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The Effects of Color on Flavor

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NORTHERN ILLINOIS UNIVERSITY

The Effects of Color on Flavor

A Capstone Submitted to the

University Honors Program

In Partial Fulfillment of the

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With Honors

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Psychology

By

Tiffany Yoo

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Abstract

Color and its relation to flavor, is a complex cognitive phenomenon that researchers today are still trying to decipher. The present literature review is an examination of the history of color, process of color perception, the effects of additional factors such as saturation, the exploration of senses that may potentially contribute to perception itself, and the different modern theories suggested. The purpose of this project was to review, revise, and narrow down which theories can be deemed as accurate in terms of the amount of support addressed by modern literature. While a clear-cut answer was not concluded, three potential theories were found to be heavily suggested by research. This literature reviews overall end goal is to be a convenient research tool that appeals to all demographics in terms of academics.

Introduction

There's a famous saying that claims "we eat with our eyes first", and while many use it merely as a joke, modern research reflects that there are some truths to it after all. Color, something that people believe to be solely perceived visually, is arguably the single most important product-intrinsic sensory cue when it comes to setting our expectations of the taste and flavor of foods and drinks (Charles & Fiszman, 2016). In simpler terms, the shade of a food item influences flavor perception, but how and why? The purpose of this literature review was to explore this phenomenon by touching briefly on the history of color perception, monumental discoveries throughout history, and to discuss modern theories that are supported by the literature.

History of Color

In order to explore the causes behind the effects of color on taste perception, researchers needed to understand perception itself, which is what researcher H. J. Eysenck (1941) sought out to do. Inspired by the first empirically supported published article within the field of perception by researcher J. Cohn, Eysenck decided to also dive deeper into the world of color perception as well. They explored three different factors, which were general preference, saturation factor, and sex difference, as potential contributors to color biases. General preference was defined as a bias towards color, the reasoning behind this factor being noted, is due to controversial research concluded by J. Cohn. Cohn denied the existence of general biases, whereas Walton, Guilford and Guilford (1933) discovered during their study that a mutual basis of feeling for specific colors existed (Eysenck, 1941). Saturation was the next factor explored, as it was mentioned in J. Cohn's study to have the most significant effect when it comes to color preferences, but research conducted by others such as Washburn, Walton and colleagues, concluded that saturation played

a minimal role when it came to color perception (Eysenck, 1941). The final factor that was measured was sex difference, which was defined as a certain preferences of colors depending on sex. This was measured based on observations and information from previously published literature and works from St. George who claimed that blue stands out more predominantly for men and Dorcus who stated that yellow is more in males were emphasized (Eysenck, 1941). In the current experiment, participants consisted of university students, a few individuals in the professional world, and two artists, but equally distribution when it came to sex. Two separate experiments were conducted, in which all were given the same condition. All participants were shown sets of colors and asked to rank the provided colors in order of preference. The difference between the two groups was for data collecting reasons, as the factors and results between sexes were measured separately. In the first group, 66 positive correlations were discovered and yielded only a single negative correlation. The results of the first group indicate that general preference and saturation do play a part in color perception and preferences. Similar discoveries were seen in the second experiment, and the only difference that was noted is that women tend to prefer yellow whereas men tend to prefer orange. In terms of the main discoveries, it was highlighted that there was a certain general color preference amongst people, saturation did play a part in selection, and that the sexes did not share a significant difference in preference other than yellow for female and orange for male (Eysenck, 1941).

History of Color Perception

Once the complexity of color was understood, researchers wanted to see how it affected other cognitive functions, one focus being flavor. The effects of color on flavor is a rather recent phenomenon, and despite only being studied for around 80 years, many theories have been suggested. While some discoveries are no longer supported by modern science, certain

ideologies still prevail today, and its beneficial to see how theories on this effect have shifted overtime.

In 1933, researchers Walton, Guilford and Guilford (1933) decided to explore this effect by conducting an experiment on previously collected data (Wm. E. Walton et al., 1933). Participants consisted of 1279 University of Nevada students, the experiment stimulus was the Milton Bradley colored papers, and data was collected over the course of 14 years. Participants were shown two colors at a time for a duration of 5 seconds, and then asked to select the more pleasing color. What they discovered was that certain color preferences between the sexes existed, such as men preferring orange over yellow (Wm. E. Walton et al., 1933). It was also noted that color preferences shifted over the years, most likely due to social waves, but despite the influence of social expectations, underlying biological factors still somewhat played a role when it came to color preference (Wm. E. Walton, 1933).

In 1960, researcher at the University of California, Rose Marie Pangborn (1960) wanted to explore sweetness discrimination and its relation to color (Pangborn, 1960). The experiment utilized solutions that consisted of various concentrations of citric acid, imitation flavors, sucralose, and colored distilled water, as a means to influence the behavior of color discrimination in participants. Participants consisted of a group of 12 highly trained individuals and 10 untrained individuals, who were asked to taste the pairs of solutions provided. Pangborn then proceeded to ask participants to review the solutions, and to rank the sweetness of each one. As result, the untrained panels were seen to associate greater sweetness to orange-red colored solutions in cases where the sucrose differences were minimal, which highlighted the effects of color influences. In regards of green colored solutions, the results remained consistent for both

groups, in which green was ranked the least sweet, and it was speculated that this was due to greens general association to tartness (Pangborn, 1960)

In 1980, researchers DuBOSE and colleagues (1980) wanted to test the effects and potential outcomes of color masking when it came to flavor perceptions (DuBOSE et al., 1980). One experiment utilized cherry and orange flavored solutions that were dyed in four varying shades as stimuluses, the reason being to see if the color concentration of the same solution influenced participants ratings. Participants consisted of 27 individuals under the cherry/red condition and 25 participants under the orange/orange condition. Participants were given a warning in the form of a disclosure message, that informed them of the deceptive food dye being used to see if it would deter them from biases. As result, researchers discovered that, despite being informed of the dyes being used, the information had no impact on participant's decisions (DuBOSE et al., 1980). It was also discovered that, overall, acceptability was seen to increase as color and flavor both increased in both red and orange solutions, but significantly more predominant when it came to red solutions.

Modern Theories

As time went on, thanks to the works of previous researchers, the causes of color and its effects on flavor perception was eventually narrowed down into three different theories, which are the Prior Experience theory, the Biological Factors theory, and the Cross-Modal Influence theory. The Prior Experience theory in simplified terms can be described as, the previous experiences of an individual in relation to color which ultimately set their expectation for certain flavors. The biological factors theory can be defined as, natural influences such as arousal and unconscious interpretations being the root cause of one's flavor perceptions. Finally, the Cross-Modal theory is simply defined as a multi-faceted process, in which the olfactory, oral-

somatosensation, and gustation, all play a part if how color effects flavor. While all these theories are all supported by modern literature, yield substantial empirical evidence, some limitations question their validity.

Prior Experience Theory

Memories can be defined as data that is stored for a multitude of purposes, one being convenience. Convenience in this sense means that if a familiar situation were to occur in the future, our brain will know how to react, for example, studying for a test. How does this correlate with flavor, well, when asking individuals what flavor a red popsicle is, the chances that a red fruit is the predominant answer shouldn't come as a surprise. Although it may go unnoticed, the brain remembers and creates associations unconsciously of the experiences acquired, listing a few examples regarding foods, red sweet strawberry, green sour apple, orange citrus, and so on. One researcher who explained this theory more in depth was J. A. MAGA (1974). MAGA wanted to see if there were any associations between color and taste, specifically with the colors red, yellow, and green, while utilizing the flavors sweet, salty, sour, and bitter. Participants consisted of 28 untrained individuals who were university students. Liquids were used as the stimulus, participants were given both colored and uncolored beverages, and asked to review the flavor profile of each one. It was discovered that colors such as yellow and green had significant results, green was seen to increase the sweetness threshold while yellow was seen to decrease the sweetness threshold, and red remained consistent when tested for sweetness. In regards of tests of bitterness, the color red was statistically seen to decrease participants perception of bitterness, whereas both green and yellow remained consistent. It was mentioned that prior experiences with natural fruits and their colors had potentially contributed to the results, ultimately influencing the

participant's perceptions of the beverages. Many may argue that this research is out of date, and while the time of its collection is, this research has been replicated multiple times with consistent results. Researchers Spence and colleagues (2010) decided to explore MAJA's research, to test and see if their discoveries still held any truth in modern times. What he concluded was that, not only did this theory remain valid, but other senses also played a part in perception. The strongest cue for memory is not visual or taste, but smell, which is what he decided to explore, further branching out research published by MAGA. After conducting a literature search through published journals and publications, he discovered that traits such as identity and intensity were all predominant factors when it came to flavor perception (2010). This theory seems like a plausible explanation for why color effects flavor perception, but it has one obvious limitation, that being, it is a very Euro/Western-centric. Memories and experiences in the sense of what is considered socially correct, are based off of cultural experiences, this means that, what one population views as sweet may not be the same for another, hence why this theory cannot be used as a universal definition. This then led researchers to the question of, could it be biology, the manifestation of an unconscious survival response then?

Potential Biological Factor

Looking around the world, it's fair to say civilization has prospered at an exponential rate, with cars, cellphones, skyscrapers, the list goes on, but one thing that hasn't changed that much is humans themselves. Biologically, humans as a species have not changed significantly, one fun way to view this is, modern human are essentially cave men with laptops. When walking out late at night, it's not uncommon to feel on edge, tense, or fear, that sensation is known as a survival instinct referred to as anxiety (Steimer, 2002). Although it may not serve much of a

purpose in today's world, it was crucial for ensuring the survival of the human species in the past. If humans still possess and act out survival instincts unconsciously, what else was passed down and influenced by the body's survival system? Foroni and colleagues (2016) believed that underlying mechanisms, such as these survival instincts, played a part in why humans perceived certain colors as more enticing when it came to food selection. He explained that the reasoning behind this theory came to be after observing non-human primates and noting how they selected foods based on brightness, specifically red and green. He suggested that this was due to biological color cues, and that red signaled higher energy content from the fruits and higher protein content from the leaves (Foroni et al, 2016). The current study examined if this effect still occurred in modern times by using images of varying red and green foods of different shades, and measured the levels of both arousal, and perceived calorie content. Arousal was hypothesized to be associated with motivation, hence why it was selected as a measure. In order to measure arousal, the 68 participants were given two images with the same color, the difference being that one was a food item, and the other image was a non-edible item. Reviewing the results, it was discovered that only for food items was the linear model statistically significant, and as the brightness of red increased, the rate of both arousal and calorie content increased. Green on the other hand, was seen to have no significant results, highlighting the effects of red. It was concluded that, although modern life may have altered human's perception of calorie content in foods, humans still seem to possess biases influenced off certain hues. This biologically backed theory essentially explained why colors are perceived and how they elicit certain responses, but the issue now is, what mechanisms are responsible for this naturally occurring process then?

Cross-Modal Theory

Previous theories insinuated that colors relation to flavor perception may be because of biological factors, but never delved deeper into what specific mechanisms, reactions, and processes took part in the effect, that is until recently. The Cross-Modal theory hypothesized that sensory receptors such as the olfactory, gustation, and oral somatosensation, all played a part in perceiving flavors. It's believed that, as visual information is being processed, these three works simultaneously to create a reaction, which in this case, would be flavor perception (Spence et al., 2010). Koza and Colleagues (2005) chose to specifically study this effect utilizing odorants to further investigate the effects of color and the perceived oronasal odor relationship. The significance of this potential correlation would be that it supports the theory that color and flavor perception stem from a multimodal effect, specifically a cross-modal effect in which the mechanisms work together. In the current study, participants that consisted of 15 individuals, were given solutions of colored, colorless, fruit-scented, and unscented liquids, that all possessed little to no gustation properties. Solutions were prepared as odorless and colorless, odor and colorless, odorless and colored, and odor and colored. Participants were handed a solution one at a time and then asked to rate each solution by the intensity of odor. The results showed that participants rated the dyed odor solutions higher in fruitiness compared to the colorless odor solution, successfully replicating previous studies that suggested the existence of a color-induced odor enhancement effect. Looking at another study, in 2007, Zampini and colleagues (2007) conducted an experiment to see if other senses could override flavor perception. Solutions of various flavors and colors were used as the stimulus, in which the colors purposely did not match the flavor profile. Participants consisted of 11 untrained females, who were informed beforehand that the shade and color of the solutions had no correlation to the flavor, then asked to rate each

solution. Participants were then asked to taste the solution and determine if the solutions were colored appropriately or inappropriately based on perceived flavor. Despite knowing that the color had no influence on the flavor of the solutions, flavor discrimination for inappropriately colored solutions suffered dramatically compared to solutions that were appropriately colored. In conclusion, this study insinuated that visual cues along with color perception can override gustation (Zampini et al., 2007). This seems to be the most plausible theory in modern times, for not only does it explain the certain mechanisms occurring during the perception process, but it is also the most predominant theory seen across multiple modern publications.

Conclusion

Perception is a complex concept, and in some respects, it is what determines how one views reality. It is also something susceptible to outside influences beyond consciousness, one example being the focus of this literature review, color and its effect on flavor. The color perception theory has seen many shifts throughout history, from being viewed and labeled as an unbiased decision, a response to previous experiences, then theorized to be the result of unconscious survival instincts, to a complex multimodal process that occurs as a product of visual information. In modern times, out of the three most prevalent theories, those being the Prior Experience theory, the Biological Factor theory, and the Cross-Modal theory, it is hinted that future research will most likely build off and continue exploring the Cross-Modal theory for its continuously consistent evidence.

Limitations

Color and its effect on flavor perception is still a rather new concept, and unfortunately as result, it is too premature to champion one theory as fact. It’s also important to note that much of

the research regarding this concept originates from Euro/Western centric ideologies, and that cultural differences between nations were not explored nor taken into consideration.

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