[McNair Scholars Research Journal](https://commons.emich.edu/mcnair)

Volume 11 | Article 8

2018

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ABSTRACT

Human taste perception can be analyzed in different areas of study. Physiology and psychology work together to construct the way we taste, and our sense of taste is not obtained merely from the tongue. The process of tasting involves olfaction, vision, and texture reception to form our overall perception of taste. The present study involved 25 participants who tasted and rated multiple samples of flavored gelatin. Half of the gelatin samples were unlikely color/flavor combinations, and half were unlikely flavor/scent combinations. Responses to the flavors as perceived were collected and used to gain insight into the interactions among sight, smell, and taste perception.

INTRODUCTION

Every time we consume food or drink, a number of physiological and psychological processes take place to construct the way we perceive that food or drink to taste. Every person's taste sensation interacts with vision and olfaction to form their overall perception. Are our learned ideas of how a certain colored food should taste stronger than our physiological olfactory system in the formation of our taste perception? While it is known that many different processes take place in the perception of taste, ample research suggests the significance of color and scent when human taste perception is concerned.

Skrandies and Reuther (2008) examined the relationships between odor, taste, color, and food in two ways: by administering questionnaires to subjects and by conducting electrophysiological experiments. Skrandies and Reuther (2008) stated that some preferences for smell and taste are refined during ontogenetic development, and that color and food are interconnected, demonstrating a relationship between the chemical senses and our perception of color (Demattè, Sanabria, & Spence, 2006, as cited in Skrandies & Reuther, 2008). Zellner, Bartoli, and Eckard (1991) stated that subjects prefer drinks that are colored to match the color of their flavor source, lending to the notion that perception of food and food preferences are determined partially by the compatibility of the food to its color (as cited in Skrandies & Reuther, 2008). Skrandies and Reuther (2008) concluded that:

> *Many cognitive effects occurred quite early in their study, suggesting rapid cognitive processing of information on odor, taste, color, and food items, making this a potentially important prerequisite for the preconscious and fast choice of food items in everyday behavior. (p. 183)*

Delwiche (2012) noted that "one can view flavor as an emergent phenomenon that arises from the combination of taste, odor, and *chemesthesis*, or a combination of multiple sensations" (p. 502). Also, "visual appearance can influence the interpretation of complex stimuli and alter the perception of taste, odor, and flavor" (Delwiche, 2012, p. 502). Delwiche (2012) explained that foods are misidentified more frequently when they are miscolored or uncolored, in contrast with identification of appropriately colored alternatives. For example, coloring a white wine with a pigment commonly seen in red wine has led subjects to describe the colored white wine with odor terms typically associated with red or dark objects (Delwiche, 2012). When the white wine is served in its original state, the wine is described with white wine odor terms that are associated with yellow or clear objects (Delwiche, 2012). Delwiche (2012) stated that color affects stimulus identification, description, and intensity ratings, however, the extent of the effect varies, depending upon how strong the flavor-color association is; "the stronger the color-flavor association, the greater the impact of color" (p. 503).

A study conducted by Ndom, Elegbeleye, and Ademoroti (2011) examined the effect of color on taste perception, quality, and liking of different fruit-flavored drinks. Ndom et al. (2011) wrote that:

> *Participants who were exposed to inappropriate color and taste stimuli had problems identifying the flavor of the fruit flavored drinks, while participants exposed to appropriate color and taste stimuli had no problem at all in identifying the taste of the stimuli. (p. 183)*

The results suggested that the specific color of a fruit-flavored drink can impact the way one may perceive the taste and the quality of the colored drink (Ndom et al., 2011). They added that, "The effect food color has on taste perception highlights the fact that perception is a cognitive process that receives information both from the sensory impact of food ingredients and from other sources of information about the food" (p. 169).

Koch and Koch (2003) studied the preconceptions of taste based on color by using a questionnaire administered to 45 college students that related eight tastes with 10 colors. The survey examined the role of color in the perceived taste of soft drinks, using the colors red, green, yellow, blue, brown, orange, purple, black, gray, and white colors commonly used in the packaging of soft drinks and the actual color of soft drinks. Taste choices offered by the survey were "sweet," "sour," "bitter," and "salty." The results showed that:

> *The colors red and orange were positively associated with sweet, green and yellow were associated with sour, yellow and orange were associated with citrusy, and red, yellow, and orange were positively associated with a non-citrus fruit taste…Only white was positively associated with salty, and only brown was positively associated with syrupy. (Koch & Koch, 2003, p. 237) ... These results indicate that a limited number of colors are positively associated with preconceptions of certain tastes. (Koch & Koch, 2003, p. 233)*

Shepherd (2006) reviewed recent advances in the brain mechanisms of smell perception and put forward several hypotheses for integrating these mechanisms into current theories of the neural basis of flavor, referred to as a "complex multisystem percept" (p. 316). Shepherd (2006) indicated that, "taste stimuli elicits basic human emotions of pleasure (sweet) and disgust (bitter), which are hard-wired in the brain from birth, while the affective responses to odor images seem to be mostly learned" (p. 318). While ingesting food, retronasal stimulation occurs, "when volatile molecules released from the food in the mouth are pumped, by movements of the mouth, from the back of the oral cavity up through the nasopharynx to the olfactory epithelium" (Shepherd, 2006, p. 317). According to Shepherd (2006), "retronasal olfactory stimulation can be studied by introducing odor stimuli at the back of the mouth or by their release from ingested foods" (p. 317). The retronasal air that is filled with food molecules is sensed as part of the taste of food and has been shown to be significant when it comes to flavor identification, in turn making a large part of flavor due to smell. Additionally, smell can be almost entirely concealed from our conscious perception due to being largely attributed to taste.

Laing, Link, Jinks, and Hutchinson (2002) conducted a study that aimed to determine whether odor and taste stimuli are processed independently when they are present in a mixture. The study was conducted using two experimental procedures: first, "to determine the number of components that subjects can identify in stimuli containing up to five common tastants" (p. 619), and second, "to determine whether the capacity of humans to analyze mixtures of odor and taste stimuli is greater than that for mixtures of tastes alone" (p. 626). The conclusion of experiment one found that "subjects could not identify all the components of mixtures once three or more tastants were present" (p. 624); experiment two found that "the capacity of humans to identify the components of odor-taste mixtures was not greater than for mixtures containing only tastants" (p. 629). Laing et al. (2002) ultimately concluded that humans have a finite capacity to classify the components of taste mixtures and odor-taste mixtures. Where odor mixtures are concerned:

> *Both physiological and psychophysical data support the proposal that a combination of neural inter-*

> *actions and the limited capacity of working memory are the primary causes of the limitation. Similar mechanisms may be responsible for the limited capacity to analyze taste mixtures and may account for human responses to odor-taste mixtures. (p. 634)*

Djordjevic, Zatorre, and Jones-Gotman (2004) "odor-induced changes in taste perception (OICTP), by examining the influence of strawberry and soy sauce odors on perceived sweetness and saltiness" (p. 405). The researchers compared the effects of imagined odors to the effects of odors actually presented. In addition, the researchers examined, "whether taste-smell interactions occur at the central level by delivering odorants (strawberry, soy sauce, odorless water) and tastants (sucrose, sodium chloride) separately" (p. 405). Djordjevic et al. (2004) found "specific taste-smell interactions: sweetness enhancement [was] induced by strawberry odor, and saltiness enhancement [was] induced by soy sauce odor, all of which were elicited with separate delivery of olfactory and gustatory stimuli" (p. 405). Djordjevic et al. (2004) stated that imagined odors demonstrated less of an effect on taste perception than physically perceived odors: "Imagined strawberry odor somewhat enhanced perceived sweetness of water and imagined soy sauce odor enhanced perceived saltiness of weak sodium chloride solutions" (p. 407). The research concluded that "odor-induced changes in taste perception (OICTP) is a centrally mediated phenomenon, and that imagined odors can to some extent induce changes in perceived taste intensity comparable to those elicited by perceived odors" (p. 405).

When attempting to understand the process of human taste perception, it is important to take into account the cases where one or more of the senses involved in taste perception is absent. Stinton, Atif, Barkat, and Doty (2010) examined the influence of smell loss on taste function by utilizing an olfactory test called the North American version of the Smell Identification Test (UPSIT) on subjects who "presented to the Smell and Taste Center with complaints of chronic chemosensory disturbance attributable to olfactory dysfunction" (p. 257). Additionally, subjects received whole-mouth and regional chemical taste tests, along with electrical threshold tests. Following the study, Stinton et al. (2010) suggested that "compromised smell function is unlikely to cause decreased ability to taste, as measured by quantitative whole-mouth and regional chemical and electrical tests of taste function" (p. 261). Stinton et al. (2010) noted that, despite their lack of evidence demonstrating smell loss having an effect on taste function, it is known that the olfactory and gustatory systems are complementary, and that odorants can become associated with taste qualities through conditioning. Stinton et al. (2010) stated that, "Although odorants can take on taste-like qualities through conditioning, tastes are less likely to take on odor-like qualities, conceivably reflecting the more independent projection pattern of the olfactory system" (p. 262).

METHODOLOGY

Participants

In the present study, a total of 25 anonymous subjects volunteered to participate in a two-part gelatin sampling procedure. About half of the participants were male, and half were female, ranging in age from eighteen years old to eighty years old. Recruitment consisted of word of mouth and advertisement of the study on social media. No specific requirements were necessary in order for one to participate. Prior to the start of sampling, each participant was verbally instructed to read the contents of the given consent form and provide a signature of consent.

Procedure

This study consisted of a two-part gelatin sampling procedure. Part One of the gelatin sampling consisted of the participant tasting five different colored gelatin samples (i.e., red, yellow, green, blue, and purple). The gelatin created by the researcher for Part One of this study had intentionally been dyed with a food coloring that contrasted with the assumed flavor for that color: red gelatin was grape flavored, green gelatin was lemon flavored, blue gelatin was strawberry flavored, yellow gelatin was orange flavored, and purple gelatin was apple flavored. In order to create these gelatin color/flavor mismatches, the researcher used a combination of Knox clear and flavorless gelatin, clear fruit-flavored extracts, and food coloring.

Following completion of the consent form, participants were given a questionnaire packet that contained questions regarding each gelatin sample. Prior to tasting, participants were instructed to answer the first question pertaining to that gelatin sample. After tasting, participants were instructed to answer the second question pertaining to that gelatin sample and so on. The first question for each sample asked, “Before tasting the specified gelatin sample, what do you imagine the flavor to be?” Answer choices for this question consisted of a list of flavors typically associated with a color: strawberry, grape, lime, blueberry, apple, lemon, and orange. The second question for each sample asked, “After tasting the specified gelatin sample, what did you perceive the flavor to be?” Answer choices for this question consisted of the same list of flavors typically associated with a color: strawberry, grape, lime, blueberry, apple, lemon, and orange.

Part Two of the gelatin sampling procedure consisted of the same participants tasting five different colorless fruit-flavored gelatin samples while simultaneously smelling a contrasting fruit-scented air freshener. Participants were asked to hold the air freshener up to their nose while they analyzed the taste of the clear gelatin. Using the same question packet from Part One, participants were instructed to answer one question after sampling had taken place. Similar to Part One, the question asked was, “After tasting the specified gelatin sample, what did you perceive the flavor to be?” Participants were asked to circle which flavor they perceived from the same list of options: strawberry, grape, lime, blueberry, apple, lemon, and orange. In order to create these clear gelatin samples, a combination of Knox clear and flavorless gelatin, along with clear fruit-flavored extracts, was used.

RESULTS

Data Analysis
Color/Flavor Mismatch

Prior to tasting the red gelatin, 22 of the 25 participants (88%) predicted the flavor to be strawberry. After tasting, 11 of the 25 participants (44%) perceived the flavor to be strawberry again, while eight participants (32%) perceived the correct flavor of grape. Prior to tasting the blue gelatin, 24 of the 25 participants (96%) predicted the flavor to be blueberry. After tasting, 12 of the 25 participants (48%) perceived the flavor to be blueberry again, while eight participants (32%) perceived the correct flavor of strawberry.

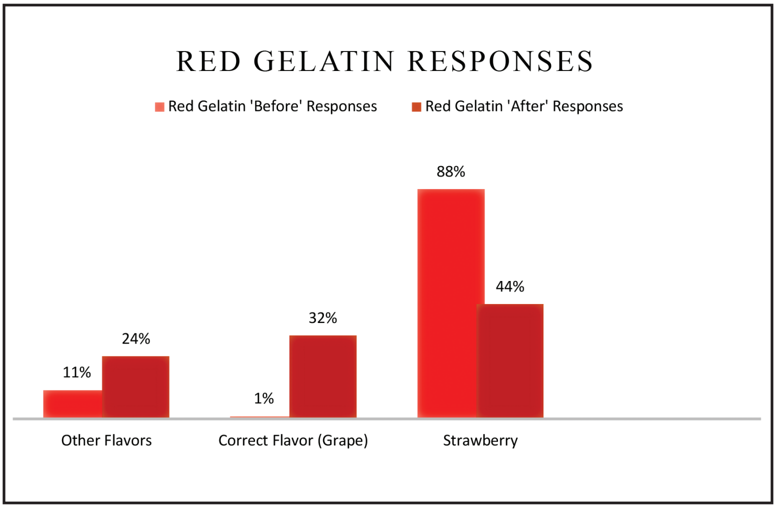

Figure 1. Comparison of red gelatin responses before and after tasting.

A Fisher Exact Probability Test was performed to examine the relationship between color and flavor perception. Among the five different colored gelatin samples, the red and the blue gelatin showed the most statistically significant relationship between before and after responses.
The color red Fisher Exact = 0.004 (2df), $p < 0.01$ (Figure 1). The color blue Fisher Exact = 0.0004 (2df), $p < 0.01$ (Figure 2).

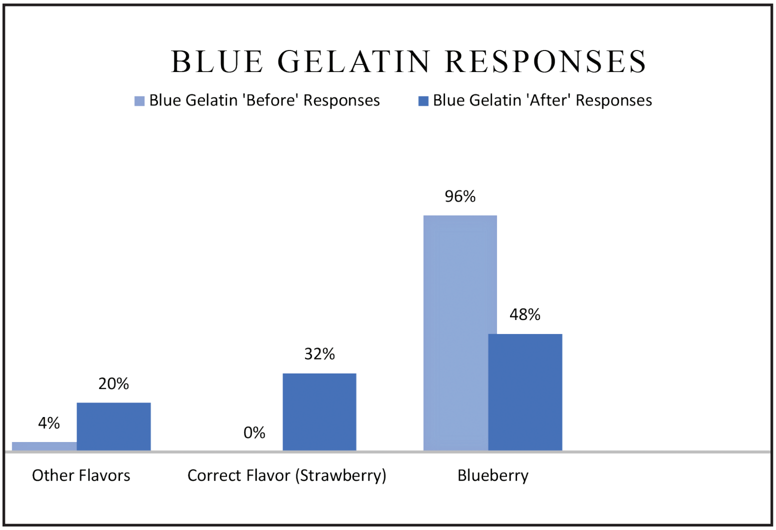

Figure 2. Comparison of blue gelatin responses before and after tasting.

Flavor/Scent Mismatch

Of the 25 participants, 32% perceived the orange-flavored gelatin sample to be the correct flavor, while 40% of participants perceived the lemon-scented air freshener to be the flavor. Of the 25 participants, 20% perceived the strawberry-flavored gelatin sample to be the correct flavor, while 48% of participants perceived the orange-scented air freshener to be the flavor. A Fisher Exact Probability Test was performed to examine the relationship between scent and flavor perception. The results demonstrated that scent did not have a statistically significant effect on participants' perception of flavor, Fisher Exact = 0.7 (2df), $p < 0.01$.

DISCUSSION

The data collected in the present study demonstrated an important interaction between color and human taste perception. Of the five colored gelatin samples, red and blue demonstrated the most significant relationship between color and its effect on taste perception. Among the clear samples, the orange flavor/lemon scent pair, along with the strawberry flavor/orange scent pair, demonstrated that a significant relationship between scent and taste perception did not take place in our study. Our results demonstrate a relationship between color and taste perception and also replicate previous findings. This research demonstrates that, when participants are exposed to inappropriate color and taste stimuli, difficulties arise in identifying the flavor. Vanderbilt (2015) suggested that our eyes are arguably the most important gustatory organ, being that more than half of our cortical real estate is dedicated to processing vision. This phenomenon ultimately lends itself to vision having an effect on how we taste food. Future research into the effects of specific colors on taste perception would be valuable in interpreting these interesting interactions. Additionally, utilizing a larger pool of participants could prove to be beneficial in gathering substantial data.

REFERENCES

Delwiche, J. F. (2012). You eat with your eyes first. *Physiology & Behavior, 107*(4), 502-504.

Djordjevic, J., Zatorre, R. J., & Jones-Gotman, M. (2004). Odor-induced changes in taste perception. *Experimental Brain Research, 159*(3), 405-8

Koch, C., & Koch, E. C. (2003). Preconceptions of taste based on color. *The Journal of Psychology, 137*(3), 233-42.

Laing, D. G., Link, C., Jinks, A. L., & Hutchinson, I. (2002). The limited capacity of humans to identify the components of taste mixtures and taste–odour mixtures. *Perception, 31*(5), 617-635.

Ndom, R. J. E., Elegbeleye, A. O., & Ademoroti, A. O. (2011). The effect of colour on the perception of taste, quality and preference of fruit flavoured drinks. *Ife Psychologia, 19*(2), 167-189.

Shepherd, G. M. (2006). Smell images and the flavour system in the human brain. *Nature, 444*(7117), 316-21.

Skrandies, W., & Reuther, N. (2008). Match and mismatch of taste, odor, and color is reflected by electrical activity in the human brain. *Journal of Psychophysiology, 22*(4), 175-184.

Stinton, N., Atif, M. A., Barkat, N., & Doty, R. L. (2010). Influence of smell loss on taste function. *Behavioral Neuroscience, 124*(2), 256-264.

Vanderbilt, T. (2015). The colors we eat. *Nautilus, Color* (026). Retrieved from http:// nautilus /issue/26/color/the-colors-we-eat