.

Accordingly, one cannot accept differences in IQ as the reason for

differences in behavioral patterns of response.

Besides the I.Q. difference between survivors of malnutrition

and controls matched for size at birth, home stimulation scores,

assessed by the inventory of Caldwell (1967) were significantly

higher in the controls matched at birth, with similar low scores

in both survivors and controls matched for I.Q. and sex. This difference in stimulation could significantly contribute to the development of dissimilar patterns of responsiveness, particularly in relation to the amount and type of verbalization.

In attempting to tease out the effects that may be due to malnutrition from those which may be due to stimuli deprivation, survivors of severe malnutrition and controls with equal scores in home stimulation were identified. Ten controls for I.Q. and sex, seven survivors of severe malnutrition, and six controls for size at birth met this requirement. When the styles of response of these children were compared no difference was found among the three groups in the mean number of total responses, in the proportion of work responses, in the proportion of total responses verbally expressed and in the styles of nonverbal non-work responses. On the other hand, the proportion of verbal not-work responses observed in controls matched at birth (0.87) was almost three times the proportion found in either survivors (0.30) or controls matched or IQ and sex (0.26). The difference between controls matched at birth and the other two groups was significant at the level of confidence of 0.001.

When the styles of verbal not-work responses were compared, it was observed that the three groups were markedly different. Controls matched at birth expressed their verbal not-work responses in terms of rationalization of competence, survivors expressed their responses

mainly as request for aid, and controls matched for IQ and sex had

similar proportions of styles of competence, requests for aid, and

substitution.

The finding of unresponsiveness as a characteristic style in

children who with or without antecedents of severe malnutrition have

as a common background a low level of home stimulation leads one

to consider that regardless of a physiological component that may

be present when the children were malnourished, the passive behabior

of survivors of severe malnutrition is probably linked to stimuli

deprivation.

The differences observed between survivors of severe malnutrition

and controls with equal scores of home stimulation seem to indicate

that besides the effect of stimuli deprivation on the styles of response,

the antecedent of clinical severe malnutrition appears to be another

influential factor.

It has been suggested by Canosa, Solomon, and Klein (1973) that

differences in performance between well-nourished and malnourished

children may be due to a lower ability of the malnourished subjects

to or concentrate on the given task. However, since these children

have a high frequency of passive responses when confronted with a

demand, failure to perform efficiently could be a consequence of this

style of behavior. For example, any task requiring systematic

scanning or elaboration of information by progressively more complicated steps requires the child to engage actively in the pursuit of an answer. Unresponsiveness as a style of behabior may lead to a quick answer without regard for its accuracy. Similarly children with passive patterns of behavior may give low scores on tasks that are penalized for time.

VIII.- INFLUENCE OF AGE AND DURATION OF MALNUTRITION ON LATER PERFORMANCE.

Dobbing (1976) through a masterly series of studies has documented his concept of the developing brain's vulnerability. According to this concept there is a pathology of brain development in which the timing of etiological factors in relation to the growth spurt sequence is of even more significance than their duration and their severity. Moderate growth restriction, which before the brain growth spurt or afterwards does not leave traces of pathology, results in permanent structural and functional alterations when it occurs at the time when the brain is passing through the period of most rapid increase in weight.

In accordance with this concept, age at the time of insult and duration of the period of malnutrition, or rather of growth restriction, becomes of the greatest importance in relation to the prognosis. The general hypothesis would be that the effect of severe postnatal malnutrition, capable of significantly restricting

somatic growth, would vary as a function of the period of life at which the lag in growth was experienced.

To test this hypothesis Cravioto and Robles (1965) examined the mental recovery of twenty Mexican Infants hospitalized for kwashiorkor. On admission for treatment six infants were below 6 months of age, 9 between 15 and 29 months, and 5 between the ages of 37 and 42 months. All children were tested with the Gesell method at regular intervals of 2 weeks. As recovery from malnutrition occurred, developmental quotients increase in most of the patients and the gap between normal age expectation and the actual performance of the child progressively diminished for all except those in the group whose age on admission was less than 6 months. These younger malnourished infants showed no tendency to "catch up" and increased in developmental age only by a figure equal to the number of months they remained in the hospital. Serial data on performance plotted against days of hospitalization showed that the older the group the greater the value of the slope.

Hoorweg and Stanfield (1972) selected from their records in Uganda three groups of children aged 11 to 17 years who had been treated for severe clinical malnutrition suffered before 27 months of age. Each group consisted of 20 former patients whose ages when admitted for treatment were less than 16 months for group one, between 16 and 21 months for group two, and between 22 and 27 months

for those included in group three. General intelligence, verbal
abilities, spacial and perceptual abilities, visual memory, short-
term memory, learning and incidental learning, and motor development
were evaluated. Significant differences among groups were found in
Memory for Designs in which group 3 performed better than groups
one and two, and in the learning task in which group two did better
than group one. In two other tests, incidental learning and short-
term memory, the differences as a function of age at which
malnutrition was treated reached a significant level of confidence
of 0.10. The findings are in the expected direction in which those
children who suffered younger do more poorly.

Intelligence Quotients, derived from a battery of tests that
included Raven Progressive Matrices, the Koch Test, and the
Goodenough Draw-a-man Test, were found significantly associated with
the age on admission for treatment of severe malnutrition in a group
of fourteen survivors examined nine to eleven years after discharge
from a hospital in El Salvador, Central America (Guillen-Alvarez,
1971).

Chase and Martin (1970) in the U.S.A., did a follow-up study
of nineteen infants who were hospitalized at less than one year of
age because of severe undernutrition. Fourty-two months after
discharge from the hospital the mean Developmental Quotient obtained
with the Yale Revised Developmental Examination was significantly

lower than the Quotient found in a comparison group of children

matched for birth date, weight, sex, race and socioeconomic status.

Children admitted to the hospital with severe malnutrition lasting

longer than the first 4 months of life gave the lowest quotients

on the follow-up. All the children admitted in the first 4 months

of their lives had 3 1/2 years later Developmental Quotients above

80, whereas 9 of 10 children who had suffered malnutrition for

periods longer than their first 4 months of life had Developmental

Quotients below 80. These findings are in line with a report of

DeLicardie et al. (1971) who found that a group of infants who,

for no detectable reason, had body weights at 15 days of life below

their birth weight continued to weight less than their matched

controls throughout the first year of life and lag behind in total

body length, head circumference, chest circumference, arm circumference

and braquial skin-fold thickness without exhibiting a significant

difference in their mental development, assessed by the Gesell

Technique. Along this same line of age and duration, Stein and

co-workers (1975) in their brilliant epidemiologic study of the

Dutch famine did not find a relation between the mental performance

of young men at the time of their military induction and their

prenatal exposure to famine. Since no evidence could be found of

interaction of prenatal famine exposure with indicators of social

environment that might had influenced compensatory learning

opportunities and promoted better subsequent mental development, and

also no evidence was found that selected survival might had masked or

distorted an association of prenatal famine exposure with mental

performance at the age of military induction, it appears as if

deficient food intake confined to the prenatal period may be either

of too short duration to produce a detectable effect on mental

performance on the young adult or the insufficient nutrient intake

period was out of phase with the brain's growth spurt, that for

the human starts around mid-gestation but has its maximal rate

postnatally and extends its duration at least well into the second

year of life. (Dobbing, 1974).

Hertzig and associates (1972) in their study of Jamaican

school-age boys who had suffered from severe malnutrition before

age two, did not find a significant correlation between age of the

child at the time of admittance for treatment and Wechsler

Intelligence Quotient. When the I.Q.'s of the 74 children were

divided into those belonging to the children admitted for treatment

before 8 months of age, between 8 and 12 months, and between 13 and

24 months, an analysis of variance showed that the means for the

subgroups were not statistically different at the 5% level of

confidence. Since Hertzig's data show very clearly that IQ mean

values in the survivors of malnutrition are misleading due to the

significant number of children who scored at the floor level of the

Wechsler, before accepting the author's conclusion of no relationship

between time at which severe malnutrition occurs and severity of

mental outcome it might be convenient to test for performance

differences in their age groups using non-parametric statistical

techniques.

Klein, Forbes and Nader (1975) in 50 children, 44 boys and

6 girls, aged from 5 to 14 years who had been treated for congenital

pyloric stenosis estimated the severity of starvation as the

percentage difference of infant's weight on admission for treatment

and expected weight for age, extrapolated from birth weight. General

intelligence, measured by the Peabody Picture Vocabulary Test and

the Raven Progressive Matrices Test, showed a significant correlation

with the estimated degree of starvation ($r=-0.323$, p less than 0.05).

The scores on a scale that measures the parental evaluation of the

child's intellectual development and expected educational potential

also correlated significantly with the severity of starvation ($r=-0.367$;

p less than 0.01). These data apparently are at variance with the

study of Berglund and Rabo (1973) who did a follow-up of 174 Swedish

boys who suffered from inatition, starting at ages 6 to 20 days,

because of pyloric stenosis. After a variable period of starvation

during which body weight became lower than birth weight the patients

recovered. A significant correlation between height at adulthood

and weight loss and duration of starvation in infancy was found, but

the performance on an intelligence test, administered at the time of

registration for military service, did not correlate with the history

of malnutrition in infancy.

Even considering the limitations inherent to the types of
studies reported it seems apparent that severity, duration, and
particularly the time at which the malnutrition insult occurs
are relevant factors in determining the permanency or transiency
of the physical and mental after effects. It must be remembered
at all times that nutritional deprivation may constitute just
another of the numerous factors present in the impoverished
environment in which infants and children develop malnutrition.

IX.- MECANISMS OF ACTION OF MALNUTRITION.

It must be emphasized that the finding of an association
between early malnutrition and lags in mental development and
learning, and distortion in behavior is by no means evidence that
the insufficient intake of nutrients and calories per se affects
intellectual competence, learning and behavior in man. In attempting
to explain the effect of malnutrition on intellectual compentece and
learning at least two possibilities can be entertained. The first
and simplest hypothesis would be that the nutrient deficiency affects
mental functioning by directly modifying the anatomical and/or
biochemical structure of the central nervous system. In favor of
this explanation it is relevant to remember that increase of cell
cytoplasm with extension of axons and dendrites (one of the processes
associated with the growth of the brain in early life) is largely a
process of protein synthesis. From the microspectrographic investigation

of the regenerating nerve fibers it has been estimated that protein

substance increases more than 200 times as the apolar neuroblast

matures into the young anterior horn cell. In experimental animals

specific amino acid deficiencies can cause structural and functional

lesions of the central nervous system (Scott 1964). In mice,

inhibition of protein synthesis in the brain produced by puromycin

is accompanied by loss of memory (Flexner et al. 1962). Delays in

myelination and reduction in cell number and in cell distribution in

the brain caused by interference with adequate nutrition in early age

have been amply documented (Dobbing, 1968; Winick and Rosso 1969;

Chase, Dorsey, and McKhann 1967; Benton, Moser and Dodge, 1966;

Davison and Dobbing, 1966; Dobbing, 1974; Guthrie and Brown, 1968;

Kerr et al. 1976; Winick 1969; Winick and Noble, 1966). Preliminary

findings of reduction in brain size and even in cell number in children

who died with severe malnutrition have been reported from Mexico

(Ambrosius 1961), Uganda (Brown 1965), and Chile (Winick 1969; Winick,

Rosso, and Waterlow 1970). In this respect Stein, Susser and Saenger

(1975) have rightly pointed out that even autopsy at death cannot

prove the irreversibility of the brain cell depletion reported

in fatal cases of early malnutrition nor indeed can be infered from

these studies whether the depletion is compatible with life and even

to be found in survivors.

In regard to functional changes link to inadequate diets

Barnes et al. (1968, 1970) and Frankova and Barnes (1968) have

documented in rats and pigs a series of disorders including learning

disability, and Platt et al. (1964) have reported electro physiological
changes in various animal species.

The second hypothesis considers that malnutrition in human
children does not need to produce structural lesions of the central
nervous system to affect intellectual competence behavior and
learning. Three possible indirect mechanisms can be postulated:

1.- <u>Loss of learning time.</u> Since the child was less responsive
to the environment when malnourished, at the very least the child had
less time in which to learn and had lost a certain number of months
of experience. On the simplest basis, therefore, the child would
be expected to show some developmental lags.

2.- <u>Interference with learning during critical periods of</u>
<u>development.</u> A considerable body of evidence exists indicating that
interference with the learning process at specific times during its
course may result in disturbances in function that are both profound
and of long-term significance. Such disturbance is not merely a
function of the length of time the organism is deprived of the
opportunities for learning. Rather, what appears to be important is
the correlation of the experiential opportunity with a given stage
of development. It is possible that exposure to malnutrition at
particular ages may in fact interfere with development at critical

points in the child's growth course and so provide either abnormalities

in the sequential emergence of competence or a redirection of the

developmental course in undesired directions.

3.- _Motivation and personality changes._ It should be recognized

that the mother's response to the infant is to a considerable degree

a function of the child's own characteristics of reactivity. One of

the first effects of malnutrition is a reduction in the child's

responsiveness to stimulation and the emergence of various degrees of

apathy. Apathetic behavior in its turn can function to reduce the

value of the child as a stimulus and to diminish the adult's responsiveness

to the child. Thus, apathy can provoke apathy and so contribute to a

cumulative pattern of reduced adult-child interaction. If this occurs

it can have consequences for stimulation, for learning, for maturation,

and for interpersonal relations, the end result being significant

backwardness in performance on later more complex learning tasks. It

has been reported in experimental animals that small but statistically

significant differences in the size of the cerebral cortex can be

obtained by manipulation of the stimulatory aspects of the

environment (Diamond et al. 1966). Recently (Castilla-Serna, Cravioto,

and Cravioto 1973) we have reported the synergistic effects of

malnutrition and stimuli deprivation on the biochemical structure of

the brain, confirming and extending the findings of Levitsky and

Barnes (1972) on the affects of nutrition and isolation on animal

behavior. Cravioto and DeLicardie in a study on the environmental

correlates of severe malnutrition (1972) found that none of the

characteristics of parents (biological, social or cultural) or family
circumstances (including income per capita, main source of income and
family size) were significantly associated with the presence or
absence of severe malnourishment. On the other hand, mother's
listening to the radio and level of stimulation available in the home
help substancially to differentiate families with or without severely
malnourished children. These microenvironmental characteristics, as
well as an inadequate mother-child interaction (Cravioto and DeLicardie,
1974), were present a long time before the appearance of the severe
episode of malnutrition.

Klein and co-workers (1972) have shown that in children
rehabilitated from lanutrition body height and head circumference
increase the level of prediction of cognitive function over and
above the prediction level given by socio-cultural factors such as
quality of house, father's education, mother's dress, mother's
personal cleanliness, task instruction, and social contacts.
Richarson (1976) has reported that the I.Q's of Jamaican school age
children who suffered severe clinical malnutrition before age 2 years
were significantly associated with the presence or absence of severe
malnutrition as such, with total body length at the time of intelligence
testing, and with a measure of the child's social background. These
studies point out the importance of the environment as a synergistic
factor both in the development of early malnutrition and its
consequences.

Research work in experimental animals leads in the same
direction. Thus, Barnes and his group on the basis of their results
from a long series of animal experiments (Barnes 1968; Frankova and
Barnes 1968; Barnes, Moore, and Pond 1970; Levitsky and Barnes 1973),
prefer to speak of the interaction between malnutrition and environmental
stimulation. The similarity of the biochemical changes produced in
the brain by nutrition or by stimulation, have led them to consider
that the physiological mechanisms which may be responsible for the
long term effects of early stimulation may not be operative if a
concurrent state of malnutrition is present during a critical period
of development. Malnutrition may thus change the experience of
perception of the environment by physiologically rendering the animal
less capable of receiving or integrating, or both, information
about the environment. These authors have also considered that even
in the absence of biochemical alterations of the brain, malnutrition
may elicit behavior that is incompatible with the incorporation of
environmental information necessary for optimun cognitive development.
Behavior primarily food-oriented and behavior expressed as apathy
and social withdrawal are two examples of the kind of behaviors
exhibited with a very high frequency by malnourished subjects.

At present we are just beginning to have enough data to tease
out the specific contributions of a lack of nutrients inadequate
stimulation and diminished experiential opportunities to defective
cognitive function. It is most probable that all factors are

interdependent and interactive. (Barnes 1976, Cravioto et al.
1966; Pollitt 1973; Richardson 1976). However, the data reviewed
leave no doubt that survivors of severe malnutrition show during
quite a long time after rehabilitation decreased measured
intelligence together with developmental lags in tasks related to
the learning of language and of certain basic academic skills. The
most important questions to be answered, hopefully by the on going
longitudinal growth studies, are related to a documentation of the
quantitative effects of deficient nutritional status on mental
development, and to the mechanisms of action of malnutrition either
alone or in conjuction with the other features of the unfavorable
macro-and microenvironments in which malnutrition flourishes.

Cravioto/DeLicardie

AKNOWLEDGEMENTS

Cravioto/DeLicardie

X - REFERENCES

Ambrosius, K., 1961, El comportamiento del peso de algunos órganos
   en niños con desnutrición de tercer grado, Boletín _
   Médico Hosp. Infantil (MEX.) 18:47

Baldwin, J. M., 1897, "Mental Development in the Child an the Race",
   The McMillan Co., New York.

Barnes, R. H., 1968, Behavioral changes caused by malnutrition in
   the rat and the pig, in "Environmental Influences"
   (Glass, H. ed.), pp. 62-60, Rockefeller University Press and
   Rusell Sage Foundation, New York.

Barnes, R. H., 1976, Dual role of environmental deprivation and _
   malnutrition in retarding intellectual development,
   Am. J. Clin. Nutr. 29:912

Barnes, R. H. Moore, A. V., and Pond, W. G., 1970, Behavioral abnorma-
   lities in young adult pigs caused by malnutrition in early
   life, J. Nutr. 100:14

Barrera-Moncada, G., 1963, "Estudios Sobre el Crecimiento y Desarro--
   llo Psicológico del Síndrome Pluricarencial (Kwashiorkor)",
   Grafos, Caracas.

Bennett, E. L., Diamond, M. C., Krech, D., and Rosenzweig, M.R., 1964,
   Chemical and anatomical plasticity of brain, Science
   146:610

Benton, J. W., Moser, H.W., Dodge, P.R., and Carr, S., 1966, Modification of the schedule of myelination in the rat by early nutritional deprivation, Pediatrics 38:801

Berlung, G., and Rabo, E., 1973, A long-term follow-up investigation of patients with hypertrophic pyloric stenosis with special reference to the physical and mental development, Acta Paediatr. Scand. 62:125

Birch, H.G., 1954, Comparative psychology, in Marcuse, "Areas of Psychology" (Harper, ed.) New York.

Birch, H.G., and Belmont, L., 1964, Auditory-visual integration in normal and retarded readers, Am. J.Orthopsychiat 34:852

Birch, H.G., and Belmont, L., 1965, Auditory visual integration, intelligence and reading ability in school children, Percept and Mot. Skills 20:295

Birch, H.G., and Bitterman, M.E., 1949, Reinforcement and learning, The process of sensory integration, Psychol. Rev. 65:292

Birch, H.G., and Bitterman, M.E., 1951, Sensory integration and cognitive theory, Psychol. Rev. 58:355

Birch, H.G., and Lefford, A., 1963, Intersensory development in

children, Mon. Soc. Res. Child Development 28:1

Birch, H.G., and Lefford, A., 1967, Visual diferentiation,

intersensory integration and voluntary motor

control, Mon. Soc. Res. Child Development. 32:1

Birch, H.G., Piñeiro, C., Alcalde, E., Toca, T., and Cravioto,

J., 1971, Relation of Kwashiorkor in early childhood

and intelligence at school age, Pediatric Research

5:579

Botha-Antoun, E., Babayan, S., and Harfouche, J., 1968, Intel-

lectual development relating to nutritional status,

Journal of Tropical Pediatrics 14:112

Brockman, L. M., and Ricciuti, H. N., 1971, Severe protein-calorie

malnutrition in infancy and childhood, Developmental

Psychology 4:312

Brown, R. E., 1965, Decreased brain wight in malnutrition and its

implications, East African Medical Journal 42:584

Cabak, V., and Najdavic, R., 1965, Effect of undernutrition in

early life on physical and mental development, _

Archives of Diseases in Childhood 40:532

Caldwell, B. M., 1967, Descriptive evaluations of child devel--

opment and of developmental settings, Pediatrics

40:46

Canosa, C. A., Solomon, R. L., and Klein, R. E., 1973, The intervention approach: The guatemalan study, in "Nutrition, Growth and Development of the North American Indian Children" (W. M. Moore, M. M. Silver, and M. S. Read, eds.) USGPO, publication No. NIH 72, Washington, D. C.

Castilla-Serna, L., Cravioto, R. A., and Cravioto, J., 1973 "Interacción de la Estimulación y la Nutrición Sobre el Desarrollo Bioquímico del Sistema Nervioso Central (Informe Preliminar)" Proc. XXXVII Meeting Mexican Pediatric Society, San José Vista Hermosa, Mor., México, December 7-8

Cravioto, J., Birch, H. G., DeLicardie, E. R., and Rosales, L., 1967, The ecology of infant weight gain in a preindustrial society.
Acta Paediat. Scand. 56:71

Cravioto, J., 1971, Infant malnutrition and later learning, in "Progress in Human Nutrition" (Margen, S., and Wilson, N. L., eds), pp. 80-96, Avi publishing Co., Westport, Conn.

Cravioto, J., and DeLicardie, E. R., 1972, Evironmental Correlates of severe clinical malnutrition and language development in survivors from Kwashiorkor or marasmus, in "Nutrition, The Nervous System and Behavior" Panamerican Health Organization, Scientific Publication No. 251

Cravioto, J., and DeLicardie, E. R., 1974, Mother-infant relationship prior to the development of clinical severe malnutrition in the child, pp. 126-137 _ Proc. VI-Western Hemisphere Nutrition Congress, Bal Harbourg Florida, August 19-22

Cravioto J., and Robles, B., 1963, The influence of protein-calorie malnutrition on psychological test behavior, in First Symposium of the Swedish Nutrition Foundation, "Mild-Moderate Forms of _ Protein-Calorie Malnutrition (Almquist and _ Wiksells, eds.) Uppsala.

Cravioto, J., and Robles, B., 1965, Evolution of adaptive and motor behavior during rehabilitation from _ kwashiorkor, Amer. J. Orthopsychiat. 35:449

Cravioto, J. DeLicardie, E. R., and Birch, H. G., 1966, Nutrition, growth and neurointegrative development. An experimental and ecologic study, Pediatrics 38:319.

Cravioto, J., Gaona-Espinosa, C., and Birch, H. G., 1967, Early malnutrition and auditory-visual integration in school-age children, J. Spec. Education 2:75

Cravioto, J., Birch, H. G., y DeLicardie, E. R., 1967, Influencia de la desnutrición sobre la capacidad de _ aprendizaje del niño escolar, Bol. Med. Hosp. Inf., Mex. 24:217

Cravioto, J., Piñeiro, C., Arroyo, M., and Alcalde, E., 1969,
Mental performance of school children who suffered
malnutrition in early age, in 7th Symposium Swedish
Nutrition Foundation, "Nutrition in Preschool and
School Age" (Almquist and Wiksells, eds.) Uppsala

Cravioto, J., Birch, H. G., DeLicardie, E. R., Rosales, L., and
Vega, L., 1969, The ecology of growth and devel-
opment in mexican preindustrial community, 1 Methods
and findings from birth to one month of age., _
Monogr. Soc. Res. Child Develop. 34:129

Cravioto, J., DeLicardie, E. R., Piñeiro, C., and Alcalde, E.,
1969, Neurointegrative Development and Intelligence
in School Children Recovered From Malnutrition in
Infancy.
Seminar on Effects of Malnutrition on growth and
Development. Memoirs golden jubileum Nutrition
Research Laboratories of India, Hyderabad, India.

Cravioto, J., Lindoro, M., and Birch, H. G., 1971, Sex differences
in I.Q. Pattern of children with congenital heart
defects, Science 174:1042

Champakam, S., Srikantia, S.G., and Gopalan, C. 1968, Kwashiorkor
and mental development, Am. J. of Clin. Nutrition
21:844

Chase, P.H., Dorsey, J., and Mckhann, G. M., 1967, The effect of

malnutrition on the synthesis of myelin lipid,

Pediatrics 40: 551.

Chase, PH., and Martin, H.P., 1970, Undernutrition and child

development, New Engl. J. Med. 282: 933.

Davison, A.N., and Dobbing, J., 1966, Myelination as a vulnerable

period in brain development, Brit. Med. Bull. 22: 40

Dean, R.F.A., 1960, The effects of malnutrition on the growth of .

young children.

Mod. Probl. of Pediat. 5: 111.

DeLicardie, E.R., and Cravioto, J., 1973, "Behavioral Responsiveness

of Survivors of Clinical Severe Malnutrition to Cognitive

Demands. "In Early Malnutrition and Mental Development.

Twelfth Symposium of the Swedish Nutrition Foundation.

Stockholm Sweden. August 20-22.

DeLicardie, E. R., Vega, L., Birch, H. G., and Cravioto, J., 1971,

The effect of weight loss from birth to fifteen days

on growth and development in their first year, Biol.

Neonat. 17: 249.

Diamond, M. C., Law, F., Rhodes, H., Lindner, B., Rosenzweig, M.R.,

Krech, D., and Bennett, E. L., 1966, Increases in

cortical depth and glia number in rats subjected to

enriched environment, Journal of Comparative Neurology

128: 117.

Dobbing, J., 1963, The influence of early nutrition on the devel-
opment and myelination of the brain, Proc. Royal Soc.
Med. 159:503

Dobbing, J., 1968, Vulnerable periods in developing brain, in _
"Applied Neurochemistry" (Davison and Dobbing, eds.)
Blackwell Scientific Publications, Oxford.

Dobbing, J., 1974, The later development of the central nervous _
system and its vulnerability, in "Scientific Foundations
of Pediatrics" (Davis, J.A., and Dobbing, J., eds.) _
Heinman, London, and Saunders, Philadelphia

Dobbing, J., 1976, Vulnerable periods in brain growth, in "The Biolo-
gy of Human Fetal Growth" (Roberts, D. F., and Thomson,
A.M. eds.) Taylor and Francis, London.

Flexner, L.B., Stellar, E., de la Haba, G., and Roberts, R. B., 1962,
Inhibition of protein synthesis in brain and learning _
and memory following puromycin, Journal of Neurochemistry
5:595

Frankova, S., and Barnes, R.H., 1969, Effect of malnutrition in early
life on avoidance conditioning and behavior of adult rats,
J. Nutr. 96:485

Geber, M., and Dean, R.F. A., 1956, The Psychological changes accom-
panying kwashiorkor, Courrier 6:3

Cravioto/DeLicardie

- 9 -

Gesell, A., and Amatruda, C., 1947, Developmental Diagnosis:

Normal and Abnormal Child Development, Hoeber, New York.

Guillen-Alvarez, G., 1971, "Influence of Severe Marasmic Malnutrition

in Early Infancy on Mental Development at School Age.

"Proceedings of the Twelfth International Congress of

Pediatrics, Viena, Austria, August 29 September 4,

Wiener Medizinischen Akademic.

Gopalan, C., and Ramalingaswami, V., 1955, Kwashiorkor in India

Indian J. Med. Res. 43: 751.

Guthrie, H. A., and Brown, M.L., 1969, Effect of Severe undernutrition

in early life on growth, brain size and composition in

adult rats, J. Nutr. 94: 419.

Guthrie, H.A., Guthrie, G.M., and Tayag, A., 1969, Nutritional status

and Intellectual performance in a rural philippine

community, Philippine Journal of Nutrition 22: 2.

Hertzig, M.E., Birch, H.G., Richardson, S. A., Tizard, J., 1972,

Intellectual levels of school age children severely

malnourished during the first two years of life.

Pediatrics 49: 814.

Hertzig, M., Birch, H.G., Thomas, A., and Arán-Méndez, Q., 1968,

Class and ethnic differences in the responsiveness of

preschool children to cognitive demands, Monographs of

the Society for Research in Child Development 33: Serial No. 117

Hiernaux, J., 1964, Weight-Height Relationships During Growth in

African and Europeans.

Human Biology 36: 273.

Hoorveg, J., and Standfield, P., 1972, The influence of malnutrition
on psychologic and neurologic development. Preliminary
communication in "Nutrition, the Nervous System and
Behavior", Panamerican Health Organization.
Scientific Publication No. 251.

Hsueh, A. M., Agustin, C. E., and Chow, B. C., 1967, Growth of young
rats after differential manipulation of maternal diet,
J. of Nutr. 91: 195.

Jackson, C.M., and Stewart, C.A., 1920. The effect of inanition in
the young upon the ultimate size of the body and of the
various organs in the albino rat.
J. Exp. Zool. 30: 97.

Kahn, D., 1965, A developmental study of the relationship between
auditory-visual integration and reading achievement in
boys. Ph. D. Dissertation, Teachers College, Columbia
University.

Kardonsky, V., V., Alvarado, M. Undurraga, O., Manterola, A., and
Segure, T., 1971, "Desarrollo Intelectual y Físico en
el Niño Desnutrido". Unpublished manuscript. Santiago,
University of Chile, Department of Psychology.

Herr, G. R., Helmuth, R., Campbell, J.V., and El Lozy, M., 1976,
Malnutrition studies in Macaca mulatta. V. Effect on
biochemical and Cytochemical composition of major organs.
Am. J. Clin. Nutr. 29: 868.

Klein, R.E., Lester, B.M., Yarbrough, C., and Habitch, J.F., 1972, "On
Malnutrition and Mental Development: Some Preliminary
Findings". Proceedings of the Ninth International Congress
of Nutrition. Mexico City, México, September 2-9.

Keys, A., Brozek, J., Henschel, A., Mickelson, O., and Taylor, H.L., 1950, The Biology of Human Starvation University of Minnesota Press.

Klein, P.S., Forbes, G.B., and Nader, P.R., 1975, Effects of Starvation in Infancy (pyloric stemosis) on Subsequent Learning Abilities, Pediatrics 87: 8.

Lashley, K. S., 1929, "Brain Mechanisms and Intelligence", Chicago, University of Chicago Press.

Levitsky, D. A., and Barnes, R. H., 1972, Nutritional and Environmental interactions in the behavioral development of the rat: Long term effects, Science 176: 68.

Levitsky, D. A., and Barnes, R. H., 1973, Malnutrition and animal behavior in "Nutrition, Development and Social Behavior" (D. J. Kallen, ed.) Washington, D.C. USGPO, Pub. No. NIH73-242.

Leitch, I., 1959, Growth, heredity and nutrition, Eugenics Review 51: 155

Liang, P. H., Hie, T. T., Jan, O.H., and Giok, L. T., 1967, Evaluation of mental development in relation to nutrition, Am. J. of Clin. Nutrit. 20 1290.

Lugo, G., 1971, "Influencia de la Clase Social Sobre el Estilo de Respuesta Ante una Demanda Cognoscitiva". Tesis, Facultad de Filosofía y Letras, UNAM, México, D.F.

Maier, N. R.F., 1932, The effect of cerebral destruction on reasoning and learning in the rat, J. Comparative Neurol 54: 45.

Cravioto/DeLicardie

- 12 -

Maier, N. R. F., and Schneirla, T.C., 1935, Principles of Animal
Behavior New York, McGraw-Hill.

Marcondes, E., Lefevre, A.B., and Machado, D.V., 1969, Desenvol-
vimiento neuropsicomotor de Crianca Desnutrida, Re-
vista Brasileira de Psiquiatria 3:173

Monckeberg, F., 1968, Effect of Early Marasmic Malnutrition on _
Subsequent Physical and Psychological Development
in: "Malnutrition Learning and Behavior", (Scrimshaw,
N.E., and eds. Gordon) Cambridge, Mass. MIT Press.

Orr, J. B., 1936, "Food, Health and Income". London, Macmillan.

Pollitt, E., 1973, Behavior of infant in causation of nutritional
marasmus, Am. J. of Clin, Nutrit. 26:264

Pollitt, E., and Granoff, D., 1968, Mental and motor development of
peruvian children treated for severe malnutrition, Re-
vista Interamericana de Psicología 1:93

Platt, B. S., Heard, C. R.C., and Steward, R.J.C., 1964, Experi-
mental Protein-Calorie Deficiency". In Mammalian Protein
Metabolism (Munro and Allison, ed), Academic Press, New
York.

Richardson, S. A., 1976, The relation of severe malnutrition in _
infancy to the intelligence of school children with
differing life histories, Pediatric Res 10:57

Robles, B., Cravioto, J., Rivera, L., Vilches, A., Santibañez,
E., Vega, L., and Pérez-Navarrete, J. L., 1959, In-
fluencia de ciertos factores ecológicos sobre la con-
ducta del niño rural mexicano, in Proc. IX Biannual
Meeting Mexican Soc. Pediat. Research, México.

Rojano, M.E., 1970, Desarrollo de conceptos antitéticos en el
niño como prueba para evaluar el lenguaje oral en la
edad preescolar temprana, Master's Dissertation, Uni-
versidad Autónoma de México.

Scott, E.B., 1964, Histopathology of aminoacid deficiencies. VII
Valine, Journal of Experimental Molecular Pathology
3:10

Stein, Z., Susser, M.W., Saenger, G., and Marolla, F., 1944-1945,
"Famine and Human Development: The Dutch Hunger Winter"
(Oxford University Press, Inc.) London.

Stoch, M.B., and Smythe, P. M., 1963, Does undernutrition during
infancy inhibit brain growth and subsequent intellectual
development?, Archives of Disease in Childhood 38:546

Srikantia, S.G., Sastry, C.Y., and Naidu, A.N., 1975, Malnutrition
and mental function. Proc. Xth. International Congress
of Nutrition, Kyoto, Japan, August 3-9

Voronin, L. G., and Guselnikov, V.I., 1963, On the phylogenesis
of internal mechanisms of the analytic and synthetic
activity of the brain. Pavlov. J. Higher Ner. Activity
13:193

Winick, M., 1969, Malnutrition and brain development. Journal or
Pediatrics 74:667

Winick, M., and Noble, A., 1966, Cellular response in rats during
malnutrition at various ages, J. Nutr. 89:300

Winick, M., and Rosso, P., The effect of severe early malnutrition
on cellular growth of the human brain, Pediatric Research
3:181

Winick, M., Rosso, P., and Waterlow, J., 1970, Cellular growth of
the cerebrum, cerebellum and brain stem in normal and _
marasmic children, Exptl. Neurol. 26:393

Wray, J., 1975, Intersensory Development in School age Children at
a high risk of severe malnutrition during the preschool
years. Unpublished manuscript.

Yatkin, U.S., and McLaren, D.S., 1970, The behavioral development
of infants recovering from severe malnutrition. J. of
Ment. Def. Res. 14:25

Figure 1.-   Proportions of tall (QU) and short (QL) six year
old rural children showing different number of
errors in the visual-kinesthetic judgment of
nonidentical forms.

Figure 2.-   Proportions of tall (QU) and short (QL) eight-
year old rural children showing different number
of errors in the haptic-kinesthetic judgment of
nonidentical forms.

Figure 3.-   Changes in Performance levels on the visual-
kinesthetic ability of tall (QU) and short (QL)
rural children.

Figure 4.-   Visual-kinesthetic intersensory development of
78-month-old children with and without antecedents
of early severe malnutrition (nonidentical forms).

Figure 5.-   Visual-kinesthetic Performance (nonidentical forms)
obtained by 78-month-old children with and without
antecedents of early severe malnutrition matched
for total scores on home stimulation.

Table   2

Main style of Response Obtained in Survivors of Early

Severe Malnutrition and Controls for Size at Birth,

and Sex and I.Q. at 5 years of Age.

("Land of the White Dust")

Proportion   of :

Behavioral Style	Survivors	Controls Matched for IQ and Sex	Controls for Size at Birth
Work	0.57	0.71	0.85
Not-work	0.43	0.29	0.15
Work Verbal	0.62	0.80	0.75
Work Nonverbal	0.38	0.20	0.25
Not-Work verbal	0.00	0.00	1.00
Competence	0.00	0.00	1.00
Not-Work Nonverbal	1.00	1.00	0.00
Passivity	1.00	1.00	0.00

ERRORS OF EQUIVALENCE
HAPTIC-KINESTHETIC

8 YEARS
QL — — — — —
QU ————————

Y-axis: CUMULATIVE PERCENTAGE OF CHILDREN
X-axis: NUMBER OF ERRORS
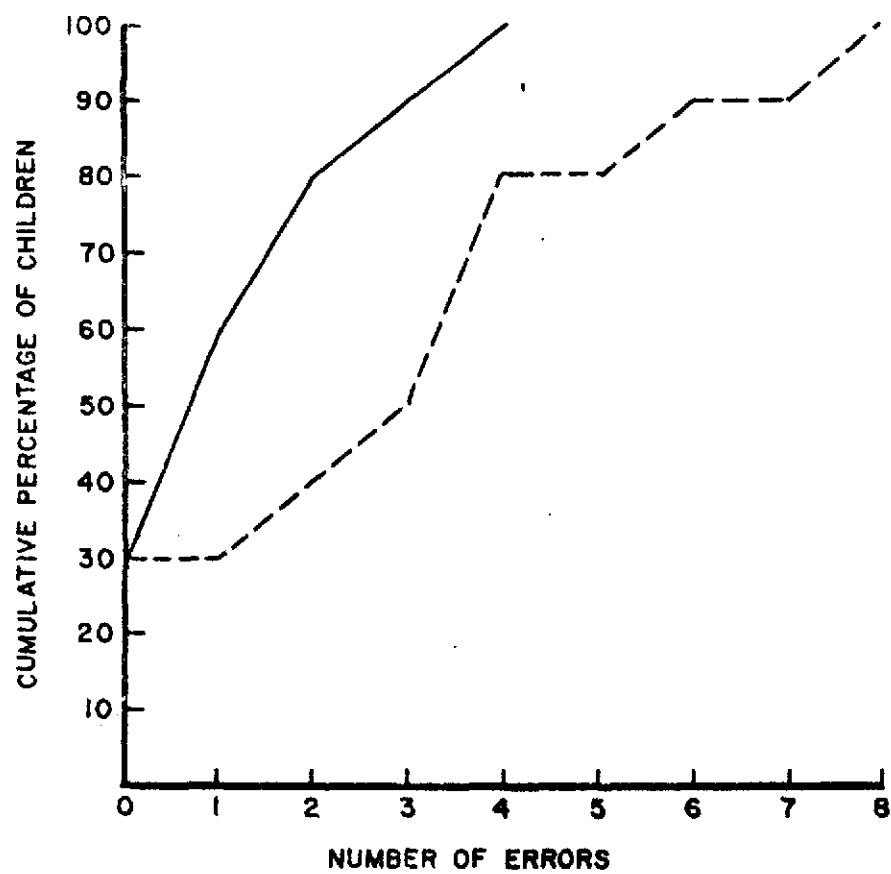
ERRORS OF EQUIVALENCE
VISUAL - KINESTHETIC
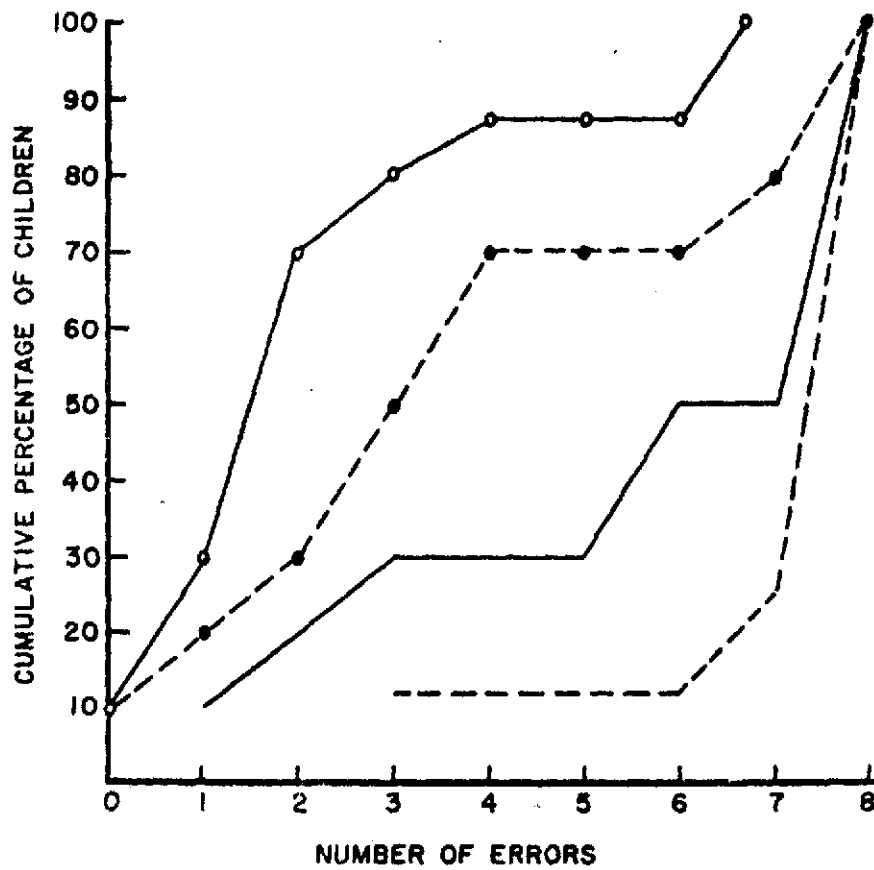
ERRORS OF EQUIVALENCE
VISUAL-HAPTIC

6 YEARS
QL ------
QU ————
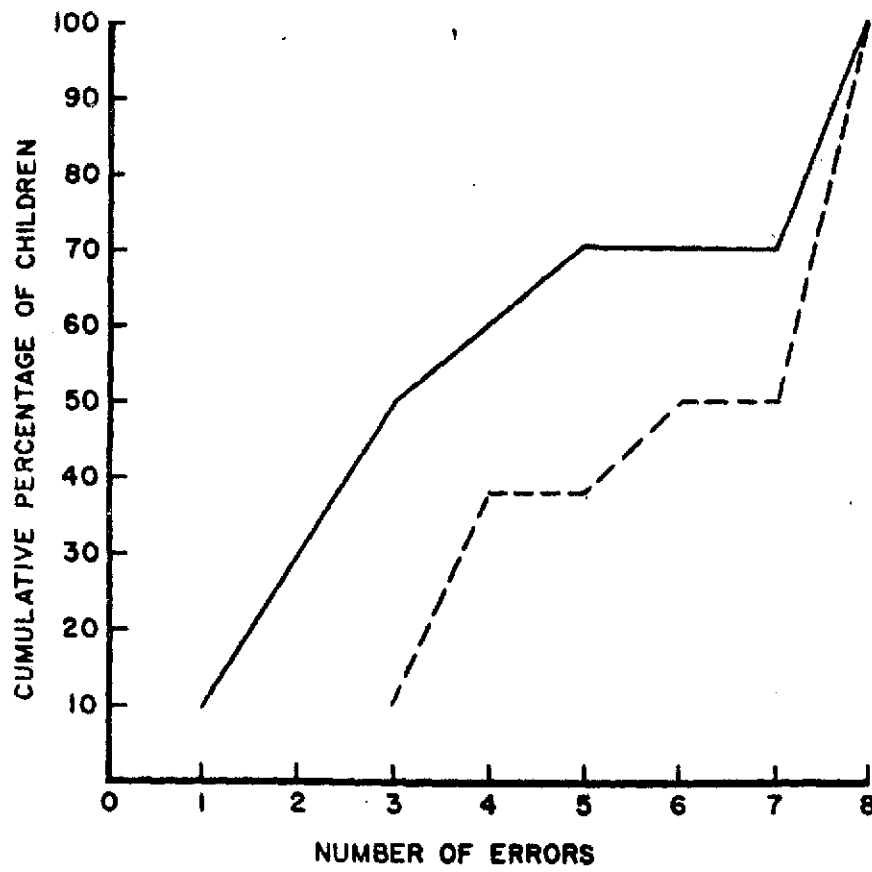
CUMULATIVE PERCENTAGE OF CHILDREN

NUMBER OF ERRORS
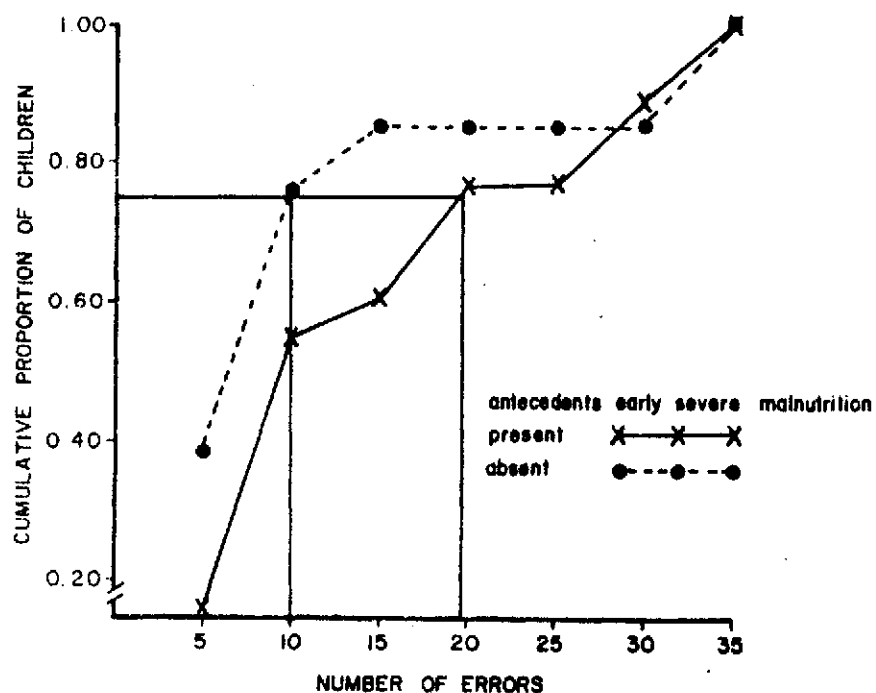
VISUAL–KINESTHETIC INTERSENSORY DEVELOPMENT OF
78–MONTH–OLD CHILDREN WITH AND WITHOUT
ANTECEDENTS OF EARLY SEVERE MALNUTRITION

(NON–IDENTICAL FORMS)

"LAND OF THE WHITE DUST"

VISUAL-KINESTHETIC PERFORMANCE (NON-IDENTICAL FORMS) OBTAINED BY 78-MONTH-OLD CHILDREN WITH AND WITHOUT ANTECEDENTS OF EARLY SEVERE MALNUTRITION MATCHED FOR TOTAL SCORES ON HOME STIMULATION

"LAND OF THE WHITE DUST"
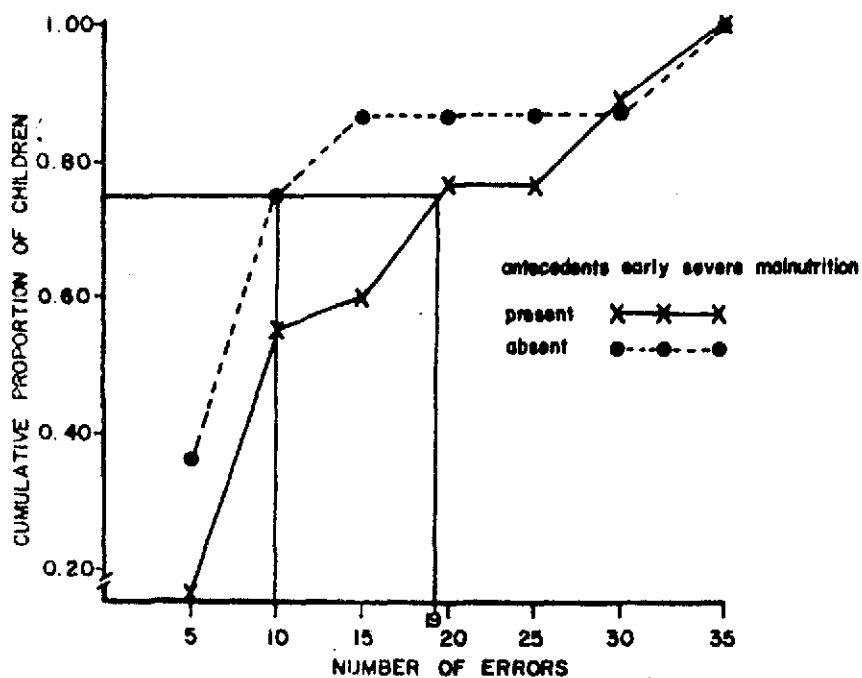
T A B L E 1

MAIN CHARACTERISTICS AND RESULTS OF STUDIES ON THE MENTAL PERFORMANCE OF SURVIVORS OF MALNUTRITION

AUTHORS	COUNTRY	CHILDREN'S AGE WHEN UNDERNOURISHED	CHILDREN'S AGE WHEN TESTED	TESTS ADMINISTERED	COMPARISON GROUP	RESULTS
Cravak and Najdavic (1965)	Yugoslavia	4-14 Months	7-14 Years	Stepanovic's Adaptation of Binet-Simon	Children of unskilled Workers	Intensity and Duration of Malnutrition in Early Life appeared to be related to magnitude of intellectual deficit after rehabilitation
Liang, et al. (1967)	Indonesia	2-4 Years	5-12 Years	Goodenough Wechsler	Age-Mates whose nutritional status at age 2-4 years was known	Previously malnourished children had significantly lower scores than the children who were regarded as non-malnourished during the 2-4 year age period.
Champakam, Srikantia and Gopalan (1968)	India	18-36 Months	8-11 Years	Specially designed tests, standardized in a comparable population	Children Matched for: age, sex, religion, caste, socioeconomic status, family size, birth order, parent's education, locality and school.	Lower intellectual performance of previously malnourished children. Differences more marked in the younger age group.
Guthrie, et. al. (1969)	Philippines	Presumably at Preschool Age	School Age	Philippine Non-Verbal Intelligence Test	Height gradient within the sample studied	Taller children at all ages performed better on intelligence than shorter children.
Guillen-Alvarez (1971)	El Salvador, C.A.	3 - 9 Months	10 - 12 Years	Raven, Koch, Goodenough	Rural children same age and socioeconomic status	Survivors of Malnutrition clustered on the lowest region of the I.Q. score distribution.
Hoorweg and Stanfield (1972)	Uganda	Below 27 Months	11-17 Years	Raven, Wechsler, WAIS, Porteus, Memory, Knox, Lincoln-Oseretzky	Children with records of good nutrition and growth during first 2-years of life.	Except for verbal abilities, a maze test and a short memory test, survivors of malnutrition had lower performance levels in all the other tests. In general those who suffered malnutrition at a younger age did poorer, particularly in several aspects of memory and learning.