THE EFFECTS OF ANALOGOUS FOOD COLOR ON PERCEIVED FLAVOR: A FACTORIAL INVESTIGATION

Lawrence L. Garber, Jr.[ab]
[a] Elon University
CB 2075
Elon, NC, 27244, USA
[a] Institute for Management Technology
Raj Nagar, Hapur Road,
Ghaziabad, Uttar Pradesh 201001, India
lgarber@elon.edu
+1 1 336 278 5931

Eva M. Hyatt [c]
[c] Appalachian State University
Marketing Department
Walker College of Business,
Boone, NC, 28608, USA
hyattem@appstate.edu

Lubna Nafees [d]
[d]Institute for Management Technology
Raj Nagar, Hapur Road,
Ghaziabad, Uttar Pradesh 201001, India
lnafees@imt.edu

[b] Corresponding Author (to be reached c/o Elon University)

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ABSTRACT

We extend research testing the effects of food color on flavor perception to analogous color. Analogous colors are those found next to each other on the color wheel. Most prior food color research tests the relative effects of *complementary* colors, which are those found apart from each other on the color wheel. We therefore test smaller, or finer, color differences, providing a more conservative test relative to most prior results.

Subjects were assigned the task of tasting and evaluating a fruit flavored beverage. Actual fruit flavor at two levels and beverage color at three levels were manipulated in a full factorial, between subjects design. Thus, each subject tasted and evaluated a single color/flavor combination.

Results show that the small differences in food color represented by analogous color are sufficiently distinct and meaningful to consumers to significantly affect their ability to correctly identify the flavor of color-associated foods, as well as to form distinct flavor profiles and particular preferences; much as the grosser distinctions represented by complementary food color have been shown to do previously. These findings extend the evidence in support of the robustness and primacy of food color as a flavor signal in color-associated foods. As with complementary color, analogous food color dominates other flavor information including taste, though the strength of the effect is generally less pronounced. Strategic alternatives for the effective deployment of analogous food color for promotional purposes are recommended.

Keywords: food color; analogous color; complementary color; flavor; taste test

1. INTRODUCTION

The primacy of food color in determining consumer response to flavor in color associated foods has been repeatedly demonstrated in a number of empirical studies (e.g., see Spence, Levitan, Shankar, & Zampini 2010). However, most of the experiments conducted therein assigned complementary or opponent colors to the treatment levels of their food color manipulations. Complementary colors are those found apart from each other on the color wheel (e.g., orange and purple). They show the strongest contrast, and their differences are therefore the most conspicuous to the human eye (Birren 2006). A food color study incorporating treatments representing small color differences provides a conservative test of the results of prior research using complementary food color, and affords the opportunity to discover new or other color-flavor dynamics.

Will the effects on flavor that these treatment levels reveal also hold for treatment levels representing smaller color differences? That question is the subject of this research. Analogous colors are those found next to each other on the color wheel (e.g., orange and yellow). Relative to the high contrast of complementary colors, analogous colors are harmonious, and blending (Bleicher 2011). Their differences in terms of the wavelengths of light that comprise them are less than those of complements, but will this lesser degree of physical difference be any the less apparent to the consumer? Will small differences in color still be distinguishable, still evoke characteristic flavor meanings, and drive varying levels of preference?

In the following we: (1) review and evaluate the extant research on the effects of food color on flavor perception; (2) develop a conceptual framework that considers consumer response to analogous food color at each of three stages in the individual choice process, including flavor identification, perception and preference; (3) provide a methodology that allows the researcher to decompose and estimate the effects of food color separately at each of the three stages; (4) provide an empirical test of the models' predictions; and (5) discuss managerial implications.

2. BACKGROUND

2.1 Analogous Food Color

Most prior research testing the effects of food color on perceived flavor treat complementary color. There are exceptions. However, research that treats small differences in food color is sparse and limited. It is limited because this research is category-specific, and is not explicitly intended to examine analogous color as a construct. Examples would include, for wines, Parpinello, Versari, Chinnici, and Galassi (2009), who test the relative color preferences of 15 Italian reds, and Ough, and Amorine (1967), who test preferences by color of five rosés; and, for teas, Wan et al. (2014) demonstrate that blindfolded Chinese tea drinkers could not identify tea type by flavor alone. These results support the notion that small differences in color affect consumer evaluation of flavor, but not in a manner that can be systemized or generalized. This research will be, to our knowledge, the first food color research that specifically treats the effects of analogous color in a systematic manner.

2.2 Staged Models of Choice

We consider perceived food color to affect the consumer at each of several stages in the choice process, as shown by the process model in Figure 1. There is much evidence that consumers go through a multistage decision process when making a purchase (Lussier & Olshavsky 1979). Following Roberts (1989), we present individual-level choice as a phased process represented by a series of nested stages where behavior at each stage is conditioned by the events of previous stages. Food color, the context in which it is presented and viewed (such as on a store shelf), and actual flavor are proposed as moderating and sequential effects, respectively, on flavor identification, flavor perception and flavor preference formation respectively. Flavor identification, perception and preference are our dependent variables in subsequent studies.

Figure 1 about Here

2.3 The Effect of Context

It is appropriate that we operationalize analogous color in this empirical research by making comparisons between color levels, and between combinations of levels of food color and taste, because color is a relative phenomenon. Note in Figure 1 that color's effect is moderated by "Context." Color is a highly interactive, relative phenomenon dependent for its effects on the entire visual field in which it is perceived, the larger sensory environment in which it is encountered, and the disposition, circumstances and situation of the viewer (Garber, Hyatt and Boya 2007). Land (1977), for instance, demonstrated that color determination depends, "not...solely on the wavelengths entering the eye from that patch but also on the wavelengths entering from the other regions of the visual field" (Crick 1994, p. 53). In particular, color has been shown to depend on an interaction with adjacent colors for its effect (Swirnoff 1989; Albers 1963; Cheskin 1957). For example, red is made to look redder when it is surrounded by green, its complement, as when a red Lava Soap pack sits next to a green pack of Irish Spring. And red appears less salient when surrounded by red, its analogue, as when Lava soap sits next to a red Lifebuoy pack.

Moreover, color effect is highly interactive with the other visual features of which an object is composed, all of which must be integrated before the total effect can be recognized (Crick 1994; Davidoff 1991; Bruce and Green 1990; Triesman 1988; Marr 1982; Triesman and Gelade 1980). An example would be Crystal Pepsi, whose transparency caused the bottle form to appear lighter in weight, whereas regular Pepsi, with its opaque dark color appears heavier and denser (Garber and Buff 1997). Indeed, there are those who argue that color cannot be perceived and understood independently of form (Collinson 1992, p. 145).

In addition, there are cultural, social and personal dimensions to color and its meaning. Hine (1996) describes the cultural dimension as visual conventions that have built up over time in respective societies. The usual example of differences in the symbolic meaning of color across cultures is that black is the color of death in Western societies, while it is white in many Asian countries. And in Japan, brighter colors are reserved for packages representing foreign products whose people they consider to be brash, and the more subtle soft gray hues are reserved for their own products. The meaning of color is also highly situational, changing over time, as in fads and fashion (Sharpe 1975; Danger 1969), and depends upon the subject category in whose context it is considered (Bruce and Green 1990; Marr and Nishihara 1978). To illustrate the latter, Hine (1996, p. 221) reports that a 1987 study showed the residents of four American cities to believe that red means love, safety, danger, strength and warmth, but when asked to think about products, they state that it means Coca-Cola.

And finally, color, along with visual perception in general, is known to interact with the other senses, in that visual color sensation may make an impression in another sense altogether (Ball 1965; Bullough 1909-10; Nelson and Hitchon 1995; Sharpe 1975), an effect known as synesthesia. Therefore, the effect that a color has on a person may be couched in terms of temperature (red is hot, blue is cool), weight (dark colors are heavy, light colors are light), sound (loud, soft) or smell (fresh). In order to isolate the main effect of analogous food color as a flavor signal, the purpose of this research, we control for all of the above context effects.

3. CONCEPTUAL DEVELOPMENT

In the following we formulate hypotheses that are consonant with the results of prior food color research, based on our contention that the color acuity of consumers is such that finer degrees of food color difference than previously examined will also yield significant results.

3.1 The Primacy of Food Color as a Flavor Signal in Color Associated Foods

We offer three reasons for food color's robust effect on perceived flavor (DuBose, Cardello and Maller 1980; Pangborn 1960). The first is temporal, the second physiological, and the third comparative. For the first, food color is typically the first piece of flavor information that the consumer encounters (Hutchings 1977) in the store (DuBose, Cardello and Maller 1980). Food color can be resolved at a greater physical distance than labeling, and is therefore processed sooner, perhaps as soon as the shopper enters the grocery aisle (Garber, Burke and Jones 2000), and, of course, the food is tasted only later, upon consumption. Thus, in Figure 1, we place food color as antecedent to actual flavor as a determinant of perceived flavor.

The second reason is that flavor is a synesthetic[1] stimulus, composed in the least of taste, smell, mouth feel and texture (Francis 1977; Hutchings 1977), and, similarly, is cued in a multimodal manner that includes appearance (Zellner, Bartoli and Eckard 1991; Christensen 1985). Therefore, food color is seen as, "…virtually essential for the correct identification of color-linked food flavors (odors and taste) such as cherry, lime and orange [DuBose, Cardello and Maller 1980]…" (Christensen 1985, p. 755).

The third reason is that, relative to taste, food color is the more vivid, affect-loaded and memorable stimulus (Cheskin 1957). Therefore, any discrepancies between food color and actual flavor are resolved in favor of food color (Garber, Hyatt and Nafees 2013; Garber, Hyatt and Starr 2000).

In prior flavor identification research, food color has been shown to dominate taste because subjects exposed to atypical color often misidentify its associated flavor as being one that is normally associated with that color, an error which Oram et al (1995) refer to as a "color biased identification error." There are two possible reasons for this kind of error, according to Oram et al. (1995, p.240): "… the color-biased identification errors suggest that the subjects are either not aware that there is a color-flavor conflict, or, if they are aware, that they cannot ignore the color. Consequently, it is quite possible that such color-biased identification errors may reflect color being perceptually more salient than flavor. Color may be perceptually more salient than flavor in those contexts because color generates a stronger neural response than flavor, or because color is typically perceived before flavor in eating experience." We believe that for these same reasons,

[1] Synesthesia refers to, "…the subjective sensation or image of another sense than the one being stimulated, as in color hearing, in which the sounds seem to have characteristic colors." (G. & C. Merriam and Co. 1959, p. 862).

color will also dominate verbal flavor information just as it has taste information.

These factors, coupled with the existence of ingrained food color/flavor associations, explain food color as a cue for specific flavor expectations, the mechanism for food color's effect on flavor perception, to the extent that, when presented with uncharacteristic food color, the tendency is to recognize a flavor which is typically associated with that color, rather than the correct flavor (Skrandies & Reuther, 2008; Wei, Ou, Ronnier, & Hutchings, 2011). Therefore, we offer the following hypothesis.

> **H_1**: When mismatched food color and actual flavor are presented, the discrepancy is resolved in favor of food color.

3.2 The Effect of Food Color on Flavor Identification

It is generally recognized that food color aids correct flavor identification, as affirmed by several studies reported in the food science and sensory literatures (DuBose, Cardello and Maller 1980; Hall 1958; Hyman 1983; Kanig 1955; Moir 1936; Oram, Laing, Hutchinson, Owen, Rose, Freeman and Newell 1995; Stillman 1993). This is particularly true for foods that assume many flavors (like beverages) and have no other visual characteristics related to flavor identification (Christensen 1985). These studies have generally found that matching color facilitates correct flavor identification, that mismatching color hampers correct flavor identification, and no color neither facilitates nor hampers (DuBose, Cardello and Maller 1980; Hall 1958; Hyman 1983; Kanig 1955; Moir 1936; Pangborn 1960; and Stillman 1993). For example, Pepsi Gold, an amber-colored cola with a "hint of lemon," was introduced in India at the time of the 2007 World Cricket Championships, signifying the gold-colored World Cup Trophy. Its failure has been attributed to a lack of acceptance of a cola as anything but dark brown in color.

Oram et al. (1995) find the effects of color on flavor identification more pronounced with children than adults, indicating that the association of food color with flavor is learned early, and that the reliance on color as a flavor signal is greater when product and flavor knowledge is limited. We therefore propose the following main effect for food color on flavor identification:

> **H_{2a}**: Mismatching food color and actual flavor hamper correct flavor identification.

> **H_{2b}:** Matching food color and actual flavor facilitate correct flavor identification.

3.3 The Effect of Food Color on Flavor Meaning

Only a few studies have examined the effects of food color on flavor perception or preference, and they present mixed or conflicting results. With respect to perception, experiments have been of three types, though not necessarily mutually exclusive: those requiring subjects to make differential judgments along a single dimension (Hyman, 1983) such as sweetness or thirst-quenching-ness; those which measure the effect of different levels of intensity or saturation of a typical food color; and those which measure the effects of food color on simple taste sensates (sweet, sour, bitter, salty).

Several studies have examined the effect of matching food color on perceptions of sweetness or on a sweet-sour dimension. Pangborn (1960) had panels of trained and untrained subjects evaluate the relative sweetness of a number of fruit flavored waters, finding that red and orange colored drinks tasted sweeter, and green drinks tasted more sour. Johnson and Clydesdale (1987) tested the effects of typical color intensity or saturation on perceptions of sweetness. Using forty untrained subjects, they found that level of perceived sweetness is directly proportional to the saturation level of red color. Norton and Johnson (1987), however, using eighteen randomly selected subjects and manipulating the intensity of four typical colors, found no relationship between color intensity and flavor ratings on a sweet-sour dimension, or on a distinct-indistinct flavor dimension. Norton and Johnson (1987) further conclude that taste is a much more powerful determinant of flavor than color on these two dimensions.

In two other studies measuring the effects of food color on a single flavor dimension, Duncker (1939) found that four of seven subjects report that white chocolate tasted "milkier" than dark chocolate, and another two subjects find white chocolate to have less chocolate taste or less taste in general. And Guinard et al. (1998), using twelve subjects, purport to find that the color intensity of sixteen beers is inversely proportional to its perceived thirst-quenching-ness (although the ten-level color manipulation was described as ranging from light to dark, which is a range of values, not color intensity).

Using a multi-attributed approach in a crossed design, Maga (1974) examined the relative effect of several colors (red, green, yellow and colorless) on the four taste sensates (basic taste sensations shorn of the complexities of flavor found in whole foods) of sweet, sour, bitter and salty, presented in water solutions, and found that green makes sweet drinks seem sweeter (Pangborn 1960 found the opposite), and yellow makes them seem less sweet. Yellow and green cause sour drinks to seem less sour, and red causes bitter drinks to seem less bitter. Similarly, McCullough, Martinson and Moinpour (1978) also manipulated basic taste sensates at two levels (sweet, sour) and color at two levels (red, blue) to derive a perceptual space using multidimensional scaling. Their results indicate that blue is perceived to be relatively sweet.

All of these studies fall short of offering results that are useful to, or approximate, a consumer context. Moskowitz (1978, p. 163), in reviewing perceptual food color/flavor studies to date, concludes that, "…no definitive study had appeared that systemizes the effect of color upon sensitivity to taste, or to pleasantness of taste." We feel that Moskowitz' conclusion continues to hold true. It remains our need as managers to understand the effects of food color on full flavor profiles as defined by Wilkie and Pessemier (1973), both on their nature and on their strength, and we propose a more comprehensive approach to the problem in the methods section. We therefore test the following hypotheses in a consumer context.

Given that foods and beverages that are colored provide more information about their nature than those that do not, and that consumers will infer more about flavor when presented with color, we predict that foods that are colored will be perceived more readily and more definitely by consumers than foods that are without color.

The aforementioned hypothesized dominance of food color as a source of flavor information over actual flavor suggest that food color predominates in the formation of flavor perceptions. Therefore, we predict that flavor expectations are indicated by food color, even in the presence of discrepant labeling, and are confirmed by tasting, even if the flavor indicated by the food color is incorrect:

> **H_3**: Differently colored versions of otherwise identical foods evoke distinct flavor profiles.

3.4 The Effect of Food Color on Flavor Preference

It is commonly believed that food color affects judgments of flavor and food liking, though this belief is not unequivocally supported by the literature examining this relationship. Nonetheless, researchers still offer broad testimonials asserting their belief in this relationship. For examples, Maga (1974) states, "Color and flavor are two primary factors that can influence food acceptability." Christensen (1985, p. 755) says, "Color is recognized as an important element in consumer ratings of food palatability, although the reasons for its importance have not been elucidated." More poetically, Birren (1963, p. 45) avers, "Color is forever a part of our food, a visual element to which human eyes, minds, emotions and palates are sensitive. Perhaps through eons of time, man has come to build up strong and intuitive associations between what he sees and what he eats. A good meal, to say the least, is always a beautiful sight to behold." And, again, DuBose, Cardello and Maller (1980, p. 1393) claim that, "Color is an extremely important attribute of most food products because it usually influences the consumer's first judgment of the product and also provides sensory information which may interact with gustatory, olfactory, and textural cues to determine the overall acceptability of the product."

Yet, oddly, neither the research these authors conduct nor the prior research they cite addresses the relationship between color and preference. Maga (1974), for example, investigates the effect of color on perceptual attributes such as sweet and sour, and reviews literature that examines the effects of food color on flavor identifiability and flavor perception. Christensen (1985) examines the effect of food color on perceptions of flavor intensity, and reviews the literature on flavor identification. And Dubose, Cardello and Maller (1980) study the effect s of food color on identification, and of the effects of color intensity, though not color itself, on hedonic quality, while reviewing the literature on flavor identification. Birren's (1963) article is descriptive in nature.

Since prior results fail to show that tasting a beverage tends not to overrule impressions of flavor formed by viewing its color, we reason that foods that exhibit mismatching colors will be equally well liked as foods that exhibit matching colors, and both will be preferred to colorless foods. We therefore propose:

H_{4a}: Foods that exhibit mismatching colors and flavors will be equally well liked as foods that exhibit matching colors and flavors.

H_{4b}: Foods that exhibit colors will be preferred to foods that exhibit no color.

4. A TEST OF THE EFFECTS OF ANALOGOUS FOOD COLOR ON FLAVOR IDENTIFICATION, PERCEPTION, AND PREFERENCE

4.1 Experimental Design

We follow the procedure introduced by Garber, Hyatt and Starr (2000), and extended to India by Garber, Hyatt and Nafees (2015), who tested the effects of complementary food color on flavor perception at three levels in the choice process--identification, meaning and liking – as we do here, though the current test is with analogous rather than complementary food colors and manipulates flavor as well as color.

4.2 Stimulus Development

We use fruit beverages in this empirical research for six reasons: 1) fruit beverage presents no issues concerning condition (i.e., color is not an important indicator of freshness, rancidness, spoilage, etc.); 2) it comes in many flavors; 3) fruit beverages are a ubiquitous and familiar product easily evaluated by most international consumers; 4) there is a simple and well-known relationship between fruit colors and the fruit flavors they represent; 5) fruit beverages are uniform in texture and mouth-feel across flavors; and, 6) a clear form is commercially available.

The orange- and yellow-colored beverages used in this research were created by adding flavorless food dyes to Catch, a popular Indian brand of clear, carbonated fruit drink, according to instructions. As a manipulation check, to assure that the colors generated credibly portrayed the flavors that they were intended to represent, several subjects who did not participate in the experiment itself were shown samples of each color of the beverage, in plain white cups that neither identified nor characterized the beverages in any way, and were asked to identify them strictly by their appearance. Without exception, they identified the yellow-colored drinks as lemon and the orange-colored drinks as orange.

4.3 Subjects and Procedure

Five hundred thirty-one graduate students at an Indian Business School that enrolls students from all parts of India (32.3% female and 67.6% male; 92% between 23 and 28 years of age) were assigned the task of tasting and evaluating a fruit flavored beverage. Actual fruit flavor at two levels (orange flavor, lemon flavor), and beverage color at three levels (orange, yellow and clear; the first two representing analogous colors) were manipulated in a full factorial, between subjects design. Thus, each subject tasted and evaluated a single color/flavor combination. Each combination may be classified as either "wrong," in the sense that the color and flavor are mismatched, as in the case of a yellow-colored orange drink or an orange-colored lemon drink, or "right," in the sense that color and flavor are matching, as in the case of an orange-colored, orange-flavored drink, or a yellow-colored lemon drink.

Half the subjects sampled orange-flavored Catch, a clear form of carbonated fruit beverage ubiquitous in India, and half sampled lemon flavored Catch. Brand identity was not revealed. Rather, subjects were told that a New Zealand beverage brand was being launched in India, and the researchers wished to know what Indian consumers thought of it. Each subject was furnished with a 3-oz. white cup served uniformly at room temperature, a cracker to cleanse the palate before tasting, and a survey form to be filled out after tasting. Within each actual flavor treatment, a third of the respondents sampled orange-colored drinks, a third sampled yellow, and a third sampled clear-colored drinks. That the subjects took notice of the color was confirmed by post-test debriefing.

The pencil-and-paper survey consisted of five parts. Part A asked respondents about their knowledge and usage of fruit beverage products. Part B asked respondents to rate the drinks they sampled across thirteen attitudinal statements (listed in Table 1) on a five-point Likert-type scale, where "5" indicated strong agreement and "1" indicated strong disagreement. The attribute list was developed from focus groups conducted for this purpose. The list is designed to represent a comprehensive bundle of benefit attributes that collectively define a fruit beverage product, from which an individual beverage profile may be derived, according to the method prescribed by Wilkie and Pessemier (1973).

Table 1 about Here

According to the mean ratings for the total sample, respondents generally found the beverage they sampled, regardless of actual flavor, to be crisp and clean tasting, and flavorful. They did not find it to be natural, good for you, or wholesome. This same general attribute profile applies across all respondent groups and manipulation levels, and is similar to that obtained by Garber, Hyatt and Nafees (2015) for an Indian student sample, and by Garber, Hyatt and Starr (2000) for a US student sample; who found the orange-flavored beverage they sampled to be flavorful, crisp, and clean, but neither natural, wholesome nor good for you.

Unlike those two prior studies, this study also manipulates flavor at two levels. Some significant differences in attribute ratings across flavor levels were found. Subjects found the orange-flavored drink to be sweeter, more natural, more flavorful and more wholesome, and found the lemon-flavored drink to have a crisper taste. Though subjects rated their liking for the orange-flavored drink higher, they liked both drinks, and the difference in liking between them is not significant.

The PROC FACTOR procedure (SAS Institute 2004) was applied to the beverage attribute ratings in order to derive orthogonal flavor factors for use in subsequent tests. Varimax rotation was used to derive the three factors retained by the MINEIGEN (minimum eigenvalue) criterion whose loadings are shown in Table 2. Twelve of thirteen flavor attributes load cleanly onto one of these factors, while the attribute "Is very tart" loads relatively highly onto both Factors 2 and 3. We interpret this double loading to mean that "is very tart" is qualitatively distinct from both factors, and therefore specify it as a freestanding variable in subsequent analyses. Since Factor 3 consisted of two attributes, one of these being the double-loaded "is very tart," we specified the lone remaining attribute in factor 3, "is very crisp," as a freestanding variable in subsequent analyses, as well.

Table 2 about Here

Part C asked respondents to evaluate their overall liking of the drink in and of itself, and their liking of the "particular flavor" of the drink, on respective 7-point valence scales ranging from "+3" ("Like it very much") to "–3" ("dislike it very much"), with a response of "0" indicating indifference or uncertainty. Part D asked subjects to identify the fruit flavor they tasted by checking the boxes associated with the correct answers from respective closed-form lists of fifteen fruit flavor alternatives, including all the usual fruit flavors represented in the category plus "Mixed fruit flavors" and "Other." In a similar manner, subjects were asked in Part D what fruit flavor they *expected* prior to tasting. Part E asked subjects to supply demographic information.

5. RESULTS AND DISCUSSION

Table 3 reports the means for those dependent measures used to test flavor perception (information pertaining to testing H_3) and preference (pertaining to testing $H_{4a,}$ H_{4b}). The dependent variables used to test flavor identification (pertaining to testing H_{2a}, H_{2b}, and H_1) are binary in nature and therefore not reported in Table 3. Two covariates, gender and age, were also tested in preliminary analyses, but were omitted from the final model specifications because they did not have significant effects on the outcomes.

Table 3 about Here

5.1 Results for Flavor Identification

To test the effects of food color on the consumer's ability to correctly identify food flavor, we ran two logistic regressions using the SAS CATMOD procedure (SAS Institute 2004). The general model specification is:

$$Y = \beta_0 + \beta_{i=1to2} * X_{i=1to2} + \beta_{j=1to2} * X_{j=1to2}$$

Where:

Y ≡ A binary dv in which a "1" indicates correct flavor Identification..

X_i ≡ A dummy variable representing the two levels of the actual food flavor manipulation.

$X_{j=1to2}$ ≡ A set of two dummy variables representing the three levels of the food color manipulation.

Results in Table 4 show that the main effects of the "wrong color," that is, orange color in the case of lemon flavor, and yellow color in the case of orange flavor, are significant and negative, indicating that "wrong" color significantly negatively affects correct color identification, in support of $H_{2a.}$ The strength of the "wrong" color's effect is greater than that of actual flavor, in support of H_1.

Table 4 about Here

To further examine the ability of actual flavor and food color to affect correct flavor identification, we compare the proportions of subjects who identify the drink they sample as lemon or orange, as reported in Figure 2, testing the significance of the differences between key proportions in the design using Kanji's Test #5, "Z-test for the equality between two proportions (binomial distribution)" (Kanji 1993, p.25). As a manipulation check, we see that, in Figure 2a, subjects identified the orange- and lemon-flavored drinks a roughly equal amount of the time, as expected, since the sample was divided evenly in term of flavor sampled. In Figure 2b, we report the proportions of those who identify their sample as orange or lemon flavored, by food color. We find that when the drink sampled is orange in color, a significantly larger proportion identify the drink as orange flavor rather than lemon, regardless of its actual flavor; when the drink sampled is clear, the difference in proportions is not significant, and when the drink is yellow, a significantly larger proportion identify it as lemon, regardless of its actual flavor. This indicates that food color has a significant effect on the food flavor identified, in support of H_{2b} and H_1.

In Figures 2c and 2d, we compare the effects of food color by actual flavor. In Figure 2c, we report the proportions who identify their sample as orange or lemon flavor, among those who sampled the lemon-flavored drink. When the sample drink is orange in color (the "wrong" color, in this case), we find once again that a significantly larger proportion identify the drink as orange flavor, in spite of the fact that it is the "wrong" color, mismatched with lemon flavor, in further support of H_{2b} and H_1. Moreover, a significantly larger proportion of subjects who sampled the yellow colored lemon-flavored drink (the "right" color) identified it as lemon, also in support of H_{2b}. A significantly larger proportion of those who sampled the clear colored lemon-flavored drink also identified it as lemon, unsurprising since it was lemon.

In Figure 2d we report results for those who were given orange-flavored drink, by color. Those exposed to the orange colored beverage (the "right" color) identified it as orange flavor a significantly greater proportion of the time than those exposed to the yellow-colored orange drink, in support of $H2_b$. The differences in proportions of those exposed to the clear drink is not significant, as expected. In the case of the yellow-colored orange-flavored drink, a larger proportion identified the yellow-colored orange-flavored drink as lemon, a reversal that is directionally correct though not significantly so. We speculate that this lack of significance is due to an asymmetry in the effect of individual colors. Whereas, in the minds of consumers, it may be that orange as a color is relatively unlikely to ever represent or mean lemon flavor, this result suggests, conversely, that consumers can more readily conceive of yellow as being more likely to at times represent or mean orange color. Though not unequivocal due to a lack of significance to this latter finding, the overall pattern of these results indicates the relative strength of food color as a flavor signal over taste, in support of each of those hypotheses related to the effects of food color on ability to correctly identify flavor in color-associated foods: H_{2a}, H_{2b} and H_1.

Figure 2 about Here

5.2 Results for Perception

The use of compensatory multi-attribute attitude models have long been used in marketing to profile competitor brands according to how they are perceived by the consumer (c.f., Hauser & Koppelman, 1979). In this research we take a similar decompositional approach to test H3, by comparing the flavor profiles of differently colored and labeled beverages across the flavor factors derived by the factor analysis reported in Table 2. We test the main and interaction effects of actual flavor and food color by fitting a series of four regressions with each of the two flavor factors and two stand-alone flavor attributes serving as dependent variables, respectively, using the SAS GLM procedure (SAS Institute 2004). The model specification follows the same general form as that shown in the "Results for Identification" section above. Results are shown in Tables 5 and 3.

Table 5 about Here

We find that actual flavor has a significant main effect on the "Crisp," "Flavorful, All natural, Inexpensive," and "Sweet" flavor factors, indicating that lemon- and orange-flavored drinks have distinct flavor profiles. Specifically, lemon-flavored drinks are perceived to be crisper in flavor, whereas, orange-flavored drinks are perceived to be more flavorful, natural, inexpensive, and sweet.

Food color has a significant main effect on "Refreshing, Good for You" flavor factor, indicating that food colors also have distinct flavor profiles, independent of actual flavor. Specifically, yellow-colored drinks are seen as more refreshing and better for you than clear or orange drinks, in support of H_3.

The interaction of actual flavor and food color has a significant effect on "Sweet," indicating that food color indirectly affects flavor perceptions by mediating the relationship between actual flavor and flavor perceptions. Specifically, clear lemon drinks are perceived to be sweeter than colored drinks, whether yellow or orange. And, perhaps conversely, yellow-colored, orange-flavored drinks are perceived to be sweeter than orange-colored orange drinks, which are in turn perceived to be sweeter than clear-colored orange drinks, in further support of H_3.

5.3 Results for Flavor Preference

To test the effects of food color on liking or preference, an ANOVA model was fitted to the data using the SAS GLM procedure (SAS Institute, 2004). Subjects rated their liking of the beverage they sampled on two separate liking scales, overall flavor liking and overall beverage liking. These proved to be highly correlated ($\rho = .765$), indicating that both questions measure the same underlying construct. Therefore, a composite liking measure was created by taking a simple mean of the two, which served as the dependent variable. Results are shown in the last row of Tables 1, 3 and 5.

Food color has a significant main effect on liking. Interestingly, the main effect of actual flavor is not significant, indicating the relative strength of food color as a flavor signal over actual flavor, in support of H4a. Specifically, yellow-colored drinks are preferred to orange drinks, and orange-colored drinks are preferred to clear drinks, indicating that drinks with actual color, in contrast to a drink with no color, are preferred, regardless of their actual flavor; in support of H_{4b}. The interaction of actual flavor and food color has no significant effect on flavor liking.

6. MANAGERIAL IMPLICATIONS

These results extend to analogous colors (fine color gradations) prior findings that food color affects the consumer's ability to correctly identify flavor as well as to form distinct flavor profiles and preferences, and dominates other flavor information sources. Put another way, these results suggest that that consumers' acuity for food color is such that even slight color differences lead to little diminution in food color's effect on flavor perception. Its further implication is that food color at all levels is inextricably linked to expected flavor in the minds of consumers. These strong color associations can be used by marketers of non-food products as well, such as pharma and hygiene products. For example, medicines for children can incorporate colors to make them more palatable since certain colors are associated with particular flavors in the minds of kids. Implications for the soap and body wash industry suggest that using colors associated with the fruits and vegetables in their products can be used to add differentiation and meaning, thereby increasing the natural feel consumer appeal of these products. For example, see http://www.originalsource.co.uk/ to see the Original Source line of bath and shower products, which claim to be natural and have deep rich colors for each of their "flavors," like mint, raspberry, lemon, etc.

Consumers' strong pre-conceived color-flavor associations make the deliberate selection of mismatched food color (however subtle) attention-getting, a favorable quality for marketing communications purposes. This can be problematic, though, if one's marketing objectives rely on detaching color's meaning and its message from its flavor implications. But not impossible. In the following, we present three possible strategies for making the introduction of a novel food color viable for marketing communications purposes. The first is to teach consumers to accept a novel color as characteristic, or emblematic, of a particular food, as brown is for cola. When the appearance of a food product is nondescript, then associating it with a new, more vibrant color can enhance its noticeability, its distinctiveness and its appeal. Such has been the case with green for peppermint or yellow for Mountain Dew and all its me-too competition (a me-too color strategy). A problem with rendering a novel food color characteristic is that it will likely be a lengthy and expensive process, requiring as it does the conditioning of consumers to accept a new color as characteristic of a particular food product. Another obstacle is the sheer diversity and multiplicity of food products (and their packages) on display. This makes it hard for the marketer to find an empty visual niche, when compared to the days when peppermint was made green or cola was made brown. Another drawback to rendering a novel color no longer novel is that it loses its ability to surprise the consumer into attention, which was the prime reason for utilizing novel color in the first place.

The second strategy is to celebrate the very incongruity of a novel food color, to announce to the consumer that its novelty is there to surprise and delight, and the proper response is to have fun and enjoy it. This is done by featuring novel color and its very incongruence in the shelf presentation. The consumer therefore knows that the incongruence is intended, is meant to be amusing, and is therefore made to feel welcome to share in the fun. An example of this is Gatorade's Blue Raspberry drink, an uncharacteristically blue-colored beverage whose name calls attention to the incongruence of the drink's color and flavor.

The third strategy for the introduction of novel food color is to sever the food color and flavor expectations connection, making it impossible for the consumer to connect the two. If color and flavor are not connected, then novel food color cannot be incongruent. First, the natural tendency of the consumer to connect color and flavor must be deliberately blocked, to permit the introduction of other color themes and associations to distinguish and contrast the brand, and lend it meaning. The most straightforward means of unlinking food color and labeling is to mask food color. The focus of the product can then be shifted to a more thematic association. Several drink brands have elected this approach by packaging their drinks in opaque bottles or plastic labels that cover the outside of the package, thus hiding the view of the actual product. An Indian example of the masking of food color with an opaque package is Nescafe Iced Cappuccino Mix (to see package, go to http://www.nestle.in/brands/beverages/nescafecappuccino), which comes in opaque boxes. The Vanilla Latte is blue and the Mocha purple, neither color a coffee-flavor-associated color.

A more subtle approach to the disconnection of the food color/expected flavor relationship is the selection or creation of food colors and flavors that are not flavor- or color-associated. In denying the consumer the ability to readily categorize the flavor cues that food color and labeling present, the consumer may be induced into a mode of more elaborated information processing in order to understand and evaluate the product. This opens an opportunity for the presentation of promotional ideas, symbols, meanings and associations through the medium of novel food color. Gatorade goes so far as to withhold specific flavor information in its "Nutritional Facts" label on its Frost line of beverages, citing only "natural flavors." The consumer is therefore blocked from falling back on old flavor habits, and can have none of the usual flavor expectations prior to tasting. The consumer is therefore forced to consider and evaluate the Frost line of drinks in an entirely new context.

A related but somewhat different approach seeks an alternative appeal that is cognitive in nature. For example, Gatorade India offers a beverage line called "Blue Bolt," (to see package, go to http://www.gatorade.co.in/gatorade-sports-drink/index.html) whose color is an electric blue, not naturally or commonly associated with any fruit flavor, whose name and body text refer to energy and activity, an alert and excited bodily state, rather than to its flavor, and whose color is designed to be consistent with those themes rather than with flavor. Additionally, as mentioned earlier, Pepsi India introduced an amber colored form of Pepsi called Pepsi Gold, signifying the Cricket World Cup Gold Trophy (to see package, go to http://blogger-2006.blogspot.com/2007/07/).

7. EXTENSIONS

Valuable future research would include generalizing on the results of this experiment by manipulating other food flavors in additional food categories, along with food color and label information. With respect to food flavor, this research implicitly assumes that flavors differ purely on the basis of how well they are liked, and may therefore be compared directly. However, flavors as complex multidimensional stimuli each have their own particular character. By replicating this study with other flavors we may account for any flavor-specific effects, as well as investigate the effects of the particular meanings of specific colors. Looking at other families of colors as well as looking at colors with even smaller differences between them might yield interesting results.   For example, future research could decompose the color comparisons, making small changes to hue, saturation and value, with the idea that these changes may have systematically different effects. Or perhaps the differences may be primarily contained in one of these dimensions.   Or each may carry their own difference in meaning; for instance, dark to light may appear differently than warm to cool, or pale red (say) versus deep red.

Investigating these effects in food categories other than beverages, such as solid foods, might show that the relationship between food color and flavor varies from one food category to another.   Extending this research to flavor categories other than fruit flavors might also yield managerially relevant findings.

Another interesting avenue for future research includes conducting taste tests in other countries. Taste testers may vary in behavior from country to country. For example, we observed Indian subjects sampling beverages in a manner which was far more careful and deliberate than American subjects. They did not swig the drinks like Americans, but would instead take many little sips and reflect on the experience each time as well in a highly cognitive manner.

Comparisons across countries represent interesting avenues for study because food and food consumption have social and cultural components. Such comparisons could help to explain prior research results for example that showed that Indian respondents liked purple drink significantly better than the correctly matched orange colored beverage (Garber, Hyatt and Nafees 2015); perhaps they simply liked purple better than orange color. Or, perhaps, there is a culture-specific meaning that caused purple to be preferable in this context, over and above its flavor associations. Further research is needed to test these possibilities.

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TABLE 1

MEAN RATINGS FOR FLAVOR ATTRIBUTES, FLAVOR FACTORS AND LIKING FOR TOTAL SAMPLE AND BY ACTUAL FLAVOR

	Total	By Actual Flavor	
Flavor Attributes [a b]	**Sample**	**Lemon**	**Orange**
Has a Very Crisp Taste	3.14**	3.25****	3.03
Has a Very Clean Taste	3.14**	3.19**	3.08
Has a Lot of Flavor	3.13**	3.02	3.25***
Is Very Good Served with food	3.08	3.03	3.12
Is Very Inexpensive	3.08	3.12*	3.10
Is Very Refreshing	3.07	2.99	2.96
Is Very Tart	3.05	2.99	3.14*
Is Very Thirst Quenching	2.95	2.88	3.02
Is Very Wholesome	2.94	2.81***	3.07
Is Very Sweet	2.93	2.71****	3.16**
Is Very Cooling	2.91	2.97	2.85*
Is very Good for Me	2.75****	2.76***	2.86*
Contains All-Natural Ingredients	2.74****	2.56****	2.93
Flavor Factors [c]			
Flavorful, All-Natural, Inexpensive	3.01	2.92	3.10
Refreshing, Good for Me	2.97	2.95	2.99
Liking [d]	4.62****	4.54****	4.70****

[a] Rank ordered by the mean ratings of the total sample.

[b] As measured on a 5-point scale, where "5" means "Strongly Agree," "1" means "Strongly Disagree," and "3" means "Indifferent" or "Don't Know."

[c] Calculated as the average of the man ratings of the component attributes.

[d] As measured on a 7-poing scale, where "7" means "Like very much,"1" means "Dislike very much," and "4" means "Don't know" or "Indifferent."

**** ≡ Significantly different from the mean at a level <.0001
*** ≡ Significantly different from the mean at a level of .001
** ≡ Significantly different from the mean at a level of .01
* ≡ Significantly different from the mean at a level of .05

Significant difference in means across flavor at a level of <.0001.

Significant difference in means across flavor at a level of .001.

Significant difference in means across flavor at a level of .05.

TABLE 2

FACTOR ANALYSIS OF THIRTEEN BEVERAGE PERFORMANCE ATTRIBUTES AND THEIR LOADINGS INTO A THREE FACTOR SOLUTION [a]

	Rotated Factor Loadings (Varimax Rotation)		
Beverage Attributes [b]	**Factor 1: Refreshing**	**Factor 2: Flavorful All-Natural Inexpensive**	**Factor 3: Crisp Tart**
Is Very Refreshing	**73**	-16	17
Is Very Good for Me	**73**	-9	-3
Is Very Thirst-Quenching	**64**	-10	-14
Is Very Cooling	**62**	-10	14
Has a Very Clean Taste	**62**	-19	11
Is Very Good Served with Food	**61**	-15	6
Is Very Wholesome	**53**	25	-29
Is Very Sweet [c]	36	19	11
Has a Lot of Flavor	18	**65**	-8
Contains All-Natural Ingredients	43	**44**	-28
Is Very Inexpensive	15	**43**	-19
Has a Very Crisp Taste [c]	21	9	**73**
Is Very Tart [c]	-14	**53**	**56**

[a] Printed values are multiplied by 100 and rounded to the nearest integer.

[b] Performance attributes are rank ordered by their loading on the factor with which they are most highly associated.

[c] Since "Is Very Sweet" is not strongly loaded on any factor, and "Is Very Tart" is doubly loaded on Factors 2 and 3, they are included as stand-alone variables in subsequent analyses. Since "Has a Very Crisp Taste," is the lone remaining variable in Factor 3 once "Is Very Tart" is removed, it is also included as a stand-alone variable in subsequent analyses.

TABLE 3

MEANS FOR FLAVOR FACTORS, LIKING [ab]

Treatment	Refreshing Good for You	Flavorful All-Natural Inexpensive	Crisp	Tart	Sweet	Liking [e]
	Flavor Performance Factors [cd]					
Total Sample	2.97	3.01	3.14	3.07	2.93	4.62
Actual Flavor						
Lemon	2.95	2.92	3.25	2.99	2.71	4.54
Orange	2.99	3.10	3.03	3.14	3.16	4.70
Food Color						
Yellow	3.08	3.06	3.28	3.01	2.95	4.83
Clear	2.91	2.96	3.06	3.16	2.98	4.46
Orange	2.93	3.02	3.10	3.02	2.87	4.58
Food Color within Lemon Flavor						
Yellow Color	3.07	3.02	3.35	2.94	2.60	4.76
Clear Color	2.88	2.90	3.19	3.20	3.00	4.29
Orange Color	2.89	2.85	3.22	2.84	2.53	4.56
Food Color within Orange Flavor						
Yellow Color	3.08	3.09	3.19	3.10	3.34	4.90
Clear Color	2.95	3.02	2.94	3.12	2.96	4.63
Orange Color	2.96	3.18	2.98	3.20	3.20	4.60

[a] Least squares means are reported here and used in subsequent analyses to control for unequal cell sizes.
[b] Test of hypotheses concerning flavor identification employ binary dependent variables and are not reported here.
[c] Each treatment cell is rated on each performance factor on a five-point scale, where a "5" indicates the highest rating.
[d] Factors are ordered left to right by the amount of variance explained.
[e] Liking for each treatment cell is rated on a seven-point scale, where a "7" indicates " Like Very Much," a "1" indicates "Very Much Dislike," and a "4" indicates uncertainty or indifference.

TABLE 4

LOGISTIC REGRESSION MODELS TESTING THE EFFECTS OF FOOD COLOR ON FLAVOR IDENTIFICATION

Manipulations	dv's are binary variables where a "1" indicates those subjects who: identify flavor as *lemon*	identify flavor as *orange*	Manipulations
Actual Flavor Dummy (1=orange flavor, 0=lemon Identifying orange flavor as lemon is incorrect)			**Actual Flavor Dummy (1=orange flavor, 0=lemon) Identifying orange flavor as lemon is incorrect)**
Parameter	-1.08	0.27	Parameter
p	(.0501)	(.6026)	p
Clear Color Dummy (i.e., noncolor, unrelated any fruit to any particular flavor)			**Clear Color Dummy (i.e., noncolor, unrelated any fruit to any particular flavor)**
Parameter	-0.17	-2.62**	Parameter
p	(.7945)	(.0014)	p
Orange Color Dummy (i.e., the "wrong" color)			**Yellow Color Dummy (i.e., the "wrong" color)**
Parameter	-1.83**	-2.29**	Parameter
p	(.0017)	(.0013)	p
Actual Flavor x Clear Color			**Actual Flavor x Clear Color**
Parameter	0.34	1.20	Parameter
P	(.6619)	(.2261)	P
Actual Flavor x Orange Color			**Actual Flavor x Yellow Color**
Parameter	1.26	1.30	Parameter
p	(.1221)	(.1462)	p
R^2	.100	.173	**R^2**
Max-Rescaled R^2	.134	.240	**Max-Rescaled R^2**
Number of Observations Read	173	173	**Number of Observations Read**

**** ≡ p < .0001
*** ≡ p < .001
** ≡ p < .01
* ≡ p < .05

TABLE 5

ANOVA MODELS TESTING THE EFFECTS OF ACTUAL FLAVOR, FOOD COLOR, THEIR INTERACTION, AND LIKING, ON FLAVOR FACTORS

	Flavor Factors [a]					
dv's	**Refreshing Good for You**	**Crisp**	**Tart**	**Flavorful All-Natural Inexpensive**	**Sweet**	**Liking**
Actual Flavor (AF)	0.50 [b] (.4779)	**6.06* (.0142)**	3.10 (.0790)	**9.83** (.0018)**	**28.85**** (<.0001)**	2.10 (.1475)
Food Color (FC)	**3.10* (.0459)**	2.08 (.1255)	1.13 (.3277)	1.05 (.3503)	0.59 (.5562)	**3.51* (.0306)**
AFxFC	0.17 (.8464)	0.00 (1.000)	2.01 (.1354)	2.33 (.0986)	**9.02*** (.0001)**	0.66 (.5154)
R^2	.013	.019	.018	.031	.084	.020

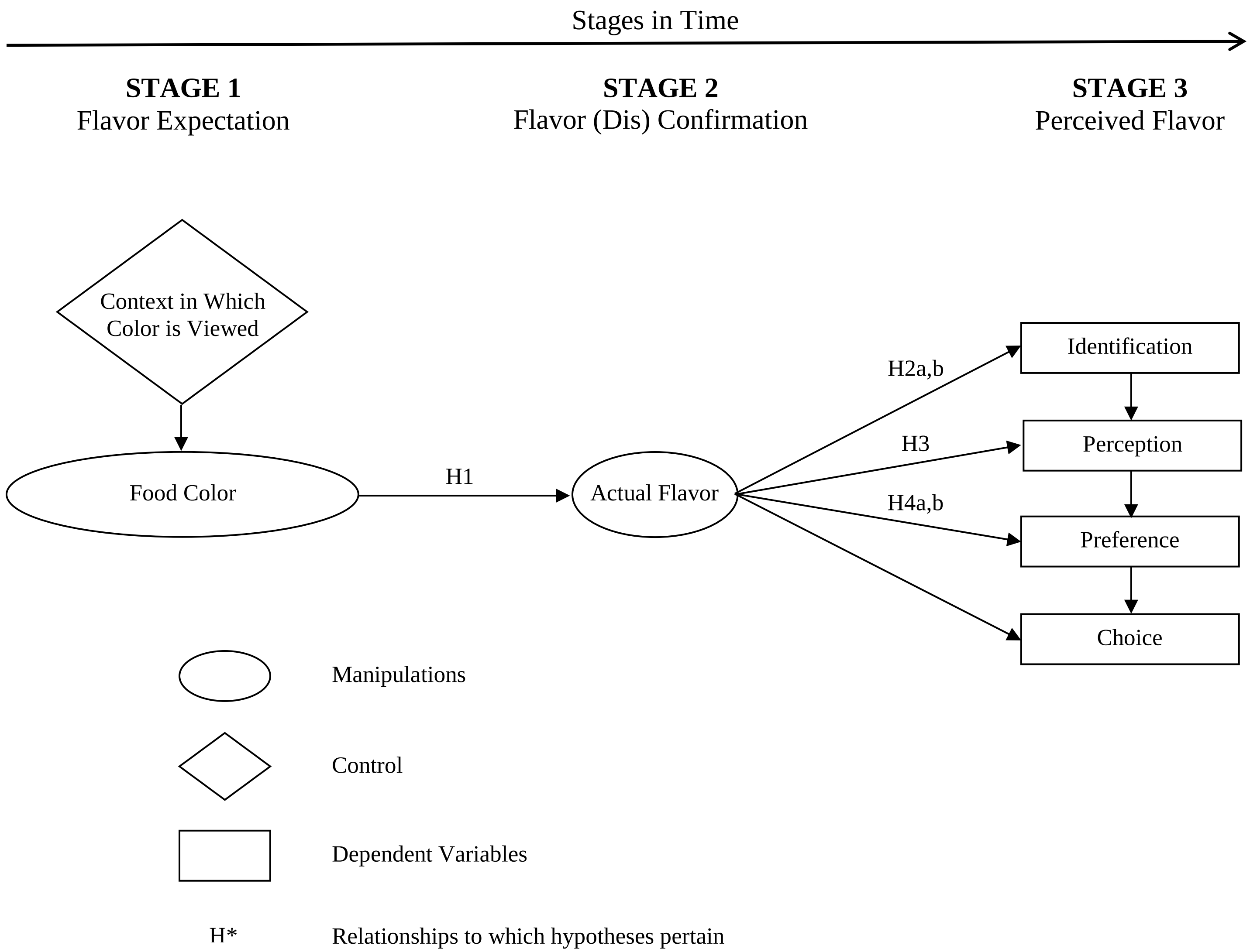
[a] Flavor factors models ordered left to right by strength of association with food color.

[b] Cells contain F values. Probabilities are in parentheses

**** ≡ p < .0001
*** ≡ p < .001
** ≡ p < .01
* ≡ p < .05

FIGURE 1

THE RELATIONSHIP BETWEEN FOOD COLOR AND TASTE AND THEIR EFFECT ON FLAVOR AT THREE STAGES OF CONSUMER CHOICE

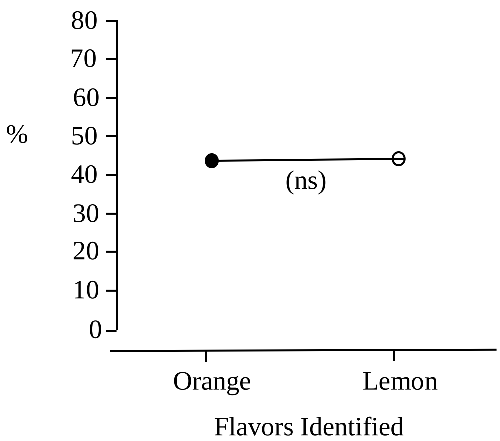


Adapted from Garber, Hyatt and Starr (2000)

FIGURE 2

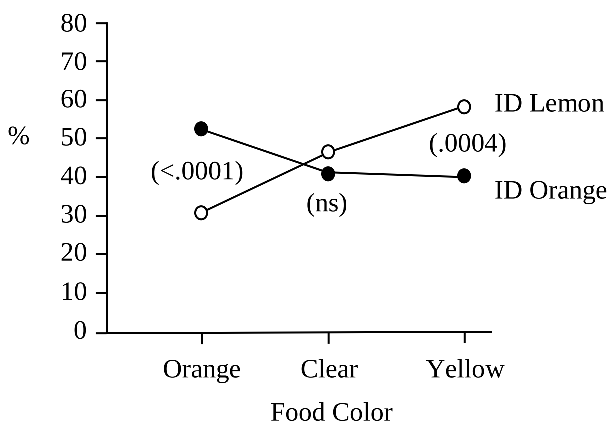
FLAVOR IDENTIFICATION BYACTUAL FLAVOR, FOOD COLOR, AND COLOR AND FLAVOR

2a. Percentage of Total Sample Identifying Orange and Lemon Flavors, Respectively



ID Orange Flavor	ID Lemon Flavor
43.7%	44.1%

2b. Percentage of Total Sample Identifying Orange and Lemon Flavors, by Color

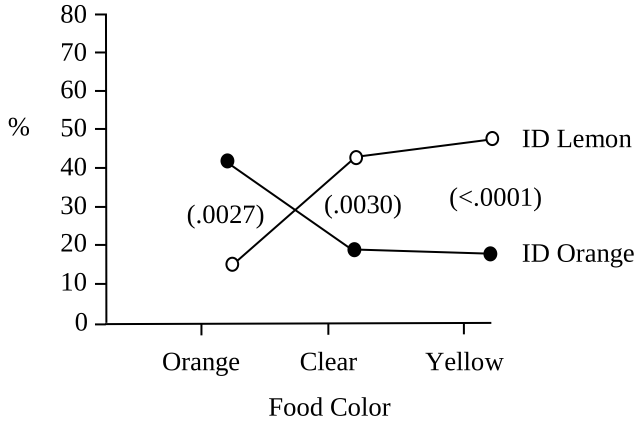


	Orange	Clear	Yellow
ID Orange	52.5%	39.3%	39.0%
ID Lemon	30.9%	45.0%	57.0%

FIGURE 2 (cont.)

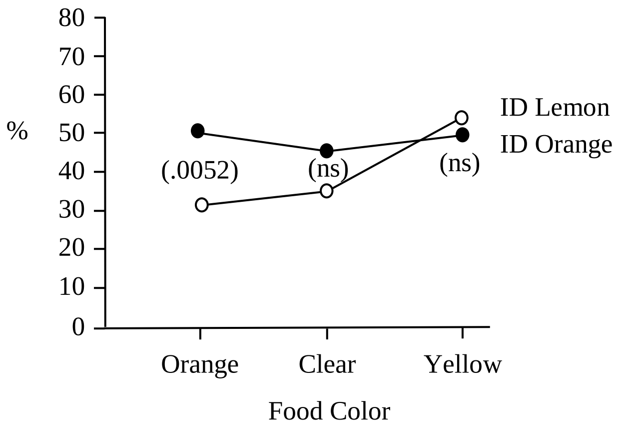
FLAVOR IDENTIFICATION BY ACTUAL FLAVOR, BY FOOD COLOR, AND BY COLOR AND FLAVOR

2c. Results for Those Who Sampled Lemon Flavored Drink



	Food Color		
	Orange	Clear	Yellow
ID Orange	55.1%	34.5%	31.5%
ID Lemon	30.3%	55.2%	62.9%

2d. Results for Those Who Sampled Orange Flavored Drink



	Food Color		
	Orange	Clear	Yellow
ID Orange	50.0%	44.0%	47.0%
ID Lemon	31.5%	35.2%	50.6%

Figure Captions

FIGURE 1

THE RELATIONSHIP BETWEEN FOOD COLOR AND TASTE AND THEIR EFFECT ON FLAVOR AT THREE STAGES OF CONSUMER CHOICE

FIGURE 2

FLAVOR IDENTIFICATION BYACTUAL FLAVOR, FOOD COLOR, AND COLOR AND FLAVOR