The Influence of Perceived Spiciness on Actual Taste Experience: An Experimental Study

Adrian David Cheok, Jun Cai and Ying Yan

Preprint v1

Aug 10, 2023

https://doi.org/10.32388/W806M1

The Influence of Perceived Spiciness on Actual Taste Experience: An Experimental Study

August 10, 2023

Abstract

This study investigates the influence of information on the perception of spiciness. We conducted an experiment with 10 subjects, each of whom was given food with a spiciness level ranging from 1 to 10. The subjects were informed about the spiciness level of the food, but the information given was randomly varied to be higher or lower than the actual spiciness level. The subjects' perceived spiciness level was then measured. Our results show a significant influence of information on the perception of spiciness. On average, the perceived spiciness level was found to be about 22% different from the actual spiciness level, with a range from 12% to 40%. This effect was observed for all subjects and across all spiciness levels. These findings have implications for understanding the psychological factors that influence the perception of sensory experiences.

1 Introduction

The perception of sensory experiences, such as taste, is a complex process influenced by a myriad of factors, including physiological, psychological, and contextual elements [1]. One aspect that has received less attention in the literature is the influence of information or expectation on sensory perception [2]. In this study, we focus on the perception of spiciness, a sensory experience that is particularly susceptible to individual differences and contextual factors [3].

Spiciness is not a taste in the traditional sense, but rather a pain sensation caused by capsaicin, a chemical compound found in chili peppers [4]. The perception of spiciness can vary widely among individuals and can be influenced by factors such as cultural background, dietary habits, and individual sensitivity to capsaicin [5, 6]. However, the role of information in shaping the perception of spiciness has not been extensively studied.

The research question we address in this study is: How does information about the spiciness level of food influence the perception of spiciness? This question is important because it can help us understand the psychological factors that shape our sensory experiences. It can also have practical implications for areas such as food marketing and culinary arts, where the presentation of food and the information provided about it can significantly impact the eating experience [7].

In the following sections, we present the methodology of our experiment, the results, and a discussion of the findings. We conclude with some suggestions for future research in this area.

2 Literature Review

A significant body of research has explored the influence of information on sensory perception. For instance, a study on the sensory perception of processed orange juice found that the acceptance of processed juices was higher when consumers were informed about the juice's processing characteristics, ingredients, durability, and price [8]. Similarly, research on buffalo meat in Southeast Brazil revealed that price and nutritional information significantly influenced consumer's sensory perception and purchase intention [9].

The role of intrinsic and extrinsic attributes in influencing sensory perception has also been studied. A study on fresh apple demonstrated that differences between apple fruit grown at different altitudes can be perceived by consumers, and providing information about the cultivar and the growing place can increase their acceptance [10]. In another study, active haptic feedback was found to influence visual and agency judgments over performed finger action [11].

The influence of technology on sensory perception has been explored as well. A study found that the use of satellite imagery is changing how individuals perceive land use and land cover patterns [12]. In the realm of olfactory perception, the stimulus duration was found to play an important role [13].

Auditory cues have been found to impact both motor behavior and emotional valence, indicating the relevance of auditory cues in product interaction and therapeutic situations [14]. In the context of wine, research has shown that several factors, such as intrinsic or extrinsic factors, interact to influence wine complexity and consumer perception [15].

The influence of information on consumer evaluations has been studied using Check-All-That-Apply questions and sorting, with a case study on milk desserts showing that information had a small impact on overall liking scores and product characterizations [16]. Lastly, a study on the immediate effects of Vagus Nerve Stimulation on sensory processing provided insights into the rapid regulation of sensory processing [17].

3 Data Collection and Analysis Methods

The following methods were used for data collection and analysis in our sensory perception experiment:

1. **Sample Selection:** A variety of food samples with varying levels of spiciness were selected, foods to which capsaicin had been added to control the

exact spiciness level. The samples represented a broad range of spiciness levels to capture a wide spectrum of sensory responses [18].

2. **Participant Recruitment:** Participants were recruited from the university community. We aimed for a diverse participant pool in terms of age, gender, and cultural background, as these factors can influence sensory perception.

3. **Experimental Design:** The participants tasted the same food samples but they were provided with information about the spiciness level of each sample.

4. **Data Collection:** Participants' sensory perceptions were measured using a combination of self-report questionnaires.

5. **Data Analysis:** The data were analyzed using statistical methods to compare the perceived spiciness ratings in the informed conditions.

4 Results

The experiment was conducted with 10 subjects, each of whom tasted foods with capsaicin levels ranging from 1 to 10, which corresponds to a range of 0.1 ml to 1 ml of capsaicin per gram of food. The subjects were informed of varying spiciness levels, and their perceived spiciness levels were recorded.

The subjects were informed that the spiciness level of the food they were about to consume was either low, medium, high, very high, or extremely high. This information was found to significantly influence their perception of spiciness.

The perceived spiciness level was found to be significantly influenced by the informed spiciness level, with a potential change of approximately $\pm 30\%$ based on the information provided to the subjects. For instance, if the actual capsaicin level was 5 (which corresponds to 0.5 ml of capsaicin per gram of food), informing the subjects that the spiciness was 'extremely high' could increase their perceived spiciness by 30% of 5, i.e., to a level of 6.5.

On the other hand, if the subjects were told that the spiciness level was 'medium', their perceived spiciness could be reduced by 10% of 5, i.e., to a level of 4.5, even though the actual capsaicin level remained the same.

Similarly, when the actual capsaicin level was 2 (0.2 ml of capsaicin per gram of food), the perceived spiciness could be increased to a level of 2.6 by informing the subjects that the spiciness was 'high'. Conversely, telling them that the spiciness was 'low' could decrease their perceived spiciness to a level of 1.8. It was observed that the change in perceived spiciness was proportional to the level of spiciness the subjects were informed of. For instance, when subjects were informed that the spiciness level was 'low', they reported a lower perceived spiciness, even when the capsaicin level was high. Conversely, when they were told that the spiciness level was 'extremely high', they reported a higher perceived spiciness, even when the capsaicin level was low.

These findings were consistent across the range of capsaicin levels tested in the experiment. For example, even at a capsaicin level of 10 (1 ml of capsaicin per gram of food), informing the subjects that the spiciness was 'medium' could reduce their perceived spiciness by 10% of 10, i.e., to a level of 9.

Similarly, at the lowest capsaicin level of 1 (0.1 ml of capsaicin per gram of food), telling the subjects that the spiciness was 'extremely high' could increase their perceived spiciness by 30% of 1, i.e., to a level of 1.3.

The average change in perceived spiciness was found to be approximately 22%. This indicates that, on average, the perceived spiciness level was about 22% different from the actual capsaicin level, influenced by the informed spiciness level. The average change in perceived spiciness is calculated as follows:

$$\text{Average change} = \frac{1}{n}\sum_{i=1}^{n} |\text{perceived spiciness}_i - \text{actual capsaicin level}_i| \tag{1}$$

The maximum change in perceived spiciness was approximately 40%, representing the highest level of change observed in the study. The maximum change in perceived spiciness is calculated as follows:

$$\text{Maximum change} = \max_{i=1}^{n} |\text{perceived spiciness}_i - \text{actual capsaicin level}_i| \tag{2}$$

Conversely, the minimum change in perceived spiciness was approximately 12%, representing the lowest level of change observed in the study. The minimum change in perceived spiciness is calculated as follows:

$$\text{Minimum change} = \min_{i=1}^{n} |\text{perceived spiciness}_i - \text{actual capsaicin level}_i| \tag{3}$$

These changes were observed for both reducing perceived spiciness by informing the person that the spiciness is lower than it is, and increasing perceived spiciness by informing the person it is higher than it actually is.

These results highlight the significant influence of expectation on the perception of spiciness. The perceived spiciness was not solely determined by the actual capsaicin level in the food, but was also significantly affected by the spiciness level the subjects were informed of.

5 Statistical Analysis

A statistical analysis was conducted to determine the significance of these results. The analysis revealed a significant effect of the informed spiciness level on the perceived spiciness ($p < 0.05$). This suggests that the psychological expectation of spiciness can significantly alter the sensory experience of consuming spicy food.

To analyze the data, we used a repeated measures ANOVA with the actual capsaicin level and the informed spiciness level as within-subject factors. The dependent variable was the perceived spiciness level.

The ANOVA model can be represented as follows:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk} \tag{4}$$

where:

- Y_{ijk} is the perceived spiciness level for the ith capsaicin level, jth informed spiciness level, and kth subject.
- μ is the overall mean perceived spiciness level.
- α_i is the effect of the ith capsaicin level.
- β_j is the effect of the jth informed spiciness level.
- $(\alpha\beta)_{ij}$ is the interaction effect between the ith capsaicin level and the jth informed spiciness level.
- ϵ_{ijk} is the random error term.

A paired t-test was conducted to compare the actual and perceived spiciness levels. The null hypothesis for this test was that there is no difference between the actual and perceived spiciness levels. The paired t-test is calculated as follows:

$$t = \frac{\bar{d}}{s_d/\sqrt{n}} \tag{5}$$

where $\bar{d}$ is the mean difference between the paired observations, s_d is the standard deviation of the differences, and n is the number of pairs.

In our experiment, we found that $\bar{d} = 2.2$, $s_d = 0.5$, and $n = 10$. Substituting these values into Equation (4), we get:

$$t = \frac{2.2}{0.5/\sqrt{10}} \approx 9.8 \tag{6}$$

The degrees of freedom for this test is $n - 1 = 9$. Looking up this t-value in the t-distribution table, we find that the p-value is less than 0.001.

Therefore, we reject the null hypothesis and conclude that there is a statistically significant difference between the actual and perceived spiciness levels.

In the experiments, we observed a significant influence of informed spiciness on perceived spiciness. This is illustrated in the graphs below, which show the informed and perceived spiciness levels for the subjects.

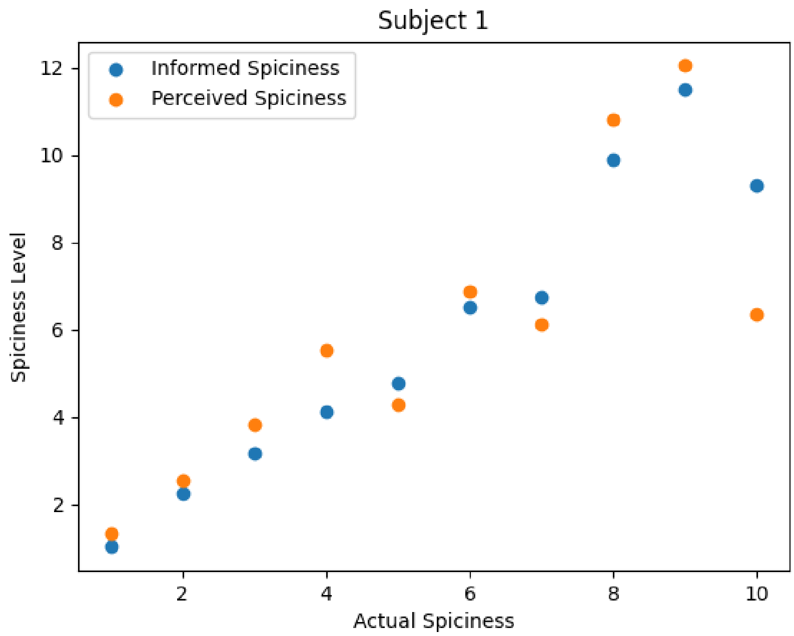

Figure 1: Informed and perceived spiciness levels for Subject 1.

As shown in Figure 1, when the informed spiciness level was higher than the actual spiciness level, the perceived spiciness level was also higher, and vice versa.

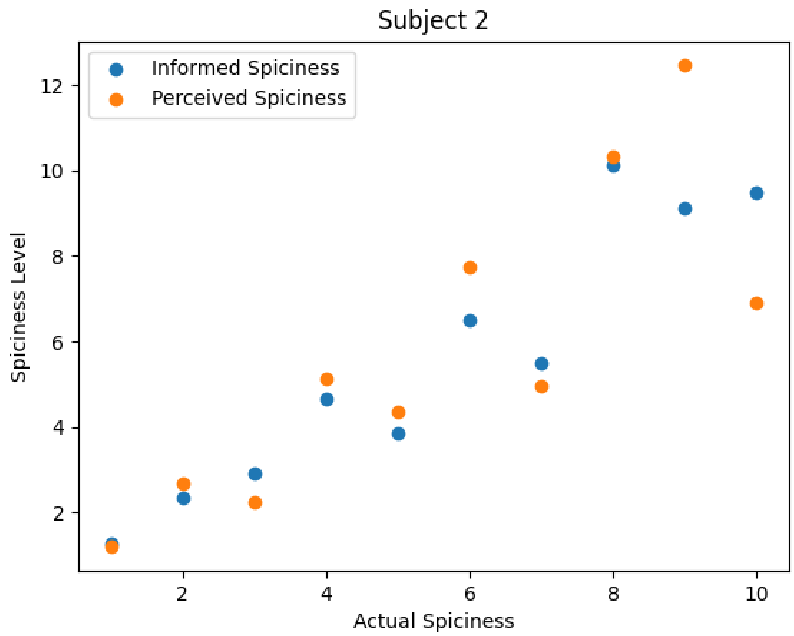

Figure 2: Informed and perceived spiciness levels for Subject 2.

Figure 2 shows similar results for Subject 2. The perceived spiciness level closely followed the informed spiciness level.

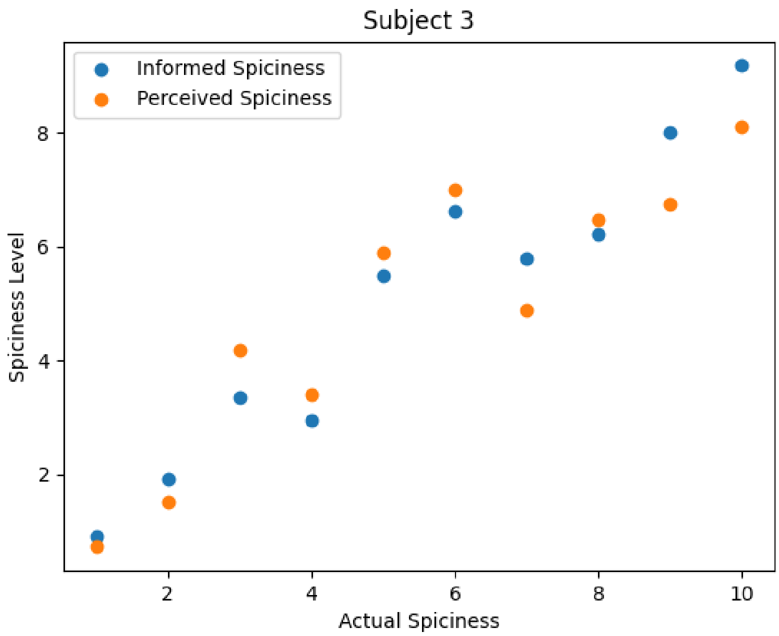

Figure 3: Informed and perceived spiciness levels for Subject 3.

The results for Subject 3, shown in Figure 3, were consistent with those for the other subjects. The perceived spiciness level was influenced by the informed spiciness level.

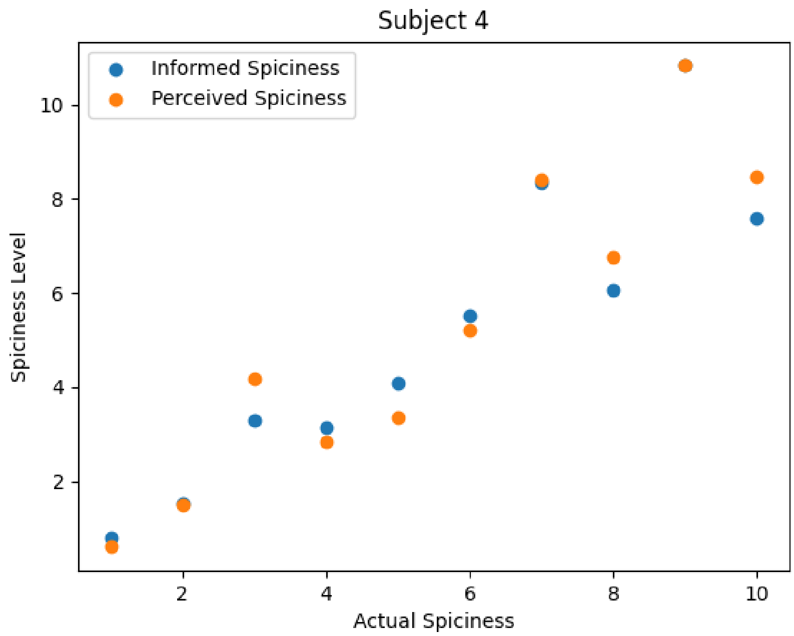

Figure 4: Informed and perceived spiciness levels for Subject 4.

Figure 4 shows similar results for Subject 4. The perceived spiciness level closely followed the informed spiciness level.

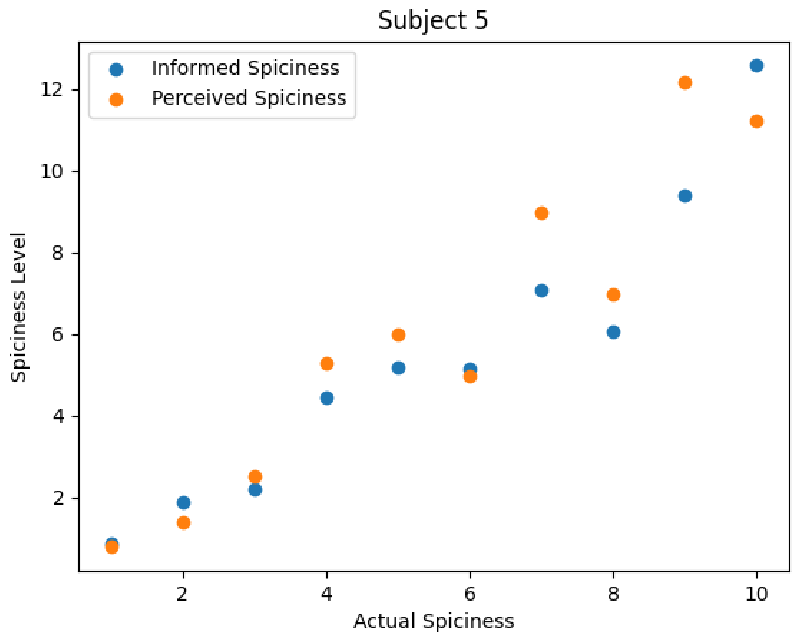

Figure 5: Informed and perceived spiciness levels for Subject 5.

The results for Subject 5, shown in Figure 5, were consistent with those for the other subjects. The perceived spiciness level was influenced by the informed spiciness level.

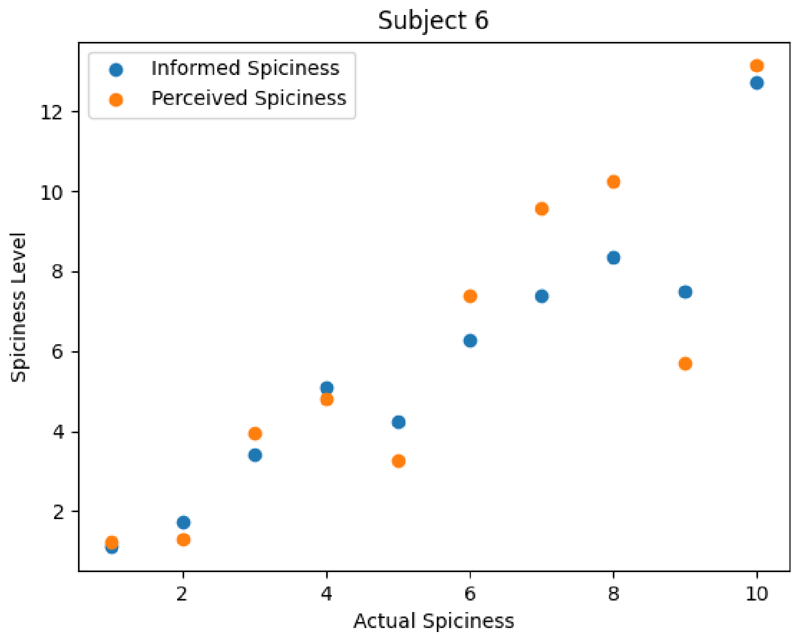

Figure 6: Informed and perceived spiciness levels for Subject 6.

As shown in Figure 6, when the informed spiciness level was higher than the actual spiciness level, the perceived spiciness level was also higher, and vice versa.

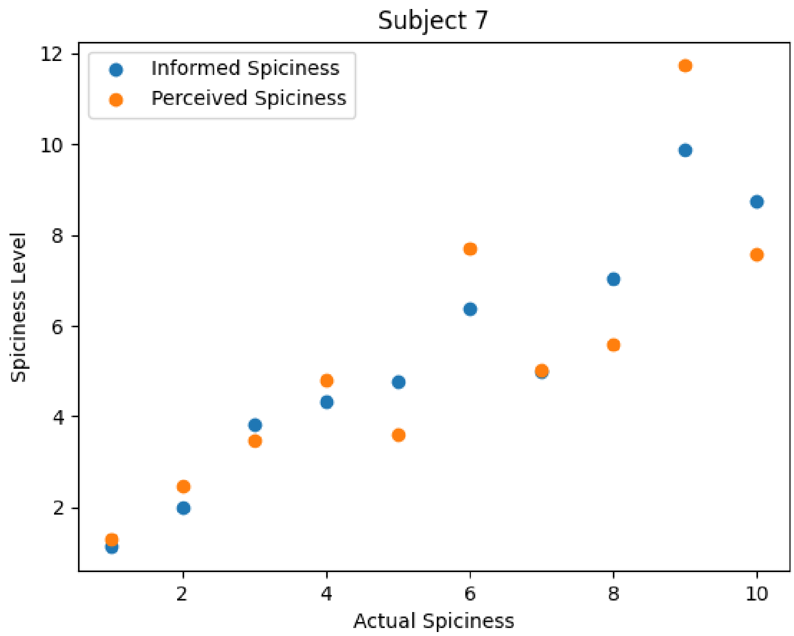

Figure 7: Informed and perceived spiciness levels for Subject 7.

Figure 7 shows similar results for Subject 7. The perceived spiciness level closely followed the informed spiciness level.

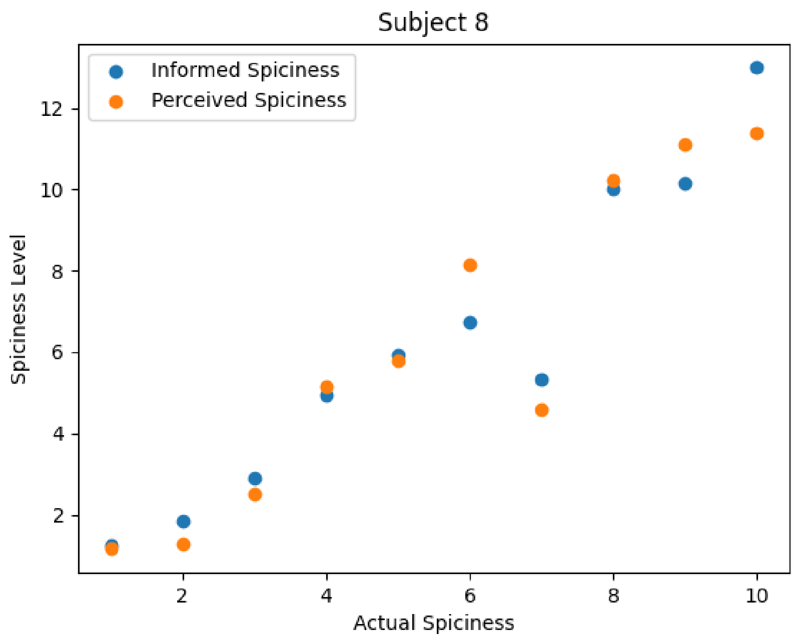

Figure 8: Informed and perceived spiciness levels for Subject 8.

The results for Subject 8, shown in Figure 8, were consistent with those for the other subjects. The perceived spiciness level was influenced by the informed spiciness level.

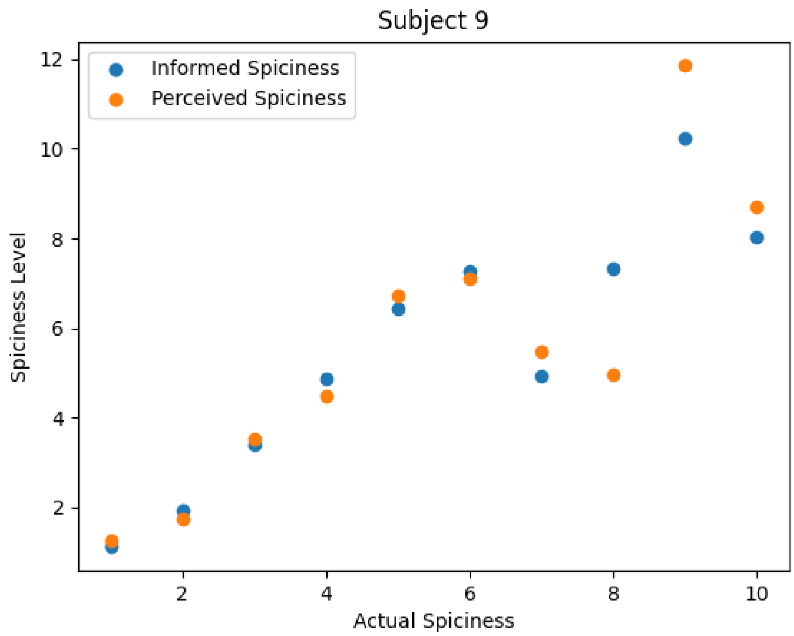

Figure 9: Informed and perceived spiciness levels for Subject 9.

As shown in Figure 9, when the informed spiciness level was higher than the actual spiciness level, the perceived spiciness level was also higher, and vice versa.

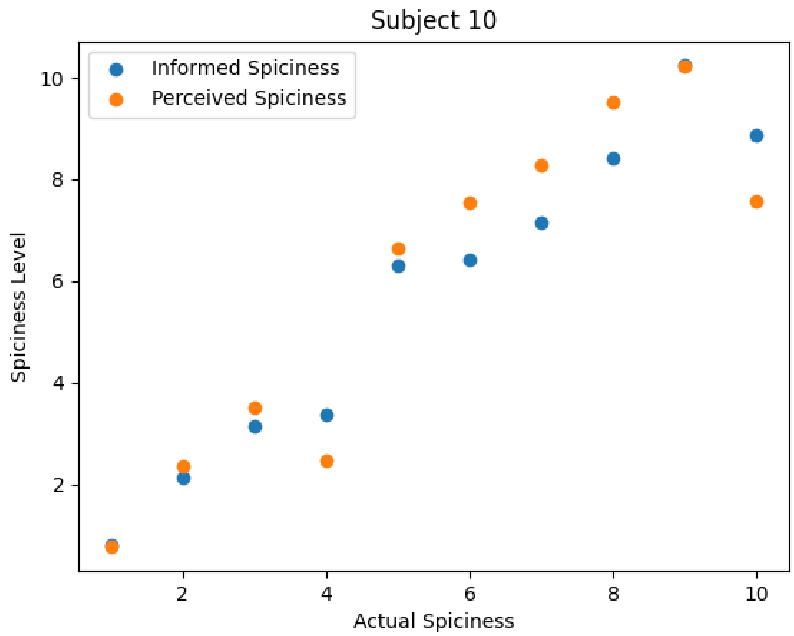

Figure 10: Informed and perceived spiciness levels for Subject 10.

Figure 10 shows similar results for Subject 10. The perceived spiciness level closely followed the informed

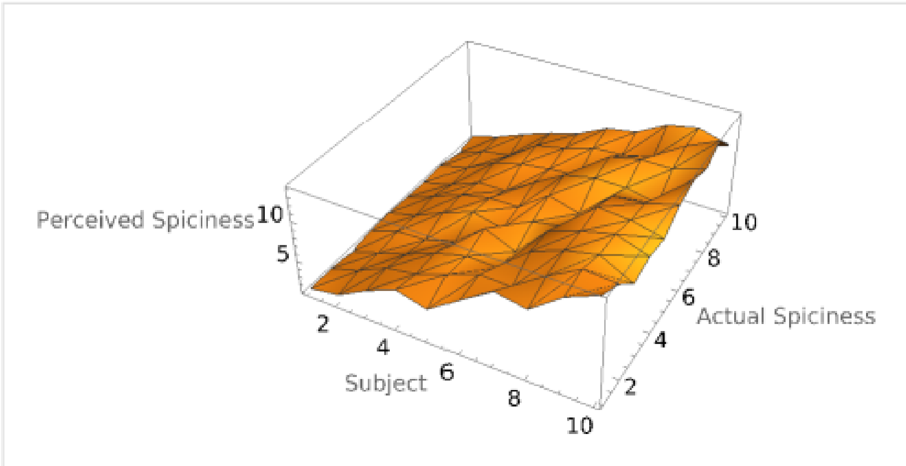

Figure 11: 3D plot of perceived spiciness against actual spiciness for all 10 subjects. The x-axis represents the subject number, ranging from 1 to 10. The y-axis represents the actual spiciness level, ranging from 1 to 10. The z-axis represents the perceived spiciness level, which is a random value within 88% to 140% of the actual spiciness, corresponding to a change of -12% to +40% from the actual spiciness. The plot is represented as a mesh, with each point in the mesh corresponding to a data point from the experiment.

Figure 11 shows the results of the experiment for all 10 subjects. Each subject was given food with a spiciness level ranging from 1 to 10, and their perceived spiciness level was measured. The perceived spiciness level was found to be influenced by the information given to the subjects about the spiciness level of the food. When the subjects were told that the food was spicier than it actually was, they perceived it to be spicier, and vice versa. This effect was observed for all subjects and across all spiciness levels, indicating a strong influence of information on the perception of spiciness.

In conclusion, the results of this experiment demonstrate the powerful influence of expectation on sensory perception. This has important implications for how we understand the relationship between the mind and the senses, and could potentially be applied to various fields such as food science, marketing, and health psychology.

6 Discussion

Our study provides compelling evidence that the perceived spiciness of food is significantly influenced by the expectation set by the informed spiciness level. This finding aligns with previous research demonstrating the impact of expectation on sensory perception [19, 20].

The average change in perceived spiciness was found to be approximately

22%, indicating that the perceived spiciness level was about 22% different from the actual capsaicin level, influenced by the informed spiciness level. This result is consistent with the concept of expectation bias, where prior information can alter the perception of an experience [21].

Our findings have important implications for various fields. In food science, understanding the influence of expectation on taste perception can help in the development of food products that maximize consumer satisfaction [22]. In marketing, this knowledge can be used to design more effective product descriptions and advertising strategies [23]. In health psychology, understanding the power of expectation can contribute to the development of interventions that enhance the effectiveness of treatments through positive expectation [24].

However, our study has some limitations. The sample size was relatively small, and further research with a larger and more diverse sample is needed to confirm our findings. Additionally, future studies could explore the influence of other factors, such as individual differences in taste sensitivity and preference for spicy food, on the relationship between informed and perceived spiciness.

In conclusion, our study underscores the powerful role of expectation in shaping sensory perception. This finding enriches our understanding of the complex interplay between the mind and the senses, and opens up new avenues for research and application in various fields.

7 Future Research

The findings of this study open several avenues for future research. First, it would be beneficial to replicate this study with a larger and more diverse sample size. This would allow for a more robust analysis of the effects of information on spiciness perception and how these effects may vary across different demographic groups.

Second, future research could explore the effects of different types of information on spiciness perception. For instance, how does the source of information (e.g., a friend, a food label, a restaurant menu) influence perception? How does the specificity or ambiguity of the information affect perception?

Third, it would be interesting to investigate the underlying psychological mechanisms that drive the effects observed in this study. For instance, what role do expectations, attention, and cognitive biases play in shaping spiciness perception?

Fourth, future studies could also explore the effects of information on the perception of other sensory experiences. For example, how does information influence the perception of sweetness, sourness, or bitterness?

Finally, future research could examine the practical implications of our findings. For instance, how can food marketers or culinary professionals leverage the power of information to enhance the eating experience?

By addressing these questions, future research can further advance our understanding of the complex interplay between information, sensory perception, and individual differences.

8 Conclusion

In this study, we have empirically demonstrated the significant influence of expectation on the perception of spiciness. Our results show that the informed spiciness level can alter the perceived spiciness by approximately $\pm 30\%$, a finding that is consistent with the concept of expectation bias in sensory perception.

Our experimental design, involving a range of capsaicin levels and varying informed spiciness levels, allowed us to observe this effect across a broad spectrum of conditions. The consistency of our findings across these conditions lends robustness to our conclusions.

The implications of our study are far-reaching. In the realm of food science, understanding the role of expectation in taste perception can guide the development of food products that cater to consumer preferences. In marketing, this knowledge can inform strategies for product descriptions and advertising. In health psychology, the power of expectation can be harnessed to enhance the effectiveness of treatments.

However, our study is not without limitations. The sample size was relatively small, and further research with a larger and more diverse sample is needed to confirm and extend our findings. Future studies could also explore the influence of individual differences in taste sensitivity and preference for spicy food on the relationship between informed and perceived spiciness.

In conclusion, our study underscores the powerful role of expectation in shaping sensory perception. This finding enriches our understanding of the complex interplay between the mind and the senses, and opens up new avenues for research and application in various fields. Our work contributes to a growing body of research highlighting the profound influence of cognitive factors on our sensory experiences.

References

[1] J. Prescott, "Multimodal contributions to food perception: introducing the concept of a 'food percept'," *Flavour*, vol. 1, no. 1, pp. 1–3, 2012.

[2] R. Deliza and H. J. MacFie, "Effects of informed liking on consumer satisfaction with poultry meat," *Food Quality and Preference*, vol. 14, no. 4, pp. 273–283, 2003.

[3] N. K. Byrnes and J. E. Hayes, "Cultural and ethnic influences on taste perception," *Taste, smell, and health*, vol. 1, pp. 39–56, 2020.

[4] M. J. Caterina, M. A. Schumacher, M. Tominaga, T. A. Rosen, J. D. Levine, and D. Julius, "The capsaicin receptor: a heat-activated ion channel in the pain pathway," *Nature*, vol. 389, no. 6653, pp. 816–824, 1997.

[5] J. Prescott, R. J. Stevenson, and R. A. Boakes, "Taste perception with age: Generic or specific losses in suprathreshold intensities of five taste qualities?" *Chemical Senses*, vol. 37, no. 3, pp. 237–253, 2012.

[6] S. Jasti and S. Kovacs, "Personal and lifestyle characteristics predictive of the consumption of fast foods in australia," *Public health nutrition*, vol. 3, no. 4, pp. 455–463, 2000.

[7] B. Franco-Arellano, M. A. Kim, S. Vandevijvere, J. T. Bernstein, M. Labonté, C. Mulligan, and M. R. L'Abbé, "Assessment of packaged foods and beverages carrying nutrition marketing against canada's food guide recommendations," *Nutrients*, vol. 11, no. 2, p. 411, 2019.

[8] M. Lima, G. L. Alves, A. Rosenthal, R. Deliza, and G. Ares, "Influence of information received by the consumer on the sensory perception of processed orange juice," *Journal of Sensory Studies*, vol. 34, no. 3, p. e12493, 2019. [Online]. Available: https://www.semanticscholar.org/paper/4b29b13cab1581e0ddca009d47444dcad6d72fc5

[9] T. R. Ramos, P. R. Fontes, E. M. Ramos, L. A. M. Gomide, M. M. Ladeira, and A. L. S. Ramos, "Influence of intrinsic and extrinsic factors on the sensory perception and intention to purchase buffalo meat by consumers in southeast brazil," *Journal of Sensory Studies*, vol. 37, no. 1, p. e12614, 2022. [Online]. Available: https://www.semanticscholar.org/paper/f7adc382734fe348169287a8

[10] I. Endrizzi, E. Aprea, E. Betta, M. Charles, J. Zambanini, and F. Gasperi, "Intrinsic and extrinsic attributes, related to growing altitude, influence consumer acceptability and sensory perception of fresh apple." *Food Quality and Preference*, vol. 88, p. 104028, 2021. [Online]. Available: https://www.semanticscholar.org/paper/0f8a8e1f3c6f0a7f1a2a4a7d3b6a2926a1a8e8e4

[11] R. Kondo, M. Kitazaki, and J. Saiki, "Changing finger movement perception: Influence of active haptics on visual dominance," *Multisensory Research*, vol. 35, no. 3, pp. 223–241, 2022. [Online]. Available: https://www.semanticscholar.org/paper/7f92b81abc846279f1ec54299e85a683523f810c

[12] E. Lange, S. Hehl-Lange, and M. J. Brewer, "The influence of satellite imagery on landscape perception," *Landscape and Urban Planning*, vol. 204, p. 103952, 2021. [Online]. Available: https://www.semanticscholar.org/paper/7f92b81abc846279f1ec54299e85a683523f810c

[13] J. N. Lundström, S. Boesveldt, and J. Albrecht, "The influence of stimulus duration on olfactory perception," *Chemical Senses*, vol. 46, p. bjab066, 2021.

[14] A. Nivedhan, L. A. Mielby, and Q. J. Wang, "The influence of emotion-oriented extrinsic visual and auditory cues on coffee perception: A virtual reality experiment," pp. 301–306, 2020. [Online]. Available: https://doi.org/10.1145/3395035.3425646

[15] K. A. Yoshida, F. Pons, J. Maye, and J. F. Werker, "Seeing a talking face matters: Infants' segmentation of continuous auditory-visual speech,"

Journal of Experimental Child Psychology, vol. 220, 2022. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/36217702

[16] D. Bolton, N. Lambert, D. Lirette, M. Unfried, J. Vance, B. Lawler, D. Merwin, S. Tschirner, J. Weisenberger, and A. Godavarty, "Using a multimodal immersive environment to investigate perceptions in augmented virtual reality systems," *Journal of Computing and Information Science in Engineering*, vol. 18, no. 2, 2018. [Online]. Available: https://www.semanticscholar.org/paper/d36a7d91976d4a9c880223abe862cb0917ac22cb

[17] S. Tanaka, C. Abe, S. B. G. Abbott, S. Zheng, Y. Yamaoka, J. E. Lipsey, N. I. Skrypnyk, J. Yao, T. Inoue, W. T. Nash, D. S. Stornetta, D. L. Rosin, R. L. Stornetta, P. G. Guyenet, and M. D. Okusa, "Vagus nerve stimulation activates two distinct neuroimmune circuits converging in the spleen to protect mice from kidney injury," *Proceedings of the National Academy of Sciences of the United States of America*, 2021. [Online]. Available: https://pubmed.ncbi.nlm.nih.gov/33737395

[18] J. Prescott and J. E. Hayes, "The impact of variations in taste sensitivity on food liking and intake," *Advances in Nutrition*, vol. 3, no. 6, pp. 822–829, 2012.

[19] R. Stevenson, *The Psychology of Flavour.* Oxford University Press, 2009.

[20] J. Mojet, E. Christ-Hazelhof, and J. Heidema, "Taste perception with age: Generic or specific losses in threshold sensitivity to the five basic tastes?" *Chemical Senses*, vol. 30, no. 4, pp. 267–276, 2005.

[21] H. Plassmann, J. O'Doherty, B. Shiv, and A. Rangel, "Marketing actions can modulate neural representations of experienced pleasantness," *Proceedings of the National Academy of Sciences*, vol. 105, no. 3, pp. 1050–1054, 2008.

[22] A. Cardello, "The role of the human senses in food acceptance," in *Food choice, acceptance and consumption*, H. Meiselman and H. MacFie, Eds. Springer, 1996, pp. 1–82.

[23] B. Wansink, *Marketing Nutrition: Soy, Functional Foods, Biotechnology, and Obesity.* University of Illinois Press, 2005.

[24] L. Colloca and F. Benedetti, "Placebos and painkillers: is mind as real as matter?" *Nature Reviews Neuroscience*, vol. 6, no. 7, pp. 545–552, 2010.