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INTERACTION AMONG GUSTATION, OLFACTION, AND VISION IN FLAVOR IDENTIFICATION

A RESEARCH ARTICLE

by Michael J. Lauth

Abstract

Even though the senses of taste, smell, and sight are distinct, there is a significant overlap among them in our perceptions of objects that helps us understand and differentiate the world. Everyone has experienced, when his or her nose gets congested, that his or her sense of taste changes as well. Many individuals do not equally understand the top-down processing with taste when someone sees objects they are about to eat. In the replicated study by our principle investigator, a random convenience sample of young adults ($n=162$) were recruited and tested to determine if they could taste four Jelly Belly flavors with one of the three different conditions: taste alone, taste with smell, or taste with smell and sight. The study revealed significant differences between the number of sensory systems used and the accuracy of flavor detection. However, no significant differences in results were observed between genders and/or for smokers versus non-smokers.

Introduction

Our perception of the world depends on various interactions between our sensory systems. The separate senses are gustation, olfaction, auditory, somatosensory and vision. According to Moir (1936, as cited by Prescott 2012), for the past 80 years researchers have been determining if the perception of gustation withfood is integrated with other simultaneous stimuli, like vision and/or olfaction. Understanding these interactions is important for researchers to understand that everyday food experience is not based only on the single sense of taste, but instead is an accumulation of multiple sensory perceptions (Stein, Huneycutt & Meredith, 1988).

The obvious example, which will be replicated in this study, is the interaction of olfactory and taste perception. Olfactory and gustation—the senses of smell and taste—are essential for survival by identifying material that is edible as food (Gibson, 1966), and preventing the ingestion of toxic material. It was shown that the activation of these two neural peripheral systems give rise to a unified flavor perception. This cross-neural sensory system has recently been used with broader implications for the development of food, beverages, and pharmaceuticals to enhance or mask tastes and smells (Delwiche & Heffelfinger, 2005).

However, there has been research showing that these two senses are not the only ones involved in taste perception. For example, DuBose et al. (1980, cited by Prescott 2012) showed that color has significant effects on our ability to recognize flavors of soda. That experiment's participants were less likely to accurately identify fruit-flavored beverages when they were unaware of the color. This has been replicated with similar results by other researchers (Bleackwell, 1995; Zellner & Whitten, 1999; Stevenson & Oaten, 2008, cited by Prescott, 2012). This demonstrates a correlation to another sense, vision, in the taste perception of flavor. If color plays a role in the detection of a flavor, then there must be a top-down processing that occurs before an individual actually tastes a substance. It is believed that the greater number of senses used with taste, like smell and vision, the more accurate the detection of a flavored stimuli will be. These studies will be replicated to determine if the simultaneous use of the vision and olfactory senses affect the accuracy of gustation.

Other factors will also be compared in our study to determine any association between smoking or gender and the participants' detection of flavor. Recently, smoking has been associated as a potential cause for olfactory impairment, but not gustatory dysfunction (Vennemann, 2008). However, as mentioned above, since the olfactory system is closely associated with the perceptions of the gustatory system, that suggests that there probably would be at least a slight impairment of the accurate perception of a particular taste by smokers. In our study, we will look for slight changes in flavor detection accuracy of smokers compared to people that do not smoke. As far as determining if gender has a role in taste, recent research has shown no significant difference in emotional processing between men and women on different primary gustatory receptors (umami, sourness, sweetness, bitterness, and saltiness); but that study did not report about accuracy of flavor identification. This might indicate either no significant difference at all between males and females on the gustatory responses, or that they simply did not test more complex flavor identification in that research (Robin, Rousmans, Dittmar & Vernet-Maury 2003).

In our replication study, we compared olfactory, vision, smoker status, and gender on the accuracy and perception of the gustatory sensory system. It is expected to find significant increases in accuracy when adding more sensory systems (vision and/or olfactory) to determinine a particular taste, as well as decreases in accuracy for people that are smokers. It is not expected to find significant differences based on gender.

Methods

Participants

A convenience sample of 162 participants, consisting of 80 males and 82 females, with an average age of 20.55 years, was recruited. Approximately 12 percent of the participants reported being smokers.

Materials

Materials consisted of the following four flavors of Jelly Bellies, manufactured by the Jelly Belly Company in Fairfield, California: Cherry, Licorice, Orange, and Green Apple. Plastic sandwich bags and paper bags were used to transport the Jelly Bellies. Finally, six data sheets were printed for each research assistant.

Procedure

The twenty-seven students enrolled in a university course in "Psychology 430: Sensation and Perception" each recruited and ran six participants individually. Participants' ages ranged from 19-23 years old and were randomly assigned to one of the following three conditions: Taste Alone, Taste Plus Olfactory, and Taste Plus Olfactory Plus Vision. The Taste Alone participants had no vision or smell capabilities while determining the taste. The Taste Plus Olfactory participants had no vision while determining taste, and the Taste Plus Olfactory Plus Vision participants had no restriction of those senses while tasting. The tests were coordinated so that none of the participants could see what the other participants were doing or how they were being tested.

The following script was read to each participant: "I will be offering you four differently flavored Jelly Belly candies, one at a time. Please taste each Jelly Belly carefully and, to the best of your ability, tell me what you think its flavor is. Do you have any questions about the procedure?" Additional instructions were given depending on the particular experimental condition, as follows: "Please close your eyes and pinch your nose throughout the tasting" for Taste Alone; or "Please close your eyes throughout the tasting" for Taste Plus Olfaction; or no additional instructions for Taste Plus Olfaction Plus Vision. During data collection, Jelly Bellies were randomly given to participants for each condition. After the data was collected, participants were debriefed and reassured that their responses fell within normal boundaries. Participants were asked if they had any further questions about the experiment and were then allowed to leave.

The Principle Investigator—Dr. Freberg—collected the raw data, and a one-way ANOVA using SPSS 20 was performed to determine any significance, followed with a post hoc Bonferroni analysis.

Results

Table 1 shows the average number of correct flavors (#) based on sensory condition and on gender (n=162). A one-way ANOVA showed that the number of correct flavor identifications differed by sensory condition, $F(2, 145) = 22.166$, $p < .001$. A post hoc Bonferroni analysis demonstrated that the three conditions were all significantly different from each other, all ps < .01. As shown by both of these analyses, Taste Alone was less accurate than Taste plus Olfaction, which was less accurate than Taste plus Olfaction plus Vision. On the other hand, as shown in Figure 1, for the average number of correct flavors (#; +/- Standard Error) as a function of sensory condition based on males (n=80) and females (n=82), there was no significant difference between genders, $F(1,145)=0.639$, $p > 0.05$.

Table 2 shows the average number of correct flavors (#; +/- Standard Error) based on whether the participant was a smoker (n=19) or a non-smoker (n=138). As Figure 2 demonstrated, there was no significant difference between the number of correct flavor identifications and whether the participants were smokers or non-smokers, $F(1/145)=0.064$, $p > 0.05$.

Discussion

Based on the results of the one-way ANOVA and Bonferroni analysis, there were significant differences between the three different conditions, ranging in accuracy from Taste only, to better accuracy with Taste plus Olfaction, to the best accuracy with Taste Plus Olfaction plus Vision. According to Frank et al. (1989, as cited in John Prescott, 2012) the smell of sweetness seems to enhance the ability to detect sweet taste. It is also shown in a majority of studies that differentiating food and drink stimuli is enhanced with the addition of vision. This can be seen in Table 1, where the more information there was about the stimuli from multiple senses (taste, smell, vision), the more accurately the stimuli were perceived. This confirms the hypothesis that the more senses that are used, the higher the accuracy of flavor detection.

Regarding the accuracy of the flavored Jelly Belly detection based on gender, it was suspected that females and males would have equal accuracy detection. This was confirmed, using the one-way ANOVA, by showing no significant difference in the results between females and males in flavor detection. In fact, seen in Figure 1, the average detection of Jelly Belly flavors were similar based on gender for all three conditions. This indicates that the addition of more sensory systems will not differentiate in flavor detection accuracy between males and females. This has been shown in the Robin et al. study (2003), which had no significant difference in emotional responses to taste between genders.

Concerning the effect of smoking on taste perception, it was hypothesized that individuals who smoke would be worse at flavor detection than individuals who do not smoke. There was, however, no observed significant difference in test results between smokers and non-smokers, which would not confirm our hypothesis. As seen in Table 2, smoking participants actually had very similar trends to non-smokers. In fact, they seemed to have slightly higher flavor accuracy compared to non-smokers. Figure 2 shows that the standard errors are moderately larger for smokers in our experiment —due to a small sample size—compared to non-smokers. This could have affected our results because of the significantly larger deviation within the smoker category.

The deviation among smokers might also be due to the vagueness of the description of the dependent variable of "smoker." Based on the research study by Vennemann et al. (2008), it was suggested that the effects of smoking depend on two main factors: how recently the individuals smoked before tasting the stimuli, and how often individuals smoked. Participants that were frequent smokers (> than 20 times per day) were at a higher risk for problems with both taste and smell. In contrast, the effects of smoking on taste and smell are normally more short term for non-chronic users. This indicated the variation in our study could be due to those factors that we did not test. If the study is repeated, I recommend determining how recently and how often the participants smoke. Also, it would be necessary to determine if the participant smokes cigarettes or marijuana, because they might have different effects.

There are also other limitations that should be noted. Even though it was observed that an increase in the number of sensory systems used correlated with an increase in flavor detection accuracy, it is not certain whether this is an integrated response, top-down processing, or some other reason. Another limitation was that the time of day that the study was run might affect the flavor detection by the participant. Time of day was not a specified factor in the study, and each participant took the test at his or her own convenience. Further research should be performed to determine the causality of these flavor detection differences.

In conclusion, it was observed that the more different sensory systems are used simultaneously, the more accurate a participant would be in identifying the Jelly Belly flavors. It was also confirmed that there was no significant difference in flavor detection accuracy between genders. The smoking portion of the study should be repeated and modified to determine if indeed individuals that smoke have lower flavor detection accuracy. These modifications could be used for the next "Sensation & Perception" class at California Polytechnic State University to look more at causality and clarification of the interaction between these three sensory systems.

Acknowledgments

Data for this experiment was obtained collectively by students of the Spring 2013 PSY 432 Human Sensation and Perception course.

Conditions	Gender	Average Correct (#)	Standard Error
Gustation	Males	0.923	0.183
	Females	0.964	0.209
	Both	0.944	0.138
Gustation Plus Olfaction	Males	2.154	0.173
	Females	2.107	0.173
	Both	2.130	0.121
Gustation Plus Olfaction Plus Vision	Males	3.179	0.179
	Females	3.346	0.166
	Both	3.259	0.122

Table 1. Average number of correct flavors (#; +/- Standard Error) to the condition based on males (n=80), females (n=82) or total (n=162).

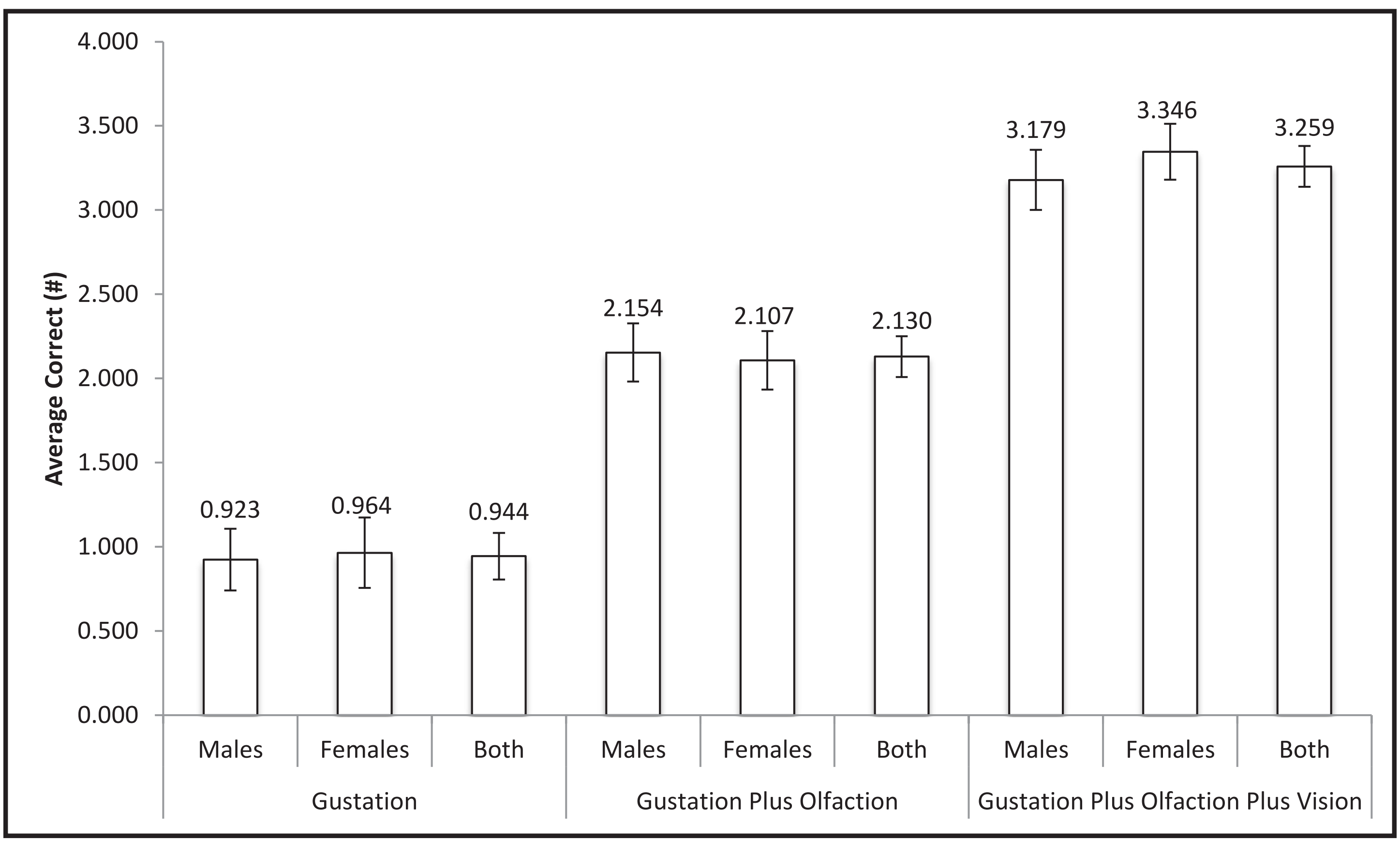

Figure 1. Average number of correct flavors (#; +/- Standard Error) for each sensory condition compared to males (n=80), females (n=82), or both (n=162).

Conditions	Smoker	Average Correct	Standard Error
Gustation	Smokers	1.143	0.340
	Non-Smoker	0.915	0.152
Gustation Plus Olfaction	Smokers	2.250	0.412
	Non-Smoker	2.163	0.124
Gustation Plus Olfaction Plus Vision	Smokers	3.000	0.707
	Non-Smoker	3.313	0.116

Table 2. Average number of correct flavors (#; +/- Standard Error) based on smoker (n=19) and non-smoker (n=138) participants.

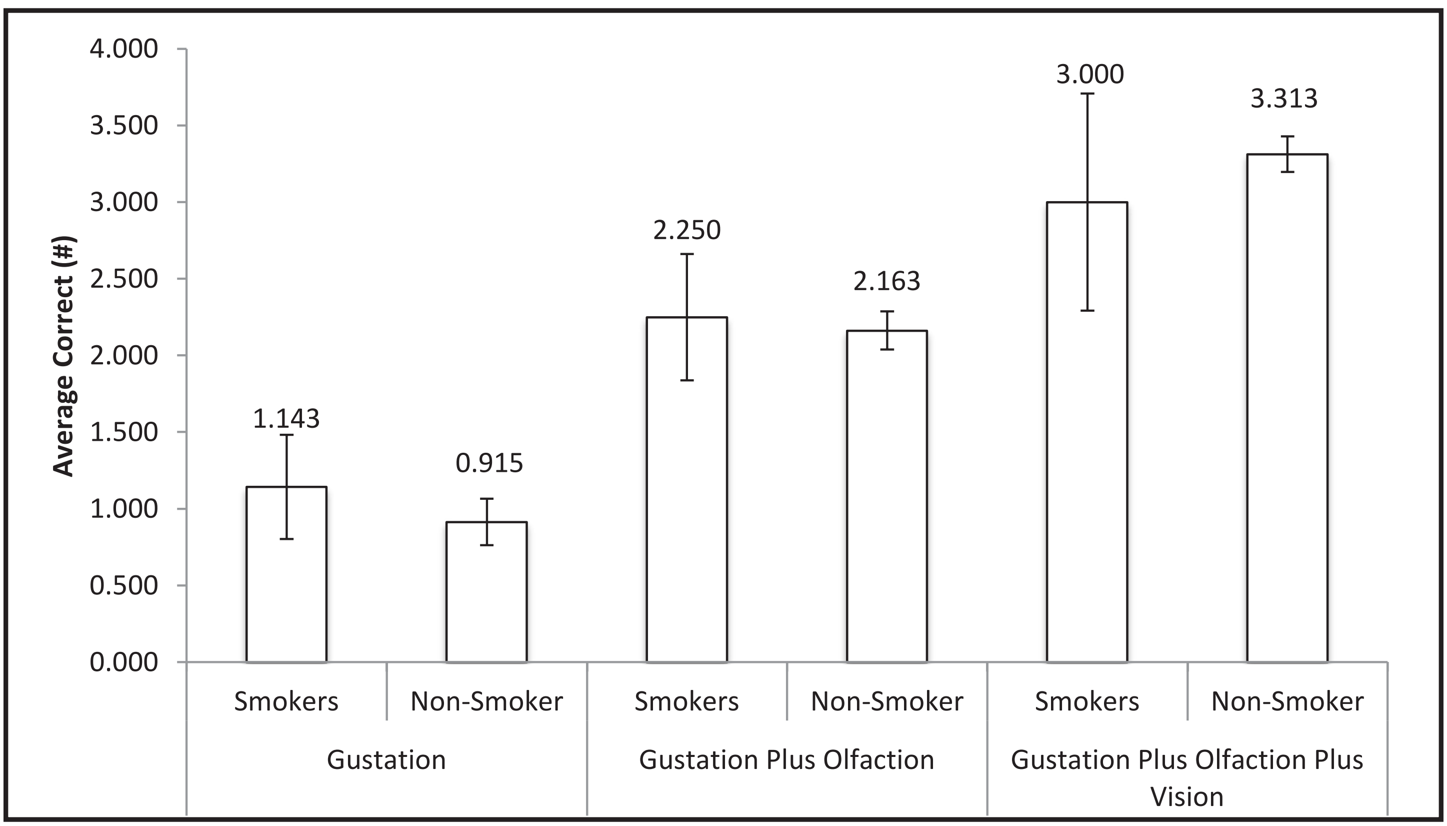

Figure 2. Average number of correct flavors (#; +/- Standard Error) based on smoker (n=19) and non-smoker (n=138) participants.

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