Symposium on

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Biochemistry, and Behavior

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Bridges between nutrition, neuroscience, and behavior

Ernesto Polliti, PhD and Merrill S Read, PhD

The focus of the 1984 Symposium of the American Society for Clinical Nutrition on Nutrient Intake, Brain Biochemistry, and Behavior illustrates the importance currently attributed to this area of research. It is increasingly apparent that the neurochemistry of the brain, and the associated cognitive processes, can be affected by nutritional deficiencies and by both the constituents and scheduling of diet.

There is a long-standing history of concern about the effect of food, or lack of it, on behavior. The Bitter Cry of Children, John Spargo's pioneering 1906 book (1) on the effects of poverty on child development, advanced many ideas subsequently supported by empirical data, on the social epidemiology of communicable diseases and on the debilitating effects of malnutrition. Spargo's documentation from the Old World is encyclopedic and supports his contention that a qualitatively and quantitatively poor diet weakens a child's physical and mental stamina.

After observing the Russian famine of 1919-1921, the eminent sociologist Pitirim A. Sorokin wrote a treatise (2) on the effects of hunger on human behavior and on the dynamics of social processes. His book, published in 1922 in Leningrad and immediately censored, did not become available until 1975. Some of his observations and hypotheses are as relevant today as they were then. The following quotation is illustrative:

Such transformation or deformation (changes) of the physiological state of the organism occur daily in everyone because the rhythm of stimulation and deadening of the nutrient center alternate daily (hunger and satiation) in response to the conditions and unconditioned reflexes which act upon it. Therefore, forms of behavior of man during the sated and hungry states alternate constantly, as a function of the physiological deformations (2) (p. 57).

Industry was not left behind. American cereal companies flourished in the late years of the 19th century, and the thrust of much of their advertising was that "we are what we eat." One major company (3), after conducting a house-to-house canvass in the tenements of New York and Chicago, advertised that anemia, lack of mental capacity, nervousness and lack of concentration in school were associated with insufficient consumption of oatmeal. Conversely, their advertising stated that oatmeal was a regular component of the diet in the homes of the Educated, the prosperous, and the competent. They found that "Boston consumes 22 times as much oatmeal per capita as do two certain states with lowest average intelligence." Oatmeal cereal contained phosphorous which is "the most important element in the structure of the brain." Lecithin was considered "most important in the structure of the nerve and nerve centers." A wheat-based cereal was touted as doing wonders in every area... no other food could match it for building strong and sturdy bodies, for restoring impaired digestion and vigor, and for revitalizing weary brains.

The effects of dietary intake on human brain form a Gordian knot of complex interrelationships among variables rooted in the neurosciences, and in the nutritional and behavioral sciences. Progress is hampered by limited knowledge about the neurochemical...
basis of behavior, and about the parameters that define the structural and process components of human information processing. Similarly, assessments of the relationships between transitory biochemical changes in the brain and changes in cognitive operations are just beginning.

Issues such as the effects of undernutrition on cognition, the influence of sugar intake on delinquent behavior, or the relationships between food additives and hyperkinesis, have direct implications for public health policy. These and similar research issues in the area of diet and behavior are of particular interest to the food and pharmaceutical industry. Because of these important social and economic interests, investigators in this area of research are at risk of drawing unjustified inferences from data, which does not conform to strict scientific criteria. Moreover, in some instances these risks are coupled with the advocacy of people whose belief in the therapeutic potency of a particular diet is well-intentioned but misinformed. Startling claims of therapeutic behavioral effects from the use of certain nutrient or diet constituents have been supported with vehemence rather than convincing data. Clearly prudence, a venerable attribute in science, is vital in this area of research.

The systematic research on nutrition and behavior that began approximately three decades ago, primarily through studies on the effects of protein-energy malnutrition on mental development, has gained breadth and depth. The focus, generally restricted to children in developing countries, has widened. Questions are now directed to well-nourished individuals, and seek to determine how levels of arousal or activity, mood, or sleep cycles are affected by specific components of daily diet.

These research developments on diet and behavior, however, should not be interpreted as evidence that the questions originally posed on undernutrition and mental development have been solved. In fact, despite 20 years of investigation, questions regarding the effects of protein energy malnutrition on cognition remain unanswered (4). Significant improvements have been made in the research paradigms, however, and more complex interac-
tional models have replaced the earlier search for main effects. It is now recognized that bivariate equations are not a good fit for the problems posed by the effects of nutritional deficiencies on brain function. There has been a conceptual shift towards multivariate approaches with the inclusion of social and behavioral factors as key intervening variables.

Within this context of more complex research design, perhaps the greatest gain from previous research is the recognition that there is no satisfactory substitute for experimental evidence that demonstrates the internal and external validity of data. That is, evidence which demonstrates that the statistical relationships observed between the independent and outcome variables express a causal relationship, and that this relationship is not unique to the laboratory, but is also observed in daily life. But the greatest gain in our understanding of the relationship between diet and brain function will come when the evidence of internal and external validity is accompanied by explanations of the mechanisms underlying the observed relationships among variables. This advancement in our scientific knowledge, however, can occur only after we have constructed a strong bridge of communication between nutritionists, neuroscientists, and behavioral scientists.

A genuine communication among these disciplines has yet to be reached, and the task is both significant and difficult. The present symposium was organized with these thoughts in mind, and with a recognition that the studies conducted by the participants move in this direction. Let us now briefly review each of the presentations.

The paper by Drs Yogman and Zeisel, "Nutrients, Neurotransmitters and Infant Behavior" noted the relationships between tryptophane metabolism, serotonin levels, and sleep-wake cycles in infants. The behavioral effects observed were obtained using normal variations in tryptophane level found in maternal milk, not at pharmacological levels. The data suggests that the nutrient composition of maternal milk may contribute to variations in early development.

Drs Yogman and Zeisel conclude with an important point worthy of reflection. They
suggest that, as methodologies are perfected, nutrition may become a useful tool not only in the treatment of behavioral problems, but also in their diagnosis and in basic studies of underlying processes. This may be particularly true in infants who are at risk of developmental disabilities due to prenatal or early postnatal adversities.

Drs Michals and Matalon's research has taken a somewhat different approach. They have reexamined a clinical condition: phenylketonuria (PKU). The low-phenylalaninediet for PKU has been accepted for 20 yr as the primary clinical intervention. Early diagnosis of PKU permitted dietary interventions throughout childhood and prevented mental retardation in a large majority of afflicted children. Yet, this therapeutic intervention does not control all aberrant behaviors in all patients; some patients still become mentally retarded for reasons that remain unknown.

Dr Matalon and his coworkers have identified several other compounds in blood which are involved in the phenylalanine-tyrosine metabolic pathway. These are present in such small quantities that they were overlooked or ignored in earlier research. These compounds are closely associated with mental retardation in those children not responding to the low phenylalanine diet. Thus, in these cases other dietary treatments may be in order.

Matalon’s work shows the importance of maintaining an open mind in terms of scientific history, clinical success vs failure, and the range of metabolites that should be considered in order to explain failure or different consequences than originally had been postulated.

Drs Lieberman, Corkin, Spring, Wurtman and Growdon, in their paper “Effects of Dietary Neurotransmitter Precursors on Human Behavior” discuss the relationship between serum tryptophane and tyrosine, and mood states and reaction time in adults. They note that tryptophane may have sedative effects, at least in pharmacologic doses. These observations extend Yogman and Zeisel’s infant data into the adult. Both studies illustrate the complexity of the underlying metabolic pathways, and further suggest that several pathways may be involved in behavior-
therefore would not be expected to become hyperactive in the normal course of events. Conversely, there was some suggestion in the data that the high-consumers of caffeine became somewhat less hyperactive on caffeine when compared with the placebo. These observations correlate with other studies on caffeine intake in adults where some individuals become more quiet, relaxed, and may even sleep better on high-caffeine intakes whereas others become nervous and insomniac.

In summarizing the symposium, it is clear from the data presented that relationships are emerging between dietary factors, biological processes, and behavioral outcomes. These relationships are not fully understood. A key to their understanding will rest upon improving and refining our behavioral methodologies along with our neurological ones. It also will be important to design studies to include study groups and suitable controls which take into account prior history and which also permit differentiation between pharmacological effects and those which might be reasonably expected with a normal dietary pattern.

References
