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ABSTRACT. The authors examined preconceptions of taste based on color with a questionnaire administered to 45 college students. The questionnaire related 8 tastes with 10 colors. The results suggested that only a limited number of colors are positively associated with preconceptions of taste. However, certain colors (e.g., red and green) showed consistent patterns of association with taste. Implications for future research examining an indirect relationship between color and taste are discussed.

Key words: color, taste perception

PERCEPTUAL DIMENSIONS OF FOOD are important for taste (Moskowitz, 1972). The idea that color can influence taste is commonplace (Current Health, 1993). For instance, cookbooks will often use phrases such as "retain color," "natural color," and "deep in color." They suggest using certain garnishes to enhance the color of the food (Tufts University Health & Nutrition Letter, 1998). There are also sections describing how to identify certain foods by color (e.g., peppers). We also use color to determine the quality of food (Trinkaus, 1995) or how well something is cooked (e.g., rare, medium-rare, well-done).

Colors that create an unnatural tint in food may also create an aversion to that food item (Tufts University Health & Nutrition Letter, 1993). According to Dean (1988), even fish seem to be influenced by the color of the lure. However, color and taste are not always positively related. For example, Long (1995) showed that redder apples do not necessarily taste better. Research on birds also supports the idea that color and palatableness of food are inversely related (Holloway, 1993). In fact, the scientific research in perception concerning the impact of color on taste has generally found no relationship between the two.

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The research on color and taste has typically been done with colored liquid and gelatin solutions. For example, Strugnell (1997) had participants rank samples of liquid based on sweetness. He then used liquids of different colors while holding the amount of sweetness constant. Participants again had to rank the drinks by sweetness. He found few consistencies between color and rank except that red tended to be the sweetest and blue the least sweet.

Alley and Alley (1998) used 10 samples of an aqueous sucrose solution in liquid and gelatin forms. The solutions were presented in four different colors plus a colorless control solution. They found that liquids were rated sweeter than solids and that solutions in color were perceived to be sweeter than the colorless control solution but no differences were found among colors. Frank, Ducheny, and Mize (1989) examined the influence of color, odor, and taste by using red coloring and strawberry odorant with aqueous sucrose solutions. Participants rated the solutions on sweetness. The results indicated that strawberry odor increased sweetness ratings but the red coloring had no effect on sweetness.

Guinard, Souchard, Picot, Rogeaux, and Siefferman (1998) determined the characteristics associated with the thirst-quenching quality of beer. They asked 12 trained judges to rate 18 beers on a variety of characteristics. Carbonation and bubble density were positively related with thirst-quenching beers, but foam, aroma, and flavor (e.g., malty, bitter, hoppy, burnt), and color were negatively associated with thirst quenching. Hyman (1983) conducted taste tests combining three tasteless food dyes (red, yellow, and brown) with carbonated water and white birch beer. He found that color had little effect with carbonated water but did influence the taste rating of birch beer.

Finally, Oram, Laing, Hutchinson, and Owen (1995) used four drinks that differed in color and flavor. Some combinations were typical and some resulted in atypical combinations of color and flavor. Child and adult tasters identified the drinks using four flavor names. Oram et al. found that drink identification by older people was less influenced by color and more influenced by taste. Norton and Johnson (1987) found that a distinctive flavor influenced the ratings of appeal, sweetness, and appropriate color of yogurt samples but that color influenced only the rating of appropriate color.

Although the studies dealing with color and taste indicate that color may have only a minimal effect on taste perception, these studies focused on the impact color has on the actual perception of food (i.e., gelatin) and drink. In the present study, we did not deal with the perception of taste but with preconceptions of taste as a result of color information. Specifically, we used a questionnaire to address the question of whether or not color influences preconceptions of taste. An examination of preconceptions of taste is important for two reasons. First, given the research indicating that color has a minimal impact on taste, examining preconceptions of taste will help determine whether color can influence how a food is expected to taste. Second, Nisan (1973) demonstrated that anticipated taste is influenced by the amount of time between selection and

receipt of a particular food. Because Reardon and Bushnell (1988) found that 6½-month-old infants could match the color of a cup with sweet and bitter tastes, color may be able to influence the anticipated taste of food or drink (Allen & Madden, 1985; Evans & Kagehiro, 1977).

Method

Participants

Forty-five upper-division business students (24 men and 21 women; mean age, 23.20) at the University of Oregon volunteered to participate in the study. Students were given class credit for their participation.

Instrument and Procedure

We designed a survey to examine the role of color in perceived taste using soft drinks as target beverages. Soft drinks were chosen because past research has concentrated on the effect of color on a liquid. Koch, Koch, and Forbes (2001) also found that soft drinks were significantly associated with certain colors. Therefore, colors commonly used in packaging soft drinks were included in the survey along with actual colors of soft drinks. The colors included red, green, yellow, blue, brown, orange, purple, black, gray, and white.

Sweet, sour, bitter, and salty were included in the questionnaire as possible tastes. Four additional tastes associated with soft drinks were also included (syrupy, bubbly, citrusy, fruity). Thus, 10 colors and 8 tastes were used in the study. We assessed the associations between each taste and color on a 10-point rating scale so that the questionnaire consisted of 80 questions; for example, "On a scale from 1 to 10 with 10 being the most sweet, how sweet is the color red?" and "On a scale from 1 to 10 with 10 being the most sour, how sour is the color green?" Four additional questions were included for demographic purposes.

Participants were administered the color and taste questionnaire and instructed to answer each question as accurately as possible. There was no time limit for completing the questionnaire.

Results

We collapsed the responses into three categories based on how the color was associated with a particular taste. Scores of 1 through 3 were classified as negatively associated whereas scores of 4 through 6 were classified as somewhat associated, and 7 through 10 were positively associated. A series of chi-square analyses was conducted to determine significant associations. Those colors positively and negatively associated with each characteristic of taste are presented in Table 1.

TABLE 1. Positively and Negatively Associated Colors with Eight Taste-Related Characteristics of Soda

Sweet	Sour	Bitter	Salty	Citrusy	Syrupy	Fruity	Bubbly
			Positive associations				
Red Orange	Green Yellow		White	*Yellow* *Orange*	Brown	*Red* *Yellow* *Orange*	
			Negative associations				
Green *Brown* *Black* *Gray*	Red Blue *Brown* *Purple* *Black* *Gray* White	Red Blue Gray *White*	*Red* Green Yellow Blue *Brown* *Orange* *Purple* *Black* Gray	Red *Blue* *Brown* Purple *Black* *Gray* *White*	*Green* Blue Black *Gray* *White*	*Brown* *Black* *Gray* *White*	Red Green *Brown* *Black* *Gray*

Note. Roman typeface indicates chi-square significance; italic indicates significance after Bonferroni correction.

Positive Associations

Results of the chi-square analyses are presented in Table 2.[1] The findings indicate that red and orange were positively associated with sweet. Green and yellow were associated with sour. Yellow and orange were associated with cit-

[1]The present study examines relationships between color and taste. If no relationship exists between a particular color and taste, it is assumed that responses will be equally distributed across the rating scale for that color–taste pairing. The appropriate chi-square test in this case is a goodness of fit test. Although there are corrections for multiple chi-squares comparisons when using a test of independence (Maxwell, 1970; Rosnow & Rosenthal, 1991; Stuart, 1955), these corrections do not apply to chi-square tests for goodness of fit. Rosnow and Rosenthal (1996) have suggested that effect sizes can be helpful in evaluating chi-square analyses. Therefore, Tables 2 and 3 present the effect size associated with each chi-square. According to Cohen (1988), .3 should be considered a medium effect size, whereas .5 should be considered a large effect size. In addition, we included the exact p values (to three decimal places. It should be noted that using a more stringent alpha level (e.g., .01) does not change the findings of the study. However, a Bonferroni correction with a critical alpha level of .0003125 does eliminate some significant relationships. Therefore, all chi-squares, effect sizes, and Bonferroni corrections are presented in Tables 2 and 3. We discuss the results using the combination of these measures.

TABLE 2. Chi-Squares and Effect Sizes for the Colors Positively Associated with Taste

Taste	Color	Chi-square	*p*	Effect size
Sweet	Red	13.88	.001	0.32
Sweet	Orange	14.95	.001	0.35
Sour	Green	11.32	.003	0.29
Sour	Yellow	12.53	.002	0.30
Bitter	Black	11.31	.003	0.29
Citrusy	Yellow	30.85	.000*	0.48
Citrusy	Orange	46.20	.000*	0.58
Salty	White	13.07	.001	0.31
Syrupy	Brown	14.68	.001	0.33
Fruity	Red	49.03	.000*	0.60
Fruity	Yellow	32.95	.000*	0.49
Fruity	Orange	23.57	.000*	0.42

Note. All chi-squares are based on $df = 2$ and $N = 45$. Effect sizes were determined using Cohen's (1988) formula for *w*.
*Indicates significance after Bonferroni correction ($\alpha = .0003125$).

rusy, and red, yellow, and orange were positively associated with a non-citrus fruit taste. Only white was positively associated with salty. Only brown was positively associated with syrupy.

Although there was a significant chi-square value for black and bitter, this was the only bi-directional relationship. Twenty-three of the respondents indicated no relationship between black and bitter, but 17 indicated a strong relationship between the two (5 indicated a moderate relationship). No colors were positively associated with bubbly. Although effect sizes for these relationships ranged from .29 for sour and green to .60 for red and fruity, the mean effect size was .40, indicating a medium to large effect for color and taste.

When a Bonferroni correction was made for multiple comparisons, several positive associations were eliminated (Table 2). For instance, no colors remained positively associated with sweet, sour, bitter, salty, syrupy, or bubbly. Yellow and orange remained positively related to citrusy, and red, yellow, and orange remained positively related to fruity.

Negative Associations

The majority of associations between color and taste were negative (Table 3). Green, brown, black, and gray were negatively related to sweetness. Red, blue, brown, purple, black, gray, and white were negatively related to sour. Red,

TABLE 3. Chi-Squares and Effect Sizes for the Colors Negatively Associated with Taste

Taste	Color	Chi-square	*p*	Effect size
Sweet	Green	8.22	.016	0.25
Sweet	Brown	26.4	.000*	0.44
Sweet	Black	55.09	.000*	0.64
Sweet	Gray	58.32	.000*	0.65
Sour	Red	14.55	.001	0.33
Sour	Blue	11.32	.003	0.29
Sour	Brown	49.43	.000*	0.60
Sour	Purple	8.22	.016	0.25
Sour	Black	49.03	.000*	0.60
Sour	Gray	45.39	.000*	0.58
Sour	White	58.32	.000*	0.65
Bitter	Red	9.84	.007	0.27
Bitter	Blue	10.91	.004	0.28
Bitter	Gray	10.24	.006	0.27
Bitter	White	30.85	.000*	0.48
Citrusy	Red	10.24	.006	0.27
Citrusy	Blue	21.01	.000*	0.39
Citrusy	Brown	36.5	.000*	0.52
Citrusy	Purple	15.76	.000	0.34
Citrusy	Black	40.95	.000*	0.55
Citrusy	Gray	53.47	.000*	0.63
Citrusy	White	29.23	.000*	0.46
Salty	Red	21.15	.000*	0.39
Salty	Green	10.91	.004	0.28
Salty	Yellow	9.03	.011	0.26
Salty	Blue	12.26	.002	0.30
Salty	Brown	18.73	.000*	0.37
Salty	Orange	22.77	.000*	0.41
Salty	Purple	26.4	.000*	0.44
Salty	Black	17.92	.000*	0.36
Salty	Gray	11.32	.003	0.29
Syrupy	Green	17.92	.000*	0.36
Syrupy	Blue	12.26	.002	0.30
Syrupy	Black	10.24	.006	0.27
Syrupy	Gray	40.54	.000*	0.55
Syrupy	White	29.23	.000*	0.46
Fruity	Brown	37.31	.000*	0.52
Fruity	Black	58.73	.000*	0.66
Fruity	Gray	53.74	.000*	0.63
Fruity	White	37.31	.000*	0.52
Bubbly	Red	13.88	.001	0.32
Bubbly	Green	8.62	.013	0.25

TABLE 3.—Continued

Taste	Color	Chi-square	*p*	Effect size
Bubbly	Brown	19.93	.000*	0.38
Bubbly	Black	40.95	.000*	0.55
Bubbly	Gray	37.31	.000*	0.52

Note. All chi-squares are based on $df = 2$ and $N = 45$. Effect sizes were determined using Cohen's (1988) formula for *w*.
*Indicates significance after Bonferroni correction ($\alpha = .0003125$).

blue, gray, and white were negatively associated with bitter. All colors except white were negatively related to salty. Red, blue, brown, purple, black, gray, and white were negatively related to citrus. Green, blue, black, gray, and white were negatively associated with syrupy. Brown, black, gray, and white were negatively related to fruity. Finally, red, green, brown, black, and gray were negatively associated with bubbly.

Effect sizes for the negative associations between color and taste ranged from .25 for green and bubbly to .66 for black and fruity. The mean effect size was .43, again suggesting a medium to large effect. Statistical significance for the chi-square tests after the Bonferroni correction are also presented in Table 3.

Patterns in Associations

Although most of the associations between color and taste were negative, 7 of the 10 colors were positively associated with at least one characteristic of taste. In fact, blue, purple, and gray were the only colors without a positive color–taste association. Just 3 of the 10 colors, however, produced positive associations with at least medium effect sizes with the four main tastes of sweet (red and orange), sour (green and yellow), bitter, and salty (white). Several colors were rated consistently across tastes. For instance, red was strongly associated with sweet but not associated with sour, bitter, and salty. Red was also positively associated with fruity (non-citrus) and negatively related to citrus. Similarly, green was negatively related to sweet but positively related to sour. Yellow and orange, on the other hand, were rated inconsistently across tastes. Yellow was positively associated with sour, citrusy, and fruity (non-citrus). Orange was positively associated with both citrusy and fruity (non-citrus).

Discussion

We conducted the present study to determine whether people have any preconceptions about taste based on color. The results indicate that a limited num-

ber of colors are positively associated with certain tastes. In fact, there are a few colors (e.g., red) that show a consistent pattern of responses across tastes, indicating color may have some influence on taste or at least the preconceptions of taste. However, most colors are not positively associated with taste. This finding is consistent with past research indicating that color has a limited impact on actual taste (Frank et al., 1989).

Nevertheless, color is commonly regarded as an important factor to consider when trying to enhance taste. It could be that visual information does not significantly influence the chemical senses of taste and smell. However, it could also be that the effect of color on food is minimal because it indirectly influences taste. In fact, it may be that color has nothing to do with the taste of food or drink but does affect the desirability of food or drink for different attributes and uses associated with sweetened foods (see Praettaelae & Keinonen, 1984).

Finally, the relationship between color and taste may reflect only the frequency with which certain colors and foods or drinks have been paired. For instance, syrupy has no colors positively associated with it after the Bonferroni correction although brown appears to be related to syrupy based on effect size. Syrups come in different colors. Maple syrup is brown, strawberry syrup is red, and blueberry syrup is blue. However, syrups are not green, gray, or white. Similarly, red, yellow, and orange are positively associated with fruity but brown, black, gray, and white are negatively related to fruity. Fruits are rarely brown, black, gray, or white.

Therefore, colors that are usually paired with a particular taste may have a strong positive association with that taste. Colors that are frequently but not always paired with a particular taste (or tastes that are paired with several different colors) may be moderately associated with that taste. Colors that are never paired with a particular taste (or indicate spoiled food) may have strong negative associations with that taste.

However, research has shown relationships between color and affect (Jacobs & Suess, 1975; Mehrabian, 1978; Valdez & Mehrabian, 1994; Wexner, 1954; Wilson, 1966), affect and buying behavior (Swinyard, 1995; Tom & Rucker, 1975), and color and buying behavior (Turley & Milliman, 2000). Thus, a few select colors may produce certain preconceptions about taste that make a particular food or drink more or less desirable. Simultaneously, these colors may also invoke related cognitions concerning affect and consumer behavior. The result of these combined cognitions may lead to a belief that the food or drink will taste good or that a product is of high quality.

If this is the case, then it should be possible to alter people's perception of taste by manipulating color, affect, and related consumer behavior (e.g., anticipated benefits or desirability). For example, can the color or color scheme of a food package influence taste? However, a systematic study of taste or of consumer behavior has not been conducted while varying multiple cognitive domains influenced by color. Therefore, the present findings suggest that color

may play a limited direct role in taste perception but that additional research needs to be conducted to examine the extent to which color indirectly influences desirability and taste.

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