

Diet and Behaviour Myth or Science?

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Hyperactivity Attention Deficit Disorder (ADHD)

- **The current term for behavioural disorder in children**
- **Food as an etiological factor in behavioural disorders has been considered for decades**
- **Lack of agreement as to the disorder that is being studied when the role of food is being considered**

Hyperactivity Attention Deficit Disorder (ADHD)

- **Early studies regarded behavioural disorders as due to brain damage ("minimal brain damage" (MBD)) and foods were not implicated in the etiology of this condition**
- **Confusion as to which aspects of behavioural disorder were due to neurological and which to environmental factors**

Hyperkinetic Reaction of Childhood

- **Hyperkinesis recognized in the DSM-II in 1968**
- **Hyperactivity considered to be due to neurological dysfunction**
- **Also determined to occur without any evident pathology**
- **More than 90 different terms used to describe hyperactive children**
- **Neurological impairment demonstrated in less than 5 percent of hyperactive children**

Current Designations of ADHD

■ Several subcategories of ADHD are now recognized, for example:

- ADHD alone
- ADHD with oppositional defiant disorder
- ADHD with conduct disorder
- ADHD with thought/mood disturbance
- ADD without hyperactivity
- Learning disability without ADHD

Current Designations of ADHD

- **There is no consensus that these are scientifically divisible conditions on a physiological basis**
- **Physiological responses are important when investigating the effect of diet on behaviour**

Environmental Factors in ADHD

- **Environmental factors were considered in opposition to the use of stimulant drugs**
 - **Claims that hyperactivity was a perception created by intolerant teachers and parents**
- **The hypothesis of neurological deficit as a cause was opposed by some authorities**
- **The idea that diet may play a role in hyperactivity became very popular in the 1970s with the trend towards healthy lifestyle and "natural foods"**

Environmental Factors In ADHD

- Dietary components as a cause of aberrant behaviour had been suggested since the 1920s
- Reactions to wheat and corn as a cause of fatigue, irritability and behaviour problems advanced by Randolph in 1940s

Suggested Dietary Factors Affecting Behaviour

- **Pharmacologically active chemicals**
- **Allergens: release inflammatory mediators that affect the central nervous system**
- **Nutritional deficiency**
- **Stress or food phobia may trigger neuropeptides that lead to the release of inflammatory mediators**

Hyperactivity and Diet

- **Benjamin Feingold hypothesised that hyperactivity is caused by a toxic reaction to food dyes, artificial flavours and natural salicylates**
- **Claimed that 70% of hyperactive children improved when these eliminated from the diet**
- **Became a popular concept with parents**

Hyperactivity and Diet

- **Several scientific studies refuted this claim**
- **The idea that food components can cause hyperactivity then fell into disrepute in medical circles**
- **However, all the studies indicated that a SMALL NUMBER OF CHILDREN DID IMPROVE ON A RESTRICTED DIET**

Hyperactivity and Allergy

- **Great Ormond Street Children's Hospital trials:**
- **"Few foods diets" designed to investigate the role of food components in childhood migraine resulted in improvement in behaviour**
- **The same diets were then used in studies on hyperkinesis**

Hyperactivity and Allergy

- **Double-blind placebo-controlled cross-over food challenge indicated that:**
 - **certain foods**
 - **food additives**
 - **natural chemicals in foods**
- **Caused deterioration in behaviour in a significant percentage of atopic children**

Foods Implicated in the London Study

■ **Forty six foods including:**

- **Milk and dairy products**
- **Eggs**
- **Wheat and other grains**
- **Fruits**
- **Nuts**
- **Seeds**
- **Soya**
- **Meats**
- **Fish**

Foods Implicated in the London Study

■ **Food additives:**

- **Food dyes, especially tartrazine**
- **Artificial flavours, especially glutamates**
- **Preservatives, especially benzoates and nitrates**

Details of the Study

- **Characteristics of the subjects:**
- **"Overactivity" with somatic complaints:**
 - **Migraine**
 - **Seizures**
 - **Abdominal pain**
- **Headaches improved in 93% of children with severe and frequent migraine**

Study Outcomes

- Patients with epilepsy who also suffer from migraine and/or hyperkinetic syndrome respond to dietary treatment:
 - Of 45 epilepsy subjects, 25 recovered and 11 improved
- Hyperkinetic subjects' behaviour:
 - 82% improved on diet
 - 27 of 76 (35%) recovered completely

Study Details (Continued)

- **On challenge, foods provoked symptoms after a time lapse of a few minutes to 7 days**
- **The average time interval was 2-3 days after eating the test food**

Study Details (Continued)

- **Evaluation of behaviour included:**
 - Connor's rating scale
 - Independent assessment by psychiatrists and psychologists
 - Parents' observations
- **Question: Did the children's behaviour improve as a result of feeling better when the physical complaints responded to diet?**

Composition of the Few Foods Diet

- *Meats: Lamb and chicken*
- *Carbohydrates: Rice and potato*
- *Fruits: Banana and pear*
- *Vegetables: Cabbage, Brussels sprouts, cauliflower, broccoli, cucumber, celery, carrot*
- *Water*
- *Supplementary nutrients: Calcium; magnesium; zinc; multivitamin*
- *Duration of diet: Four weeks*

Alberta Children's Hospital Studies

- **50% of 24 preschool aged (3 to 5 years) hyperactive boys improved on diet**
- **All foods were provided for 10 weeks for every member of the subject's household**
- **Nutritional deficiencies thereby controlled**

Alberta Children's Hospital Studies

■ **Diet eliminated:**

- *Artificial colours*
- *Artificial flavours*
- *Monosodium glutamate (MSG)*
- *Preservatives*
- *Caffeine*
- *Chocolate*
- *Specific foods which caused an adverse reaction in individual children based on previous testing*

■ **Restricted simple sugars**

Details of Study

- **Subjects selected on the basis of diagnosed hyperactivity (DSM-III)**
- **A few had atopic symptoms, and most came from a family with a history of allergy and intolerances**
- **Other symptoms improved such as:**
 - **Halitosis**
 - **Night awakening**
 - **Inability to fall asleep**

Experimental Design Problems

- **Lack of clear diagnostic criteria for the various subcategories of behavioural disorders**
- **Lack of diagnostic tests for food allergy and intolerance**

Experimental Design Problems

(continued)

- **Difficulty in determining whether changes in behaviour are due to response to physical symptoms**
- **Difficulty in controlling the contribution of environmental factors, such as increased parental attention**
- **Difficulty in controlling the placebo effect**

Sugar Regulation and Behaviour

- **"Reactive hypoglycaemia" or "Functional hypoglycaemia" (FH) blamed for a variety of behavioural problems such as :**
 - Irritability
 - Fatigue
 - Schizophrenia
 - Neurosis
 - Alcoholism
 - Drug addiction
 - Juvenile delinquency
 - Anxiety
 - Childhood hyperkinesis
 - Lethargy
 - Depression
 - Suspiciousness
 - Bizarre thoughts
 - Hallucinations
 - Mania
 - Violent behaviour

Sugar and Behaviour

- **No controlled studies show low blood sugar levels and impaired insulin response in conditions other than diabetes**
- **A small number of people shown to respond with aberrant behaviour after sugar challenge**
- **May be mediated by mechanisms other than impaired insulin regulation**

Sugar and Behaviour (continued)

- **Preliminary studies on >1,000 subjects indicate that simple sugars may be metabolized to alcohol by unusual microbial colonization of the intestine (Davies 1994)**
- **Catecholamine control of sugar regulation may be impaired in ADHD**

Catecholamines and Sugar

- **Connors' study (1986):**
- **39 ADHD children challenged with sugar after a breakfast condition:**
 - **Fasting**
 - **Protein**
 - **Carbohydrate**
- **Performed worse after carbohydrate compared to fasting or protein breakfast**

Catecholamines and Sugar

(continued)

- **Behaviour better when sucrose given after a protein breakfast, compared to behaviour after a carbohydrate breakfast**
- **Normal controls showed no change in behaviour in any testing modality**
- **Insulin levels not affected**
- **Cortisol and growth hormone secretion suppressed in normals, but not in ADHD children after a carbohydrate meal**

Caffeine and Behaviour

- **Individual differences exhibited between habitual consumers and those who rarely ingest caffeine**
- **Response to 300 mg caffeine challenge:**
- **Regular caffeine drinkers:**
 - Increased alertness
 - Decreased irritability
- **Non-caffeine consumers:**
 - Upset stomach
 - Jitteriness

Caffeine and Behaviour

- **Insomnia is a common side effect in both groups**
- **Methylxanthines act as competitive antagonists for adenosine receptors**
 - Adenosine mediates the activities of hormones such as:
 - catecholamines
 - histamine
 - glucagon
 - calcitonin
 - secretin
 - TSH
 - ACTH
 - ADH
 - LH
 - FSH
 - PTH
 - TRH

Adenosine Effects

- *ACTH* *adrenocorticotropic hormone*
- *ADH* *anti-diuretic hormone*
- *LH* *luteinizing hormone*
- *FSH* *follicle-stimulating hormone*
- *PTH* *parathyroid hormone*
- *TSH* *thyroid stimulating hormone*
- *TRH* *TSH releasing hormone*

Effects of Caffeine on Children's Behaviour

- **Caffeine detectable in umbilical cord blood and breast milk**
- **Rate of caffeine elimination from the body is much slower in infants than in adults**
- **Caffeine effects likely to last longer in children**

Effects of Caffeine on Children's Behaviour (continued)

- **Cola drinks may affect children in several ways:**
 - **Direct pharmacological effect of caffeine**
 - **Excessive sugar may affect behaviour**
 - **Nutritional deficiency as a result of excessive intake of low-nutrient drinks**
 - **Reaction to artificial colours, flavours, preservatives**

Theories of Dietary Effects on Brain Function

- **Amino acid-derived neurotransmitter levels in the brain are affected by dietary precursors:**
 - *serotonin (tryptophan)*
 - *histamine (histidine)*
 - *tyramine (tyrosine)*
- **Enzyme defects, such as phenolsulphotransferase in blood platelets may cause migraine and behaviour changes**

Theories of Dietary Effects on Brain Function

- **Opiate-like peptides in milk and wheat might lead to food cravings, addiction and withdrawal symptoms**
- **Opiates may induce mast cell degranulation and release biogenic amines that affect brain function**
- **Decreased activity of the cytochrome P-450 complex may lead to abnormal metabolism**

Nutrient Deficiency

■ Theory

- Elimination of foods high in sugar, artificial colours, flavours, preservatives removes a lot of "junk foods" from the diet
- Diet becomes more nutritionally complete
- Aberrant behaviour is the result of nutritional deficiency, especially of micronutrients such as vitamins and minerals

Micronutrient Deficiency and Behaviour

■ Iron deficiency anaemia:

- Restlessness, irritability, disruptive behaviour, learning disability

■ Low thiamine levels:

- Poor impulse control, irritability, hostility, sleep disturbances, restlessness, night terrors, insomnia, sleep-walking, fatigue, depression, headache, abdominal pain, chest pain

Micronutrient Deficiency and Behaviour

- Zinc deficiency:

- Moodiness, depression, hyperactivity, irritability, photophobia, antagonism, temper tantrums, learning problems

- Magnesium deficiency:

- Excessive fidgeting, restlessness, psychomotor disturbances, learning difficulties

Micronutrient imbalance

- **Excessive amounts of micronutrients may also affect behaviour:**
- **Lead and other heavy metal toxicity**
- **Excessive copper may impair zinc absorption**
- **Excessive carbohydrate may lead to high cadmium levels: thought to impair academic performance**

Movement Disorders Caused by Reactions to Foods {Gerrard et al 1994}

■ **Shaking head and Headache**

- Beef
- Pork
- Milk
- Potato
- Coffee
- Tea
- Chocolate
- Citrus fruit
- Raspberry
- Strawberry

Movement Disorders Caused by Reactions to Foods {Gerrard et al 1994}

- **Shoulder shrugging ; Hoarseness**
 - **Egg**
 - **Coffee**
- **Contraction of arms and legs**
 - Tachycardia**
 - Chest pains**
 - Indigestion**
 - **Aspartame**

Study Details

- **Foods identified by elimination and placebo-controlled double blind challenge**
- **Allergy skin tests all negative, indicating the reactions were probably not caused by IgE-mediated Type I hypersensitivity**
- **Accompanying physical symptoms also cleared when foods were eliminated**
- **Conclusion: movement disorders triggered by an action on dopamine and other neurotransmitter pathways in the brain**

Immune System and CNS Interactions

- **In disease, dysregulation in one system can result in effects in the other**
- **Such interaction has been demonstrated in allergy**
- **The key event in allergy is release of inflammatory mediators from mast cells**
- **Activation of mast cells can occur in response to a variety of triggers**

Mast Cell Activators

- **Allergen-specific IgE is the major mast cell activating factor in classical allergy (Type I hypersensitivity)**
- **Other antibody classes (IgM; IgG) in response to specific antigen activate mast cells via the anaphylatoxins produced in the complement cascade**

Mast Cell Activators (continued)

- **Food components can activate mast cells in the absence of antibody (sulphites; lectins)**
- **Neuropeptides (e.g. vasoactive intestinal peptide (VIP); Substance P) can stimulate mast cell release of histamine, leukotrienes and other mediators of allergy**

Pavlovian Conditioned Release of Inflammatory Mediators

- **Release of inflammatory mediators from mast cells shown in animal experiments:**
 - Rats sensitized to egg albumin and conditioned to a audio-visual stimulus released Mast Cell Protease II in response to the a-v stimulus alone
 - Guinea pigs sensitized to bovine serum albumin and conditioned to an olfactory stimulus released histamine in response to the odour alone
- **Question: Can a similar conditioned response occur in humans?**

Anecdotal Reports of Conditioned Response In Humans

- **From the Allergy Nutrition Clinic, Vancouver**
- **Case 1: 22 year old male: previous anaphylactic reactions to peanut**
- **Experienced severe urticaria starting on the face and spreading to whole body within 15 minutes of standing next to a child spreading peanut butter on a cracker**

Anecdotal Reports of Conditioned Response In Humans

- **Case 2: 21 year old male: previous anaphylactic reactions to peanuts and nuts**
- **Experienced symptoms of severe anaphylactic reaction on several occasions when told by his friends that he had consumed nuts as an ingredient in a meal**
- **No nuts were present.**

Anecdotal Reports of Conditioned Response In Humans

- **Case 3: Kindergarten-aged child strongly skin test positive to peanut**
- **"Became ill; experienced breathing difficulty" after observing another child eating a peanut butter sandwich on the other side of a classroom**

Alternative Explanations for Responses

- **Inhalation of volatilized peanut antigen
(Case 1: Case 3)**
- **Anxiety attack mimics symptoms of
anaphylactic reaction
(Case 2; Case 3)**
- **Food phobia and stress response activates
mediator release via neuropeptides
(Case 3)**

Alternative Explanations for Responses

- **Mediator release is the key event in clinical expression of allergy symptoms, whatever the initial triggering mechanism may be.**
- **Dilemma: If a sensory signal is responsible for mediator release, double-blind food challenges would be invalidated because of the absence of the sensory signal.**

Current Thinking on the Link Between Diet and Behaviour

- **Allergy symptoms will cause a child to feel ill, miserable, irritable, restless, have difficulty sleeping, and difficulty concentrating: Removal of the allergen will lead to improvement in behaviour**
- **Debilitating allergy symptoms may induce social exclusion: The child responds with frustration and antisocial behaviour**

Current Thinking on the Link Between Diet and Behaviour

- **Inflammatory mediators cross the blood/brain barrier and induce behavioural changes via CNS stimulation: Removal of the allergen eliminates the inflammatory mediators**
- **Natural chemicals in foods and food additives have a direct pharmacological effect on CNS functions**

Reasons for Improvement on Diet

- **Exclusion of food allergens leads to remission of allergy symptoms:**
 - **The child feels better and behaviour improves**
- **Removal of excess sugar and additives eliminates "junk food" from the child's diet:**
 - **A more nutritious diet reduces behavioural effects due to malnutrition**

Reasons for Improvement on Diet

- **A specially formulated diet requires extra care and attention, which is focused on the child:**
- **A change in status and family dynamics may have a positive effect on the child's behaviour**

Dietary Management in Behaviour Disorders

- **A small number of behaviourally disordered children will respond positively to dietary manipulation**
- **The opportunity to improve the quality of life of the child and family justifies lifestyle and dietary changes**

Dietary Management in Behaviour Disorders

- **The best candidates for dietary intervention are children with:**
 - **poor eating habits**
 - **physical as well as behavioural symptoms**
 - **family history of adverse reactions to foods, additives, stimulants and environmental factors**

Dietary Guidelines

- **Initial elimination diet removes food allergens suspected on the basis of:**
 - **history**
 - **appropriate tests**
 - **careful record of food intake and symptoms**
- **All food additives and caffeine are removed**
- **Simple sugars are restricted**

Dietary Guidelines

- **A nutritionally complete diet is prescribed, using nutrients from alternate sources**
- **Elimination diet is followed for four weeks**
- **If improvement is achieved, sequential incremental dose challenge identifies specific triggers of adverse reactions**

The Test Diet

- **Eliminate the most likely food allergens:**
 - *Milk and dairy products*
 - *Wheat and corn*
 - *Peanut*
 - *Apple*
 - *Orange, grapefruit*
 - *Tomato*
 - *And any other suspected individual food allergens*

The Test Diet (continued)

- **Eliminate food additives, especially:**
 - **Artificial colours**
 - **Artificial flavours**
 - **Preservatives:**
 - *Benzoates*
 - *BHA and BHT*
 - *Nitrates and nitrites*
 - *Propyl gallate*
 - *Sulphites*
 - **Aspartame**

The Test Diet (continued)

- **Eliminate foods high in related naturally occurring chemicals:**
 - *Benzoates*
 - *Caffeine*
- **Use simple sugars in moderation.**
- **Dilute fruit juices half and half with water**
- **High sugar foods should be consumed at the end of a meal, not as between-meal snacks**

The Test Diet (continued)

- **Food should be taken every 2 – 2½ hours**
- **Divide meals into six feedings**
- **Avoid highly-perfumed products**