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The Effects of Low-Sugar Diets on Behavior and Paired-Associate Learning in Normal Children

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THE EFFECTS OF LOW-SUGAR DIETS ON BEHAVIOR AND PAIRED-ASSOCIATE LEARNING IN NORMAL CHILDREN

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ABSTRACT

An experiment was conducted to determine whether reduced sugar diets improve learning and/or alter behavior in normal children. The 14 Ss--seven males and seven females--were elementary school students, ranging in age from 8.01 to 10.06, matched for age, sex, race, and SES, and screened for medication and learning disabilities. They were sequentially assigned to low-sugar and usual diet groups for two- and four- week periods. In a pretest-pottest design, assessment instruments were a paired-associate (PA) learning task and a Nutrition Behavior Inventory (NBI). The pretest mean NBI indicated at least some sugar-related symptoms in the Ss. One-way analyses of variance (ANOVAs) for the low-sugar diet versus the usual diet on NBI scores, as well as trials-to-criteria and number correct on PA scores showed insignificant results. A two-way ANOVA for sex and the low-sugar diet versus the usual diet on NBI scores was insignificant. Likewise, a two-way ANOVA for SES and the low-sugar diet versus the usual diet proved insignificant. A multiple regression analyzing the effects of age, sex, race, and SES on NBI, PA number-correct scores, and PA trials-to-criteria scores showed significant correlations. It was concluded that two- and four-week low-sugar diets have no effect on normal children's learning and behavior. The possibility that the children were experiencing residual effects from earlier sugar

ingestion, which influenced their posttest scores, was discussed. Further experimentation using one-, two-, and three-month diet periods was recommended.

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INTRODUCTION

Symptomology

Several research studies using mental patients and other special populations, as well as numerous case histories, have demonstrated that ingestion of quickly-absorbed carbohydrates is linked to a condition characterized by certain emotional, cognitive, behavioral, and somatic symptoms. Most of these studies focus on refined sugars. Although researchers and practitioners argue the direct or indirect influence of refined sugars on symptomology, they concur that symptoms frequently dissipate when their afflicted patients eliminate refined sugars from their diets. For the purposes of clarity and neutrality, the following discussion will be limited to refined (processed) sugars and will refer to the presence of sugar-influenced symptoms as a "sugar-related disorder."

Depression, irritability, nervousness, and free-floating anxiety are frequently associated with sugar-related disorders. After an individual has ingested refined sugar, he/she may feel "low," neurasthenic (Harris, 1924; 1936), or on the verge of a "nervous breakdown" (Rennie & Howard, 1936). Crying spells are common (Abrahamson & Pezet, 1951). These patients frequently feel bored or apathetic toward life in general (Portis et al., 1950). Many exhibit flat affect and unresponsiveness. Tintera (cited in Dufty, 1975), an endocrinologist, and Mason (cited in Hall, 1975) noted that their sugar-sensitive patients were very

irritable and difficult to get along with. Dr. Joseph Wilder, a specialist in psychiatry, describes "a tendency to deny everything, to contradict everything, and refuse everything at any price" (cited in Cheraskin, et al., 1974; p. 81). Subject to uncontrollable fits of anger as well as persistent edginess, these patients frequently exhibit outbursts that interfere significantly with family, social, and work relationships (Ross, 1975). Roberts (1967) suggests that some marital problems may be aggravated by sugar-linked irritability. Sugar-affected patients may also exhibit a "Dr. Jekyll/Mr. Hyde" pattern (Feingold, 1975; Smith, 1979), where they are pleasant and cheerful for a period of time and then quite unexpectedly become angry and unapproachable. In a 1950's study of 200 psychiatric patients, whose symptoms abated or completely dissipated after several weeks on low-sugar diets, 60% were depressed, 45% were irritable, and 32% reported crying spells prior to treatment (Salzer, 1966). In a 1953 study of 600 psychiatric patients, Dr. Stephen Gyland (cited in Fredericks & Goodman, 1969) found that 89% of his patients displayed poor dispositions, negative attitudes, and an inability to get along with others. Seventy-seven percent exhibited depressive symptomology, and 46% reported crying spells prior to treatment. Accompanied by a great expenditure of unproductive energy (Siegel, 1979), tremors, and cold sweats, (Portis & Zitman, 1943; Portis & Alexander, 1944), acute nervousness is common. Patients complain that they feel tense and "all nerves" (Dufty, 1975). According to Salzer (1966), 50% of the patients in his study

reported nervousness, and 41% reported episodic sweating. Ninety-four percent of the patients in Gyland's (Fredericks & Goodman, 1969) study complained of nervousness and 86% complained of nervous sweating. Associated with "crazy spells" (Harris, 1936; Portis, 1950; Abrahamson & Pezet, 1951), hysteria, mild paranoia (Joseph, 1976; Smith, 1976), phobias (Hawkins, 1973) and/or sinking spells (Ross, 1975), many patients experience free-floating anxiety, or a feeling of impending doom (Clark, 1979). Of Salzer's (1966) 200 patients, 50% reported constant and unprovoked anxiety, and 31% reported phobias. Of Gyland's (Fredericks & Goodman, 1969) patients, 62% complained of free-floating anxiety, and 23% complained of phobias.

Several cognitive problems are symptomatic of sugar-related disorders. Most pronounced are difficulties concentrating (Fredericks & Goodman, 1969; Dufty, 1975), confusion and fuzzy thinking (Abrahamson & Pezet, 1951; Gyland, 1953), disorientation, and lapses of memory (Hall, 1975). Gyland (Fredericks & Goodman, 1969) reported that 67% of the patients in his study were very forgetful, and 50% had difficulty making decisions. While Salzer (1966) found that 30% of his subjects had difficulty concentrating, Gyland (Fredericks & Goodman, 1969) found 42%. Twenty percent of Salzer's and 57% of Gyland's patients experienced confusion. Perceiving everyday events as stressful, patients may avoid crowds and enclosed places.

Antisocial or asocial thoughts and actions may occur. In addition, many suffer visual distortions (Salzer, 1966; Fredericks & Goodman, 1969), auditory misperception (Ross, 1974), and other discriminatory problems (Joseph, 1976; Clark, 1979). Hoffer (1979) finds a high incidence of learning problems in these patients.

Among the behavioral symptoms associated with sugar-related disorders are insomnia, hyperactivity or hypoactivity, continual hunger, and binging on quickly-absorbed substances. After three or four hours of sleep, patients frequently awaken, unable to sleep again. They may feel anxious and overwrought (Harris, 1924). These episodes, which typically occur between midnight and two in the morning, are frequently preceded by nightmares. Salzer (1966) reports insomnia in 50% of the patients in his study, and Gyland (Fredericks & Goodman, 1969) reports insomnia in 62% of his patients. In addition, 27% of Gyland's patients experienced night terrors or nightmares. Behavior patterns range from restlessness to ennui. Unable to sit quietly, many sugar-affected individuals fidget and tap their feet. They pace or dart from one activity to another (Smith, 1979; Schworm, 1982). Although excessive activity is most frequently linked with sugar-related disorders (Feingold, 1975; Kershner & Hawke, 1979; Prinz, 1980), many patients exhibit hypoactivity. They are constantly fatigued and weak. Feeling a need to sit and rest, they withdraw from friends and family. They may be

considered antisocial or "loners" (Smith, 1976). Portis, et al. (1950) observed attacks of weakness, dizziness, and fainting in many of their patients. In Salzer's (1966) study, 67% of his patients reported exhaustion, 42% reported dizziness, and 14% reported fainting. Of Gyland's patients (Fredericks & Goodman, 1969) 87% complained of exhaustion, 86% complained of faintness, 73% of vertigo, 72% of drowsiness, and 62% of insomnia and nightmares. These symptoms were most pronounced a few hours after quickly-absorbed carbohydrate meals and when meals were delayed (Smith, 1976). Roberts (1972) reports a high incidence of traffic accidents, presumably resulting from drowsiness and misperception, in these patients. Another frequent symptom is binging and/or craving for sweets, caffeine, alcohol, and tobacco. Food choices may seem bizarre (Cott, 1972). Although Salzer (1966) did not pursue this symptomology, Gyland (Fredericks & Goodman, 1969) detailed the following dietary behaviors: (1). compulsive eating of sugar and sweet foods, 89%; (2). compulsive eating of starches, 86%; (3). two to 20 cups of caffeinated coffee per day, 84%; (4). two to eight cups of caffeinated tea per day, 71%; (5). one to ten bottles of caffeinated cola per day, 66%; (6). one or more sugared drinks per day, 36%; (7). daily drinking of alcohol, 76%. Despite the quantities of stimulating substances consumed by these individuals, they are frequently hungry. They nibble all day. Paradoxically, they may also have poor appetites and/or feel

too weak to eat.

Physical symptoms linked to sugar-related disorders vary considerably. Many of these symptoms correspond with separate maladies, making it difficult to determine whether a somatic complaint should be considered symptomatic of sugar-related disorders or considered a disorder itself.

> When seen for the first time and in the absence of a good history, the attack [display of symptoms] may suggest some brain diseases, such as infection, neoplasm [tumors], or vascular accident [apoplexy]...the attacks may suggest epilepsy, acute alcoholism, amnesia, or...hysteria. It is for these reasons that patients...frequently are referred to neurological or psychiatric clinics (cited in Abrahamson & Pezet, 1951; p. 101).

Digestive problems, including abdominal pain (Ross, 1975), gas and indigestion (Harris, 1924; 1936), and peptic and duodenal ulcers (Harris, 1936; Abrahamson & Pezet, 1951; Yudkin, 1972) are frequently linked to sugar-related disorders. Twenty-nine percent of the patients in Salzer's (1966) study reported chronic indigestion, and 16% reported abdominal spasms. In Gyland's study (Fredericks & Goodman, 1969), 69% reported various digestive problems. Other patients have listed constipation and "irritable colon" (Harris, 1924; 1936). One of the more frequent somatic complaints is headaches (Mason, 1958; Ross, 1975), which generally occur in midafternoon, during the night, or when meals are delayed (Portis, et al., 1950). These headaches may be very intense and are sometimes considered migraines (Abrahamson & Pezet, 1951; Saper & Magee, 1981). Seventy-one percent of Gyland's (Fredericks & Goodman, 1969) patients and 45% of Salzer's (1966) patients reported chronic

headaches. Liver and pancreatic dysfunctions have also been associated with sugar-related disorders. In his earliest studies Harris (1924) noted glycosuria in his patients. Pancreatic insolomas, both malignant and benign, have been found (Abrahamson & Pezet, 1951). According to Dufty (1975), a series of physiological changes occur in the liver, which cause it to enlarge. Fatty acids are stored in the most inactive areas and eventually in active organs, such as the heart and kidneys. Other researchers have associated sugar-related disorders with circulatory problems. Fifty-four percent of Gyland's (Fredericks & Goodman, 1969) patients and 37% of Salzer's (1966) patients reported episodic palpitation and rapid pulse (tachycardia). In addition, several patients complained of cold hands and feet as well as numbness (Salzer, 1966; Gyland, 1953). According to the American Public Health Association and other research (Harris, 1936; Hoffer, 1974; Ross, 1975), these patients suffer a high incidence of coronary attacks. Some sugar-affected patients also gain weight, even becoming obese. Thirty percent of Gyland's (Fredericks & Goodman, 1969) and 19% of Salzer's (1966) patients were obese, prior to treatment. Other somatic conditions that have been associated with sugar-related disorders are low blood pressure (Harris, 1924; Dufty, 1975), allergies and asthma (Abrahamson & Pezet, 1951; Dufty, 1975), rheumatic fever (Abrahamson & Pezet, 1951), rheumatoid arthritis, and neurodermatitis (Fredericks & Goodman, 1969).

In his extensive pediatric practice, Dr. Lendon Smith (1976; 1979; 1981) has identified several symptom clusters characteristic of children with sugar-related disorders. According to Smith (1976; 1981), girls frequently respond with passive symptomology. Tending to withdraw and become loners, they frequently appear depressed. Headaches, stomachaches, and other somatic symptoms are common. Typically, drowsiness and lethargy are associated with obese girls, while headaches and migraines are associated with thin girls. On the other hand, boys with sugar-related disorders tend to be hyperactive, or "hyperactive approachers" (Smith, 1976). Assuming the role of "cheerful pest," they jump from one thing to another. They take apart toys and break things. Many become behavior and truancy problems (Cott, 1972; Smith, 1976; Schauss, 1980). After apologizing for a misdeed, these patients frequently do the same thing again. They express disappointment in birthdays and holidays, as well as in daily events. They never seem satisfied. Seeking immediate gratification, they are subject to sefishness, low frustration tolerance, and temper tantrums (Smith, 1976; 1979; 1981). Unaware of the time of day or household rhythm, they retire late, arise early, and get up several times during the night. Hair-twisting, nail-biting, blanket-chewing, bed-rocking and head-banging are typical habits in young children. Hyperactive approachers are often thin and very ticklish. Unable to waken from extreme somnolence, older

children as well as younger children, may wet their beds. In addition, encopresis is often reported. Because quiet, withdrawn children rarely present problems for parents and teachers, their symptoms may be minimized or overlooked. As Smith (1976) admonishes, it is important to remember that some symptoms may never appear. Each characteristic surfaces on a continuum, ranging from seldom to always, with disorders emerging at points along the extreme ends.

One of the most controversial symptoms of sugar-related disorders is low blood sugar, i.e., insufficient glucose sugar in the blood to adequately nourish brain cells. Usually labelled "hypoglycemia," "hyperinsulinism," or simply "low blood sugar," this condition has also acquired other names. For some practitioners and researchers, the presence of low blood sugar has become critical for diagnosis of sugar-related disorders.

Diagnosis

Low blood sugar (glucose) is usually determined by a Glucose Tolerance Test (GTT). In this procedure a sample of the patient's blood is taken after fasting for at least eight hours. The "normal" fasting reading is usually considered to be between 80 and 120 milligrams of glucose per 100 cubic centimeters of blood (80-120 mg./100 cc.). After the individual drinks 100 grams of glucose sugar solution, additional blood samples are drawn at one-half-hour or one-hour intervals. The two-hour GTT is generally used for diagnosing high blood sugar (diabetes),

and the four-hour GTT is generally used for suspected low blood sugar (Harris, 1924). According to most physicians, the "normal" glucose reading should peak at 160 mg./100 cc. in 30 to 60 minutes and return to the initial level within two hours (Abrahamson & Pezet, 1951). While failure to return to the normal fasting range within two hours generally indicates diabetes, a drop below the normal range during the fourth hour generally indicates low blood sugar.

Measurement of blood glucose has become an important issue because blood glucose significantly alters brain and body functioning. Since refined sugar is chemically similar to glucose, it largely bypasses digestion and goes directly to the intestines where it is absorbed into the blood (Dufty, 1975). The resulting glucose and oxygen imbalance causes the pancreas to produce large amounts of insulin which suddenly decreases the blood glucose level (Surwitt, et al, 1983). In some cases the blood glucose level is adequately maintained by the interplay of adrenalin and insulin. If, however, the pancreas responds at an emergency pace, it produces excessive amounts of insulin (hyperinsulinism). Subsequently, the blood glucose level becomes too low too fast, and the organism suffers cellular malnutrition (Harris, 1924; Smith, 1979; Fredericks, 1983). In an attempt to restore balance, sympathetic responses commence, the pituitary and adrenal glands release their hormones, and the liver converts its stored glycogen into glucose (Abrahamson &

Pezet, 1951; Fredericks & Goodman, 1969; Surwit, et al., 1983). Affect, cognition, and behaviors associated with sympathetic functioning may be observed. Dufty (1975) calls this phenomenon the first stage of the "sugar blues."

> All this is reflected in how we feel. While the glucose is being absorbed into the blood, we feel "up"... this surge of mortgaged energy is succeeded by the downs, when the bottom drops out of the glucose level. We are listless, tired; it requires great effort to move or even think until the blood glucose level is brought up again (Dufty, 1975; p. 47).

The characteristic cravings for stimulating substances, including refined sugar, are most pronounced during these low periods. If refined sugar is consumed, a new crisis, i.e., even lower blood sugar, begins before the old one ends, and a hormonal pendulum which swings higher and higher develops (Abrahamson & Pezet, 1951; Fredericks & Goodman, 1969; Dufty, 1975). In time the overactive pancreas, as well as the adrenals, may become exhausted, and chronic high blood sugar (hypoinsulinism or diabetes), as well as stress, result. Thus, except for diabetes, diets high in carbohydrates do not raise blood glucose sugar (Harris, 1936; Abrahamson & Pezet, 1951; Biermann, 1971). When a patient is described as "sugar-starved" or having "low blood sugar," that does not mean that he/she should be given sugar snacks (Abrahamson & Pezet, 1951).

Several physicians have found this four-hour GTT inadequate for diagnosing low blood sugar, and have developed other techniques. Although their methods have greatly improved our understanding of the various forms of low blood sugar, they have

also produced extensive controversy regarding diagnostic labelling and interpretation. For example, low blood sugar has been confused with insulin shock (Harris, 1924) and, paradoxically, with diabetes (Harris, 1936).

Harris (1936) contends that the GTT should be carried out a full six hours to confirm the existence of low blood sugar (hyperinsulinism or hypoglycemia). During the third or fourth hours, there may be periods of normal readings as well as periods of marked low blood sugar.

> I have observed a number of patients whose blood sugar readings were normal for four hours after the ingestion of the dextrose [glucose], but fell rapidly and to very low levels in the fifth or sixth hour (Harris, 1936; p. 521).

In addition, Harris (1936) found that some patients show an initial diabetic reading, followed by a low blood sugar reading during the fifth or six hour. He concludes that this condition (dysinsulinism) should be treated as low blood sugar. Since patients' veins may be difficult to locate and frequent sampling is inconvenient, Harris recommends drawing only two samples: (1). a fasting blood sample, and (2). a sample five or six hours after glucose ingestion.

Some researchers also feel that GTT results are influenced by recently digested foods. The Exton-Rose Test was developed to avoid this problem. Abrahamson & Pezet (1951) have demonstrated that fat ingestion and starvation usually produce elevated GTT readings, while carbohydrates and protein consumption produce lower readings. Originally designed for identifying diabetes,

the Exton-Rose begins with a fasting blood sample and ingestion of only 50 grams of glucose solution. After 30 minutes a second blood sample is taken, and the patient drinks another 50 grams of glucose solution. After 30 minutes a third blood sample is drawn. Like the GTT, a normal fasting reading is 80-120 mg./ 100 cc. In the first half hour, the reading should not increase more than 75 mgs. The third reading should rise no more than five milligrams above the second. If either of these readings is higher, and if there is no subsequent drop below the normal fasting range, diabetes is confirmed. On the other hand, a high and low blood sugar combination (dysinsulinism) or a normal and low combination are considered positive indices of low blood sugar. To determine whether the blood glucose level will eventually fall below the normal fasting level, a six-hour Exton-Rose must be administered.

Abrahamson & Pezet (1951) also point out that the relative increase or decrease in glucose levels is more significant than numerical readings per se. For example, a rise from 80 mg. to 140 mg. produces effects similar to a rise from 180 mg. to 240 mg. Conversely, a drop from 140 mg. to 80 mg. produces effects similar to a drop from 180 mg. to 120 mg. Thus, the so-called "normal range" may be irrelevant for many patients. Other researchers have attempted to alleviate this problem by establishing criteria based on relative glucose levels. When the blood glucose readings on any of the test samples fall more

than 20 mg.% below the fasting level or when the blood glucose level falls more than 50 mg.% in one hour, Salzer (1966) considers the condition low blood sugar (relative hypoglycemia or subclinical hyperinsulinism). Existence of symptoms associated with low blood sugar, as well as their alleviation after dietary manipulation, reinforce his diagnosis. Salzer's normal GTT (Ross, 1975) shows the blood glucose level rising to 50% above the fasting level and returning to the fasting level in the second hour. This level must be maintained for all six hours. In the Goodman (1969) GTT, a fasting sample is drawn, and the patient is instructed to eat a normal breakfast. After 45 to 60 minutes, a second blood sample is taken. If the blood glucose level has not risen 50% or more during this time, low blood sugar ("flat curve") is also confirmed (Portis & Alexander, 1944; Portis, et al., 1950). If the blood glucose level does exceed 50%, additional samples must be drawn for at least six hours. Fredericks and Goodman (1969) have found that even a 2 mg.% drop below an individual's fasting level may produce symptomology.

Discouraged by the glucose tolerance enigma, physicians have attempted to discern medically observable or palpable signs for diagnosing low blood sugar. Only Harris (1936) has described a sign. It is most pronounced when the patient's stomach is empty; however, it does not appear in many cases (Fredericks & Goodman, 1969). Harris noted a pain or tenderness in the upper left quadrant of the abdomen, the area above the pancreas.

Other diagnostic indices include the patient's family and prenatal history (Smith, 1976). Like the symptomology previously described for individual patients, family characteristics operate on a continuum. A large percent of sugar-sensitive people have at least some Nordic, Irish, or American Indian ancestry. Their eyes are often blue, green or hazel, and their hair is usually blond, reddish, or light brown. Three to four family members probably have diabetes, alcoholism, allergies, obesity, and/or migraines (Cott, 1972; Smith, 1976). Frequently, two to three family members exhibit violent tempers and may have legal problems. In addition, family members often admit to insomnia, school problems, severe depression, irritability, and psychosis. Smith (1976; 1979) proposes that all alcoholics and criminals be given glucose tolerance tests. In many cases, the mothers of sugar-sensitive patients suffered high fevers, infections, anemia, toxemia, high blood pressure, pneumonia, and/or rubella during pregnancy. They often report using large quantities of alcohol, medications, or anesthesia. Bleeding or threatened miscarriage are common. Usually 16 years old or younger or 36 years old or older, many of these mothers ate large amounts of quickly absorbed carbohydrates, such as processed sugars and flour, and smoked more than one pack of cigarettes per day. Prepartum weight gain was often greater than 30 pounds or less than 18 pounds. After a typical gestation period of more than 44 weeks or less than 36 weeks,

these mothers were frequently in labor for less than one hour or more than 20 hours.

Patients who exhibit symptoms of sugar-related disorders often demonstrated extreme sensitivity early in life (Smith, 1976; Ackerman, et al, 1982). Generally weighing less than 4 1/2 pounds or more than 10 pounds at birth, these babies seemed socially overresponsive and became easily upset in crowds, as well as frightened by lights and noise. Exhibiting separation anxiety before six months, they reacted vehemently when left by their parents. Frequently, they resisted cuddling. Many of these babies had difficulty relaxing, and they did not sleep through the night until two or three months old. When exploring their surroundings, they would bite, touch, and approach <u>everything</u>. Temper tantrums were early and prolonged. Seventy-five percent of these "hyperactive approachers" are boys (Smith, 1976).

Another diagnostic tool which has gained popularity is the questionnaire. According to Fredericks and Goodman (1969), all patients who respond positively to questions concerning anxiety, compulsive eating, and any personality change should be suspected of low blood sugar. Bumpers (cited in Cheraksi, et al., 1974) developed a 48-item Health Appraisal Indicator which deals with depression, nervousness, irritability, perception, and sugar and caffeine consumption. In his experience, individuals are probably suffering at least some sugar intolerance if they

respond positively to any three of the following: (1). chronic fatigue; (2). nervous exhaustion; (3). shakiness; (4). periodic faintness, especially when meals are delayed; and (5). sleepiness during the day or after meals. A score of 25 or more out of a possible 48 also indicates at least some sugar intolerance. Schauss (1980) developed a 52-item Nutrition-Behavior Inventory which asks questions similar to those in Bumper's questionnaire. Each answer is ranked from "rarely" (0) to "always" (3), and the higher the score over 30, the more likely the individual's symptoms are directly or indirectly related to refined sugar consumption.

Removing refined sugar from patients' diets is one of the simplest methods currently used for determining sugar-related disorders. If symptoms ameliorate or dissipate within several weeks, a sugar-related problem is inferred. If symptoms persist, there may be a pancreatic tumor or enlargement (Harris, 1936; Abrahamson & Pezet, 1951) or some other sources of stress (Fredericks & Goodman, 1969; Smith, 1976). These diets appear safe and relatively convenient for both patient and physician. To circumvent discomfort associated with cravings, hunger, and withdrawal (Ross, 1975), sugar-avoidance diets usually include six to eight high fat and/or protein meals. The Harris diet (Harris, 1936) consists of high fat and moderately low carbohydrate meals and frequent snacks. In cases of night tremors and insomnia, nocturnal feedings are added. After prescribing

the Harris diet for many of their own patients, Abrahamson & Pezet (1951) made several modifications. They proposed avoidance of only the quickly absorbed carbohydrates, which includes all sugars, alcohol, honey, syrups, grape and prune juice, figs, raisins, dates, bananas, plums, and potatoes for three months. They also discourage use of caffeine and tobacco. According to Fredericks and Goodman (1969), decreased sugar, increased protein, and increased vitamin B complex to counteract stress are essential. Goodman further believes that all carbohydrates should be avoided, and Fredericks contends that even the taste of artificial sweeteners may set off a pancreatic reflex, as with sugar. Concerned that any refined carbohydrates rob the body of B vitamins, thereby exacerbating stress reactions and low blood sugar, Cheraskin, et al., (1974) and Ross (1975) recommend avoiding all quickly absorbed carbohydrates. They list sugar, honey, alcohol, and dried fruit. Since starch disintegrates zinc and chromium, which are essential for pancreatic activity (Hall, 1975), Cheraskin, et al., (1974) recommend avoiding potatoes, lima and baked beans, peas, corn, and rice. They also prescribe 15 to 20 grams of high quality protein at breakfast to sustain blood glucose levels during the morning. Other meals should be high in protein, and moderate in complex carbohydrates. According to Hoffer (1974), individuals with this "Saccharin Disease" should limit sucrose consumption to about 1 1/2 ounces per day. While Smith (1976; 1979; 1983) recognizes that quickly absorbed carbo-

hydrates and caffeine exacerbate low blood glucose levels, he initially recommends sugar avoidance accompanied by frequent protein nibbling. Later it may be necessary to remove other foods from the patient's diet. Saper and Magee (1981) concur with Cheraskin, et al. Avoid foods which promote a drastic elevation and subsequent fall in blood sugar, i.e., simple carbohydrates and starches.

Treatment

In lieu of diet manipulation, drugs have been used to treat sugar-related disorders. Harris (1924; 1936) has successfully reversed symptomology in some of his patients by administering belladonna, a drug which depresses parasympathetic activity. In an attempt to obtain a symptom-free balance between sympathetic and parasympathetic hormones (Abrahamson and Pezet, 1951), other drugs may be used to stimulate the sympathetic nervous system. Adrenocorticotropic hormone (ACTH) or cortisone have also been administered to counteract the excessive secretion of insulin (Abrahamson & Pezet, 1951). While drug therapy may be beneficial for some patients, problems concerning individual dosage and homeostatic maintenance persist. In addition, drug therapy may present chemical dependency complications. Since mood altering chemicals include belladonna, depressants, anti-depressants, as well as alcohol, and since many of these patients report high alcohol consumption, drug therapy may be especially pernicious for these patients.

Etiology

Hypotheses regarding derivation of sugar-related symptomology describe pancreatic and/or adrenal overstimulation, insufficient nutrients for proper functioning, and genetic predispositions. Varying dramatically from individual to individual, these proposed causes are extremely interdependent and difficult to separate.

Excessive pancreatic and adrenalin stimulation may relate to organic factors, oversensitivity due to overconsumption, and/or oversensitivity due to stress. Organic causes include malignant or benign pancreatic tumors (Abrahamson & Pezet, 1951), generalized pancreatic enlargement (Abrahamson & Pezet; Fredericks & Goodman, 1969), adrenal exhaustion (Cheraskin, et al., 1974; Dufty, 1975), and metabolic deficiencies (Pauling, 1968; Rimland, 1974; Dufty, 1975). While organic dysfunction may account for some cases of excess insulin and adrenal hormone production, a series of metabolic and enzymatic changes, concomittant with overconsumption of quickly-absorbed carbohydrates are implicated in others (Abrahamson & Pezet, 1951; Yudkin, 1973; Cott, 1972; Louv, 1978; Mayer & Goldberg, 1983). When refined sugar is consumed, the pancreas often releases such large quantities of insulin that the blood sugar level plummets. The individual experiences cravings, nervousness, dizziness, and fatigue. Prior experience has rendered the pancreas "too sensitive and...overgenerous. Instead of making only the amount

of insulin needed to handle the amount of sugar just taken into the blood, an excess of insulin [is]...produced (Abrahamson & Pezet; p.111). Responding to this emergency and attempting to restore the blood glucose/oxygen balance, sympathetic responses from the autonomic nervous system release adrenal hormones. The fight-or-flight response which ensues may be exhibited in aggressive, hyperactive behavior or in passive, withdrawn behavior (Selye, 1956). Additional symptomology may result from vitamin, mineral, and protein exhaustion, as well as further glucose dissolution (Hall, 1975; Girdano & Everly, 1979). Frequent insulin flooding eventuates in continual fight-or-flight responses and changes (Selye, 1956; Benson, 1974; Girdano & Everly, 1979). Although some researchers believe that excess sugar per se triggers this sequence (Harris, 1924; Ross, 1975), others implicate blood glucose fluctuation (Abrahamson & Pezet, 1951; Fredericks & Goodman, 1969; Rimland & Larson, 1981).

Metabolic causes refer to faulty insulin absorption, hormonal imbalances, and enzymatic deficiencies (Yaryura-Tobias & Neziroglu, 1975; Philpott, 1979). An individual may suffer chronic low blood glucose because his/her body converts glucose into stored glycogen too quickly. Sufficient glucose for energy becomes unattainable (Smith, 1976).

Symptoms associated wtih nutrient deficiency disorders, notably beri-beri and pellagra (Dufty, 1975; Lonsdale & Shomberger, 1980; Fredericks, 1983), frequently correspond with

symptoms characteristic of sugar-related disorders. Since sugar metabolism requires certain vitamins and minerals, and since refined sugar itself contains no nutrients, frequent refined sugar consumption may create deficits in these substances (Fredericks & Goodman, 1969; Yudkin, 1973; Mayer & Goldberg, 1983). Depression, mental confusion, irritability, fatigue, and hypersensitivity are associated with B vitamin depletion (Hoffer, 1974; Hall, 1975). Thiamine (B-1), riboflavin (B-2), and niacin (B-3) are used in carbohydrate metabolism and in conversion of stored glycogen into glucose (Girdano & Everly, 1979; Pelletier, 1979). Since pyridoxine (B-6), a precursor for at least 50 enzymes, is responsible for metabolism of all the amino acids (Hall, 1975), its depletion may create a myriad of other deficiencies. Vitamin B-5 and choline are necessary for producing adrenal hormones during insulin regulation and the fight-or-flight response (Hall, 1975). In addition, nearly all the B vitamins are dependent upon ascorbic acid (Dufty, 1975; Hall, 1975). After a sudden influx of glucose, large amounts of sodium and potassium are used (Dufty, 1975). Calcium is taken from teeth and bones. Other chemical changes and eating patterns may interfere with substance availability and/or absorption. Like refined sugar, processed flours and rice rob the body of vitamin C and B complex (Fredericks & Goodman, 1969). High starch diets tend to dissipate chromium which stimulates several enzyme systems and facilitates insulin

production (Pfeiffer, et al., 1973). Zinc is necessary for protein synthesis as well as the activation of more than 30 enzymes (Hall, 1975). Manganese, which may decrease after excessive vitamin B usage, is also responsible for activating numerous enzymes (Dufty, 1975). Manganese deficiencies are associated with hyperactivity (Davis, 1970; Rimland, 1974). Additionally, fasting, diuresis, dehydration, exercise, and sleep affect enzymatic patterns (Williams, 1979). During stress, cortisol and the amino acid tryptophan are metabolized (Smith, 1976). Tryptophan, which is derived solely from dietary protein, is a precursor of serotonin, and low serotonin levels are associated with depression, schizoid characteristics, and hyperactivity (Sarason & Sarason, 1980; Lezak, 1981). Although Wurtmann (1982; Brody 1982) found that carbohydrate consumption increased tryptophan levels in rats, carbohydrates may also increase stress reactions in some humans, thereby decreasing net tryptophan and serotonin availability. Wurtmann's experiments also used relatively small quantities of sugar (Kolata, 1982).

In addition to stress generated from excessive sugar intake and nutrient deficiencies, there may be environmental and/or perceptual factors.

> Stress, which may be anything from prolonged emotional tension to an accident or surgery or pregnancy is very frequently the prelude to the development of low blood sugar. The secondary stresses alone--excessive uses of sugar, excessive caffeine intake, poor nutrition, missed meals--are enough to initiate hypoglycemia in some individuals; others will survive such minor insults without penalty until a major stress is superimposed (Fredericks & Goodman, 1969, p. 123).

Addictive substances (Fredericks & Goodman, 1969), allergic reactions (Feingold, 1975; Schauss, 1980), pollution, lead toxicity, and fluorescent lighting (Schauss, 1980) have been found to elicit stress responses. Chronic anxiety and daily pressure also trigger stress mechanisms (Kutash & Schlesinger, 1980). On the other hand, a situation that is neither challenging nor zestful may produce low-grade tension. These individuals generally appear bored and uninteresting, and "their lives are as flat as their GTT curves" (Portis, et. al., 1950). The metabolic and perceptual changes that follow create additional stress (Smith, 1976). "Stress alters individual biochemistry. Biochemical stress alters an individual's psychological and physical state" (Braverman, 1979; p. 272).

Considerable variation in chemistry and structure determine the direction and intensity that stress and normal responses will take. Metabolic activity may vary ten-fold, and enzymatic patterns may vary from ten to 50-fold (Stockard, 1941; Williams, 1979). As in the case of phenylketonuria certain enzymes may be nonexistent. Several researchers contend that individual vitamin and mineral requirements differ significantly, so that recommended daily allowances fall far below what some people need for normal functioning (Pauling, 1968; Cott, 1972; Cheraskin, et al., 1974; Brenner, 1982). The size and shape of glands determine hormone production (Williams, 1979). Size, shape, and position of other organs influence physiology (Stockard, 1941). Although most people have two splanchnic

nerves connecting the digestive tract with the sympathetic nervous system, some people have three (Williams, 1979). Differences in neuronal distribution and nerve patterns influence perception of the environment. According to Smith (1976), some individuals may have overly sensitive nervous systems which perceive the environment as hostile or threatening. As a result, they secrete massive amounts of adrenalin and insulin. Other studies associate stress, learning problems, and poor concentration with overly sensitive nervous systems (Charleton-Siefert & Stratten, 1980; Ackerman, et al., 1982).

Previous Research

Most research linking symptomology with refined sugar consumption has originated from physician's case studies, studies within the criminal justice system, and studies dealing with learning disabled and/or hyperactive children. Because exact food intake is difficult to monitor in non-institutionalized settings, few studies have been made with "normal" populations.

Since many case studies contradict popular medical thought and contain an aura of "miraculous recovery," they are often regarded suspiciously. Until Abrahamson & Pezet (1951), Gyland (1953) and Salzer (1966) began systematic data collection, successful cases were frequently unreported. Dr. Seale Harris (1924; 1936) pioneered the discovery that many patients with neurasthenic symptoms improved after low fat, low carbohydrate

diets, accompanied by frequent snacks, for several weeks. He later concluded that the diet essential for maintaining blood glucose levels in these patients contained low sugar and frequent high protein feedings. Harris (1924) describes a 62-year-old physician with low blood pressure, nervousness, irritability, and insomnia. When he followed Harris' diet, his symptoms disappeared. When he discontinued the diet, his symptoms resumed. Although Harris was initially ignored by his colleagues, he was finally honored by the American Medical Association 25 years later. Both Pezet (Abrahamson & Pezet, 1951) and his wife suffered depression, dizziness, and fatigue. When they removed sugar from their diets, their symptoms dissipated. Pezet later collaborated with Dr. Abrahamson who had found similar results in many of his patients. After a series of tests, various diagnoses, and treatments which offered litle, if any, relief, Dr. Stephan Gyland (1953) prescribed the Harris diet for himself. Within a few weeks, all his symptoms improved considerably.

> If all physicians would read the work of Dr. Seal Harris ...thousands of persons would not have to go through what I did. During three years of serious illness, I was examined by fourteen specialists and three nationally known clinics before a diagnosis was made by means of a six-hour glucose (sugar) tolerance test...previous diagnoses have been brain tumor, diabetes, and cerebral arteriosclerosis...Since then I have used this hard earned knowledge in diagnoses and curing the condition in numerous patients (Gyland, 1953).

Semi-invalid and forced to retire, an engineer had a variety of symptoms including low blood sugar (Fredericks & Goodman, 1969).

After adopting the Harris diet, he improved greatly and returned to work. A 39-year-old woman was hospitalized for possible low blood sugar and an array of typical symptoms. Although her GTT fasting reading fell within the normal range, she was prescribed the Harris diet. Subsequently, all symptoms disappeared (Fredericks & Goodman, 1969). In another case, a 45-year-old woman who suffered migraines, gastric cramps, chronic fatigue, and apathy sought psychoanalysis for anxiety and depression. While the stress of therapy seemed to make her symptoms worse, a low-sugar diet with B complex supplementation, as well as frequent protein snacks, reversed her symptoms (Fredericks & Goodman, 1969).

Numerous diet studies with juvenile and adult offenders demonstrate that decreased sugar intake relates to fewer disciplinary problems (Schauss, 1980; Turkington, 1983). These studies include experimental research as well as case studies. One of the first studies was at New Jersey's Morris County Jail Rehabilitation Center in 1973 (D'Asaro, et al., 1975; Schauss, 1978). After eight weeks of diet education, vitamin supple-ements, and high protein evening snacks, the researchers found the following: (1). improved mood and self-motivation; improve-ment in previously measured impaired perceptions; and minimal cravings. The chief probation officer of the municipal court in Cuyahoga Falls, Ohio found that 600 of 734 convicted delinquents had very high sugar diets and very few wholesome foods

(Rasmussen & Karas, 1983). When the inmates followed a diet restricting refined sugar and flour, caffeine, alcohol, additives, and preservatives, their behavior and capabilities improved remarkably. In 1979 two Alameda Probation Department youth camps slowly decreased refined sugar in diets of 350 juveniles (Schauss, 1980). After several months, the youths were reportedly quieter and less aggressive. In a 1980 study (Schoenthaler, 1982), refined sugar intake was reduced in a juvenile delinquent home over a seven-month period. The low sugar group demonstrated a 45% lower rate of disciplinary action and left an average of 10 days earlier, as compared to the control group. The Purple Heart Homestead for juvenile delinquents, a federal prison study (Schauss, 1980), and the Full Circle Residential Treatment Center (Rasmussen & Karas, 1983) report similar results.

Numerous studies dealing with diet manipulation of hyperactive and/or learning disabled children have been documented. Feingold (1975) describes Johnny, a very intelligent child who could neither concentrate nor learn. He frequently exhibited aggressive periods and craved sweets. After refined sugar and additives were removed from his diet, his behavior and learning problems were ameliorated. Jerry's (Schauss, 1980) psychological report described him as hyperactive, easily distractible, and frequently unable to follow directions. Often truant and subject to violent behavior, Jerry scored 83 on his NBI. After

refined sugar and other processed foods were removed from his diet, Jerry's behavior and NBI score improved dramatically. In a controlled study, Kershner and Hawke (1979) placed hyperactive children on a diet that restricted processed foods for six months. Not only did they improve greatly on scales measuring hyperactivity, but they also exhibited increased attention spans, less irritation, and better peer relations.

Although most of these studies focus on special populations, many researchers conclude that large quantities of refined sugar, which are typical of the average American diet, have similar effects on the normal population. They reason that symptoms may be so obscure that they remain unnoticed. Perception, performance, and/or IQ may be depressed, though the individual appears to be doing well. Behavior patterns may be overlooked or excused because they do not interfere with performance or are considered normal for that individual. According to HEW's figures, 49.2% of the people in their 1966-1967, non-institutionalized sample exhibited low blood sugar symptoms (Dufty, 1975). Other researchers have estimated that 10-20% of the normal population suffer some sugar-related problems (Abrahamson & Pezet, 1951; Fredericks & Goodman, 1969).

The purpose of the following experiment was to determine the effects of reduced sugar intake in the diets of normal children. Refined sugar, i.e., any sugar which has been voided of its B and C vitamins, was specified, because these substances

have been consistently implicated in prior studies. Since previous research has dealt primarily with elementary school children, boys and girls between the ages of seven and 10 were selected. Two-week and four-week time periods were used to determine the effects of diet duration.

Hypotheses

Several hypotheses concerning diet, duration, sex, and socioeconomic status (SES) were proposed. It was anticipated that at least 10% of the sample would exhibit sugar-related symptoms as reflected in initial NBI scores. Those Ss who scored more than 30 on their NBIs would have lower paired-associate learning scores than those Ss who scored less than 30 on their NBIs. After following a low-sugar diet, Ss would exhibit decreased NBI scores and increased learning scores relative to a control group. Ss in the four-week low sugar condition would show more improvement than Ss in the two-week condition. Since lower SES groups presumably ingest more simple carbohydrates than higher SES groups, it was anticipated that effects would be more pronounced in lower SES families. Since boys appear to have a higher incidence of overly-sensitive nervous systems, the effects were anticipated greater for boys than girls.

METHOD

Subjects. The 58 Ss (22 males & 36 females) were second-, third-, and fourth-grade volunteers from two public schools in a medium-sized, heterogeneous community. Their mean age was 8.04 (range: 7.05-10.06). Seventy-eight percent of the Ss were Caucasian, 19% were Negro, and 3% were Oriental. Mean annual family income was between $25,000 and $34,999 (range: under $5000-$50,000 and over). Reportedly, all Ss were healthy and capable of working at grade level. None were medicated, restricted to special diets, considered learning disabled, or mentally handicapped.

The seven Ss (3 males & 4 females) who completed all aspects of the experiment in the LS condition were matched for sex, age, race, and SES with 7 Ss (3 males & 4 females) in the UD condition. Seventy-nine percent were White, and 21% were non-White. Mean age was 8.5 (range: 8.01-10.06), and mean annual family income was $25,000 to $34,999 (range: under $5000-$50,000 and over). At the end of the experiment all Ss were rewarded, regardless of their ability to follow dietary instructions.

Design. There were four independent variables (IV). The within-subject variables were sex and SES, the latter designated as (1). under $5000; (2). $5000-9,999; (3). $10,000-14,999; (4). $15,000-19,999; (5). $20,000-24,999; (6). $25,000-34,999;

(7). $35,000-49,999; and (8). $50,000 and over. The between-subject variables included two diet plans and two durations for each diet. In the experimental diet group (LS), Ss were asked to eliminate refined sugar (sucrose) from their diets and were given specific instructions regarding sugar substitutes and label-reading. These directions served to maximize the probability of limiting sucrose consumption to Hoffer's (1974) recommended 1 1/2 oz. per day per adult. In a usual diet (UD) control group, Ss were instructed to continue their routine diets. Like the LS group, they were given specific instructions regarding substitutes and labeling. Because some studies indicate that effects from reduced-sugar diets become noticeable only after three weeks (Fredericks, 1976), the durations of the dietary conditions were set at two and four weeks. To control for sample bias, the Ss were sequentially assigned to the four groups (Underwood, 1966).

The instruments for measuring learning and suspected sugar-related disorder were performance on a paired-associate (PA) learning task (Calkins, 1894) and scores on the NBI (Appendix A). To establish baselines for these dependent variables (DV), pretests were given.

Apparatus & Materials. The materials included a Parental Permission Form (PPF) (Appendix B), a Parental Questionnaire (PQ) (Appendix C), the NBI, Dietary Instructions (Appendices D & E), PA pretest and posttest cards (Appendix F), Teacher's

Instructions (Appendix G), and a Post Questionnaire (Post-NBI-19) (Appendix H).

In the PPF parents were informed that their children may benefit from participating in a learning experiment, administered at school by their child's teacher and an outside researcher. There would be no risk of any kind. They were additionally told that the experiment may involve a minor dietary adjustment that would be palatable as well as healthy. Their children would receive a small gift for their participation. The parents were assured personal confidentiality and a written summary of the experimental results.

The PQ was used to screen out possible confounding variables in the Ss and to correlate some of their characteristics with those found by other researchers (Smith, 1976). The PQ included 15 questions involving family history and the child's physical, mental, and emotional well-being.

On the NBI there were 52 items regarding the Ss' recent activity levels, mood swings, and eating patterns. Each child and his/her parent completed this inventory together. It was scored on a Likert-type scale (Anderson & Borkowski, 1978), ranging from "Never" (0) to "Usually" (3). Any score above 30 was considered indicative of at least some sugar intolerance. Since one of the items in Schuass' (1980) inventory dealt with cigarette smoking which was inappropriate for this group of young Ss, another comparable characteristic, namely bed-wetting

(Smith, 1976), was substituted. A 19-question NBI (pre-NBI-19) was constructed from the 52-question inventory to compare with a posttest.

Four different sets of dietary instructions were typed on 8 1/2" x 11" paper. Each included specific start and completion dates. In the event that teachers might delay administering posttests, diet completion dates were set 2 days after the actual experimental durations. In the LS condition, Ss were instructed to read food labels and to avoid granulated, brown, and powdered sugars, as well as foods labeled "sucrose", "dextrose", "sugar", "turbinado", "corn syrup", or "carbohydrates". Acceptable sugar substitutes, including aspartame, nutri-sweet, saccharin, sorbitol and naturally occurring sugars such as fresh fruit were listed. In addition, several popular foods containing "hidden" sugars were listed. Allowances were made for deviations from assigned diets.

For the pretest and posttest PA tasks, there were sets of 160, 5" x 7", white index cards with 2 1/2-inch, standard lowercase printing, hand-drawn with a black felt-tipped pen. Eighty cards in each set contained both stimulus and response terms, while the remaining 80 cards contained only stimulus terms. To minimize intervening variables as well as simplify the task, all stimulus terms consisted of unfamiliar (Martin, 1965; Underwood, Runquist & Schultz, 1959) low-associative (Archer, 1960; Cieutat, 1963; Noble, 1961), and easily pronounced (Underwood &

Schultz, 1960) nonsense CVCs (Deese, 1960; Martin, 1967) with low formal (Horowitz, 1962) and low conceptual (Unemoto, 1962) intralist similarity. All response terms were three-letter words matched for high meaningfulness (Asch & Ebenholtz; 1962, Martin, 1965; Wollen, 1969) and high familiarity (Cook & Brown, 1963; Kellas & Butterfield, 1970; Morikawa, 1959) via Thorndike's and Lorge's (1944) index of 1000 most frequently used words. To further simplify the learning task, the response terms were easily pronounced (Underwood & Schultz, 1960) with high conceptual similarity (Ekstrand & Underwood, 1963) and low formal similarity (Underwood, Ekstrand, & Keppel, 1964). None of the stimulus or response words were used for more than one pair (Horowitz, 1962; Underwood, 1966). A cassette recording in a portable player regulated equal study times and recall times (Bugelski, 1962; Murdock, 1960). The beginning (and end) of each five-second study interval and each five-second recall interval was designated by a bell. The end of each trial was designated by two bells. Between-trial intervals were 10 seconds. Since the first card of each trial might be viewed longer than the other cards, the first cards of each trial were concealed by a blank index card and flipped down only at the bell signal. Specific directives were also recorded on the cassette to remind the teacher and the Ss of the procedure. Three-by-five-inch index cards were prepared for each Ss response. Three cards were stapled together for the three

practice trials. Six cards were stapled together for the six test trials.

The Teacher's Instructions explained the PA cards, cassette, and learning task procedure. It also provided directions to be read to the Ss. In the class instructions the Ss were told that they would be playing a word guessing-game, where they were to remember as many word pairs as they could. First they would study two words together. Later, when they saw only the first word, they would write down the missing word. The Ss were also apprised that there would be some "nonsense" words. After a short practice, they would have several chances to remember some new pairs. To reduce experimenter bias, the teachers were given neither experimental background data nor the identities of Ss and their dietary conditions. The teachers were also asked to administer all PA tests at the beginning of the day to keep times between food intake and testing constant.

The Post Questionnaire consisted of the same 19 questions drawn from the pre-NBI-19. They dealt with S depression, fatigue, irritability, and sugar/caffeine cravings experienced within the prior week.

Since the PQ, NBI, Diet Plans, 3" x 5" cards and Post-NBI-19 were prepared for S use, each was identified by an S number. This system allowed substantial anonymity, yet enabled later pretest-posttest matching, and, if necessary, S name and score matching.

Procedure. After the teachers agreed to assist in the experiment, they sent PPFs to their students' parents. On an appointed date, approximately one week later, the teacher or experimenter administered a practice pretest and a pretest, using the study-recall method (Battig, 1972; Underwood, 1966). They were instructed to present the tests first thing in the morning, presumably one to two hours after breakfast. The practice pretest not only helped familiarize Ss with the PA task, but also adjusted for learning-to-learn variables in the posttest (Postman & Schwartz, 1964). Packets containing the PQ, pretest NBI, PA 3" x 5" cards, and individual diet specifications were distributed in sequential order (Postman & Schwartz, 1964) so that each class contained equal numbers of Ss in each condition. The teacher or experimenter read the PA instructions to the Ss and seated himself/herself in front of the class with the 5" x 7" cards placed perpendicular to his/her desk or lap. The stimulus-response pairs and the stimulus terms had been block randomized separately for each trial (Anderson & Borkowsky, 1978), and Ss were given a study trial and a recall trial twice in the practice pretest. When the bells rang, the teacher or experimenter turned the top card face-down on his/her desk or lap. The Ss wrote their answers on one 3" x 5" card for each recall trial and then folded the page over before starting the next study trial. In this way they could not read answers from the previous trials. After writing their names on the

practice answer cards, the Ss gave them to the teacher or experimenter. Within a few minutes, they began the PA pretest, using the same procedure, new stimulus-response terms, and new answer cards. Seven study trials alternated with seven recall trials. Before the Ss began their diets, the PQ and NBI were completed. Both these inventories were returned to the teachers within a few days.

On individually assigned dates the Ss initiated their special diets. The dates were staggered so that all Ss could take the PA posttest at the same time. In this way variables associated with maturation and interim learning could be eliminated. All Ss were given posttests by the same person who had administered their pretests.

Because warm-up effects operating in the PA pretest might confound posttest results (Hamilton, 1950) the Ss were given three study and three recall practice posttest trials. The PA posttest consisted of seven study and seven recall trials. In both tests new stimulus and response terms were used, and posttest procedures corresponded to those in the pretest. Ss also received the post-NBI-19 posttest, which they completed at home with parental help, and returned to the teacher within a few days.

RESULTS

According to the NBI-52 scores for the initial Ss, the predicted 10% or more Ss exhibited sugar-related symptoms. Eighty-five percent scored 30 or more, 70% scored 40 or more, 61% scored 50 or more, and 24% scored 60 or more. Of these Ss, the mean NBI-52 was 48 (range: 10-89). The mean NBI-52 for boys was 34 (range: 10-54) and 53 (range: 11-89) for girls. The NBI-52 for the 14 matched Ss was 42, and 67% scored 30 or more.

Multiple regressions for sex, age, race, SES, PA trials-to-criteria, PA number correct, and NBI-52 scores were conducted. With sex, age, race, and SES as IVs, the PA number correct scores were significant at the .02 level (R=.45), and the PA trials-to-criteria scores were significant at the .05 level (R=.41). Another multiple regression was conducted to determine the relationship between sex and NBI-52 scores. Contrary to prediction, females had significantly higher scores than males (see Table 1).

Table 1
Mean NBI-52 Scores for Males & Females (p .01)

Variable	M	SD	R
sex	.34	-.28	.53

Three one-way analyses of variance (ANOVAs) were calculated to determine the effects of the LS versus the UD conditions on

post-NBI-19 scores, post PA count, and post PA trials-to-criteria scores. None were significant. Since female Ss had shown significantly higher NBI-52 scores than males, a one-way ANOVA for the effects of diet on NBI was calculated separately for females. It was also insignificant (see Table 2).

Table 2
Analysis of Variance for Females in LS vs. UD Groups and NBI Scores

Source	df	SS	MS	F	p.
Between diets	1	240.7	240.7	1.14	>.05
Within diets	4	845.3	211.3		
Total	5	1086.0			

Two-way ANOVAs were calculated for sex and diet and NBI-19 scores, as well as SES and diet and NBI-19 scores. Both were insignificant (see Tables 3 & 4).

Table 3
Two-Way Analysis of Variance for Sex and LS or UD Conditions on NBI Scores

Source	df	SS	MS	F	p.
Between sex	1	3.0	3.0	.03	>.05
Between diets	1	176.4	176.4	1.55	>.05
Interaction (sex x diet)	1	74.8	74.8	.66	>.05
Within	8	906.8			
Total	11	1161.0			

Table 4
Two-Way Analysis of Variance for SES and LS or UD Conditions on NBI Scores

Source	df	SS	MS	F	p.
Between SES	1	140.1	140.1	1.3	>.05
Between diets	1	140.1	140.1	1.3	>.05
Interaction (SES x diet)	1	36.6	36.6	.3	>.05
Within	8	858.1	107.3		
Total	11				

Thus, the two- and four-week low-sugar diets had no significant effects on post scores, compared to the control group.

DISCUSSION

One of the possible reasons for these results may be self-selection of Ss. Unlike previous studies, S participation was strictly voluntary, and Ss could drop out at any time. It had been hoped that the teachers could encourage the Ss to incorporate the experimental conditions into their studies on nutrition. However, most teachers declined, and only a few students participated. Subsequently, the Ss that volunteered may have been better informed and more interested in nutrition than those who refused. Most of the Ss who dropped out after the PA pretest completed either all six pairs (60% of Ss) or zero pairs (33% of Ss). Thus, extreme pleasure or displeasure with pretest scores may have contributed to decisions to drop out. It appears that the Ss who dropped out were very similar to the Ss that remained throughout the experiment. Mean age for the Ss that dropped out was 8.8 (range: 7.05-9.11), and mean SES was $25,000-$34,999. Fifty-nine percent were female, and 41% were male. Only 58% of the Ss that dropped out had been assigned the more difficult LS condition, indicating nearly equal disinterest in these groups. Although assigning all Ss to the experiment and restricting them to their diets may have produced different results, it was entirely beyond the scope of this experiment.

There are several interpretations of the statistical data. First, it might be concluded that low-sugar diets do not affect

learning and behavior in normal children. However, since there was a trend toward lowered NBI scores, there appears to be additional explanations.

It is possible that four weeks was insufficient time to dissipate an overly-sensitive pancreas and/or replenish nutrient stores. Ross (1975) contends that the benefits of a low-sugar diet may not be experienced until three months have lapsed. After one month Ss "feel lousy" (1975, p. 113) and crave sweets and starches. After two months they have "it's over with" (1975, p. 113) feelings, alternating with continued cravings. After three months they report feeling healthier and relieved from addiction. The Ss in the current experiment may not have had sufficient time to correct deficits in vitamin C and B-complex as well as certain minerals. Breaking the sugar habit itself might have initiated a new stress, which further decreased glucose, vitamin, mineral, and protein availability. In addition, the LS diet alone may have been inadequate to reduce symptomology. It might have been necessary to eliminate all processed foods and/or quickly-absorbed carbohydrates to yield significant effects. Furthermore, the protein meals which have been used in prior research to alleviate discomfort and cravings as well as B-complex administration, per se, may have been necessary for symptom reversal. Thus, the Ss in this experiment may have demonstrated a continuation of symptoms because other foods or stresses were overriding the effects of sugar reduction.

Investigation of the NBI revealed questions which may be biased in favor of hypoactivity and popularly-conceived "feminine characteristics." This may account for female Ss having higher NBI-52 scores than the male Ss. Many questions dealt with weakness, depression, fatigue, quiescence, and passivity. When the Ss were boys, both parents and children may have resisted attribution of these characteristics. In previous research, the focus had been on hyperactivity which is popularly conceived as "all boy." Boys may have appeared more sensitive to sugar in previous research due to a male sex bias. Although additional questions dealing with hyperactivity may have equalized the sex bias in this experiment, it is doubtful that parents describe their daughters as "hyperactive" with the same reluctance that they describe their sons as "weak."

Recommendations for further group testing include a longer experiment with several different conditions. Durations should include one, two, and three months. Various experimental groups should include the following: (1). reduce refined sugar only; (2). reduce all quickly-absorbable carbohydrates; (3). take B-complex along with a low-sugar diet; (4). take 6 small protein meals along with a low-sugar diet; (5). remove all processed foods. Since these conditions are difficult to enforce with humans, an animal study, where the animals were first fed the "typical American diet," may be advisable.

Individual experimentation may beneficial to those who

suspect some sugar-related symptoms or who are simply curious about what a low-sugar diet might do for them. Following the Harris diet, which precludes all processed foods, and quickly-absorbed carbohydrates, while building nutrient stores, may yield results similar to Gyland's and Salzer's patients. Careful accumulation of pre- and post-diet data may uncover trends that are statistically verifiable.

Appendix A

NBI QUESTIONNAIRE

To the Parent: There are 52 items on this questionnaire. Please answer them together with your child. There are only 4 choices for each question: NEVER, RARELY, OCCASIONALLY, or USUALLY. Pick the answer that is closest to how your child feels or reacts in the given situation. There are no right or wrong answers. This is merely a survey.

NEVER	RARELY	OCCASIONALLY	USUALLY	
				1. His/Her vision gets blurred or double.
				2. His/Her gums bleed.
				3. After falling asleep, he/she wakes up and then cannot get back to sleep.
				4. His/Her muscles feel painful and sore.
				5. My child gets headaches.
				6. My child has allergies or asthma.
				7. My child gets cramps in his/her legs.
				8. My child has had itching or crawling sensations on his/her skin, with no apparent cause.
				9. He/She sighs or yawns during the day.
				10. His/Her stomach or intestines get upset.
				11. If he/she misses a meal, he/she may notice a faster heartbeat.
				12. He/She gets mad for no apparent reason.
				13. He/She easily gets bruises or black-and-blue marks.
				14. He/She has nightmares or bad dreams.
				15. He/She gets faint, dizzy, has weak spells, or cold sweats.
				16. It is hard for him/her to concentrate.

NEVER	RARELY	OCCASIONALLY	USUALLY	
				17. He/She may be sleepy after eating.
				18. He/She nibbles between meals and seems hungry.
				19. He/She gets very tired or exhausted.
				20. He/She gets jittery or nervous when hungry.
				21. He/She no longer feels tired after eating.
				22. My child feels hungry or faint if he/she does not eat often.
				23. He/She feels better after the first meal or snack of the day.
				24. He/She drinks coffee, tea, chocolate milk, or cola in the morning to get started.
				25. My child easily forgets things.
				26. My child eats sweet things or drinks caffeinated tea, coffee, cola, or chocolate.
				27. He/She has more than 3 cups of tea, coffee, cola, chocolate, or any other caffeinated beverage per day.
				28. My child adds sugar to most things that he/she eats or drinks.
				29. He/She is very restless.
				30. He/She becomes sleepy during the day.
				31. He/She likes to taste alcoholic beverages.
				32. My child does not work well under pressure.

NEVER	RARELY	OCCASIONALLY	USUALLY	
				33. He/She has difficulty making decisions.
				34. My child craves sweet foods, candies, or drinks.
				35. He/She looks or feels depressed.
				36. He/She worries about things.
				37. He/She gets easily confused.
				38. He/She finds it hard to decide on things.
				39. At times he/she feels overwhelmed.
				40. He/She feels depressed or feels blue over nothing.
				41. My child is easily irritated.
				42. My child is fairly impatient.
				43. He/She blows little things out of proportion and easily loses his/her temper.
				44. He/She gets fearful and anxious.
				45. He/She feels nervous.
				46. He/She eats when nervous or bored.
				47. My child is very emotional.
				48. He/She has had brief or serious thoughts about killing himself/herself.
				49. My child has been known to cry for no apparent reason.
				50. He/She may feel drowsy during the day.
				51. In the past year, he/she has had bed-wetting incidents.

52. The 2 foods that he/she craves the most are:

_____ & _____

ALL INFORMATION IS STRICTLY CONFIDENTIAL AND WILL BE KEPT SEPARATE FROM THE TEACHER'S AND OFFICE'S RECORDS. PLEASE DO NOT INCLUDE YOUR NAME.

Appendix B

PARENTAL PERMISSION FORM

Dear Parents,

I am a Masters Candidate in psychology, conducting a research project in several University City elementary schools. I will be aided by some of the teachers in presenting a short game to the students during regular class time.

Your child may benefit from participating in the research project. There will be no risks or adverse effects on your child. The project may involve minor dietary adjustments which are both tasty and healthful, and your child will receive a small gift for his/her participation. In addition, you will be given a short questionnaire to complete at home, and you will receive a written summary of the experimental results.

All information will be kept strictly confidential and separate from the teachers' and office's records. Your participation is voluntary, and you may withdraw from the experiment at any time.

If you agree to allow your child's participation and agree to complete a questionnaire, please fill out the following permission slip and return it to your child's teacher by the end of this week.

My child _____ and I will participate in this research.

Signed: _____

Date: _____

Appendix C
PARENTAL QUESTIONNAIRE

1. Is your child currently on any medication? Yes_____ No_____
   a. If yes, what is the brand name(s)? _____
   b. If yes, how long has he/she been on this medication? _____
2. Does your child take vitamin supplements? Yes_____ No_____
   If yes, what brand name? _____
3. Is your child currently on a special diet? Yes_____ No_____
   If yes, for what reason? _____
4. Does your child have any allergies? Yes_____ No_____
   a. If yes, to what? _____
   b. If yes, does your child take allergy shots? Yes_____ No_____
5. Has your child been sick with an elevated temperature in the past week? Yes_____ No_____
6. How ticklish is your child? Extremely_____
   Some, but not a lot_____
   Very little_____

Has your child ever been described as:

7. learning disabled? Yes_____ No_____
8. a slow learner? Yes_____ No_____
9. hyperactive? Yes_____ No_____
10. somewhat disruptive in the classroom? Yes_____ No_____
11. a behavior problem? Yes_____ No_____

Is your child:

12. Male_____ Female_____
13. Negro_____ White_____ Other_____
14. What is your child's age? _____Years and _____Months
15. What group best describes your family's total annual income?
    Under $5000____ $5000-$9999____ $10,000-$14,999____
    $15,000-$19,999____ $20,000-$24,999____ $25,000-$34,999____
    $35,000-$49,999____ $50,000+____

THIS INFORMATION WILL BE KEPT STRICTLY CONFIDENTIAL & SEPARATE FROM TEACHER AND SCHOOL RECORDS. PLEASE DO NOT INCLUDE YOUR NAME.

Appendix D
EXPERIMENTAL RESEARCH
DIRECTIONS - LS

The following dietary instructions and the attached questionnaire sheets are part of the research project in which you previously agreed to participate. Your cooperation in this important study is deeply appreciated.

(1). Please complete all the questions on the Parental Questionnaire and on the NBI Questionnaire to the best of your ability, and return them both to your teacher by _____. Do not put your name on them.

(2). Dietary Instructions. In this research project it is very important to read the labels of all food packages to determine their contents. Beginning the morning of _____ (before breakfast), avoid eating any foods or beverages that contain and/or are labelled with any of the following:

"sugar"	"brown sugar"	"syrup"
"refined" or "processed sugar"	"sucrose"	"turbinado"
"white sugar"	"cane sugar"	"carbohydrates"
"granulated sugar"	"corn syrup"	"cane syrup"
	"powdered sugar"	"corn sugar"

There are several sweeteners with similar flavors that you may use as substitutes:

"honey"	"aspartame"	"dextrose"
"molasses"	"lactose"	"raw (unprocessed sugar)"
"sorbitol"	"fruits" & "fruit sugars"	"saccharin (various types)"*
"nutri-sweet"		

Some common foods that often contain added amounts of "hidden" sugars are: ketchup (some brands), peanut butter (some brands), breads (some), crackers (some), canned fruit (some brands), breakfast bars, instant breakfast, granola bars, candied dry fruit, Tang & other fruit juice drinks (some), canned vegetables (some), tomato sauce (some), yogurt with fruit, cereals (some "non-sweetened" as well as pre-sweetened), mayonnaise (some).

*Consider health warning on package when using saccharin substitutes.

While you may find this avoidance diet easy to follow, there will be times when you forget to follow it. If this happens, it is important to keep a record of:

Food or Drink Consumed	How Much	Date

Continue following these dietary instructions until the morning (before breakfast) of _____.

Any questions regarding this diet or the questionnaires should be addressed to the teacher, who will be in contact with the experimenter. Your participation is voluntary, and you may withdraw from the experiment at any time.

Appendix E

EXPERIMENTAL RESEARCH
DIRECTIONS - UD

The following dietary instructions and the attached questionnaire sheets are part of the research project in which you previously agreed to participate. Your cooperation in this important study is deeply appreciated.

(1). Please complete all the questions on the Parental Questionnaire and on the NBI Questionnaire to the best of your ability, and return them both to your teacher by _____. Do not put your name on them.

(2). Dietary Instructions. In this research project it is important that you eat foods that you normally eat and make no changes in your regular eating habits. Continue eating in this manner beginning the morning of _____.

While you may find this avoidance diet easy to follow, there will be times when you forget to follow it. If this happens, it is important to keep a record of:

Food or Drink Consumed	How Much	Date

Continue following these dietary instructions until the morning (before breakfast) of _____.

Any questions regarding these diet instructions or the questionnaires should be addressed to the teacher, who will be in contact with the experimenter. Your participation is voluntary, and you may withdraw from the experiment at any time.

Appendix F

PAIRED ASSOCIATE WORDS

Practice Pretest

kax-you

zib-sea

von-big

Pretest

yem-car	zos-arm
tuv-box	wup-low
kaf-sat	vib-one

Practice Posttest

yob-war

gax-eye

nof-pay

Posttest

baz-did	zeb-day
vug-had	yob-red
gaw-use	cax-man

Appendix G

TEACHER INSTRUCTIONS

Dear Teachers,

Thank you for agreeing to assist with this experiment. I believe you are aware of the importance of thorough research to find better ways to educate our children.

For this study the children will do a paired-associate (PA) learning task; i.e., they will memorize pairs of 3-letter words, which are printed on the enclosed 5" x 7" index cards. First the students will see both words of each pair in a study trial. Then they will see only the first word of each pair in a recall trial, attempt to remember its second half, and write this second half on a 3" x 5" answer card (included in the student's packets). This procedure will continue for several cassette-regulated trials. The first word of each of these 6 word pairs will be a "nonsense word," and the second word of each pair will be a common English word. For example, the words "cem-and" might be a word pair (see Sample A in Teacher's Packet). After the students see "cem-and" in a study trial, they will see only "cem-" in a subsequent trial (see Sample B). They should write the word "and" on their answer cards.

You will be showing the students the separate word-pairs and words by flipping the enclosed 5" x 7" index cards. Since they have been methodically randomized, it is essential that they remain in this order. The enclosed cassette is a timing and directive device which will tell you when to show a new card. While sitting in front of the class, hold all the cards, including the blank ones, perpendicular to your lap or desk, so that all participants can easily see them. Check that the letters will appear right-side-up for the class. Turn on the cassette. When you hear a bell on the tape, flip the top card face-down on your lap or desk. This will expose the next card. Continue to flip cards over at the one-bell signals. When you hear 2 bells, flip the card over and pause. The students will then see a blank card and have 10 seconds to fold their answer cards over at the stapled corner, in preparation for the next trials. Continue following the directions on the cassette, and again flip the cards at the one-bell signals. You may want to play the cassette for yourself prior to working with the class.

Step-By-Step Directions: Do first thing in the morning.

(1). Pass out the student packets, containing 3" x 5" index answer cards, a Parental Questionnaire, NBI Questionnaire, and Experimental/Dietary Instructions.

(2). Tell the students to get out their 3" x 5" cards and to put all the other papers away to bring home to their parents. Tell them to remove the outside rubber band so that they have a big pack of stapled cards and a small pack of stapled cards. They will also need a pencil.

(3). Read the following instructions to the students: "In a few minutes we will be playing a Word Guessing Game. I will show you several cards, like this one (show Sample card A), with 2 words on them. Look at the words and try to remember that they go together. Then I will show you 5 other cards with different pairs of words on them. Try to remember these, too. Next I will show you 6 cards that have only the first words on them, like this one (show Sample B). When you see a first-word-only card, try to remember its matching word and write it down on your answer card (display a pack of answer cards). The object of the game is to remember as many matching words as you can. You will be given several chances to guess the matching words. Write your answers, one under the other, like this (Show Sample C), and start your answers at the top. Now, write your name on the front of the bigger pack of answer cards."

(4). Continue: "Now we will practice the game. Take the smaller pack and your pencil and get ready to study these practice cards. This tape recording will tell us what to do next." Turn on cassette and prepare to flip the smaller stack of 5" x 7" cards. The cassette will direct 3 study trials alternating with 3 recall trials.

(5). "Now we will begin the real game. We'll see who has good memories today. Get out the larger pack and fold up the page with your name on it (see figure 1). I'm going to turn the cassette on again to begin the game." Turn on the cassette and prepare to flip the larger stack of 5" x 7" cards. The cassette will direct 7 study trials, alternating with 7 recall trials.

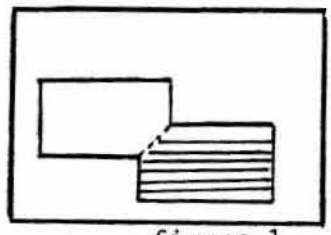

figure 1

(6). When the tape has finished, tell the students the correct answers if you want to, letting them check their skills. (See enclosed answer sheet). Check only the last card.

(7). Tell the students to wrap the rubber band around their 2 stacks of cards and collect all the cards.

(8). Return the 5" x 7" practice and pretest cards, the students' 3" x 5" practice and pretest answer cards, and

the cassette to me. I will pick them up at the office after 1:00 PM on _____.

(9). After the students and their parents have completed the Parental Questionnaire and the NBI at home, they should return them to you, per their instructions, by _____ _____. I will pick these up at the office after 1:00 PM on _____.

There will be a follow-up test in about 6 weeks on _____ _____. The procedure will be the same, and I will bring you the materials _____.

If you have any questions, please do not hesitate to call me.

Sincerely,

Betsy Eller
725-8777 (home)
577-5400 (MWF - Adult Care Unit)

Appendix H

POST QUESTIONNAIRE

Dear Parents,

This is the final component of the experiment in which you and your child agreed to participate. Please answer the 19 items on this questionnaire with your child. Pick the answers that are closest to the way your child has felt or reacted in the past week only. There are no right or wrong answers. This is merely a survey.

NEVER	RARELY	OCCASIONALLY	USUALLY	In the past week my child has
				(1). had headaches.
				(2). fallen asleep, awakened, and then been unable to return to sleep at night.
				(3). sighed or yawned during the day.
				(4). become mad for no apparent reason.
				(5). felt faint, dizzy, or weak.
				(6). forgotten things.
				(7). felt blue or depressed over nothing.
				(8). felt very tired or exhausted.
				(9). had difficulty concentrating.
				(10). had nightmares or disturbing dreams.
				(11). felt nervous or jittery before meals.
				(12). had an upset or uncomfortable stomach.
				(13). been restless.
				(14). had difficulty making decisions.
				(15). been easily irritated.
				(16). been impatient.
				(17). felt nervous.
				(18). cried for no apparent reason.
				(19). wanted sweets or colas.

Please return this questionnaire to your child's teacher by _____. After it is received, your child will receive a small gift for his/her participation. If there were any deviations from your child's dietary instructions, please enclose the list or note them on the back of this sheet.

Thank you very much for your time and cooperation.

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