

Table sugar (i.e., sucrose, a glucose-fructose disaccharide) has a negative overall reputation in North America. For example, although it has only been shown to be directly linked to tooth decay, the general public erroneously regards sugar as a contributor to several other conditions, such as heart disease and acne [1]. Sugar is also commonly believed to influence behavior adversely [2]. In particular, it is popularly reputed to cause hyperactivity in children, especially those with a predisposition to hyperactive behavior [1]. This paper first presents experimental evidence which seriously challenges the alleged correlation between sugar intake and elevated activity levels in children. Then it discusses some likely reasons for the evolution and maintenance of this widespread misconception.

The Weight of Scientific Evidence does not Suggest that Sugar Disrupts Behavior, Even in "Hyperactive" Children

When clinicians describe a child as being "hyperactive" they are referring to a condition known as Attention Deficit Hyperactivity Disorder (ADHD). ADHD is a preadolescent syndrome which is estimated to afflict 3% of all U.S. children [3]. Some of the diagnostic indicators of ADHD are: restlessness in class, distractibility, a tendency to interrupt or intrude on others, excessive talking, and impatience. Of course, all children exhibit one or more of these symptoms from time to time. However, as described in The Diagnostic and Statistical Manual of Mental Disorders, in order to be diagnosed with ADHD, a child must display at least 8 of the 14 listed behaviors for a minimum of six months.

In theory, sugar intake could trigger ADHD symptoms by at least three mechanisms. First, hyperactive symptoms might result from hyperglycemia, which immediately and transiently follows sucrose ingestion. Second, these symptoms might develop due to reactive hypoglycemia, which can develop several hours post-ingestion. Third, allergic responsiveness to sucrose might conceivably be an underlying cause of childhood hyperactivity [4].

However, the available data fail to implicate any sugar-related mechanisms in the behavioral problems of hyperactive or nonhyperactive children. These data generally come from studies which use a "dietary challenge" design. In such studies, children consume a food item containing sucrose (the sucrose challenge condition) or an artificial sweetener (the placebo condition) and then are assessed for any effects on cognitive or behavioral functioning. With few exceptions, experiments of this type have been unable to link sugar to either behavioral or cognitive dysfunction. A meta-analysis of 16 different investigations which addressed this issue over the past 15 years found no evidence for a role of sugar in compromising any measured intellectual or behavioral qualities of children [5].

But despite these resoundingly consistent results, the subject remained unresolved because many of the studies had been criticized for, among other objections, using only a single dose of sucrose. To avert this and other shortcomings, Wolraich et al. carried out the definitive study, which used three-week diets (rather than a single challenge dose) high in either sucrose, aspartame, or saccharin [6]. The results were concordant with those of earlier work -- neither aspartame nor sucrose was found to cause measurable effects on any of the cognitive or behavioral tests evaluated.

The Sugar-hyperactivity Misconception Originated from a Study Published in 1980

The possibility of a causal relationship between dietary sugar and ADHD was first supported empirically by Prinz and coworkers [7]. These investigators compared hyperactive (as defined by their parents) children (4-7 years old) to a group of nonhyperactive, age-matched controls. The variables measured were intake of various dietary ingredients, which were recorded in a 1-week food diary, and several behaviors, which were observed in a simulated playroom. Of special interest here was the finding that consumption of sugar products was positively correlated with "destructive-aggressive" and "restless" behaviors in the children previously characterized by their parents as "hyperactive". Subjects in the control group also demonstrated a positive correlation between grams of sugar consumed and playroom behavior, but not in terms of destruction-aggression or restlessness. Instead, control children had a sugar intake that was positively correlated with their number of "quadrant changes", which was used as a measure of movement about the playroom setting. Thus, for both groups of children, activity levels -- as manifested by

destruction-aggression, restlessness, and quadrant changes -- appeared to vary directly with sugar levels in the diet.

However, Prinz and colleagues interpreted their data conservatively, stating, "The results suggest that the effects of sucrose consumption on the behavior of hyperactive children need to be further investigated." Since no experimental manipulation was performed (the children were free to choose the foods they ate), the direction of causality was not addressed. For instance, this study could not rule out the possibility that more active subjects preferentially select sugary foods. Alternatively, a third factor may have promoted both the levels of sugar intake and playroom activity.

Unfortunately, the lay press did not exercise the same caution that the authors did in interpreting their study. Soon the notion was popularized that sugar-laden foods may not only affect overt motor behavior in children but also more subtle behavioral dimensions such as cognitive, social, and academic performance [8,9,10,11,12,13]. The absence of any research demonstrating the actual bases for ADHD and other behavioral abnormalities presumably would have fostered such unwarranted claims.

In addition to the general public, teachers, who occasionally are called upon to counsel parents in modifying their child's behavior, came to believe in the adverse effects of sugar [14]. DiBattista et al. showed using questionnaires that primary school teachers overwhelmingly considered sugar to have unhealthy behavioral effects. For instance, 90.7 % of respondents chose sugar from among a list of food items as an ingredient which exacerbates the behavioral problems in hyperactive children. Further, 89.7% indicated that sugar has an activating influence on the behavior of normal (i.e., nonhyperactive) children. Perhaps more disturbing, was the finding that the teachers' biases led them to provide misinformation to the parents of hyperactive children. In fact, 65.8% had advised the parents of hyperactive children to try lowering the child's sugar intake, and 78% of these parents were known to have complied.

Like teachers, physicians often serve as a trusted source of information; and many medical practitioners also adopted the unsupported connection between sugar and agitated behavior [15,16]. Consequently, dietary intervention, in the form of low-sugar or sugar-free meals, was often touted as the solution to hyperactivity in children [17].

There are Multiple Psychological Explanations for the Persistence of the Perceived Sugar-Hyperactivity Relation

It may be the case that a small percentage of children have a response to sugar that involves hyperactivity. However, given that the weight of scientific literature does not find sugar to be responsible for disordered behavior in either hyperactive or normal children, why might the mistaken notion have persevered and remained so widespread? One possibility is sugar's image as a high energy food. Perhaps one might assume that a high sugar intake naturally results in a tendency to "use up" the calories it provides, by increasing behavioral activity. If this is in fact a "logical" deduction to a lay person, then the notion that sugar is the cause of hyperactivity may just be intuitive to the general public, especially in the absence of any other proven culprit.

There are several ways in which a pre-existing intuition about the unhealthiness of sugar may be reinforced. First, parents, teachers, and others may observe that children are often more active during situations in which sugar is being consumed (e.g., birthday parties, school recess) and misattribute the change in behavior to sugar, rather than to some inherent characteristic of the situation itself, such as a lack of structure [18]. Second, people who expect sugar ingestion to be followed by disordered behavior, may take special note of and remember only those instances in which the two events occur in succession, and disregard those instances in which sugar intake preceded normal behavior. This effect results from the psychological phenomenon known as "The Illusory Correlation" [19]. Third, parents may be more comfortable with, and therefore, more inclined to identify their child's agitated behavior as a symptom of an external and emotionally neutral factor, like sugar, instead of a more personal factor like genetics or upbringing. Fourth, pre-existing biases about sugar may prompt observers to perceive children as being overly active, even when they are not. Hoover and Milich performed an experiment which lends credence to this fourth possibility [20]. In their experiment, all children received drinks containing the nonsugar

sweetener, aspartame. However, parents who were misled into believing that their child had consumed a sugar-sweetened drink rated their child as being significantly more active, compared to the ratings given by parents who were told the truth. In a similar experiment in which all children consumed a drink sweetened with sugar, Spring and Alexander found that parents perceived their child as more active, impulsive, and fidgety only when led to believe that sugar (not aspartame) was used as the sweetener. In other words, these latter two studies demonstrated that it was the parent's expectation about whether their child consumed sugar, not whether or not the child actually did, that determined how the child's behavior was perceived.

In summary, the image of sugar as an aggravating influence on child behavior will probably be hard to extinguish, even if the public were exposed to the experimental research on this issue. Lay intuitions regarding sugar tend to be confirmed by its frequent co-occurrence with situations in which children are more active, and are further compounded when these co-occurrences are selectively remembered. Moreover, individuals may be prone to "see" hyperactive behavior, even when it is absent, following periods in which sugar was consumed; and for emotional reasons, may be unlikely to seek explanations for their "observations" that are more personal than the sugar-hyperactivity relation.

Conclusion

Sugar continues to be condemned as a source of hyperactivity in children. When I casually asked 10 of my fellow medical school classmates to tell me their opinions on the sugar-hyperactivity issue, seven of them described at length the detrimental powers of sugar on childhood behavior. Clearly, these attitudes need to be corrected so that they are not communicated to future patients. Again, there is no available evidence that sugar precipitates or even contributes to elevated activity in children who are normal or those who suffer from ADHD. Accordingly, it would be inappropriate and unnecessarily burdensome to pursue a sugar-free diet in the hope of ameliorating a child's disordered behavior. In fact, in light of the foregoing discussion, it is probably safe to conclude that withholding sweet food from youngsters is probably more likely to provoke disruptive behavior than serving it to them.

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