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 AHDH 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**
- **<u>Headaches</u> 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**
- **<u>Question</u>: 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**
- **<u>Question</u>: Can a similar conditioned response occur in humans?**

Anecdotal Reports of Conditioned Response In Humans

- **From the Allergy Nutrition Clinic, Vancouver**
- **<u>Case 1</u>: 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

- **<u>Case 3</u>: 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.**
- **<u>Dilemma</u>: 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 life-style 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**