HUE AND TASTE PERCEPTION: WHEN COLOR MEETS THE TONGUE

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ABSTRACT

The effects of packaging and presentation on taste experiences have been the focus of many studies seeking ways to maximize marketing success. The appearance of a food product has been shown to contribute to expectations of how that product will taste. Research into the evolutionary forces behind color vision suggests a biological basis for expectations of specific taste qualities due to a food's hue. The present study investigates this relationship through a blind taste test of lemonade in which the cup containing the product varied in hue. Partially consistent with hypotheses, red produced higher sweetness ratings than green. In addition, green and blue produced higher sour ratings than red and yellow. These findings are consistent with studies that suggest that trichromatic color vision evolved as an advantage in the detection of preferred food sources.

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BACKGROUND

The appearance of a food product has been shown to contribute to expectations of how that product will taste (Levitan, et. Al, (In Press)). In addition to expectations, the ability to identify a taste, as measured by perceptual threshold, differs among hues (Maga, 1974). The task of identifying which of two samples is sweeter requires lower concentrations when the color of the substance is green than when it is red or yellow. Sour sensitivity were also reduced when the substance was green or yellow. These differences in sensitivity allow us to use color as a means of discriminating from among samples (Hoegg & Alba, 2007). Whether these threshold changes occur as a result of associations is unclear.

Preferences for food appear to be somewhat linked to color. Children prefer red candy to other hues (Walsh, et. Al, 1990). However, Hoegg and Alba did not replicate these findings in adults. Surprisingly little research examines the effect of color on perceived taste; this is especially true when considering the color of a product's packaging rather than the color itself.

The forces behind the evolution of trichromatic color vision continues to be debated among researchers, but there is little, if any, disagreement over whether foraging for food was involved. First hypothesized as an adaptation to detect the ripeness of vegetation (Osorio & Vorobyev, 1996), it is now thought to me more complicated (Sumner & Mollon, 2000; Regan, et. Al, 2000; Riba-Hernandez, Stoner, & Lucas, 2005). Although ripeness is likely a factor, it cannot fully explain the emergence of several phenotypes, none of which are optimized for ripeness detection (Sumner & Mollon, 2000). Detecting fruit and leaves, particularly when they are placed in specific backgrounds, is enhanced by specific phenotypes of trichromacy (Regan, et. Al 2000; Smith, et. Al, 2003), however, this advantage varies with environment and is even eliminated in favor of dichromacy in some cases. The content of fruit may be more responsible for this adaptation than ripeness or even presence (Riba-Hernandez, Stoner, & Lucas, 2005). Receptors in the eye that are most sensitive to red and green may be responsible for detecting fruit that is high in concentration of glucose.

Color vision in humans is trichromatic, involving three types of receptors in the eye, which vary in their sensitivity to specific wavelengths of light. This system allows us to perceive a wide range of hues and it evolved from one receptor to the four we have today. This evolution may shed light on the associations we make with various hues.

The present study investigates the relationship of packaging color and taste experience through a blind taste test in which the packaging of the product varied in hue. If the red/green opponency adapted to detect fruit high in glucose concentrations and red is preferred by children who may associate this hue with sweet fruit, red should be perceived as more sweet than other hues. In addition, because yellow and green fruits are more likely to be perceived as sour than red and blue, we predict that these hues will produce higher sourness ratings.

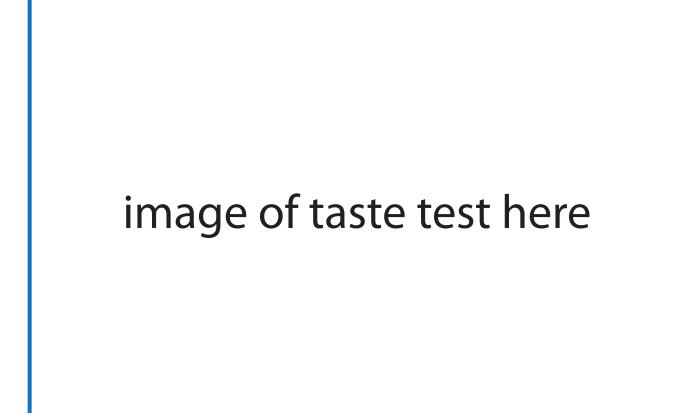


The packaging of sour candy, as well as the candy itself, is often yellow and green. If we associate these hues with sourness, perhaps due to the citrus fruits seen here, do we then expect the food to be sour? Does the food taste more sour?

METHOD

- Undergraduate students (N = 64) enrolled in a perception and cognition course participated for extra credit.
- Four containers of sugar-sweetened lemonade were prepared and poured into cups in the participants' view. The lemonade in each container was identical, however, combinations of container and assigned color were counterbalanced to ensure mixing differences did not affect the comparisons.
- Participants were told the study involved discriminating types of artificial sweeteners and the effects those sweeteners have on perceptions of sweetness and sourness. In addition, it was suggested that the cup color was a means of tracking counter-balanced samples.
- Participants were given lemonade in four cups which varied in hue (red, yellow, green, and blue). The colors of the cups were fully-saturated and chosen for their consistency of perceived brightness. They were color-matched to Pantone samples 186, 116, 355, and 272, respectively.
- Crackers were provided in addition to instructions to proceed with the next taste ratings only when no previous tastes remained.
- Participants rated the individual samples on scales of 1 to 7 for each of sweetness and sourness and were also asked to indicate which sweetener the sample contained (aspartame, saccharin, sucralose, or sugar).

image of taste test here



Participants were very engaged in this task. Many spent as long as 10 minutes to rate the four samples. Several students commented to the experimenters that they were certain which contained sugar and several asked to be given their personal results afterward.

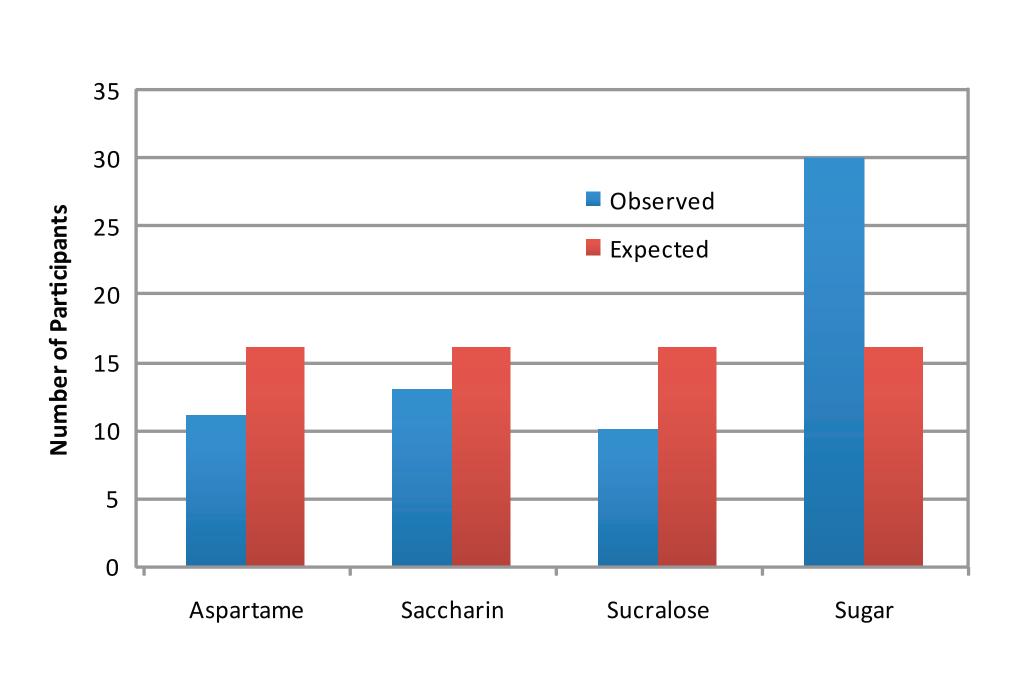
It should be noted that seven students in the class were asked to refrain from participation because experimenters know the students were exposed to several studies about color's effects during the previous semester.



RESULTS

Identification of Sweetener

■ 47% of participants (n = 30) indicated that the blue cup contained sugar. This differs significantly from chance, $\chi^2(3) = 16.63$, p = .001.



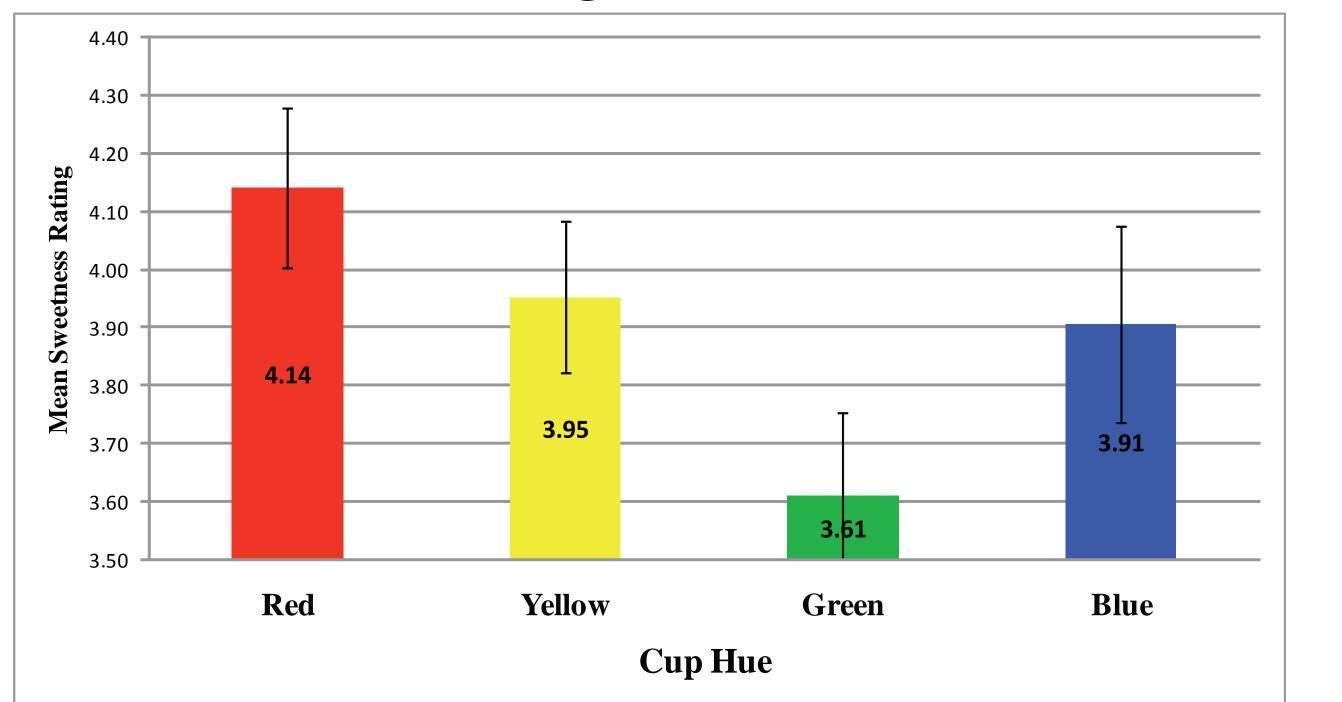
RESULTS (cont.)

A MANOVA revealed multivariate effect of hue, $F_{(6,58)} = 4.367$, p = .001; Partial $\eta^2 = .31$.

Ratings of Sweetness

- There was a main effect of hue on ratings of sweetness, $F_{(3, 189)} = 2.84$, p = .039.
- In post-hoc comparisons, red produced higher sweetness ratings than green, $Mean\ Difference = .531, p = .013.$

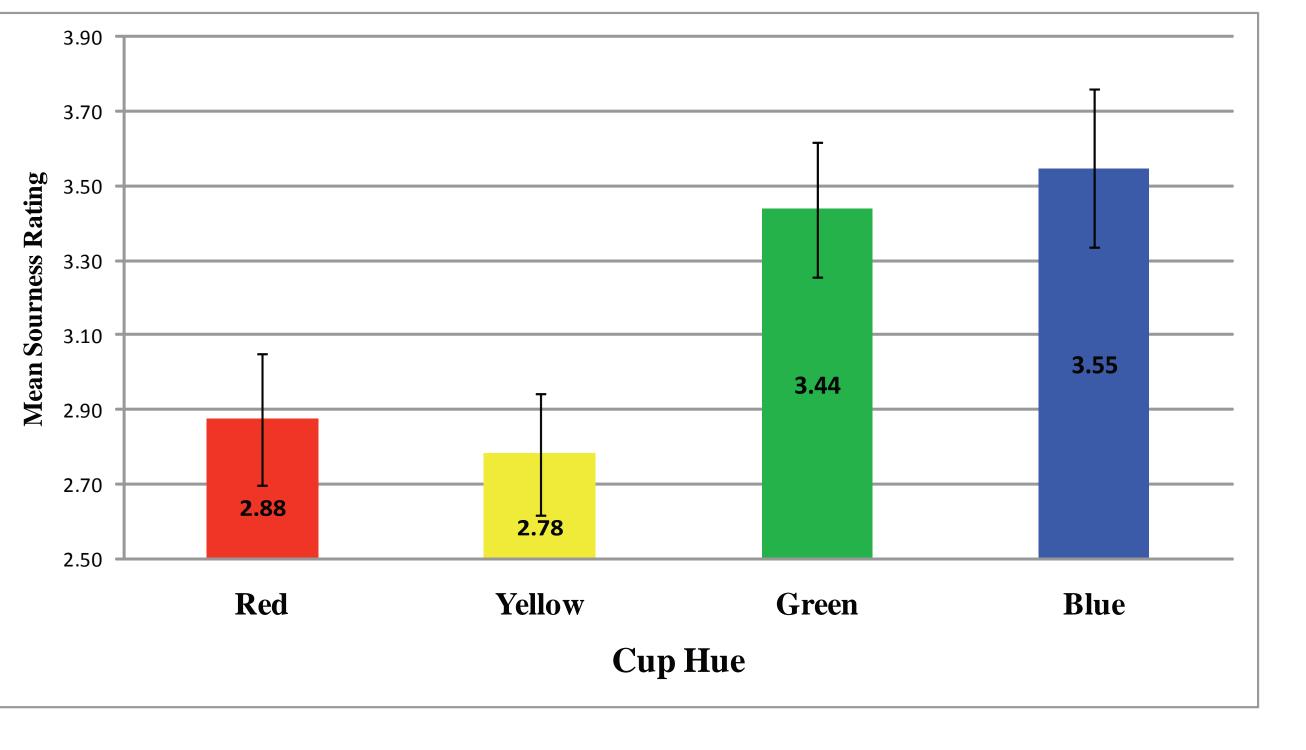




Ratings of Sourness

- There was a main effect of hue on ratings of sourness, $F_{(3, 189)} = 9.63$, p = .001.
- Sourness ratings were higher in the blue condition than yellow, *Mean Difference* = .766, p = .008 and marginally higher than red, *Mean Difference* = .672, p = .089. Green produced higher sourness ratings than yellow, *Mean Difference* = .656, p = .017.

Sourness Ratings as a Function of Hue

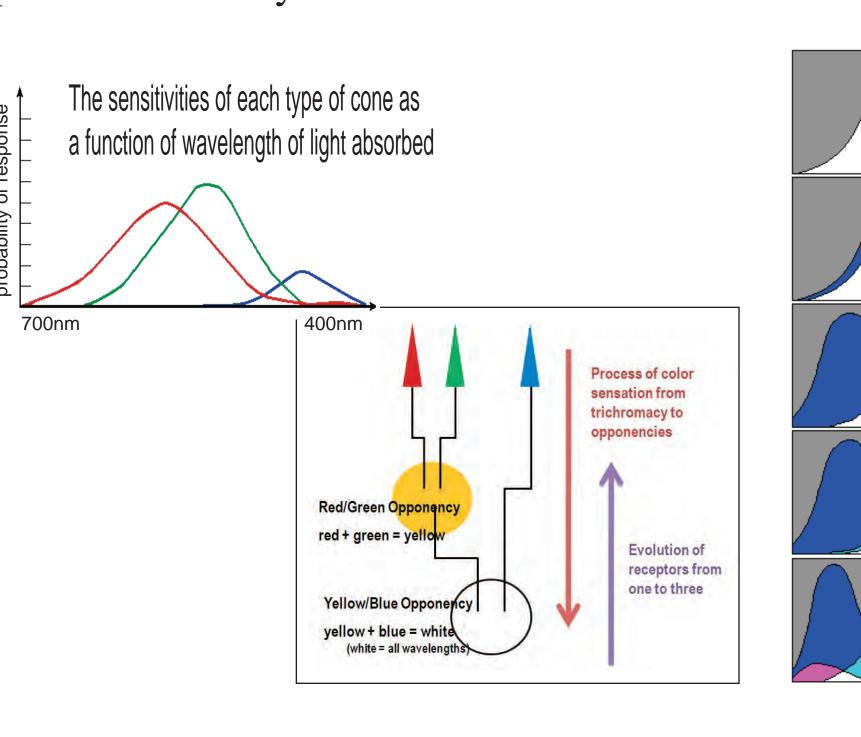


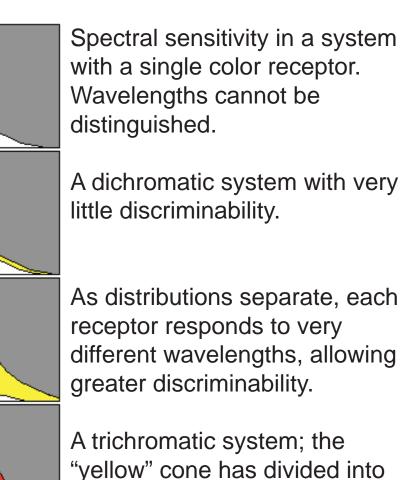
DISCUSSION

Partially consistent with hypotheses, the sample served in red cups was rated as sweeter than that served in green cups. One explanation for this finding is an influence created by the association of each hue with a taste quality, namely red with sweet and green with sour. Although the effects of expectation on visual and auditory perceptual processes are well-known, there is not enough research to determine if expectations affect taste or if a package's hue affects expectations. These ideas certainly warrant further investigation.

The results of sourness ratings are surprising, but, when considered with the effect on sweetness, suggest an explanation for both main effects. Although the yellow cups produced lower sourness ratings than green or blue, green produced high ratings, partially supporting our hypothesis. The most interesting finding was that the sample in the blue cup was rated higher in sourness than red or yellow. Since there is relatively little blue food, the relationship between hue and taste may be more complicated than simple associations.

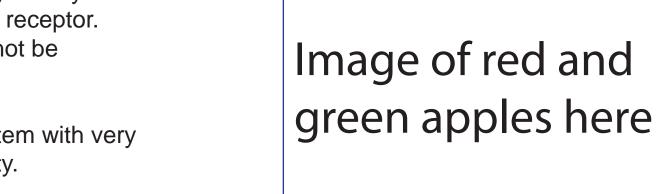
Trichromatic color vision involves three types of receptors in the eye called cones, which vary in their sensitivity to specific wavelengths of light. The "red" or "L" cone is named for its sensitivity to light of relatively long wavelength. These receptors are most likely to respond when the light it absorbs is approximately 560nm. "Green" or "M" cones respond maximally to approximately 530nm, and "blue" or "S" cones approximately 417nm. There is some variation in these sensitivities, however, and several phenotypes exist among primates that determine them. Some species of monkeys remain dichromatic and some have members of both categories.

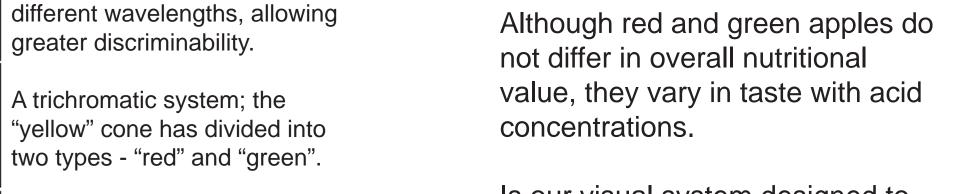




Greater divergence results in

greater discriminability.





Is our visual system designed to detect foods that provide specific nutrition?

The distribution of response probabilities in two conditions can be used to determine how well one distinguishes the two conditions. The distance between the means of these distributions, known in signal detection theory as "d-prime", is a measure of this distinguishability. Likewise, the distance between the means of spectral sensitivity curves is correlated with the individual's ability to distinguish between wavelengths. Our trichromatic system allows us to perceive a wide range of hues as a result of these distances and it evolved from one receptor to the four (including one receptor not specialized for color) we have today as a result of some pressure to do so.

Our findings are consistent with those of Riba-Hernandez, Stoner, and Lucas (2005), who examined the sugar content of fruits eaten by several species of monkey and discovered that animals with phenotypes with the greatest distance (in nanometers) between peak sensitivities of the L and M cones were better detectors of fruit that is high in glucose concentration than their counterparts. In addition, the greater the distance, the higher the glucose concentration of the fruits that animal was known to eat. Although glucose is not higher in caloric value than sucrose or fructose, detecting fruit that is high in glucose concentration may be an advantage due to the faster rate at which glucose is digested. Glucose is usually rated as less sweet than fructose or sucrose, so it is possible that the sweetness of these fruits correlates with dominant hue. It is important to note that Riba-Hernandez did not report spectral analyses of the fruit or if the hue of the fruit analyzed correlated with glucose content. However, the specific hue is not particularly relevant to their conclusions. What makes an object more visible if its hue is distinguishable from its background and other competing objects.

It is more difficult to explain our sourness findings since sourness is not often associated with energy or nutrition and blue is rarely found in food foraged by primates. However, the differences found clearly indicate that the opponencies of red/green and yellow/blue may be generalized to sourness experiences. Future research should examine the possibility that the earlier division of receptors into a yellow/blue opponency occurred in response to pressure to discriminate foods that vary in acid concentrations.

The most puzzling finding was the result of additional analysis of the "cover story" for the study. Nearly half of the participants indicated that the blue cup contained sugar, although the sample in the blue cup received the highest sourness ratings. Table sugar is sucrose, which is generally sweeter than glucose, however, the alternatives were artificial sweeteners. Do people believe that artificial sweeteners make foods sweeter than sugar?

REFERENCES

Hoegg, J. & Alba, J. W. (2007). Taste perception: More than meets the tongue. *Journal of Consumer Research*, 33, 490-498.

Levitan, C. A., Zampini, M., Li, R., & Spence, C. (In Press). Assessing the role of color cues and people's beliefs about color-flavor associations on the discrimination of the flavor of sugar-coated chocolates. *Chemical Senses*.

Maga, J. A., (1974). Influence of color on taste thresholds. *Chemical Senses and Flavor*, 1, 115-119.

Osorio, D., & Vorobyev, M. (1996). Colour vision as an adaptation to frugivory in primates. *Proceedings: Biological Sciences*, 263(1370),

Pangborn, R. M. and Hansen, B. (2000). The influence of color on discrimination of sweetness and sourness in pear-nectar. *American Journal of Psychology*, 76(2), 315-317.

Regan, B.C., Julliot, C., Simmen, B., Viénot, F., Charles-Dominique, P., Mollon, J.D. (2000). Fruits, foliage and the evolution of primate colour vision. *Philosophical Transactions: Biological Sciences*, 356 (1407), 229-283.

Riba-Hernandez, P., Stoner, K. E., & Lucas, P. W. (2005). Sugar concentration of fruits and their detection via color in the Central American spider monkey. *American Journal of Primatology*, 67, 411-423.

Smith, A.C., Buchanan-Smith, H.M., Surridge, A.K., Osorio, D., and Mundy, N.I. (2003). The effect of colour vision status on the detection

and selection of fruits by tamarins. *The Journal of Experimental Biology*, 206, 3159-3165.

Sumner, P. and Mollon, J.D. (2000). Chomaticity as a signal of ripeness in fruits taken by primates. *The Journal of Experimental Biology*,

203, 1987-2000.
Walsh, L., Toma, R., Tuveson, R., & Sondhi, L. (1990). Color preference and food choice among children. *Journal of Psychology, 124*(6), 645-653.

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