The Physiological Effects of Anticipating Spicy Food

Principle Investigators: Elise Dulmes, Caroline Gasao, Tyler Mershon, Ingie Osman, Angela Schraml, and Swetha Ravi

University of Wisconsin-Madison, Department of Physiology

Lab 603, Group 1

Key Terms: ElectroDermal Activity (EDA), ElectroCardioGraphy (ECG), Heart Rate, Respiration, Anticipation, Sympathetic Nervous System, Spicy Stimuli

Word Count: 4630

Abstract

This study was designed to measure changes in heart rate, respirations, and electrodermal activity (EDA) due to anticipation of eating a range of peppers on the Scoville Heat Scale (starting at 30,000-50,000 scoville units and working up to 1,000,000 heat units). Our hypothesis stated that each measured variable would increase in anticipation to eating spicy food--in this case peppers. For all 30 participants, baseline heart rate, respiration, and skin conductance measurements were taken for one minute using electrocardiography (ECG), electrodermal activity (EDA), and a respiratory belt, respectively. A positive control was measured followed by a recovery period to return to baseline measurements. During the experimental portion, participants were informed that there was a range of peppers to try and they were to eat the spiciest one they felt they could tolerate. Time was allotted from when one experimenter left the room to go fetch these 'peppers', to when they returned to inform participants they would not actually need to consume any peppers (note: no physical peppers were used by the experimenters). This allowed time for possible changes in physiological measurements to develop. Following the experiment, participants completed a survey rating their current hunger level and spicy food tolerance. Analysis of our results show significant differences between the average resting and average experimental values for heart rate, respiratory rate, and skin conductance. Additionally, our post-experimental survey also shows an interesting correlation between self-reported spice tolerance and the physiological changes observed.

Introduction

One of the fascinating aspects of the human brain that sets it apart from other animals is the innate ability to cultivate creative intelligence, which allows for limitless visualization. Possible futures, created and experienced as visions in the mind's eye, are important for problem solving alternatives, solution selection, and purposive action planning. All of which are required for adaptive functioning allowing humans to navigate their personal, temporal course through life (Christensen, 2002). Mental imagery is defined as "the mental invention or recreation of an experience that in at least some respects resembles the experience of actually perceiving an object or an event, either in conjunction with, or in the absence of, direct sensory stimulation," (Esther, et al., 2011). Human survival critically depends on the ability to anticipate, even in the absence of sensory stimulation, and this anticipation is based on the internal processing where mental representations can gain precedence over sensory input (Esther et al,. 2011). Based on this information, we hypothesize that if anticipatory mental imagery is necessary for maintaining homeostasis and ultimately human survival, then the anticipatory mental imagery of eating a spicy pepper can provide sufficient stimulus to elicit physiological responses.

Physiological responses to spicy stimuli are initiated by the body's response to capsaicin- the chemical compound found in many spicy foods, including chili peppers. In response to ingesting capsaicin, sensory neurons called thermal nociceptors are activated and stimulate the body's sympathetic nervous system (Liu, 1996, Ohnuki, 2014, Watanabe, 2001). The sympathetic nervous system activates the "fight or flight" response and secretes epinephrine. The effects of epinephrine secretion involved in this "fight or flight" response include an increase in heart rate and an acceleration of lung action. Additionally, stimulation of the sympathetic nervous system innervates eccrine glands, making sweat a result of epinephrine secretion as well. Therefore, ingesting spicy stimuli usually results in an increase in heart rate, respiration, and sweating, so we expect to see these results while monitoring ECG, respirations, and EDA with a BIOPAC System.

Our proposed experiment aims to measure physiological responses of individuals in anticipation of ingesting spicy stimuli. Electrocardiogram (ECG) will be used to measure heart rate in order to monitor any changes induced by anticipatory ingestion of capsaicin. Electrodermal activity (EDA) will be used to measure sweat response in order to monitor changes in the body's sweat production that anticipatory ingestion of capsaicin induces. A respiratory belt will be used to measure the number of respirations in order to monitor change in breathing that anticipatory ingestion of capsaicin induces.

O'Doherty et al. (2002) conducted a study to identify changes in brain activity in response to anticipation of a taste reward. Researchers found greater activity in the brain with anticipation of a sweet taste in comparison with anticipation of a neutral taste. Furthermore, they discovered that areas of the brain were also activated to a moderately unpleasant taste, although not as noticeably. Researchers suggested that future studies provide a stronger aversive taste to potentially increase signals in the brain in anticipation of receiving this taste "reward" (O'Doherty et al., 2002). Physiological changes can occur as a result of this increased brain activity due to the anticipation of a stimulus.

We hypothesize that in anticipation of ingesting a spicy pepper, individuals will experience an observable increase in heart rate, respirations, and electrodermal conductance. Finding measurable physiological changes due only to anticipation or visualization of food could help build our understanding on social media's influence on our brains and health. A literature review of this growing field reports dramatic neural and physiological changes in response to viewing the types of food pictures most social media users see multiple times a day. These images have been found to change eating behaviors, neural activity, and attention in experimental subjects (Spence, 2016). Moreover, people eat more and prefer more energy dense foods after viewing food advertisements (Boyland et al., 2011). Another literature review found that increases in neural activation of the brain regions involved in emotional processing, executive functioning, and reward processing occurred in all subjects but were amplified for high calorie foods--an amplification that was even more exaggerated in obese subjects (Pursey et al., 2014). Foods judged by subjects to be more pleasant also drew their attention faster than other foods--an effect that was also amplified in subjects with higher body weights (Nummenmaa et al., 2011). Such trends are more concerning now than they ever have been considering the obesity epidemic in the United States in combination with the ease of scrolling through Instagram "foodporn". Previous studies on the topic of physiology, neural activity, and food anticipation have tended to be based on foods high in salt, sugar, fat, and calories. Our study on heart rate, respirations, and EDA changes in response to only the mental visualization and anticipation of a spicy pepper is a novel addition to the research regarding food and the brain.

Materials and Methods

30 students at the University of Wisconsin-Madison were recruited as participants for this study. All participants signed a consent form prior to the start of the experiment to gather their informed consent and ensure their confidentiality in this experiment. Data was gathered by measuring heart rate, respirations, and electrodermal activity (EDA), which measures skin conductance as a result of sweat production, at both baseline and experimental levels. Heart rate was measured using electrocardiography (ECG) electrodes (*BSL Multi-lead ECG Cable/SS2L*, BIOPAC Systems, Inc. Goleta, CA), respirations were measured using a respiratory transducer (*BSL Respiratory Effort Xdcr/SS5LA,* BIOPAC Systems, Inc. Goleta, CA), and skin conductance was measured by using an electrodermal activity (EDA) finger electrode (*BSL EDA Finger Electrode Xdcr/SS3LA*, BIOPAC Systems, Inc. Goleta, CA). These devices were all used in conjunction with the BIOPAC Systems, Inc. software, which was used to collect and compare data.

After baseline data collection, the experiment was explained and subjects were told that they would be eating a spicy pepper (Note: a script was followed for each participant in attempts to keep the experiment consistent). Experimenters then recorded the subjects' physiological changes in anticipation of eating the pepper. Although participants wouldn't actually be consuming peppers, experimenters used the mental imagery of a pepper as an extreme stimulus to elicit a physiological food anticipation response, and measured the resultant changes in heart rate, respirations, and EDA (Ohnuki, 2001, Reinbach, 2009). After the measurements were collected, subjects were told they would not be eating any peppers and were asked to complete a short post-experimental survey containing questions pertaining to their self-rated tolerance to spicy food as well as the degree of hunger they were experiencing at the time of data collection (Figure 9). Analysis of resulting data was first evaluated without consideration of the post-experimental survey. We then used the survey to parse out our data and see if any trends arose. These trends, or lack thereof, help guide the discussion about our results.

Pilot Study Setup

Prior to data collection, experimenters conducted a pilot study with members of the experimental group to test positive and negative controls. The negative control in this study is baseline heart rate, respiration, and EDA, measured once on each participant. The negative control ensures the reliability of the equipment so that when participants are connected to the equipment, their baseline data will be consistent. In this pilot study, participants sat up straight with both feet firmly on the floor. The EDA electrode was placed on the index and middle fingers of the participant's non-dominant hand, and the ECG electrodes were placed on the dominant wrist and the inside of both ankles. Participants placed their arms on their laps with their palms facing down, and the baseline data was collected for 60 seconds, as this is a time period found to accurately represent physiological conditions (Kobayashi, 2013). The positive control in this study was heart rate, respirations, and EDA during physical activity. Each pilot study participant jogged in place for 30 seconds-- enough time experimentally found to elicit physiological changes in measurements-- while experimenters recorded heart rate, respirations, and EDA measurements. The positive control ensures the BIOPAC equipment will be able to accurately read changes in heart rate, respirations, and EDA and provides evidence that the experimenters can make these measurements. The electrodes and respiration belt remained connected to the participant and positive control data was collected.

Experimental Setup

Prior to the start of the experiment, all participants signed a consent form, formatted and approved by the UW-Madison Physiology Department, to inform them of any potential harm and ensure their confidentiality. Upon arrival, participants were brought to a testing room that was isolated from any external stimuli that could impact data collection. Participants were then instructed to sit up straight with both feet firmly on the floor and their gaze directed at the experimenter. The participants were connected to all three physiological measurement instruments at the beginning of the experimental trial and they remained attached throughout the duration of the experiment. The EDA electrode was placed on the index and middle fingers of the participant's non-dominant hand, while the ECG electrodes were placed on the dominant wrist and the inside of both ankles. The participants were instructed to place their arms on their laps with their palms facing down, to ensure the reliability of the instruments and their data collection. The measurements were continuously recorded via BIOPAC, and saved on an external flash drive.

Trial and Recording

To test the negative control, baseline physiological measurements of EDA (microsiemen), heart rate (beats per minute), and respirations (breaths per minute), were recorded for 60 seconds for each participant before informing them that they will have to eat a spicy pepper. To test the positive control, experimenters took measurements of EDA (microsiemen), heart rate (beats per minute), and respirations (breaths per minute) while participants jogged in place for 30 seconds. Experimenters then gave participants 2 minutes to return to a small range around baseline measurements before beginning the experiment. One experimenter then read a description of the experiment and informed participants that they had to eat a spicy pepper while the experimenters measured their physiological responses. After each subject was told they would need to consume the pepper, an experimenter left the room and notified the subject that they were retrieving both a glass of milk and the pepper. This provided time for potential physiological changes to occur in anticipation of the experimenter returning with the pepper, and for the data to be properly recorded. During this time, experimenters continued to measure EDA (microsiemen), heart rate (beats per minute), and respirations (breaths per minute). Upon the experimenter's return with an empty box, intended to make participants think it contained the peppers, experimenters informed participants that they would not actually have to consume a pepper. Experimenters ended heart rate, respiration, and EDA measurements and removed the equipment from participants. After the measurements were taken, experimenters instructed participants to complete a short post-experimental survey. This survey included questions pertaining to their self-rated tolerance to spicy food as well as questions pertaining to the degree of hunger they were experiencing at the time of data collection. This survey was included to determine whether a participant's views of spicy food had any impact on their physiological response as well as whether a participant's hunger, and the physiological responses that go along with it, impacted their measurements.

Data Analysis

Raw ECG, EDA, and respiration data was processed in BIOPAC to beats per minute, microsiemens, and breaths per minute, respectively (Figure 4). The data obtained from BIOPAC was analyzed by looking at average respiratory rate (BPM), average maximum EDA (microsiemens), and average heart rate (bpm). Figures 6-8 show the average measurements for each variable from a participant who had representative data. For our statistical analyses, an unpaired two-tailed t-test was used to compare the average respiratory rate (baseline versus experimental), average maximum EDA (baseline versus experimental), and average heart rate (baseline versus experimental) to see if there were any statistically significant differences ($p < 0.05$). Tables 2-4 show the results of the statistical analyses.

Results

ECG

In order to analyze the data from the BIOPAC recordings, the average heart rate within a one-minute interval was used for baseline and experimental data. In order to compare the baseline and experimental data, the mean, standard deviation, and sample size for both baseline and experimental data was used in an unpaired, two-tailed t-test (Table 2). Figure 1 compares heart rate for baseline and experimental data, showing the means and the standard deviations. A significant difference ($p=0.004$) was found between these two groups. Figure 6 shows an increase in heart rate during positive control testing, and a decrease back to baseline during the rest period and then a slight increase again as participants sat in anticipation of eating the spicy pepper.

Respirations

In order to analyze the data from the BIOPAC recordings, the number of respirations within a one-minute interval was used for baseline and experimental data. In order to compare the baseline and experimental data, the mean, standard deviation, and sample size for both baseline and experimental data was used in an unpaired, two-tailed t-test (Table 3). Figure 2 compares number of respirations for baseline and experimental data, showing the means and the standard deviations. A significant difference ($p=0.0011$) was found between these two groups. Figure 7 displays an increased in respiratory rate (RR) throughout the entire duration of the experiment, beginning with baseline of 10 breaths per minute and ending with 17 breaths per minute.

EDA

In order to analyze the data from the BIOPAC recordings, the maximum EDA within the experimental interval was used for baseline and experimental data. In order to compare the baseline and experimental data, the mean, standard deviation, and sample size for both baseline and experimental data was used in an unpaired, two-tailed t-test (Table 4). Figure 3 compares EDA for baseline and experimental data, showing the means and the standard deviations. A significant difference ($p=0.0002$) was found between these two groups. Figure 8 shows an increased in EDA during positive control testing and a return to baseline value during the rest period, but not an increase in EDA during the experimental portion.

Discussion

The results of this study support our hypothesis that there are observable physiological changes due to anticipation of eating a spicy pepper. A significant difference between the average baseline and experimental values was found for each response we measured, meaning that heart rate ($p < 0.05$), respiratory rate ($p < 0.05$), and sweat secretion ($p < 0.05$) all noticeably increased as participants anticipated eating spicy peppers. The increase in levels from all three physiological measurements is significant as the body anticipates the event of consuming a spicy pepper.

Additionally, when analyzing the post-experimental surveys in which we asked how tolerant the participant was to spicy food, it is apparent that there is a trend between tolerance and physiological response. On average, the more tolerant the participant self-reported being, the lesser of a physiological response was seen in heart rate, skin conductance, and respiratory rate (Figure 5). This correlation was not analyzed via a t-test because, as there were only 5 participants in the group of level 1 spice tolerance, 6 in level 2, 3 in level 3, 11 in level 4, and 5 in level 5 meaning the sample sizes for self-rated spice tolerance were too small. However, had the sample size been larger, it would have been interesting to see whether this would prove to be statistically significant. Data was also separated and graphed by self-reported hunger level and no trend was observed (Figure 10).

Limitations

Limitations regarding experimental conditions might have influenced the results of the study. To elicit physiological changes in anticipation of eating spicy food, the experimenter informed each participant they would need to consume up to the spiciest pepper they could tolerate on the Scoville Scale. One of the limitations regarding our participants was maintaining confidentiality. If a participant somehow knew prior to recording data they would not actually have to consume a pepper, per the Physiology Department rules, this could be an explanation if a significant response was unable to be obtained. However, because our results were found to be significant, we can confidently say we minimized this issue. Furthermore, we were not aware of any participants' prior knowledge of our experiment and we attempted to mitigate this knowledge by including a non-disclosure agreement in our consent form.

Our results may be due to confounding variables as well. For example, nervousness or discomfort would also likely cause increases in heart rate, breathing, and sweating. The number of experimenters in the room was limited in an attempt to minimize this. Additionally, in one participant's experiment, an ECG electrode disconnected from the skin and complete results during the allotted time period were not able to be obtained. If participants were talking at any point during the period of time when the experimenter left the room to obtain the spicy pepper, the respiration measurement may not have been complete. In these cases, this might have influenced final results, but a significant impact was not found.

Overall, the study had a strong experimental design that remained consistent throughout each experiment by reading subject instructions from a script and keeping precise time for each phase of the experiment. For example, the time of two minutes for each participant to return to baseline after recording the positive control was consistent in all 30 of the the experiments as each individual could vary in the amount of time needed to return to baseline; however, this period of time was upheld for each participant. The timeline established for each experiment was followed closely to eliminate any confounding variables that could arise while recording data.

Future Directions

In future experiments, participants should be chosen that would be more representative of the whole student body. This would not only increase sample size allowing for more data to be collected, but there could be an increase in physiological changes recorded due to participants lack of knowledge on the rules of how experiments should be conducted. Participants could also be more inclined to believe they would be eating a spicy pepper by bringing actual peppers into the room instead of an empty box and therefore may show a more dramatic anticipatory response. This could give greater insight as to how individuals anticipate spicy food and the physiological changes that occur as a result.

Conclusion

Studies have shown that human survival critically depends on the ability to anticipate, even in the absence of sensory stimulation, and this anticipation is based on the internal processing where mental representations can gain precedence over sensory input (Esther et al,. 2011). The purpose of this study was to measure the physiological response (heart rate, EDA, & respiratory rate) in anticipation of eating spicy peppers and our data indicates that statistically significant increases in each of these variables does occur. Understanding this information is especially important from a clinical lens in regards to the brain's response to stimuli like social media and food advertisements. Most Americans have constant access to various food stimuli much more tempting than a raw ghost pepper, and the short and long term effects of this are still being discovered.

Acknowledgements

We would like to express gratitude to Dr. Lokuta, the teaching assistants, and the peer learning volunteers involved with Physiology 435 for assistance and guidance during the research process. We would also like to thank the University of Wisconsin-Madison for opening up their facilities in order for us to carry out our study. Lastly, we would like to thank the students that participated in our study, without whom this study would not have been possible.

Figures and Tables

Time elapsed	Subject experience
0:00-2:00 min	Take participant to isolated room and ask the individual to sign a consent form. Connect participant to equipment (ECG, EDA, and respiratory belt) and BIOPAC software.
2:00-3:00 min	Experimenters measure baseline heart rate, EDA, and respirations for 60 seconds.
3:00-3:30 min	Experimenters measure positive control data for heart rate, EDA, and respirations for 30 seconds.

3:30-5:30 min	Participants are given 2 minutes to return to baseline measurements.
5:30-6:30 min	Tell participant they will have to eat a spicy pepper while experimenters take physiological measurements. Measure heart rate, EDA, and respirations during this time.
6:30-7:30 min	Experimenter 1 exits room to “retrieve pepper and milk.” Measure heart rate, EDA, and respirations during this time.
7:30-8:00 min	Experimenter 1 returns and subject is told they won’t actually have to eat the pepper.
8:00-9:30 min	End heart rate, EDA, and respiration measurements. Remove equipment and take post-experimental survey.

Table 1. Experimental Timeline: Following the signing of the consent form, ECG, EDA, and a respiratory belt were connected to the participant. The participant’s baseline heart rate (HR), skin conductance (SC), and respiratory rate (RR) were measured via these instruments, and remained on until the conclusion of the experiment. A positive control was then taken by asking the participant to jog in place. Upon returning to baseline, the experimenter again elicited a physiological response by telling the participant he/she would be eating spicy food. When experimenter 2 returned (from retrieving the peppers and milk), the participant was told there would be no pepper eating and the experiment was concluded. All equipment was removed, and a post-experimental survey was given. The results of the experiment were analyzed using paired, two-tail t-tests between baseline and experimental conditions.

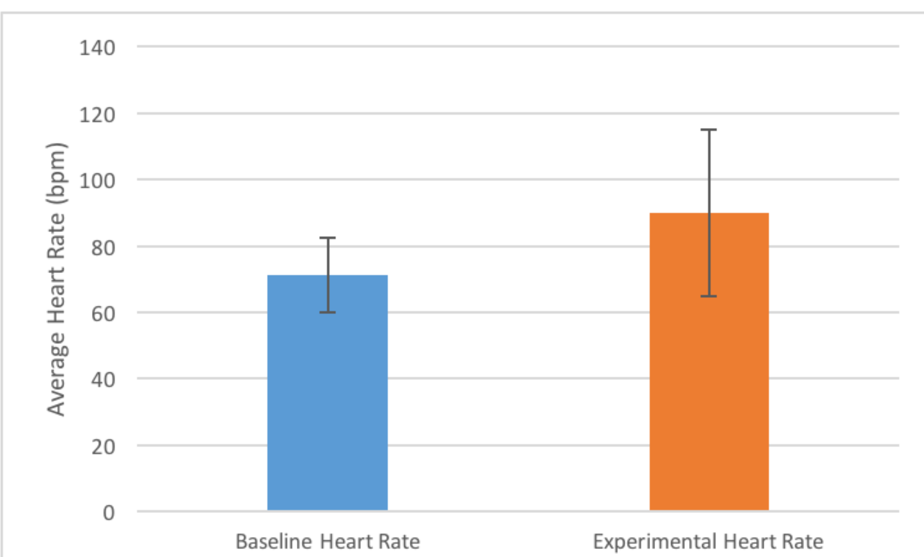


Figure 1. Summary Data. Average heart rate was calculated for both baseline and experimental data. Shown are the means ± standard deviation. There was a significant difference between baseline and experimental heart rate (p=0.0004, two-tailed t-test).

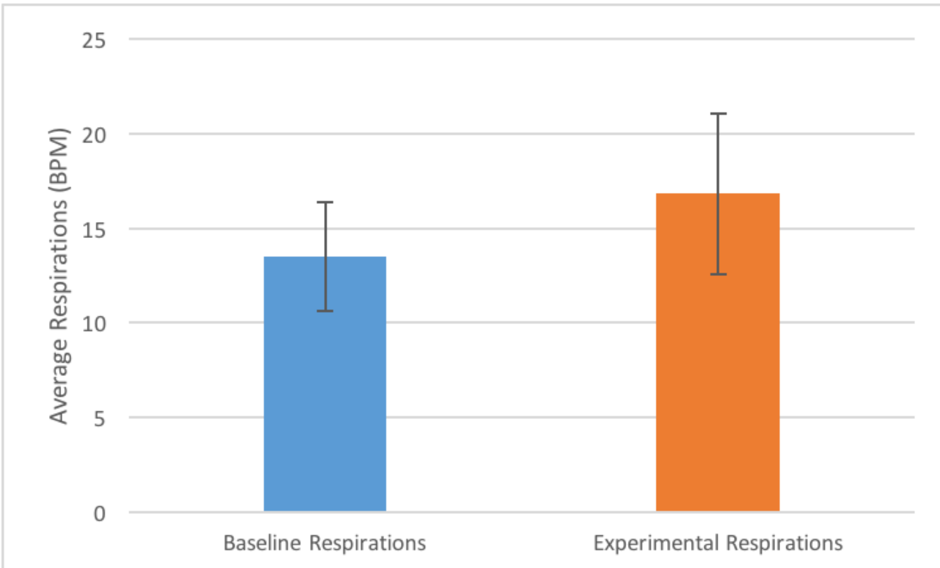


Figure 2. Summary Data. Average number of respirations was calculated for both baseline and experimental data. Shown are the means ± standard deviation. There was a significant difference between baseline and experimental number of respirations (p=0.0011, two-tailed t-test).

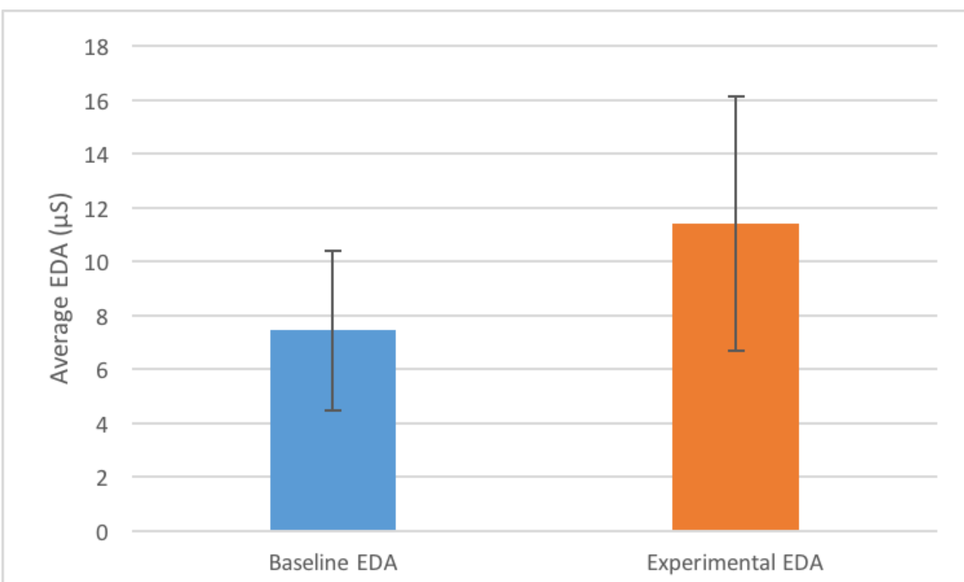


Figure 3. Summary Data. Average maximum EDA was calculated for both baseline and experimental data. Shown are the means ± standard deviation. There was a significant difference between baseline and experimental EDA (p=0.0002, two-tailed t-test).

	Experimental	Baseline
Mean	90 bpm	71.167 bpm
Standard Deviation	25.072	11.182
N (Number of Subjects)	30	30
Two-tailed p-value	**0.0004**	

Table 2. Summary Data. Unpaired, two-tailed t-test results for average heart rate values.

	Experimental	Baseline
Mean	16.84 BPM	13.48 BPM
Standard Deviation	4.249	2.874
N (Number of Subjects)	25	29
Two-tailed p-value	**0.0011**	

Table 3. Summary Data. Unpaired, two-tailed t-test results for average respiration values.

	Experimental	Baseline
Mean	11.4 µS	7.426 µS
Standard Deviation	4.728	2.944
N (Number of Subjects)	30	30
Two-tailed p-value	**0.0002**	

Table 4. Summary Data. Unpaired, two-tailed t-test results for average maximum EDA values.

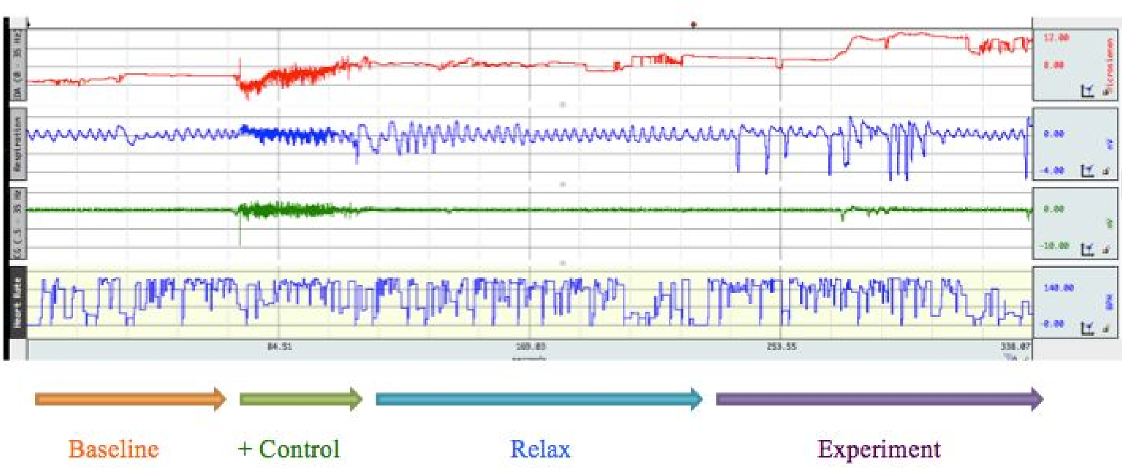
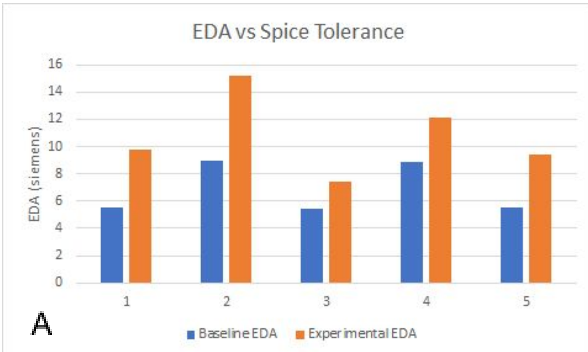
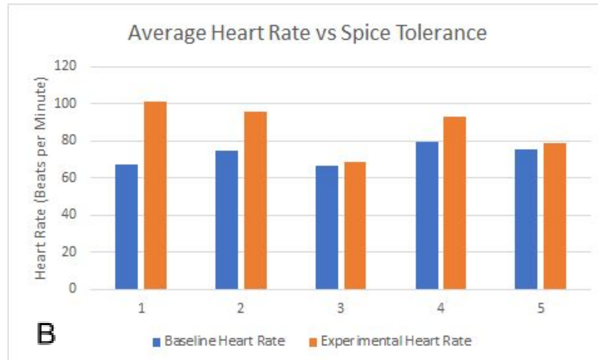


Figure 4. This figure is a screenshot of raw data on BIOPAC for the entire experimental time frame. Phases of the experiment are labeled by the arrows, and changes in EDA (top/red line), respirations (second/blue line), ECG (third/green line), and heart rate (bottom/blue line) throughout data collection can be seen.





.

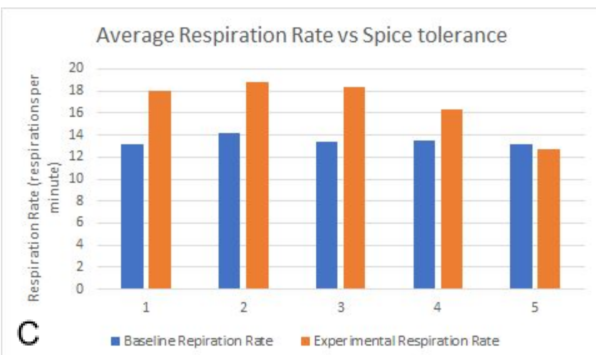


Figure 5. A. The average baseline and experimental EDA plotted against the levels of spice tolerance claimed by participants on post-experimental survey. **B.** The average baseline heart rate and experimental heart rate plotted against the levels of spice tolerance of the participants. **C.** The average baseline respiration rate and experimental respiration rate plotted against the spice tolerance of the participants.

Figure 6. Representative data of average heart rate collected from a volunteer as they sat at rest for 1 minute (baseline), lightly jogged for 30 seconds (+ control), sat at rest again (relax), and sat in anticipation during the experiment.

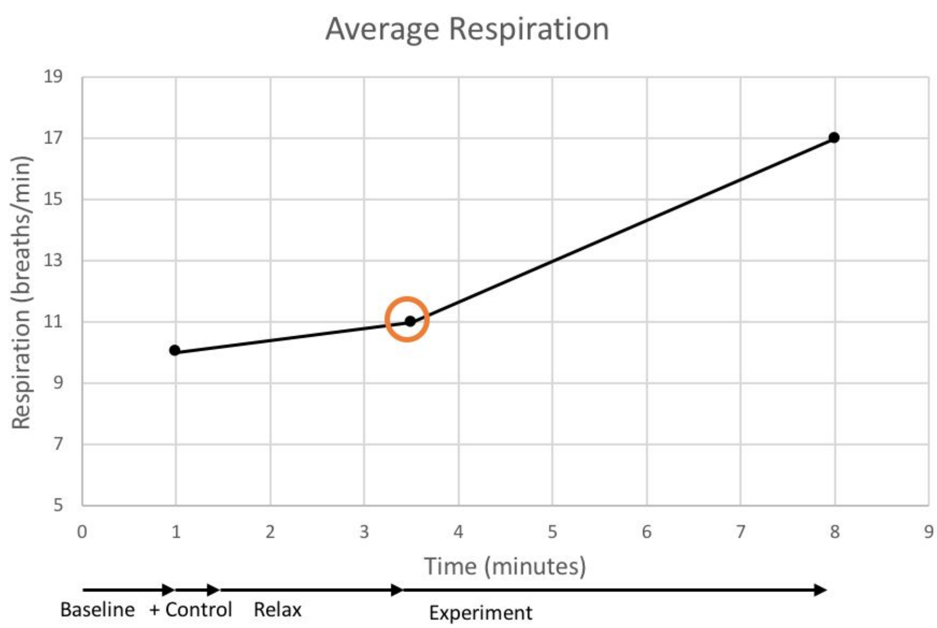


Figure 7. Representative data of average respiration collected from a volunteer as they sat at rest for 1 minute (baseline), lightly jogged for 30 seconds (+ control), sat at rest again (relax), and sat in anticipation during the experiment.

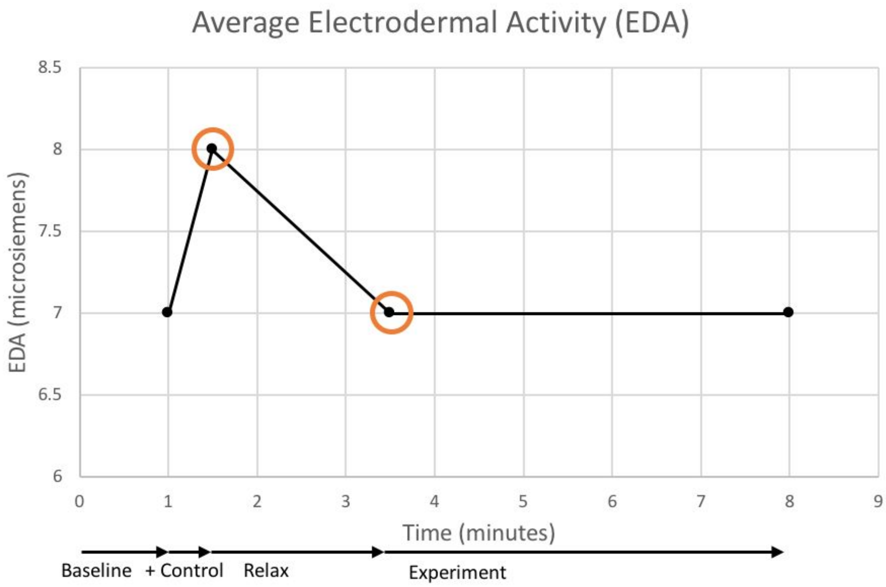


Figure 8. Representative data of average electrodermal activity collected from a volunteer as they sat at rest for 1 minute (baseline), lightly jogged for 30 seconds (+ control), sat at rest again (relax), and sat in anticipation during the experiment.

Post-experimental Survey

Age: _______________

Gender: ______________

How would you rate your current hunger level? (1- not hungry at all, feeling full, 5- very hungry, ready to eat)

1 2 3 4 5

To what degree would you rate your tolerance of spicy food? (1-no tolerance, do not like it, 5 - high tolerance, consume spicy food often)

1 2 3 4 5

Did you enjoy your participation in this study?

Yes No

Figure 9. This survey was given to each participant after the study ended to see if any trends emerged between the experimental data and self-rated spice tolerance.

Figure 10. A. shows the baseline and experimental EDA values grouped by self-reported level of hunger. **B.** shows the baseline and experimental heart rate values grouped by self-reported level of hunger. **C.** shows baseline and experimental respiration rate values grouped by self-reported level of hunger. These

Works Cited

E.J. Boyland, J.A. Harrold, T.C. Kirkham, C. Corker, J. Cuddy, D. Evans, *et al.* "Food commercials increase preference for energy-dense foods, particularly in children who watch more television." Pediatrics, 128 (2011), pp. e93-e100

Christensen, Glenn L. "Mental Simulations, Anticipations, and Dreams: Toward a Theory of Consumption Visions in Consumer Behavior." Order No. 3076938 The Pennsylvania State University, 2002. Ann Arbor: *ProQuest.*

Esther et. al.,(2011). "The power of imagination. How anticipatory mental imagery alters perceptual processing of fearful facial expressions." *Science Direct* 54(2), 1703-1714, 2011.

Kobayashi, H. "Effect of measurement duration on accuracy of pulse-counting." *Ergonomics*, 56(12), 1940–1944, 2013.

Liu, M, et al. "The Sympathetic Nervous System Contributes to Capsaicin-Evoked Mechanical Allodynia but Not Pinprick Hyperalgesia in Humans." *Journal of Neuroscience*, PubMed, 15 Nov. 1996

Nummenmaa L, Hietanen JK, Calvo MG, Hyönä J (2011) "Food Catches the Eye but Not for Everyone: A BMI–Contingent Attentional Bias in Rapid Detection of Nutriments." *PLOS ONE* 6(5): e19215

O'Doherty, J, et al. (2002). "Neural Responses during Anticipation of a Primary Taste Reward." *Neuron 33,* 815-826.

Ohnuki, Koichiro, et al. "Capsaicin Increases Modulation of Sympathetic Nerve Activity in Rats: Measurement Using Power Spectral Analysis of Heart Rate Fluctuations." *Bioscience, Biotechnology, and Biochemistry..*, Taylor & Francis Group, 22 May 2014.

Ohnuki, K, et al. "CH-19 Sweet, a Non-Pungent Cultivar of Red Pepper, Increased Body Temperature and Oxygen Consumption in Humans." *Bioscience, Biotechnology, and Biochemistry.*, U.S. National Library of Medicine, Sept. 2001.

K.M. Pursey, P. Stanwell, R.J. Callister, K. Brain, C.E. Collins, T.L. Burrows "Neural responses to visual food cues according to weight status: A systematic review of functional magnetic resonance imaging studies." *Frontiers in Nutrition*, 1 (2014), p. 7

Reinbach, H.C., et al. "Effects of Capsaicin, Green Tea and CH-19 Sweet Pepper on Appetite and Energy Intake in Humans in Negative and Positive Energy Balance." *Clinical Nutrition*, Churchill Livingstone, 3 Apr. 2009.

Spence, C., et all. "Eating with our eyes: From visual hunger to digital satiation" *Brain and Cognition., ScienceDirect,* Dec 2016.

Watanabe, T. "Capsaicin-, Resiniferatoxin-, and Olvanil-Induced Adrenaline Secretions in Rats via the Vanilloid Receptor." *Bioscience, Biotechnology, and Biochemistry.*, PubMed, 1 Nov. 2001.