

The Science Linking Food Dyes with Impacts on Children's Behavior

A possible link between food ingredients and adverse behaviors such as hyperactivity was first raised in the 1970s. Over the past 40 years, many double-blind studies have concluded that food dyes and other ingredients can impair behavior in some children.

In 2011, even the FDA acknowledged the growing body of evidence, concluding that:

Exposure to food and food components, including artificial food colors and preservatives, may be associated with adverse behaviors, not necessarily related to hyperactivity, in certain susceptible children with ADHD and other problem behaviors, and possibly in susceptible children from the general population.¹

The agency, however, still has not pursued any action to protect or even inform the public. Instead, its statements to the public are that dyes are “very safe,” and that results from studies linking dyes to hyperactivity are “inconclusive, inconsistent, or difficult to interpret.”² In contrast, the British Food Standards Agency has encouraged the food industry to stop using certain food dyes; advised consumers to consider eliminating those dyes from the diets of children showing signs of hyperactivity; and helps consumers to find products free from those food dyes.³ The European Parliament passed a law that requires that foods sold in the European Union (EU) that contain certain food dyes bear a warning notice that the dye(s), “may have an adverse effect on activity and attention in children.”⁴ As a result, many companies reformulated their products and now few foods sold in the EU contain these dyes, which include those most commonly used in the United States.

Since 2011, the evidence that dyes are linked to harmful effects in children has continued to mount. Three separate meta-analyses, including one sponsored by an arm of the food industry, concluded that dyes can trigger hyperactivity or ADHD symptoms in sensitive children. The Editor-in-Chief of the *Journal of Psychology and Psychiatry* notes that the “pendulum has swung” away from the previous view that diet did not trigger symptoms of ADHD. The editor concluded that “studies suggest a statistically significant but clinically limited role for dietary treatments” of ADHD, a role that is “far less than envisaged by some promoters of the diet-behavior narrative but greater than expected by their sceptics.”

We estimate,⁵ using information cited by the U.S. Centers for Disease Control and Prevention⁶ and the meta-analysis sponsored by the food industry,⁷ that, conservatively, more than half a million children in the United States suffer adverse behavioral reactions from food dyes, with an estimated cost exceeding \$5 billion per year—an entirely preventable cost. Removing dyes from the food supply is one of the few public health measures that could be deployed to reduce behavioral problems in children.

New* Scientific Reports Bolster Decades of Evidence

* Since FDA last examined the issue in 2011

2011: Stevens LJ, Kuczek T, Burgess JR et al. “Dietary Sensitivities and ADHD Symptoms: Thirty-five Years of Research.”⁸

- This review by Purdue University and Ohio State University Medical School researchers concluded that a subpopulation of children with ADHD improves significantly on a dye-free diet and experiences ADHD symptoms when challenged with food dyes, and that those children are often sensitive to other foods. They recommended a trial “elimination” diet for children not responding well to conventional treatment or whose parents wish to pursue a dietary approach.

2012: Nigg JT, Lewis K, Edinger T, Falk M. “Meta-Analysis of Attention-Deficit/Hyperactivity Disorder or Attention-Deficit/Hyperactivity Disorder Symptoms, Restriction Diet, and Synthetic Food Color Additives.”⁹

- This meta-analysis by researchers from Oregon Health & Science University and the Life Sciences Research Organization and funded by the International Life Sciences Institute, an arm of the food industry, found that a restriction diet (eliminating dyes and other foods and additives) reduced ADHD symptoms in approximately 33 percent of children with ADHD. It estimated that 8 percent of children with ADHD may have symptoms related to food dyes. The researchers deemed the findings “too substantial to dismiss.”
- The studies were separately analyzed according to whether adverse behavior was assessed by parents (20 studies, 794 children), teachers or another observer (10 studies, 323 children), or by attention tests (6 studies, 154 children). They found that dyes were associated with a statistically significant increase in ADHD symptoms when assessed by parents or by attention tests. (The results regarding assessments by teachers/observers fell just short of statistical significance.)
- After restricting the analysis only to FDA-approved dyes and objective, computerized measures of attention, a significant effect was associated with FDA-approved food dyes. Those results are not susceptible to a rater’s beliefs and not explainable by publication bias.

2012: Arnold LE, Lofthouse N, Hurt E. Artificial food colors and attention-deficit/hyperactivity symptoms: Conclusions to dye for.¹⁰

- This review by researchers from Ohio State University concluded that “Recent data suggest a small but significant deleterious effect of AFCs [artificial food colors] on children’s behavior that is not confined to those with diagnosable ADHD.”
- It stated that artificial food colors “appear to be more of a public health problem than an ADHD problem” and suggested “minimizing children’s exposure to artificial food colors.”

2013: Sonuga-Barke EJ, Brandeis D, Cortese S, et al. “Nonpharmacological Interventions for ADHD: Systematic Review and Meta-Analyses of Randomized Controlled Trials of Dietary and Psychological Treatments.”¹¹

- This meta-analysis by British, Belgian, Swiss, German, French, Spanish, Dutch, Hong Kong, and American researchers of six non-pharmacological treatment options for ADHD found that excluding synthetic food dyes was the most effective, often in individuals with food sensitivities.

- It concluded that excluding artificial food colorings from the diet, unlike most of the other treatment options, produced statistically significant reductions in ADHD symptoms in individuals selected for food sensitivities even when the analysis was limited to studies where the individual making the assessment was considered blind to treatment.
- It differed from the Nigg et al meta-analysis by only analyzing studies of children who had been formally diagnosed with ADHD. It found that the effect of excluding dyes from the diet on ADHD symptoms was greater but similar in magnitude to what was found in the previous meta-analysis.

2013: Arnold LE, Hurt E, Lofthouse N. Attention-Deficit/Hyperactivity Disorder: Dietary and Nutritional Treatments.¹²

- This review by researchers from Ohio State University examined the quality of evidence for elimination diets (those that eliminate dyes as well as other foods and additives) and rated it as “good” in both children diagnosed with or having symptoms consistent with ADHD, and children without ADHD but exhibiting some ADHD symptoms.
- It recommends an elimination diet for children who are documented to react to dyes or other additives or foods.

2014: Stevenson J, Buitelaar J, Cortese S et al. “Research Review: The Role of Diet in the Treatment of Attention-Deficit/Hyperactivity Disorder – An Appraisal of the Evidence on Efficacy and Recommendations on the Design of Future Studies.”¹³

- This review by an international team of researchers and on behalf of the European ADHD Guidelines Group critically appraised three systematic reviews and associated meta-analyses on artificial dyes (Nigg et al. and Sonuga-Barke et al. listed above and the one by Schab described below), concluding that “(t)he results suggest that food colour elimination is a potentially valuable treatment approach for ADHD” that “may be beneficial for children thought to be adverse responders to food colour exposure.”

2014: Faraone SV, Antshel KM. “Towards an evidence-based taxonomy of nonpharmacologic treatments for ADHD.”¹⁴

- This review by researchers from SUNY Upstate Medical University used guidelines developed by the Oxford Center for Evidence-Based to evaluate non-drug treatments for ADHD. Those guidelines are used to assess the degree to which treatments are supported by scientific evidence. The review gave both exclusion of food dyes and restricted elimination diets (that restrict/eliminate certain foods or additives) its second-highest rating (4 out of 5), just behind FDA-approved medications (5 out of 5), and stronger than a dozen other non-drug treatments, such as psychotherapy or clinic-based social-skills training (each of which earned a 1 out of 5). The reviewers also rated artificial food dye exclusion as being far more effective at treating ADHD than behavioral parent training or supplementation with omega-3-fatty acids.

2014: Nigg JT, Holton K. “Restriction and Elimination Diets in ADHD Treatment.”¹⁵

- This review by researchers from Oregon Health & Science University and American University concludes that “a small but extensively discussed literature yields an emerging consensus that dietary intervention to remove additives (color (sic) and perhaps preservatives) likely yields a small aggregate benefit.”

Significant Studies and Meta-Analyses Published Before 2011

Schab DW, Trinh N-H T. "Do Artificial Food Colorings Promote Hyperactivity in Children with Hyperactive Syndromes? A Meta-Analysis of Double-Blind Placebo-Controlled Trials."¹⁶

- Published in 2004, this meta-analysis of 15 studies concluded that the results "strongly suggest an association between ingestion of [synthetic food dyes] and hyperactivity."
- It estimated that the magnitude of the effect of dyes is about a third to a half the deterioration in behavior that would occur if medications were withdrawn from children being treated for ADHD.

Bateman B, Warner JO, Hutchinson E, et al. "The Effects of a Double Blind, Placebo Controlled, Artificial Food Colourings and Benzoate Preservative Challenge on Hyperactivity in a General Population Sample of Preschool Children.;" and McCann D, Barrett A, Cooper A, et al. "Food Additives and Hyperactive Behaviour in 3-Year-Old and 8/9-Year-Old Children in the Community: A Randomized, Double-Blinded, Placebo-Controlled Trial."¹⁷

- These two ground-breaking, double-blind, placebo-controlled studies were sponsored by the British government and published in 2004 and 2007. The second study is called "the Southampton study" since it was conducted by researchers at the University of Southampton.
- Unlike earlier studies, these tested the sensitivity of children in the general population, and were large (each tested nearly 300 children). Mixtures of chemically-related azo dyes, including some not used in the United States, and the preservative sodium benzoate (not believed to affect behavior) were tested. Over 90 percent of food dyes used in the United States are azo dyes.
- The results from the first study (in three-year olds) were replicated in the second study, adding more weight to the conclusions. The second study concluded that "[a]rtificial colours or a sodium benzoate preservative [or both] in the diet result in increased hyperactivity in 3-year-old and 8/9-year-old children in the general population."
- An independent scientific committee reviewing the Southampton study concluded that "the results of this study are consistent with, and add weight to, previous published reports of behavioral changes occurring in children following consumption of particular food additives."¹⁸
- The British government subsequently urged manufacturers to stop using the dyes tested in the studies (which includes the three dyes most widely used in the United States: Red 40, Yellow 5, Yellow 6) and advised parents of children showing signs of hyperactivity to eliminate those dyes.
- The editors of an American Academy of Pediatrics' journal stated "the overall findings of the study are clear and require that even we skeptics, who have long doubted parental claims of the effects of various foods on the behavior of their children, admit we might have been wrong."¹⁹
- In a response to these two studies, the European Parliament voted to require a warning label on products containing the dyes.²⁰

Endnotes

- 1 Aungst, Jason. Evaluation of studies on artificial food colors and behavior disorders in children. 2011. At <http://www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/FoodAdvisoryCommittee/UCM273033.pdf>; also cited in Cheeseman MA. Artificial food color additives and child behavior. *Environ Health Perspect*. Jan 2012; 120(1): A15–16.
- 2 IFIC Foundation and FDA. Overview of food ingredients, additives & colors. <http://www.fda.gov/Food/IngredientsPackagingLabeling/FoodAdditivesIngredients/ucm094211.htm> and <http://www.fda.gov/downloads/Food/IngredientsPackagingLabeling/ucm094249.pdf>; FDA Consumer Health Information. How safe are color additives? December 10, 2007; Katz, Linda M. How safe are color additives? August 6, 2014. http://www.foodsafety.gov/blog/color_additives.html, <http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm048951.htm>
- 3 UK Food Standards Agency. Products free from the colours associated with hyperactivity. At <http://www.food.gov.uk/policy-advice/additivesbranch/foodcolours/colourfree/#.UIL9gRD0hD4>; and UK Food Standards Agency. Food additives and children's behavior. At <http://www.food.gov.uk/policy-advice/additivesbranch/foodcolours/colourfree/#.UIL9gRD0hD4>; and Agency revises advice on certain artificial colours. Sep 11, 2007. www.food.gov.uk/news/newsarchive/2007/sep/foodcolours.
- 4 European Union. Regulation (EC) No 1333/2008 of the European Parliament and of the Council of 16 December 2008 on food additives. Available online. <http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:354:0016:0033:en:PDF>
- 5 Lefferts, L. Seeing Red: Time for Action on Food Dyes. 2016.
- 6 Centers for Disease Control and Prevention. Attention-deficit/hyperactivity disorder (ADHD): facts about ADHD and data & statistics. Oct. 9, 2015. <http://www.cdc.gov/ncbddd/adhd/facts.html> and <http://www.cdc.gov/ncbddd/adhd/data.html>; and Pelham WE, Foster EM, Robb JA. The economic impact of attention-deficit/hyperactivity disorder in children and adolescents. *J Pediatr Psychol*. 2007;32:711-727.
- 7 Nigg JT, Lewis K, Edinger T, Falk M. Meta-Analysis of attention-deficit/hyperactivity disorder or attention-deficit/hyperactivity disorder symptoms, restriction diet, and synthetic food color additives. *J Am Acad Child Adolesc Psychiatry* 2012;51(1): 86-97.e8. doi: 10.1016/j.jaac.2011.10.015.
- 8 Stevens LJ, Kuczek T, Burgess JR, et al. Dietary sensitivities and ADHD symptoms: thirty-five years of research. *Clin Pediatr (Phila)*. 2011;50(4):279-93. doi: 10.1177/0009922810384728.
- 9 Nigg JT, Lewis K, Edinger T, Falk M. Op. cit.
- 10 Arnold LE, Lofthouse N, Hurt E. Artificial food colors and attention-deficit/hyperactivity symptoms: conclusions to dye for. *Neurotherapeutics*. 2012 Jul;9(3):599-609. doi: 10.1007/s13311-012-0133-x.
- 11 Sonuga-Barke EJ, Brandeis D, Cortese S, et al. Nonpharmacological interventions for ADHD: systematic review and meta-analyses of randomized controlled trials of dietary and psychological treatments. *Amer J Psychiatry*. 2013 Mar 1; 170(3):275-89.
- 12 Arnold LE, Hurt E, Lofthouse N. Attention-deficit/hyperactivity disorder: dietary and nutritional treatments. *Child Adolesc Psychiatr Clin N Am*. 2013; 22(3): 381–402, v. doi: 10.1016/j.chc.2013.03.001.
- 13 Stevenson J, Buitelaar J, Cortese S et al. Research Review: The role of diet in the treatment of attention-deficit/hyperactivity disorder – an appraisal of the evidence on efficacy and recommendations on the design of future studies. *J Child Psychol Psychiatry*. 2014;55(5):416-27. doi:10.1111/jcpp.12215.
- 14 Faraone SV, Antshel KM. Towards an evidence-based taxonomy of nonpharmacologic treatments for ADHD. *Child Adolescent Psychiatric Clin N Am*. 2014; 23(4):965–972. doi: 10.1016/j.chc.2014.06.003
- 15 Nigg, JT, Holton, K. Restriction and elimination diets in ADHD treatment. *Child Adolesc Psychiatr Clin N Am*. 2014 Oct;23(4):936-53. doi: 10.1016/j.chc.2014.05.010.
- 16 Schab DW, Trinh N-H T. Do artificial food colorings promote hyperactivity in children with hyperactive syndromes? A meta-analysis of double-blind placebo-controlled trials. *J Dev Behav Pediatr*. 2004;25(6):423-34.
- 17 Bateman B, Warner JO, Hutchinson E, et al. The effects of a double blind, placebo controlled, artificial food colourings and benzoate preservative challenge on hyperactivity in a general population sample of preschool children. *Arch Dis Child*. 2004;89(6):506-11; and McCann D, Barrett A, Cooper A, et al. Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: a randomised, double-blinded, placebo-controlled trial. *Lancet* 2007 Nov 3;370(9598):1560-7.
- 18 UK Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment. Statement on research project (T07040) investigating the effect of mixtures of certain food colours and a preservative on behavior in children. Sept. 2007. <http://cot.food.gov.uk/sites/default/files/cot/colpreschil.pdf>.
- 19 Editor's note. ADHD and Food Additives Revisited. *AAP Grand Rounds*. 2008;19;17 doi: 10.1542/gr.19-2-17.
- 20 European Union. Op cit.