Effects of Artificial Food Colorings in Children With Hyperactive Symptoms

A Critical Review and Results of a Controlled Study

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• The "Feingold diet," which eliminates artificial food colorings, has been claimed to be beneficial to hyperactive children. Previous studies have yielded equivocal results. We sought to maximize the likelihood of demonstrating behavioral effects of artificial food colorings by (1) studying only children who were already on the Feingold diet and who were reported by their parents to respond markedly to artificial food colorings, (2) attempting to exclude placebo responders, and (3) administering high dosages of coloring. The design was a double-blind crossover with order randomized; 11 children maintained on the Feingold diet were challenged with food coloring and placebo (one each week). Evaluations by parents, teachers, and psychiatrists and psychological testing yielded no evidence of a food coloring effect.

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Feingold has suggested that artificial colorings and flavorings are involved in the genesis of childhood hyperactivity[1,2]; the elimination of such food constituents, the "Feingold diet," has been claimed to alleviate hyperactive symptoms. Several studies, which will be reviewed, have attempted to evaluate Feingold's claims. Most of these studies involved unselected hyperactive children. This report presents a placebo-controlled study of the effects of artificial food colorings on the behavior of children who were maintained on the Feingold diet because their parents believed that the diet had been of marked benefit to them.

REVIEW OF THE LITERATURE

The first controlled study in this area was a crossover study by Conners et al[3] in which one-month trials of the Feingold diet and a control diet were compared in 15 hyperactive children. A significant difference favoring the Feingold diet was obtained on teacher ratings but not on parent ratings. The authors advised caution in interpreting the results because of the small sample size, an unexplained order effect, and the fact that only a few children were responsible for the significant diet effect.

Harley et al,[4,5] in an impressive study controlling the entire food intake of families, compared the Feingold diet with a control diet given for one month each, in random order, and in double-blind fashion, to 46 unmedicated hyperactive children. Evaluations consisted of standard parent and teacher questionnaires, neuropsychological testing, and direct observation in the classroom and laboratory. No consistent diet effect was found. As in the Conners et al report, there was a significant order effect, with the Feingold diet superior to the control diet only when it was the second treatment, which obfuscates interpretation of the results. Parent ratings of the ten preschool children showed a significant, favorable effect for the Feingold diet; however, direct observations did not parallel this finding.

Phase 2 of this study[5] challenged nine apparent responders to the Feingold diet with artificial food coloring; no response to the challenge was found. Overall, the authors believe that the study provides little support for the Feingold hypothesis, though they suggest that it might be worthwhile to study preschool children further.

Another experimental approach has been to put hyperactive children on the Feingold diet and introduce artificial food colorings or placebo on a double-blind basis. Goyette et al[6] and Conners[7] have reported a series of three studies using this strategy. Children in whom hyperactivity was diagnosed using clinical and rating-scale criteria were eligible for these studies if parent questionnaires showed a minimum 25% reduction in symptoms during a one-month open trial of the Feingold diet. Children were maintained on the diet and challenged double-blind with cookies containing placebo or artificial food colorings (26 mg/day).

The results were inconclusive. The first study showed no significant diet effects on teacher or parent questionnaires (one significant finding was in the direction opposite that predicted), but a test of visual-motor tracking ability, the Zero Input Tracking Analyzer and Auxiliary Distraction Task (C. K. Conners, PhD, A. Delamater, PhD, unpublished data, September 1977), administered one hour after cookie ingestion, indicated a significant, deleterious effect of the food colorings. It was hypothesized that artificial food colorings might cause only short-term effects, thereby explaining negative findings on parent and teacher questionnaires (though this possibility is not consistent with reports by Feingold of dramatic deterioration with diet violation).

In the second study, significant deleterious effects of artificial colorings were found on parent ratings of the children's behavior within three hours of cookie ingestion, but teacher ratings were unavailable because of a teacher strike. Therefore, a third study was conducted,[7] but this last study showed no diet effects.

Using a more complex design, Williams et al[8,9] studied

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the effects of the Feingold diet and stimulant medication in clinically diagnosed, stimulant-responsive hyperactive children. The children, who were already receiving medication, were placed on the Feingold diet and subsequently challenged with artificial food colorings (dispensed in cookies) and placebo, as well as with active medication and placebo. All children received each treatment combination for one week (stimulant medication combined with each type of cookie and placebo medication combined with each type of cookie). A significant diet effect was found on teacher ratings of hyperactive symptoms, but not on parent ratings. Diet did not have as marked an effect as medication, but this study lends support to Feingold's hypothesis that artificial food colorings may affect the behavior of hyperactive children.

In a recent study, Weiss et al[10] studied 22 behaviorally disordered children with reported histories of improvement when placed on the Feingold diet, a sample similar to ours. While on the diet, the children were exposed, double-blind, to artificial food colorings (35.3 mg/day) on eight days randomly selected during a 77-day period of study. On the other 69 days the children received a matching placebo. No overall diet effect was found. One child, one of the youngest (34 months old), reacted significantly to the food coloring, but a dietary effect in only one of 22 children preselected for clinical dietary response suggests a rare occurrence of adverse effect.

Swanson and Kinsbourne,[11] in another recent study, used the challenge strategy to evaluate the effects of 100 and 150 mg of food colorings, much higher doses than in previous studies. Forty children with symptoms of hyperactivity were admitted as inpatients. Half of the children were considered hyperactive on the basis of previous improvement with methylphenidate administration on a laboratory learning task. All children were placed on the Feingold diet and challenged in the morning with food coloring or placebo four and five days later in a crossover design. Response was evaluated using standard rating scales and a laboratory rote visual learning task.

The authors do not report whether institution of the diet affected the children's behavior. A significant difference between the artificial food coloring and placebo was found on the rote learning task in the 20 hyperactive children but not in those not classified as hyperactive. The artificial food additives did not affect the objective behavioral ratings of either group of children.

Several issues suggest caution when interpreting the positive results from this study. First, diagnosing hyperactivity on the basis of stimulant effect on a learning task is idiosyncratic, and there was no a priori rationale for predicting that subdividing patients on the basis of this "diagnosis" would identify diet responders; thus, the crucial analysis, suggesting a dietary effect, was apparently post hoc.

Also, the Fig 1 presented by Swanson and Kinsbourne[11] suggests that the differences obtained were not due to a differential effect of the artificial colorings in the two groups of children, but to a different pattern of placebo effect. The hyperactive children performed better over time with placebo, but worse with food coloring; the nonhyperactive children performed worse over time with both the placebo and active challenge. These particular results are uninterpretable.

In a preliminary report,[12] Swanson and Kinsbourne reported results on half of the sample. In this initial sample, children were exposed to the challenge or placebo in the morning and afternoon. Though the morning challenges produced a significant food coloring effect (but only after three hours), the afternoon challenge did not yield entirely consistent results. Finally, it should be noted that analyses for order effects, which are crucial in evaluating results of crossover studies, were not reported.

Several other studies are relevant. Levy et al,[13] studying a sample of 22 clinically diagnosed hyperactive children placed on the Feingold diet, did not find significant differences in behavior between a tartrazine (yellow dye No. 5) challenge (5 mg/day) and a placebo. Tartrazine is of special interest because of evidence of cross-reactivity with salicylates, which Feingold originally implicated in the etiology of hyperkinesis.

Rapp,[14] studying 24 clinically diagnosed hyperactive children, suggested that testing with sublingual dyes and foods can demonstrate behavioral responsiveness to these challenges and predict subsequent improvement with dietary restrictions. However, the results were not analyzed statistically, and while the author attempted to include a placebo control, it is not clear that the study was blind, since the placebo used was not identical in taste and texture to the challenge substance.

Trites et al[15] and Tryphonas and Trites[16] present evidence from a double-blind study that suggests that allergic hyperactive and learning disabled children show behavioral improvement on a diet that eliminates the suspected food allergen. However, the high rate of improvement on the placebo diet, the fact that the difference between the placebo and the elimination diet was found only on global clinician ratings but not on teacher or parent ratings, and the possibility that parents could "guess" which diet the child was receiving make these results less than conclusive.

Finally, we[17] studied a hyperactive child who was reported by his parents to have shown marked improvement on the Feingold diet. The child received 11 independent trials of cookies that were either natural or contained all commonly used artificial colorings. The results showed no significant effects of food coloring on any of the rating scales. The mother guessed the type of cookies at a level beyond chance, but only if three forced guesses were included. The mother reported mild irritability as the main effect of the artificial food coloring.

To summarize the available studies, it seems fair to say that no single study has reported a consistent dietary effect on the symptoms of the hyperkinetic syndrome. In addition, the positive findings that have been reported have generally been a result of post hoc analyses, have been relatively sporadic and not consistent between studies, and so may be chance findings. The National Advisory Committee on Hyperkinesis and Food Additives, a committee supported by the Nutrition Foundation, and the Interagency Collaborative Group on Hyperkinesis, which was established under the auspices of the Department of Health, Education, and Welfare, issued reports in 1975 and 1976[18,19] that concluded that the role of artificial food additives in the etiology of childhood hyperactivity was unclear. These reports urged that controlled clinical studies be carried out to clarify the relationship between food additives and hyperkinesis. Studies prior to the current one were unsuccessful in clarifying this relationship.

It is conceivable that previous studies (except that by Swanson and Kinsbourne[11]) used inadequate doses of food colorings. Most studies administered 26 mg/day of food coloring, a dosage the Nutrition Foundation estimated to be the average daily intake of food coloring for US residents. This estimate was arrived at by dividing the total amount of food coloring consumed in the United States by the total population. However, food intake surveys by Weiss (Bernard Weiss, MD, oral communication, August 1977) and the US Department of Agriculture

(USDA)[20] have indicated that this estimate is too low for prepubescent children. The USDA survey suggests that 50 to 60 mg/day more closely approximates the average intake of artificial food coloring for children in the United States, so we administered 78 mg/day to ensure an adequate dosage.

If artificial additives affect only a small proportion of hyperactive children, significant dietary effects are unlikely to be detected in heterogeneous samples of hyperactive children. Therefore, children who had been placed on the Feingold diet by their parents and who were reported by their parents to have derived marked behavioral benefit from the diet and to experience marked deterioration when given artificial food colorings were targeted for this study. This sampling approach, combined with high dosage, was chosen to maximize the likelihood of observing behavioral deterioration with ingestion of artificial colorings.

SUBJECTS AND METHODS

Entry Criteria

Referrals were solicited through local chapters of the Feingold Association. To be considered for study, children between the ages of 4 and 13 years had to be on the Feingold diet. Only children whose parents reported that the child reliably adhered to the diet and whose condition regularly deteriorated quickly and dramatically with artificial food colorings were accepted. Informed consent was obtained from parents prior to study initiation.

Experimental Conditions

The Nutrition Foundation provided cookies composed of natural ingredients of the type recommended in the Feingold diet and free of artificial food colorings (placebo cookies) and another supply of cookies (active cookies) that were indistinguishable from the placebo cookies with regard to taste and appearance and that each contained 13 mg of a mixture of all Food and Drug Administration-approved artificial food colorings in proportions thought to reflect normal patterns of consumption. The exact ingredients of the cookies can be obtained from us or from the Nutrition Foundation.

Table 1.—Study Design: Cookie Conditions Over Four-Week Period*

		Week			
	Baseline†	1†	2†	3	4†
Cookie	None	Placebo‡	Placebo/ active§	None	Active/ placebo§

*Children remained on the Feingold diet throughout.
†A complete evaluation was done (parent, teacher, child, and psychiatrist ratings; distractibility test).
‡Administration was nonblind; two children were dropped from further study after week 1.
§Order was randomized.

Treatment Schedule

Dietary management during the study was identical to that followed previously by the family and was as recommended by the Feingold Association. To maximize the likelihood of finding a significant diet effect, all children were given a nonblind, one-week trial of placebo cookies prior to the double-blind investigation. Children who reacted adversely to the placebo were eliminated from further study.

Children then received, double-blind with order randomized, both the active and placebo cookies for one week each. Interposed between the two experimental conditions was a one-week washout period without cookies, which was extended if necessary to ensure that the child was back to his baseline status before beginning the second type of cookie. The design is given in Table 1.

Children received one cookie the first day of each week (13 mg/day of artifical colorings) and an additional cookie each day to a maximum of six (two cookies three times a day) on the sixth and seventh days (78 mg/day). Cookies were given at breakfast, lunch, and after school to evaluate the effects of the challenge at home and school. No one involved in the evaluation and care of the children knew the type of cookie the child was receiving.

Assessments

Before the study, parents and teachers completed Conners Rating Scales[21,22] and a scale we developed to assess typical hyperactive symptoms.[23] A psychiatric evaluation was performed and a Children's Diagnostic Scale[24] was completed. The child was given a test of distractibility that was developed in our laboratory,[25] and the psychologist rated the child's behavior during testing.

At the end of the placebo week and each double-blind trial, all scale ratings and testing were repeated. The distractibility test was administered 1.5 hours after ingestion of two experimental cookies. Teachers and mothers also rated global severity of illness, and mother and psychiatrist rated overall change. To evaluate the timing of behavioral reactions to the experimental conditions, teachers and parents completed the Brief Conners Questionnaire[26] three and five days after the initiation of each type of cookie.

Teacher, parent, psychiatrist, and child were asked to guess the type of cookie at the end of each trial. The child also completed (with help if necessary) a modified version of the Brief Conners Questionnaire and rated overall change and global severity.

Analyses consisted primarily of two-way analyses of variance for repeated measures (treatment by order).

RESULTS

Sample Characteristics

Thirteen children were referred. The conditions of two were reported to become worse in the initial placebo trial and they were dropped from further study. The clinical characteristics of the 11

Table 2.—Sample Characteristics

No./Age, mo/Sex	Baseline Teacher Hyperactivity Factor Score*	*DSM-III* Diagnosis at Referral	Additional Clinical Description
1/55/M	1.2	None	Hyperactive at younger age
2/63/M	Not in school	ADD-H†	. . .
3/68/F	0.5	None	Mainly irritable; cried frequently
4/86/F	1.5	ADD-H†	Typical hyperactive child, mild severity
5/123/F	0.8	ADD‡	. . .
6/124/M	0.2	Developmental reading disorder	Hyperactive at younger age
7/129/M	1.3	ADD-H†	Typical hyperactive child, mild severity
8/133/M	1.5	ADD-H†	. . .
9/143/F	1.7	ADD-H†	. . .
10/147/F	0.0	Overanxious disorder	Primarily overanxious; few hyperactive symptoms
11/131/M	0.8	None	Hyperactive at younger age

*Scores ranged from 0 to 3.
†ADD-H indicates attention deficit disorder with hyperactivity.
‡ADD indicates attention deficit disorder without hyperactivity.

Table 3.—Behavioral Effects of Artificial Colorings and Placebo

Raters	Measure	Means: Artificial Coloring	Means: Placebo	F*
Mothers (N = 11)	Hyperactivity†	3.00	2.64	0.08
	Distractibility‡	2.59	2.45	0.34
	Parent-teacher questionnaire§	1.10	1.25	0.35
	Global severity||	1.09	1.55	1.52
	Improvement¶	5.18	5.18	0.07
Teachers (N = 8)	Hyperactivity†	2.00	2.06	0.45
	Distractibility‡	2.38	2.38	0.00
	Parent-teacher questionnaire§	0.65	0.63	0.00
	Global severity||	1.13	0.88	0.75
	Hyperactivity factor#	0.75	0.68	0.00
	Inattention factor#	1.03	0.86	1.24
Psychiatrists (N = 11)	Hyperactivity**	3.00	3.27	0.74
	Immaturity**	3.55	4.00	0.94
	Improvement¶	5.91	5.91	0.00
Psychologists (N = 10)	Hyperactivity†	1.80	2.30	3.82
	Distractibility‡	1.40	1.60	0.60
Children (N = 10)	Parent-teacher questionnaire§	1.02	1.07	0.01
	Global severity||	1.30	1.40	0.28
	Improvement¶	6.20	6.10	0.34

*All of the *F* values are nonsignificant.
†Ratings were made on a scale of 1 to 7, with higher ratings indicating more symptoms.[23]
‡Ratings were made on a scale of 1 to 5, with higher ratings indicating more symptoms.[23]
§Values are the means of ten items on the Brief Conners Questionnaire (range, 0 to 3).[26]
||This is a four-point (1 to 4) rating of overall difficulty. Higher ratings indicate more difficulty.
¶ Improvement was rated on an eight-point scale of change compared with baseline (1 indicates completely well; 5, unchanged; 8, much worse).
#Factors from the Conners Teacher Questionnaire were used.[21]
**Ratings (1 to 6) are from the Children's Diagnostic Scale.[24]

children included in the study are given in Table 2. Five were diagnosed as currently hyperactive (attention deficit disorder with hyperactivity in *DSM-III*) despite the diet. Three of these five had hyperactivity factor scores on the Connors Teacher Questionnaire of 1.5 or more (a common score criteria for diagnosing hyperactivity); another had a score of 1.3; the last child was only 5 years old and not in school, so a teacher evaluation was not obtainable.

Of the remaining six children, three had histories (reported by parents) that could justify a retrospective diagnosis of hyperactivity. In these cases, the parents felt that the Feingold diet was responsible for the reduction of hyperactive symptoms. Since all children were on the Feingold diet at the time of evaluation and had supposedly been helped considerably by the diet, minimal symptoms could be expected at referral.

Of the three children not clinically diagnosable either currently or retrospectively as hyperactive, all had some history of behavioral difficulties; one child was diagnosed as having an attention deficit disorder without hyperactivity, and the other two had histories indicating that irritability had been more salient than typical hyperactive symptoms.

Dosage

Three children failed to ingest the maximum of six cookies per day. Two increased to only four cookies per day during one of the two trials because of reactions severe enough that the mothers refused to increase further. The reaction occurred with the active cookie in one case and with the placebo in the other. The third child refused to eat more than four cookies per day during either trial because of a small appetite. The data were analyzed including all children and also including only those who ingested 78 mg/day of artificial coloring.

Treatment Effects

No significant order effects or interaction effects between treatment and order were found. Hence, only treatment effects are given in Table 3, which presents results for the total group.

None of the ratings by parents, teachers, children, psychologists, or psychiatrists demonstrated significant differences between placebo and artificial colorings. Moreover, no type of rater (parents, teachers, psychiatrists, nor children) guessed beyond chance the type of cookie.

Table 4.—Distractibility Test Results*

Condition	Mean No. of Errors and Degree of Distractibility: High	Low	None
Food coloring	18.4	15.4	15.0
Placebo	20.4	21.8	17.0

*An analysis of variance for repeated measures was used. The *F* values for food coloring (0.077), distractibility (2.161), and the interaction (1.103) were nonsignificant. N = 5.

The test used to evaluate distractibility did not demonstrate a diet effect (Table 4). Data were available for only five children because four children were too young to take the test and in two cases equipment failure prevented retest. (The psychologist administered the Ravens Progressive Matrices to these six children to enable behavioral ratings.)

Repeat analyses excluding children who ate less than six cookies a day yielded identical results. Therefore, the reduced dose in three children did not obscure a group diet effect.

Repeat analyses excluding children not diagnosable as hyperactive did not alter the negative results. In addition, there was no evidence of a relationship between age and dietary effect.

Clinically, most of the children did not react dramatically to *either* type of cookie, very much contrary to the expectations of their parents. The parents of the six children who did show some difference between the two periods (ie, who reacted more to one type of cookie than to the other) guessed the type of cookie correctly three times and incorrectly three times.

The parents were the only raters who reported noticing clear differences in behavior between the two conditions. All others (teachers, psychiatrists, psychologists) noted minimal, if any, differences. The children often supported their parents' observations, but their reports were singularly lacking in conviction.

COMMENT

Previous studies have not conclusively demonstrated behavioral effects of artificial food colorings; occasional positive findings may be attributable to chance. This study, which was designed to maximize the likelihood of detecting a dietary effect, found none.

Several factors might account for our negative findings. One is that the cookies were not accurately labeled (a possibility suggested by members of the Feingold Association). Therefore, an assay to test the contents of ten cookies was obtained (Charles Graichen, FDA, oral communication, February 1978). In every instance, the analysis was consistent with the research code.

Another possible objection is that our sample was not characteristic of hyperactive children, since most did not meet usual clinical criteria for hyperactivity, and that more typical hyperactive children might have reacted to the food colorings. This argument seems implausible, however, given the lack of behavioral effects in this study even in children very clearly diagnosable as hyperactive using the most stringent criteria. Furthermore, the Feingold diet hypothesis did not originate from observations of carefully diagnosed children but from anecdotal reports on children similar to the ones we studied.

It may also be argued that the small sample size (N = 11) lessened the likelihood of demonstrating diet differences. However, since the entry criteria were designed to include only diet-responsive children, the sample size appears to us to be sufficient, clinically and statistically. Furthermore, the absence of trends indicating a deleterious effect of the colorings argues against the likelihood that insufficient power was responsible for the negative statistical results obtained.

The parents involved in this project, as indicated by their participation, were clearly well-meaning, altruistic people who sincerely believed in the efficacy of the Feingold diet and who volunteered their children to provide empirical evidence for their strongly held belief. In spite of the strong opinions held by the parents, they were no better than other raters in distinguishing between artificial colorings and placebo.

This study included only one child younger than 5 years of age. In the Weiss et al study,[10] the only child who reacted to the colorings was younger than 3 years of age. In the Harley et al study,[4,5] only preschoolers were rated worse when receiving the colorings. It is possible, though not necessarily likely, that a behavioral effect of artificial colorings is present in some very young children only. If so, it is important but not clearly relevant to an understanding of hyperactivity that typically comes to professional attention during middle childhood.

Potentially relevant are in vitro studies that showed some food dyes to be biologically active[27] and capable of affecting neurotransmitter activity[28]; it is unknown, however, if these dyes cross the blood-brain barrier. Shaywitz et al[29] found behavioral effects of food colorings in animals; however, this study was not entirely consistent (eg, activity was increased compared with baseline with 2 mg of food coloring but decreased with 1 mg), has not been replicated, and its relevance to humans appears dubious, given the present findings. The results of this study indicate that artificial food colorings do not affect the behavior of school-age children who are claimed to be sensitive to these agents.

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References

1. Feingold BF: *Why Your Child Is Hyperactive.* New York, Random House, 1975.

2. Feingold BF: Hyperkinesis and learning disabilities linked to artificial food flavors and colors. *Am J Nurs* 1975;75:797-803.

3. Conners CK, Goyette CH, Southwick DA, et al: Food additives and hyperkinesis: A controlled double-blind experiment. *Pediatrics* 1976;58:154-166.

4. Harley JP, Ray RS, Tomasi L, et al: Hyperkinesis and food additives: Testing the Feingold hypothesis. *Pediatrics* 1978;61:818-828.

5. Harley JP, Matthews CG: Food additives and hyperactivity in children, in Knights R, Bakker DJ (eds): *Treatment of Hyperactive and Learning Disordered Children.* Baltimore, University Park Press, 1980, pp 121-130.

6. Goyette CH, Conners CK, Petti TA, et al: Effects of artificial colors on hyperkinetic children: A double-blind challenge study. *Psychopharmacol Bull* 1978;14:39-40.

7. Conners CK: Artificial colors in the diet and disruptive behavior, in Knights R, Bakker DJ (eds): *Treatment of Hyperactive and Learning Disordered Children.* Baltimore, University Park Press, 1980, pp 113-120.

8. Williams JI, Cram DM, Tausig RT, et al: Relative effects of drugs and diet on hyperactive behaviors: An experimental study. *Pediatrics* 1978;61:811-817.

9. Williams JI, Cram DM, Tausig RT, et al: *Determining the Relative Effectiveness of Dietary and Drug Management of Hyperkinesis.* Working Paper Series, Health Care Research Unit, The University of Western Ontario, London, Ontario, Canada, 1976.

10. Weiss B, Williams JH, Margen S, et al: Behavioral response to artificial food colors. *Science* 1980;207:1487-1489.

11. Swanson JM, Kinsbourne M: Food dyes impair performance of hyperactive children on a laboratory learning test. *Science* 1980;207:1485-1487.

12. Swanson J, Kinsbourne M: *Artificial Food Colors Impair the Learning of Hyperactive Children.* New York, Nutrition Foundation, 1975.

13. Levy F, Dumbrell S, Hobbes G, et al: Hyperkinesis and diet: A double-blind crossover trial with tartrazine challenge. *Med J Aust* 1978;1:61-64.

14. Rapp DJ: Does diet affect hyperactivity? *J Learn Dis* 1978;11:56-62.

15. Trites R, Tryphonas H, Ferguson H: Diet treatment for hyperactive children with food allergies, in Knights R, Bakker DJ (eds): *Treatment of Hyperactive and Learning Disordered Children.* Baltimore, University Park Press, 1980, pp 151-163.

16. Tryphonas H, Trites R: Food allergy in children with hyperactivity, learning disabilities and/or minimal brain dysfunction. *Ann Allergy* 1979;42:22-27.

17. Mattes JA, Gittelman-Klein R: An intensive cross-over study of the effects of artificial food colorings in a hyperkinetic child. *Am J Psychiatry* 1978;135:987-988.

18. National Advisory Committee on Hyperkinesis and Food Additives: *Report to the Nutrition Foundation.* New York, Nutrition Foundation, 1975.

19. Interagency Collaborative Group on Hyperkinesis: *First Report of the Preliminary Findings and Recommendations of the Interagency Collaborative Group on Hyperkinesis.* US Dept of Health, Education, and Welfare, 1976.

20. Sobotka TJ: *Estimates of Average, 90th Percentile and Maximum Daily Intakes of FD & C Artificial Food Colors in One Day's Diets Among Two Age Groups of Children.* Division of the Consumer Studies, Food and Drug Administration, 1976.

21. Conners CK: A teacher rating scale to use in drug studies with children. *Am J Psychiatry* 1969;126:884-888.

22. Parent Questionnaire, in *ECDEU Assessment Battery for Pediatric Psychopharmacology,* rev 2. Rockville, Md, Early Clinical Drug Evaluation Unit, National Institute of Mental Health, Psychopharmacological Research Branch, 1973.

23. Gittelman-Klein R, Klein DF, Katz S, et al: Comparative effects of methylphenidate and thioridazine in hyperkinetic children: I. Clinical results. *Arch Gen Psychiatry* 1976;33:1217-1231.

24. Children's Diagnostic Scale, No. MH-9-30, 1-73, in *ECDEU Assessment Battery for Pediatric Psychopharmacology,* rev 2. Rockville, Md, Early Clinical Drug Evaluation Unit, National Institute of Mental Health, Psychopharmacological Research Branch, 1973.

25. Radosh A, Gittelman R: The effect of appealing distractors on the performance of hyperactive children. *J Abnorm Child Psychol,* to be published.

26. *ECDEU Assessment Manual for Psychopharmacology,* No. ADM-76-338. US Dept of Health, Education, and Welfare, 1976.

27. Levitan H: Food, drug and cosmetic dyes: Biological effects related to lipid solubility. *Proc Nat Acad Sci USA* 1977;74:9214-9218.

28. Augustine GJ, Levitan H: Neurotransmitter release from a vertebrate neuromuscular synapse affected by a food dye. *Science* 1980;207:1489-1490.

29. Shaywitz BA, Goldenring JR, Wool RS: Effects of chronic administration of food colorings on activity levels and cognitive performance in developing rat pups treated with 6-hydroxydopamine. *Neurobehav Toxicol* 1979;1:41-47.