ABSTRACT

A PARAMETRIC ANALYSIS OF THE EFFECTS OF OLFATORY EXPOSURES ON FOOD CONSUMPTION IN HUMANS

Obesity has quickly spread across the world, creating a global epidemic. One reason for the increase may be overconsumption. Humans are very sensitive to the many inviting properties of food, such as taste, texture, and smell. This study investigated the effects of different lengths olfactory cue exposures on the quantity of food consumed by adults. Past research on this subject has produced opposing results. Studies in food priming, reinforcer sampling, and motivating operations suggest olfactory exposures to food increase food consumption. In contrast, literature on habituation and sensory-specific satiety suggest the opposite effect: olfactory exposures decrease food consumption. The present study hypothesizes that both effects are possible, such that a brief exposure to the smell of the food may increase food consumption, while a prolonged exposure to the smell may decrease consumption.

A total of 184 Psychology 10 students at California State University, Fresno were exposed to one of four durations of pizza smell (0 minutes, 5 minutes, 10 minutes, and 15 minutes) and then presented with pizza to consume. A one-way ANOVA did not indicate a statistical significant difference in consumption across the time exposures. The lack of statistical significance does not imply that duration of smell exposure produce no effect on consumption. Rather, addressing the limitations in the study for future research may result in a significant understanding of the interaction between smell exposure and consumption.

Kellee Chi
May 2013
A PARAMETRIC ANALYSIS OF THE EFFECTS OF OLFATORY EXPOSURES ON FOOD CONSUMPTION IN HUMANS

by

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A thesis
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CHAPTER 1: INTRODUCTION

Obesity has quickly emerged as a global health concern. One-third of the adult population in America is now classified as obese and the numbers continue to climb in prevalence. Unfortunately, children are not exempt from this dismal fate as they are being diagnosed as obese at a younger age each year (Centers for Disease Control and Prevention [CDC], n.d.). Over the past few years, there has been a concomitant increase in childhood in the development of Type 2 diabetes. For every three Caucasian children born in the year 2000 and after, one is expected to develop diabetes (Davis & Cooper, 2008). With the abundance of health risks that obesity poses, not only for the individual but also for the next generation, obesity needs to be addressed immediately. Many factors associated with the condition have been identified, including genetic, environmental, and behavioral. Interventions targeting unhealthy behaviors may be the most promising treatment (CDC, n.d.). Overconsumption, lack of exercise, and unhealthy eating habits all contribute to weight gain.

The focus of this study is overconsumption. To decrease the amount of food consumed, one place to begin is with the food itself. Humans are very sensitive to the many inviting properties of food, such as taste, texture, and smell. Understanding these sensory properties of food and how they affect quantity of consumption may provide insight to interventions manipulating the sensory food cues to decrease consumption. Past research on the effects of external food cues (particularly olfactory exposure) on food consumption has produced opposing results. On one hand, prior exposure to olfactory cues has been shown to increase quantity of consumption. Coelho, Idler, Werle, and Jansen (2011) found that women who knowingly used chocolate-scented lotion ate more chocolate chip
cookies than women who used the unscented lotion. Ferriday and Brunstrom (2011) demonstrated that a 1 minute smell exposure to food not only increased the amount consumed, but also the desire to eat and the “prospective” amount that could be eaten. In contrast, research has also shown that olfactory exposure can decrease the amount of food eaten. Jansen and Van Den Hout (1991) reported that unrestrained eaters who were asked to smell eight different foods in 12 minutes consumed fewer calories than prior to the cue exposure. For the restrained eaters, an opposite effect occurred, with an increase in caloric intake after the cue exposure.

There is little doubt that smell impacts food consumption. However, the debate lies in whether exposure to the smell of the food increases or decreases the amount of food consumed. Initially, it may seem that the wafting smell of a plate of food will increase appetite and indeed, many studies have suggested this to be the case. On the other hand, according to Wansink (2004) and other researchers, experiencing the smell of the food can depress the amount of food eaten. With these contradictory results, the answer to the question of how smell affects food consumption seems unclear. Perhaps the answer lies in a combination of the two views. Smell can both increase and decrease consumption; not simultaneously, but through varying lengths of time exposure. Perhaps a brief exposure to the smell of food can increase the amount an individual eats but a prolonged olfactory cue exposure can decrease the amount. The present study investigates whether this parametric relationship exists between the length of exposure to olfactory food cue and quantity of consumption in normal weight individuals. If this relationship does exist, olfactory exposure can be a simple self-management behavioral technique that will help increase consumption for those who need it and decrease consumption in others, depending on the length of the exposure. For example,
individuals who are overweight or dieting can smell the food for a longer period of time prior to eating and this may help in their weight loss. In contrast, those who need to increase their intake for health reasons, such as patients undergoing chemotherapy or people suffering from depression, can smell the food briefly before eating it and thus increase the amount of food consumed. Understanding the effects of olfactory exposure on the quantity of food consumption can be critical towards developing behavioral change techniques for a wide variety of health concerns related to eating in individuals. This may provide one more solution in the fight against obesity.
CHAPTER 2: LITERATURE REVIEW

Obesity

Obesity can be assessed via body mass index (BMI), a calculation of height and weight ratio which typically indicates the level of body fat. Individuals with a BMI of 30 or greater fall into the obese category. In recent years, the prevalence of obesity has drastically increased and the numbers continue to climb upward. This condition has propelled itself to the forefront of health concerns as the World Health Organization has termed obesity a global epidemic (World Health Organization [WHO], n.d.). Flegal, Carroll, Ogden, and Curtin (2010) revealed that in the United States alone, over one-third of adults are classified as obese. The alarming statistics have pushed many researchers to study the condition from all directions, in hopes of quickly developing methods toward curtailing the rampant increase in prevalence.

Obesity affects not only physical appearance but also carries health consequences. People who are obese are at a greater risk for hypertension, high blood pressure, heart disease, sleeping disorders, diabetes, and joint problems. Effects can carry through to the next generation, as children of obese parents have a greater predisposition to develop other illnesses (CDC, n.d.).

Several causes for obesity have been identified. First are physiological factors, such as genetics and metabolic rate. Some individuals are predisposed to generating or storing greater levels of adipose tissue due to their genetic makeup. Others may have slower rates of metabolism, causing nutrients to be stored longer in their body than their leaner counterparts. The environment also exerts a powerful influence on an individual’s body weight. African Americans and Hispanics have the highest rates of obesity in America. Women of lower
education and socioeconomic status are also more likely to develop obesity. This may be attributed to the lack of resources to purchase healthy products. Unhealthy behavioral practices are a third contributor to obesity. Body weight is often displayed as an equation where the caloric intake should be equaled to caloric output to maintain. When intake exceeds output, then weight gain occurs (CDC, n.d.). With the convenience of automatic transportation and the advent of appealing electronic devices, Americans have been increasingly engaged in more sedentary activities and less physical exercise, particularly children. The decline in exercise leads to decreases in caloric output and therefore creates an imbalance.

On the other side of the equation is the overconsumption of calories without appropriate exercise, which leads to weight gain (CDC, n.d.). Companies are using newer, more enticing marketing strategies to captivate consumers to buy their food products, which often are unhealthy. The alluring sight, smell, and taste of many high caloric foods present an almost irresistible situation for consumers to overeat. Increased varieties of fatty foods are more readily available for purchase. Although these seemingly overwhelming factors are captivating Americans to eat more, understanding the causes of overconsumption may be key towards behavioral intervention.

**Habituation**

Habituation literature provides support for decrease in food consumption through prolonged smell exposure.

**Basic Habituation and Satiation**

One major determinant of food consumption in humans is habituation. Habituation is the decrease in response to repeated exposures to a stimulus. Initial exposures to a stimulus typically result in increased responding, also known as
sensitization. Subsequent repeated exposures then result in habituation, which is decreased responding. The rate at which habituation occurs is not absolute and many different properties can increase or decrease it. For example, variations in the stimuli and time of presentation slow down habituation. In contrast, a rapid presentation of a simplistic stimulus increases the rate of habituation (Murphy, McSweeney, Smith, & McComas, 2003).

Habituation occurs in the behavior of food consumption, with food functioning as the stimulus. The decrease in responding during repeated exposure to a food stimulus is attributed to “satiation,” but its definition differs from that of physiological fullness. Physical satiation requires ingestion and certain physiological measures to be met, such as blood glucose levels and distention (Murphy et al., 2003). However, during the process of habituation, the decrease in consumption is not due to physical fullness. Researchers were able to prove that by presenting a novel food item to participants after they had terminated their meal. If the participants were physiologically satiated, they would not respond to the new stimulus, but if they had habituated, then response should increase with respect to the new food item. Indeed, there was a sharp increase in response, demonstrating that the decrease in response to the first food item was due to habituation (Temple, Giacomelli, Roemmich, & Epstein, 2008b). “Satiation” then carries with it two different definitions: one refers to the physiological fullness and the other is associated with habituation which leads to a decrease in response.

**Rate of Habituation and Properties of Food**

The rate of habituation is critical to consumption because a slower rate of habituation equals a longer period of response. In food consumption, the increased duration of the response leads to greater caloric intake. Correlations between rate
of habituation and obesity have been found, although the precise relationship between the two is unclear. Temple, Giacomelli, Roemmich, and Epstein (2007) found that overweight individuals habituated slower to the food stimulus compared to the healthy weight participants. The researchers were unsure whether a causal relationship exists, such that slower habituation leads to obesity or vice versa. This study does indicate that rate of habituation has correlations with body weight and further investigation may help understand weight gain.

Many properties of food and the process of eating itself affect the rate of habituation. For example, foods with more complex sensory properties lead to slower levels of habituation than simple foods. In addition, eating the food in the same environment can also help increase habituation to that food (Epstein, Temple, Roemmich, & Bouton, 2009). One powerful property in altering the rate of habituation is variety in the food stimulus. Temple, Giacomelli, Roemmich, and Epstein (2008a) demonstrated this by dividing participants into two conditions. One group was presented with their favorite food for nine trials while the other groups received four different foods in the nine trials. During each trial, the salivary response was measured and on the tenth trial, the children were allowed to consume as much of the food as they wanted. Results indicated an occurrence of habituation in the single item group as exemplified through the decline in salivary response. The decreasing pattern was not seen in the variety group. In addition, during the consumption phase, the variety group ate about 40% more food than the same item group. Results suggest that dietary variety not only increases salivary response but also consumption amount compared to a monotonous food item.

Ernst and Epstein (2002) found that variety of foods also impacts motivated responding for food in adult men. Similar to the previous study, participants were
divided into two groups: a variety group and a single item group. The single item group only had access to turkey sandwiches while the variety group had access to turkey sandwich, roast beef sandwich, and potato chips. In order to obtain the food, the men had to earn points through a computer game which allowed researchers to measure their motivated responding for food. After eight trials, both groups showed a downward trend in the rate of response. But throughout the trials, the varied group maintained a higher response rate than the turkey sandwich only group. Researchers went one step further to access whether physical satiety was leading to the decline by introducing chocolate in trial 9. The response increased back to baseline levels, which suggested that habituation rather than physical satiety was responsible for the previous decrease in response.

Distractions during food consumption also affect the rate of habituation. Individuals who were asked to engage in a task between consumption trials had slower levels of salivary decrease than the control group which did not receive any tasks. One explanation for this effect is that distractions during eating slow down one’s ability to habituate to the food. This finding has large implications for many eating situations familiar to us. Individuals often engage in activities such as watching television or reading magazines while they are eating. The increased consumption in these situations may be attributed to the distracters effect on slowing the rate of habituation (Epstein et al., 2009).

Habituation and Sensory Cues

The consumption of food is not always necessary for habituation to occur. Repeated exposure to certain sensory cues alone has led to salivary habituation. Epstein, Palugh, and Coleman (1996) exposed obese and non-obese women to 10 trials of lemon yogurt. Participants were only given a small amount of the
stimulus on their tongue and were not allowed to swallow so saliva could be collected and measured. Both groups of women had similar levels of baseline salivary response to the taste of the lemon yogurt. After an initial spike in salivary response, the obese and non-obese participants had decreases in the amount of salivation through the remaining ten trials. Non-obese individuals showed a much sharper decrease and researchers hypothesized that the difference is due to the obese participants’ slower habituation to the sensory properties of food.

Visual cues have also been shown to elicit habituation (Temple et al., 2008b). Temple and colleagues wanted to investigate the changes in motivated responding between children who were allowed to consume the food immediately and children who had to wait 20 minutes before eating the food. As the children accumulated points towards their edible reward, those in the waiting group could see the food as they were working. This setup was intended to measure the change in responding when participants were exposed only to visual cues and not consumption. If decreases occurred in the waiting group, then habituation was responsible for the change and not physical satiety, because there was no energy intake. Participants in the waiting group showed decreases in responding as the 20 minutes progressed, indicating that habituation towards the food was possible through visual cues. When a novel food item was introduced after the 20 minutes, the responding increased again, which is consistent with the pattern of habituation but not physical satiety. One critique the researchers had for this study was that they failed to account for the presence of olfactory cues in addition to the visual cues during the waiting condition. The exposures to both sensory properties may have been responsible toward inducing the habituation process (Temple et al., 2008b).
Indeed, previous studies have demonstrated the ability of olfactory cues to invoke habituation in humans. Epstein et al. (2003) presented children with a heated cheeseburger to smell for one minute. Cotton was inserted into their mouths during this time to measure the amount of salivary discharge. The same procedure was repeated for nine trials using a cheeseburger each time. Salivary response followed a decreasing trend throughout the nine trials. On the 10th trial, researchers presented a heated apple pie to assess whether response could be recovered through a novel stimulus. Smelling the novel stimulus, participants recovered to baseline salivary response. The findings of the study suggest that olfactory cues can bring about habituation of salivary response towards food (Epstein et al., 2003).

Unfortunately, previous studies investigating the effects of olfactory cues on habituation have only been in regards to motivated responding and salivary responses. Although the two have implications for quantity of consumption, no study has been conducted yet investigating the relationship between exposure to olfactory cues and consumption. The smell of a food is a large contributor to its taste and therefore influences food consumption. If repeated exposures to olfactory cues led to habituation of the smell, then a decreased amount should be consumed. Epstein et al. (2009) indicate a study of habituation across sensory modalities of taste and smell has yet to take place but it could be possible. Gathering the findings of previous studies, they suggest that habituation of the smell of a food could lead to lower levels of intake than if the individual was not exposed to olfactory cues prior to consumption.
Sensory-Specific Satiety

Another area of research suggesting a decrease in food consumption after smell exposure is sensory-specific satiety and specifically olfactory sensory-specific satiety

Sensory-Specific Satiety Basics

Similar to habituation, the process of sensory-specific satiety demonstrate support that exposures to sensory properties of food affect subsequent consumption. Sensory-specific satiety is a decrease in the pleasantness of a food after it has been eaten to satiety. Prior to consumption, the food contains a certain level of pleasantness for the individual, but with consumption, the pleasantness decreases. Again, “satiety” here refers not to physiological fullness. Individuals experiencing sensory-specific satiety differentiate the feeling from eating a large meal. Rather than feeling full, the reason the individual terminated the first course of a meal was because he was “tired of eating” (Hetherington & Rolls, 1997).

This form of satiety is specific to certain sensory properties of the food, such as the color, shape and texture. For example, the color of a eaten food item is rated lower in pleasantness than an identical item of a different color that was not eaten (Rolls, Rowe, & Rolls, 1982).

Rolls, Rolls, Rowe, and Sweeney first investigated sensory-specific satiety in humans in 1980. In the first experiment, they wanted to access whether the eaten food would be rated less pleasant than the uneaten item. Participants were presented with eight edible stimuli to taste and to rate on the level of pleasantness. They were then given one of the food items to eat until they were content. Then, the eight stimuli were presented again for the participants to rate 2 minutes and 20 minutes after the end of the meal. Results revealed larger decreases in pleasantness ratings for the food consumed compared to other seven items not
consumed. Equally important, this change in rating was seen only 2 minutes after consumption, which was not enough time for nutrient absorption. Therefore, researchers attributed the decrease in rating to the sensory properties of the food (Rolls et al., 1980).

Rolls and colleagues (1980) took their findings one step further in a second experiment. They wanted to examine whether the level of pleasantness had any implications for the amount of consumption. The procedures were similar to those of experiment, except after participants ended their meal and finished their second rating of the eight foods, they were presented with a surprise second course. The second course was either the same as the food they consumed in the first course or a different food item. Participants who received a different food as the second course consumed more of the food than participants who received the same food. The level of consumption corresponded with the pleasantness ratings, because the eaten food item in the first course was rated as less pleasant and eaten less in the second course. In contrast, the uneaten items were rated higher in the pleasantness after the first course and more were consumed if a different food was presented as the second course. A food item with lower pleasantness rating was eaten in lower quantities during subsequent presentation (Rolls et al., 1980).

**Sensory-Specific Satiety and Olfaction**

Sensory-specific satiety can occur in the smell of a food as well. The smell of a food eaten to satiety has been shown to decrease in pleasantness prior to consumption and relative to other uneaten items. Hetherington, Rolls, and Burley (1989) showed, just 2 minutes after the participants finished the food, the pleasantness in the smell of the eaten food decreased dramatically. As the researchers emphasized, at this time, the body has not yet absorbed the food that
was consumed, therefore sensory-specific satiety rather than physiological fullness influenced the decrease in ratings. The pleasantness of the smell was later evaluated at 20 minutes, 40 minutes, and 60 minutes. Although the ratings were still lower than prior to consuming the food, they were not as low as the pleasantness rating at 2 minutes. These results suggest that not only can sensory-specific satiety occur with smell but that it can also occur relatively quickly after consumption.

Rolls and Rolls (1996) demonstrated that the decrease in the pleasantness of the smell could even occur without the consumption of the food. In prior studies, individuals reached satiety after consuming a food for 5 minutes. In this study, chewing the food for the same amount of time, 5 minutes, was enough to elicit the change in pleasantness of the smell of the food. After the results from experiment supported the existence of olfactory sensory-specific satiety, researchers wanted to determine whether it can be produced with olfactory cues alone in a second experiment. Participants rated four foods on their pleasantness of smell and taste. Then they were either given a banana or a piece of chicken to smell for 5 minutes, the same duration as the previous experiments for chewing and consuming. The stimulus was covered with a cotton piece to ensure that only olfactory cues were presented without visual cues. After 5 minutes, participants rated the four foods again on the pleasantness of smell. Participants who smelled the banana as their stimulus had a larger negative change in pleasantness ratings for bananas compared to baseline. Those who smelled chicken for 5 minutes also had decreased levels of pleasantness ratings for chicken compared to baseline ratings. Through this experiment, Rolls et al. (1980) revealed that olfactory sensory-specific satiety can be produced with olfactory cues alone even though it is weaker than if the food was chewed or eaten to satiety. In a previous study
described above, pleasantness ratings correlate with amount of food subsequently consumed (Rolls et al., 1980). Therefore, the lower pleasantness ratings produced by olfactory sensory-specific satiety can lead to lower levels of consumption. Together with the findings from habituation studies, both sensory-specific satiety and habituation suggest that repeated exposures to olfactory cues can lead to decreased consumptions of food.

**Olfactory Cues and Increases in Appetite**

In contrast to the findings summarized above, other studies have shown that olfactory cues of food lead to increased consumption. Humans possess a high sensitivity to scents, as they can distinguish approximately 200,000 odors. This sensitivity is important because smell is a vital component of taste, surpassing the effects of both texture and display of the food (Lyman, 1989). Previous research has demonstrated the ability of smell to increase appetite, a situation probably many of us have experienced. Fedoroff, Polivy, and Herman (1997) conducted a study in which restrained and unrestrained participants were either exposed to 10 minutes of pizza smell or no smell. During the 10 minutes, some of the participants were asked to engage in free thoughts and the others were asked to think only about pizza. Then, they were all offered pizza to consume *ad libitum*. Restrained eaters who were exposed to the smell ate more pizza than those who did not receive an olfactory cue despite the cognitive task. Researchers summarized that olfactory cues elicit appetite in restrained eaters and increased consumption. Unrestrained eaters in the free thoughts condition also ate more when they were exposed to the smell. However, unrestrained eaters who engaged in pizza thoughts ate less in the smell condition than those in the control condition with no exposure to olfactory cues. This reverse finding in unrestrained eaters was
not explained by researchers but it seems consistent with some of the habituation literature on olfactory cues.

Ferriday and Brunstrom (2008) also reported increases in consumption after food cue exposure. Participants who were exposed to the smell of the food for 1 minute ate more pizza and planned to eat more than the non-cue group. The researchers suggest that exposures to food cues increase the desire for consumption and create physiological changes, a phenomenon known as “cue reactivity.” However, the participants of the study included unrestrained and restrained eaters. A post hoc analysis was done to further dissect the results. The analysis indicated that unrestrained eaters exposed to a cue had a larger prospective portion size than unrestrained eaters with no exposure. Cue exposure had no effect on prospective portion size for restrained eaters. Unfortunately, a post hoc was not conducted for the effects of cue exposure on the quantity of consumption on unrestrained eaters only. The reported increase in consumption due to the smell exposure was from the results of both restrained and unrestrained eaters. Therefore, the effects of the exposure on healthy weight individuals are unclear from this study.

Smell alone has also been shown to produce physiological changes in the body, such as increased salivation, insulin release, and gastric acid. These are all necessary processes for the consumption and digestion of food which provide support that olfactory cues can stimulate appetite (Yeomans, 2006). Besides biological findings, there are also behavioral concepts such as motivating operations (Tapper, 2005) and reinforcer sampling (Ayllon & Azrin, 1968), which may provide explanations for why olfactory exposure may lead to increased consumption in humans.
Motivating Operations

Motivating operations may be a contributor toward the increase in consumption following smell exposure.

Motivating Operation Basics

Motivating operations have often been explored in appetite research (Tapper, 2005). A motivating operation is a change in the environment which makes an item more or less reinforcing as a reinforcer. It also increases or decreases the likelihood of the occurrence of behaviors that have been reinforced by that item in the past (Michael, 1982). Changes which lead to increases in reinforcer effectiveness are establishing operations, while changes that lead to decreases in reinforcer effectiveness are abolishing operations. For example, consider deprivation as the motivating operation. In that hunger state, a turkey sandwich will increase in reinforcing effectiveness and the individual will engage in more of the behaviors which in the past have provided him access to that sandwich. On the other end of the spectrum, if the individual is physically full, the turkey sandwich will decrease in its effectiveness as a reinforcer. He or she will also exhibit less of the behaviors that have been previously been reinforced by food. There are two broad categories of motivating operations: unconditioned and conditioned. Unconditioned motivating operations (UMOs) are situations which are innate in the individual, such as food and water deprivation, oxygen depletion, and sleep depletion. Conditioned motivating operations (CMOs) come about through learning history. An originally neutral event or stimulus, as a result of experiences, acquire the ability to function as a motivating operation. Conditioned motivating operations are further divided into three classes: transitive CMOs, surrogate CMOs, and reflexive CMOs (Cooper, Heron, & Heward, 2007).
Surrogate Conditioned Motivating Operation

Surrogate conditioned motivating operations (CMO-S) are events or items that have been paired with an unconditioned motivating operation and later alone, can produce the effects of that UMO. For example, temperature decrease is an unconditioned motivating operation, which increases the reinforcing effectiveness of items that warm up the body as well as the frequency of behaviors that produced warmth. If an individual encounters snow which causes him or her to be cold, then snow by itself can function as a CMO-S. In the future, the sight of snow will increase the reinforcing effectiveness of items that will bring about warmth as well as increase the occurrence of behaviors that produced heat (Tapper, 2005).

Stimuli related to food can function as a surrogate conditioned motivating operation to the unconditioned motivating operation of food deprivation. Studies have shown that certain stimuli can initiate consumption of food in animals because they have been previously paired with food when the animal was food deprived. Tapper (2005) proposed that environmental stimuli such as the sight of a restaurant can function as a surrogate CMO. If an individual always enters the restaurant when he or she is hungry, then the restaurant is paired with the UMO of food deprivation. This pairing would cause the restaurant to function as a surrogate CEO such that it would elicit hunger even if the individual was not hungry prior to entering.

Olfactory Cues as a Surrogate Conditioned Motivating Operation

It is easy to see how the smell of a food can function as a surrogate conditioned motivating operation similar to the restaurant. Food is typically consumed during a state of deprivation, a motivating operation. During consumption, the smell of the food is usually apparent, therefore the smell is
paired with food deprivation and food presentation. Following the role of surrogate motivating operations, the scent itself can produce the effects of the previously paired motivating operation of food deprivation with feelings of hunger. Smelling the food can then increase the reinforcing effectiveness. If olfactory cues of food can acquire the function of surrogate motivating operation, it can be problematic. According to Cooper et al., (2007), the CMO-S can elicit behaviors as if the motivating operation was present even if it was not. This implies that the smell of a food can elicit feelings of hunger even if the individual was not food deprived, causing him or her to intake unnecessary calories.

Reinforcer Sampling and Food Priming

Reinforcer sampling and food priming are two possible mechanisms that may support the increasing effects of smell on food consumption.

Reinforcer Sampling and Food Priming Basics

Reinforcer sampling may provide an additional explanation for the increased consumption elicited by olfactory cues. Reinforcer sampling was a technique used by Ayllon and Azrin (1968) to increase the amount of appropriate behavior by patients at a psychiatric hospital. Patients received tokens for engaging in proper behaviors and those tokens could be used to access activities such as listening to music or watching a movie. Expending the tokens would require the patients to continue behaving appropriately to earn more tokens. However, these activities were not very reinforcing and not many patients exchanged tokens to participate. Researchers decided to increase the effectiveness of the activities as reinforcers by providing all patients with a “sample.” Prior to entering the music room, all patients were required to line up outside of the room
while the music played for a few minutes. Those who wished to participate could present the tokens and those who did not could return to their rooms. After 4 weeks of the music sampling, there was an increase in attendance by patients who were participating prior to the experiment. In addition, a large majority of patients who did not attend before the experiment began to attend as well.

Sobell, Schaefer, Sobell, and Kremer (1970) combined reinforcer sampling with another technique in their experiment. Much like the patients of the previous experiment, patients at the Patton State hospital received tokens for exhibiting appropriate behavior. One of the reinforcers offered was food such that patients received food by exchanging tokens. However, a similar problem arose where food was not functioning as a very effective reinforcer. This was a critical concern because the patients were missing their meals. Some of these “chronic meal-missers” did not accrue enough tokens to redeem food, while others possessed enough tokens but did not want to exchange them for the food. For patients who were missing their meals, researchers separated them into three conditions. They watched people eat, ate one bite, or were given a free meal. Researchers utilized reinforcer sampling by offering the patients one bite to consume. Patients who had to watch others eat were receiving visual cues of the food without consumption, a technique known as response priming. For participants who previously missed their meals despite adequate tokens, results showed an increase in their percentage of meals bought with the tokens in all three interventions. Reinforcer sampling and visual food priming produced similar increases demonstrating that both techniques increased the reinforcing effectiveness of food.
The Function of Olfactory Exposures as Reinforcer Sampling

Sobell and colleagues recognized afterwards that the food priming condition contained both visual and olfactory exposures (Sobell et al., 1970). The increasing effects of the food priming technique may be due to the patients smelling as well as seeing the food. This finding suggests that olfactory exposures may play a role in the reinforcing effectiveness of food and lead to increased responses to it because smell may be enacting a food priming mechanism. This increasing ability may be further supported by the studies on reinforcer sampling. The success of reinforcer sampling operates through providing the individual a small sample of the reinforcer. Smell alone may serve that same sampling function for food. Sobell et al. (1970) provided patients in the reinforcer sampling condition with one bite of the food. Within this bite, the patient was exposed not only to the sight, taste, and texture of the food but also the smell of it. Smell helped elicit the increase in responding to the food. It is unclear from these two studies whether the smell itself can produce the same effects alone but together with other sensory properties, it can operate through reinforcer sampling and food priming to increase response to food. The increased response led to larger quantities of consumption than prior to the intervention.

Summary

Smell is vital to the taste of food and an influential determinant in consumption. Upon reviewing the literature, two different processes seem to suggest that olfactory food exposures can decrease consumption in humans. Arising from the habituation studies, repeated presentations of the smell of a food to an individual leads to a decrease in motivated responding for the food and salivary response. The decreasing pattern is characteristic of habituation.
Repeated olfactory exposures alone produced habituation in responses that are related to food consumption. Therefore, there are strong implications that a decreased amount of food will be eaten after experiencing the smell due to habituation. Research on sensory-specific satiety also provides support. After smelling a food item for 5 minutes, it was rated as less pleasant than the other foods that were not smelled, creating olfactory sensory-specific satiety. In previous studies, it had been demonstrated that pleasantness correlates with a subsequent amount of food consumed. Consequently, the lower pleasantness ratings produced by olfactory sensory-specific satiety will lead to decreased food consumption. Studies in sensory-specific satiety and habituation suggest that repeated exposures to olfactory cues can reduce food consumption in humans.

On the other hand, there is also literature that provides support for the opposite effect: olfactory exposures to food can increase consumption. Smell has been shown to increase appetite and several behavioral explanations have been found. The smell may function as a surrogate conditioned motivating operation. It signals the presence of food and elicits feelings of hunger as if the motivating operation of food deprivation is present even if it may not be. This would then result in increased food consumption despite the individual’s hunger level. Olfactory exposures can also be related to reinforcer sampling where the smell acts as a small sample of the larger reinforcer, food. After being exposed to the sample, there is increased response to the reinforcer which can be greater food consumption. Studies on food priming reveal a similar mechanism that olfactory exposures may be operating under to produce the increased food response. Together, motivating operations, food priming, and reinforcer sampling all offer mechanisms for which olfactory cues could be operating under to increase food consumption in humans.
The studies on olfactory exposures to food seem to be separated into two opposite camps. One side suggests that the smell of food will increase consumption while the other side suggests it will decrease consumption. It is difficult to negate the findings that support each side but it may not be necessary to do so. Perhaps both views are correct in that smell can serve a dual function of increasing and decreasing consumption. Of course, smell cannot simultaneously carry out both functions but perhaps the one factor mediating both sides is time. A brief exposure to the smell of the food may elicit consumption but longer exposures may lead to decreases in consumption. The present question would be to investigate where on the time spectrum the exposure to olfactory cues crosses from increasing to decreasing food consumption.

**Research Question**

Do brief exposures to the smell of food affect the quantity of food consumption differently than longer smell exposures?
CHAPTER 3: METHODS

Participants

Approximately 198 Psychology 10 students were recruited from the California State University, Fresno undergraduate population. However, 14 participants were excluded because they did not fit the criteria resulting in a final sample size of 184. A power analysis was used to determine that approximately 45 participants were necessary in each of the four groups given a medium effect size and alpha= .05. College students were chosen in part due to convenience sampling and also because effects in adults are of interest rather than children. Participants with food allergies to pizza, on a calorie restricting diet, and those currently taking medication affecting their appetite were excluded from the study. Individuals with impaired sense of smell were also excluded. In addition, participants must have indicated a moderate-high liking for the food used in the experiment. The study took place on campus.

Independent Variable

The independent variable is exposure to the olfactory cue of food prior to consumption. There were four different time exposures: 0 minutes, 5 minutes, 10 minutes, and 15 minutes (see Table 1). Pizza was used as the target food item. This variable is presumed reliable and valid.

Dependent Variable

The primary dependent variable in this study is the quantity of food consumed by the participant. Quantity was measured by weighing the plate of food. Researchers weighed the food on a plate prior to presenting it to the participants. After the participants terminated the meal, the plate was weighed
again and the difference from the initial weight indicated the number of grams of food consumed. These measures also provided the rate of consumption by dividing the amount consumed over the amount of time spent eating. The methods used to measure the dependent variable are presumed to be reliable and valid. Water was also provided *ad libitum*. The amount of water consumed was measured by subtracting the final weight of the water bottle from the initial weight. The study was conducted at the same time each day to control for possible effects that time of day may have on quantity of consumption.

A 9-point hedonic scale of food preference was used to assess the students’ liking for food items in the experiment (see Appendix A). This measure is presumed reliable and valid (Peryam & Pilgrim, 1957). Only participants with a moderate-high liking (scoring above 4 and below 9) were recruited for the experiment because participants reporting a liking on either end of the extremes may consume extremely high or extremely low amounts of pizza and thereby skewing the overall data.

Table 1

<table>
<thead>
<tr>
<th>Groups</th>
<th>Session</th>
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</thead>
<tbody>
<tr>
<td>Group #1 (Control Group)</td>
<td>0 minute exposure</td>
</tr>
<tr>
<td>Group #2</td>
<td>5 minute exposure</td>
</tr>
<tr>
<td>Group #3</td>
<td>10 minute exposure</td>
</tr>
<tr>
<td>Group #4</td>
<td>15 minute exposure</td>
</tr>
</tbody>
</table>

Upon providing informed consent, (see Appendix B) each participant received a participant identification number to keep the confidentiality of the
results. The number was written at the top of their questionnaire (see Appendix C) and a sticker with the number was given to the individual. When all participants completed the forms, the research assistant went over the procedures to the study and guidelines that should be followed. Participants were then led into a second room where consumption took place (see Appendix D). The purpose of this was such that participants would not be able to smell the pizza while they were filling out the consent forms and questionnaires. However, depending on the condition, participants waited for a different duration of time prior to being led into the next room. The setup equalized the wait time for each group prior to consuming pizza. Participants in the 15-minute condition were exposed to the pizza smell for 15 minutes before being presented with the food while participants in the 0-minute condition were presented with the food almost immediately upon entering the second room. Therefore, in order to account for the 15 minutes of wait time, all the groups were asked to wait for 15 minutes before pizza will be presented. The 0-minute group was asked to wait 15 minutes in the first room. The 5-minute group was asked to wait 10 minutes. The 10-minute group was asked to wait 5 minutes and the 15-minute group was led immediately into the second room after the researcher explained the procedures. For the 5-minute and 10-minute groups, the remaining time, 5 minutes and 10 minutes respectively, were spent in the second room with the smell exposures (see Table 2).

When participants entered the second room, a bottle of water and a colored card were already placed on each desk with a designated number on the desk. Participants sat down at the corresponding desk which matched their participant number. For the 0 minute group, research assistants entered the room and immediately began distributing a covered plate of pizza to each individual. The plates of pizza were pre-weighed by research assistants using a digital scale and
Table 2

*Distribution of Wait Time*

<table>
<thead>
<tr>
<th>Group</th>
<th>Wait Time in Room 1</th>
<th>Smell Exposure Time in Room 2</th>
<th>Total Wait Time Prior to Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group #1 (0 minute exposure)</td>
<td>15 minutes</td>
<td>0 minutes</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Group #2 (5 minute exposure)</td>
<td>10 minutes</td>
<td>5 minutes</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Group #3 (10 minute exposure)</td>
<td>5 minutes</td>
<td>10 minutes</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Group #4 (15 minute exposure)</td>
<td>0 minutes</td>
<td>15 minutes</td>
<td>15 minutes</td>
</tr>
</tbody>
</table>

the participant number was written at the bottom of the plate. Each plate contained six typical slices of pizza, approximately 600g total. According to pilot data, an individual typically ate three to four slices of pizza and the highest amount eaten by a single person was five slices. If a participant consumed all the pizza on the plate, a research assistant delivered another pre-weighed plate with two additional slices but no more were given to the individual after that. The most pizza any participant could possibly receive was eight slices. The size of the slices varied in order that participants did not stop eating when they reached the typical number of slices that they consume. Participants in group #1 sat down at the desks and were instructed to eat as much pizza as they would like. Magazines unrelated to exercise, food, or dieting, were provided for them to read during eating. Individual dividers were setup at each seat separating the participants such that each individual was unable to observe the activity of other participants in the room. This was designed to reduce the effect observers may have on quantity of food consumption.
After the pizzas were distributed, participants were instructed to begin eating and research assistants marked the starting time. Once participants were finished eating, they were instructed to leave all materials on the table and turn over their participant number card to indicate that they were finished. Turning over a small card allowed researchers to see when each participant finished and therefore calculate the total amount of time for consumption. The gesture was subtle enough such that it should not overtly distract other participants from eating. When all participants were finished, they rated their liking of pizza again (see Appendix E). After all participants evacuated the room, research assistants weighed all the plates again and recorded the final weight in grams. The difference was the amount of pizza consumed and together with the amount of time needed to finish eating by each participant, a rate of consumption was calculated as well. The amount of water consumed in grams was also recorded. These various measures and those on the questionnaire were evaluated later to determine if a relationship existed among these variables and duration of olfactory exposure.

For the participants in the 5-minute, 10-minute, and 15-minute groups, the setup was similar except for the wait time when participants first enter into the second room. When group #2, the 5-minute smell exposure group, entered the second room, the pizzas were not immediately distributed. There were pizza boxes present in the room to infuse it with the smell of pizza. Participants were told that the pizza were being divided and will be coming in a couple minutes. After 5 minutes, research assistants distributed the previously weighed plates of pizza to each participant. Again, water and magazines were available. After the pizzas were distributed, the procedures were identical to those of group #1. For group #3, the procedures were similar to that of group #2 except participants
waited 10 minutes upon entering the second room before the pizzas were
distributed. For group #4, procedures were similar to those of group #2 except
participants waited 15 minutes before the pizza will be distributed. Pizzas were
kept inside the boxes and special heat insulating bags until they were ready to be
distributed so that the temperature of the pizza would not affect the amount
consumed.

**Treatment Integrity**

A task analysis checklist of the procedures was created to evaluate the
treatment integrity of the study (see Appendix F). During each session, each box
to the corresponding step in the procedure was check if it was completed
appropriately. If the step was not completed, the box was left empty. Treatment
integrity was also assessed by measuring the validity of the pizza smell exposure.
At the start of consumption, an individual walking into the pizza room for the first
time that session, rated the strength of the smell of pizza around the room. Four
separate ratings were taken, one on each side of the room (see Appendix G). The
task analysis checklist used to assess treatment integrity was utilized during every
experimental session and all of the steps were completed appropriately. Average
rating on the strength of the pizza smell in the room across all sessions was a four
out of five which was considered a “strong smell.”

**Interobserver Agreement**

Each plate of pizza was weighed by two different individuals on two
separate scales. Interobserver agreement was calculated by obtaining the
difference in the two weight measurements. The weight of the plates was identical
on 54% of measurements across all sessions. There was a difference of one gram
on 34% of weight measurements and a difference of 2 grams on 9% of all weight
measurements. A difference in weight of 3 or more grams across the observers was 3% of all measurements. The discrepancy of one or two grams was considered negligible and may be attributed to a small variance in the sensitivity of the digital scales.

**Research Hypothesis**

It was proposed that a brief exposure (0 and 5 minutes) to the smell of the food would lead to larger quantity of consumption while a longer exposure (10 and 15 minutes) would lead to lower amount of food consumed compared to the control group.
CHAPTER 4: RESULTS

To determine whether a statistically significant difference existed in the quantity of pizza consumed across the four different smell exposures, a one-way ANOVA was used. Using an alpha of .05, there was no statistically significant difference found in the quantity of food consumed across the 0-minute, 5-minute, 10-minute, and 15-minute groups. Similar analysis conducted on secondary dependent variables of quantity of water drank, and rate of food consumption did not yield any statistically significant difference across the four smell exposure conditions. Of the 184 participants, 13 reported an increase in liking of pizza after consumption, 65 reported a decrease in liking, and 104 no change in liking of pizza. There was no statistically significant difference with change in liking across the four smell exposure groups. The descriptive statistics for quantity of consumption for each group are detailed in Table 3.

Table 3

<table>
<thead>
<tr>
<th>Smell Exposure</th>
<th>N</th>
<th>Mean in g</th>
<th>Standard Deviation in g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 minute</td>
<td>42</td>
<td>251</td>
<td>124</td>
</tr>
<tr>
<td>5 minute</td>
<td>46</td>
<td>267</td>
<td>114</td>
</tr>
<tr>
<td>10 minute</td>
<td>53</td>
<td>258</td>
<td>111</td>
</tr>
<tr>
<td>15 minute</td>
<td>43</td>
<td>265</td>
<td>96</td>
</tr>
</tbody>
</table>

It was hypothesized there might be a difference between men and women participants in their pattern of consumption. An independent samples t-test was used to examine gender difference in consumption. Men ($M = 347.36, SD =$
132.82) consumed significantly more pizza than women \((M = 225.15, SD = 82.98)\), \(t\)(182) = -6.61, \(p = .000\), \(d = 1.08\).

Subsequent analyses were conducted on each gender separately to further investigate the primary and secondary dependent variables. A one-way ANOVA did not indicate any statistically significant difference in quantity of food consumption across all smell conditions among female participants. Rate of consumption, change in liking of pizza, and quantity of water drank also did not yield any statistically significant results. There was no statistical significance in quantity of food consumed, change in liking of pizza, or rate of consumption for male participants across the different smell exposures. In analyzing water consumption, those who were in the 15-minute smell condition \((M = 381.14, SD = 103.98)\) drank significantly more water than participants in the 0-minute smell condition \((M = 263.21, SD = 147.96)\), \(t\)(26) = -2.44, \(p = .022\), \(d = .922\).
CHAPTER 5: DISCUSSION

The present study investigated the effects of smell exposure on the quantity of food consumption in non-dieting adults. The limited research on this topic is still growing and more studies are needed to continue the investigation. However, current literature on smell exposure and food consumption provides support for two opposing sides. Fedoroff et al. (1997) demonstrated that participants exposed to 10 minutes of pizza smell exposure consumed more than participants in the no smell condition. Furthermore, Ferriday and Brunstrom (2008) found that a 1-minute smell exposure was sufficient to increase consumption in women as well as increasing the amount the individual expected to consume in the future. These results suggest that smell exposure may enhance the amount of food eaten.

Several behavioral processes provide support for the increase. Smell may function as reinforcer sampling or food priming (Sobell et al., 1970) and these two processes may be possible contributors to the underlying mechanisms responsible for the increase in consumption. Smell can also be a surrogate conditioned motivating operation such that it evokes a motivating operation of hunger even though the individual may not be hungry. The smell has been paired with food consumption in the past when the individual was in a state of hunger and therefore the smell alone may be sufficient to evoke the feeling of hunger (Tapper, 2005).

In contrast, sensory-specific satiety and habituation literature suggests that although there may be an initial increase in consumption through smell exposure, there will be a decrease after prolonged exposure. Epstein and colleagues (2003) found decreased salivary response after exposing the children to nine trials of 1-minute cheeseburger smell. On the 10th trial, researchers presented a 1-minute smell of apple pie and salivary response increased again. Repeated smell
exposures to the same food item were correlated with a decrease in salivary response suggesting that participants habituated to the smell of the food. Although no known study has examined the implications between salivary response and actual food consumption, it is probable that a positive relationship exists such that increased salivation would be correlated with increased quantity of food consumed.

Therefore, several areas of literature seem to suggest that smell increases food consumption in humans. Meanwhile, an equally strong argument could be made that smell exposure decreases consumption based upon other existing bodies of research. Both sides possess sound research support proving it difficult to determine whether smell had an increasing or decreasing effect on food consumption. The current study arose from the idea that perhaps both sides may be correct. It is possible that a brief exposure to the smell of food would lead to an increase in food consumption while prolonged exposures would lead to a decrease in consumption. This pattern is not altogether different from the habituation pattern of initial sensitization and subsequent satiation. Therefore the focus of this study was investigating the existence of a parametric smell exposure effect on quantity of food consumption.

Results of this study did not yield statistical significant differences in quantity of food consumed between the four smell exposure conditions. In a study conducted by Jansen, Broekmate, and Heymans (1992), participants demonstrated a decrease in food craving after 25 minutes. Therefore, it is possible that statistically significant differences may have been found if the smell exposure conditions extended to 25 and 20 minutes.
Limitations

There are several limitations within this study that ought to be addressed for future research. First, the study was originally designed to only include men because it was hypothesized that they would be less conscientious than women when eating in front of others. However, due to the gender composition of the students in Psychology 10 students, there were almost three times more females than male students. Therefore, women were included in the study as well in order to obtain the appropriate number of participants. This provided inaccurate data because as the above analyses indicate, there are large disparities in consumption between the two genders. When both sets of data are combined in the calculation, significant differences within a group may be masked by extreme values in the other gender group.

The setting of the study also provided limitations as well. Although each participant had individual dividers that prevented other participants from observing their consumption during the study, the experimental setting may still have affected the consumption of the participants. Most individuals typically do not eat pizza within a divider next to strangers. The quantity of consumption may not be the actual amount eaten had the participants been in their typical eating environments under similar smell exposure conditions. In addition, participants were aware that they were part of an experiment and some individuals may have curbed their eating knowing that they were under close observation.

Pizza consumption did not take place in the same location for all participants and this difference in rooms may have introduced confounds in the study. The distance between the consent room and the smell infused room was held constant in order to decrease the likelihood that walking distance would contribute to increased hunger. However, one of the pizza smell rooms was
smaller than the other and this impacted the seating arrangement of the participants such that they sat closer to other participants. Furthermore, the smaller room was also warmer than the larger room and therefore, increased the smell intensity of the pizza. It is possible that both of these factors could impact the quantity of food consumption.

Third, variations in the size of the participant group during each experimental sessions may have had unexpected effects on participant behaviors. The number of participants each day was intended to be uniform across all sessions. Unfortunately, due to participant cancellations, this was not possible. The size of the group ranged from as few as 3 participants to as many as 20 participants. This could have impacted the consumption behavior of the participants because, it is possible that some individuals consume less when surrounded by a smaller group and consume more when surrounded by a larger group. The reverse could also be true.

Procedural limitations also existed within the current study. Participants were required to wait in the first room in order to equalize the total wait time for all experimental groups. Individuals in the 0-minute smell exposure waited in the consent room for 15 minutes. Those in the 5-minute smell exposure group waited for 10 minutes and those in the 10-minute smell exposure group waited for 5 minutes. Participants in the 15-minute smell exposure group did not have to wait in the consent room. This design was intended to control for wait time as a possible variable affecting consumption. The only difference between the two rooms should have been the presence or absence of pizza smell. However, participants in the 15-minute smell exposure conditions were not only exposed to 15 minutes of pizza smell, but they also had access to water and magazines in the pizza room. Some of these participants started drinking the water at their station
and this may have impacted their hunger level and subsequent pizza consumption. In addition, they also had a longer access to water and therefore may have drunk more than participants in the other conditions. Meanwhile, participants in the 0-minute smell exposure spent their entire wait time in the consent room, which did not have any water or materials on the desks.

Lastly, the food preference rating scale may have posed some limitations for the study as well. Participants were recruited based upon their response on a food preference rating scale (see Appendix A) such that their rating of pizza must fall between a 5 and an 8. This rating was reaffirmed when participants arrived to complete the consent form where they were asked to rate their liking of pizza again. Participants whose preference did not fall in the appropriate range were excluded from the study. Several participants indicated a fairly high liking for pizza but when they came into the study, they only took one to two bites of pizza. In the post-questionnaire rating, their liking for pizza remained high. One possible explanation for this imbalance between rating and consumption may be that participants had a preference for a type of pizza that was different from the kind served in this study. Pizza may seem like a uniform food but there are many aspects of pizza that could differ, such as the thickness of the crust, the sweetness of the sauce, the blend of cheeses, and the taste created by the combination of all the ingredients together. For this reason, pizza chain stores across the country can utilize similar ingredients and present a product that is distinct from all other competitors. For future research, participants should be asked to rate their preference of the specific type of pizza that will be used in the study to gain a more accurate depiction of liking.
Future Research

Future research should consider rectifying the limitations in the current study. One prominent change would be to conduct the study with only women and only men because they display extremely diverse eating behaviors. If taken separately, it may present a clearer picture of the possible effects of smell exposure on food consumption for each gender.

It would also be interesting to conduct this study with each participant separately because most individuals typically do not eat pizza with 20 other strangers in a room. In addition, as evident from the descriptive statistics, the large values of standard deviation suggest there are a range of scores masked by means in the data. Further research is needed to investigate the variables that affect the processes at play impacting such variability in consumption. Ideally, each session would contain one participant exposed to a particular smell condition, perhaps in a setting that the individual typically eats rather than in an experimental setting. This procedure may prove to be rather laborious and time consuming, however, if all 180 participants were to be studied individually. One solution to this problem may be a single-subject approach to the design. The consumption behavior of several participants would be measured repeatedly and eventually exposed to all four smell conditions. This would also alleviate some of the extreme individual differences that occur in the group design data. However, the researcher would need to be cautious of possible habituation effects that may take place with repeated consumption of the same food item and not mistake the decrease in quantity of consumption as the result of increased smell exposure.

It would also be interesting to conduct the study with a different food item that produces an equally strong distinctive smell but with smaller units. Consumption may be affected by the size of a single unit of the food. Participants
in the study may have felt the need to consume the entire slice of pizza if they were moderately hungry and that may have impacted their pursuit of a second slice. If popcorn was used, the individual may be less intimated to finish another kernel. Furthermore, pizza is typically consumed in a group setting such as at a party. The social stimuli present when participants typically eat were absent in the experimental setting and thus, the quantities of pizza consumed may not be accurate indicators of pizza consumption in their daily live. A food item that is often eaten alone may be a better choice for the setup of this experiment.

An exciting direction for future research would be to take a more applied approach and study the effects of smell exposure on the consumption behavior of restrained eaters and individuals who lack adequate nutrition but have a loss of appetite. Restrained eaters and dieters were excluded from the present study, but it would be interesting to see whether smell exposure to the food would alter their quantity of consumption. If so, this can be a rather simple self-management technique to decrease caloric intake. It would be equally beneficial to conduct this study with individuals who have deficiencies in nutrition but experience lack of appetite towards nutritional foods. This may include “picky-eaters” in children or patients undergoing treatments with decreased appetite, yet they still need nutrients to help their body recover. Perhaps smell may play a role in affecting their level of consumption.
CHAPTER 6: CONCLUSION

Obesity undoubtedly remains one of the most prominent problems today, with its impact becoming increasingly detrimental to individuals of all ages across the world. Amongst the abundance of research on possible origins, genetics, and diets in search of solutions for combating obesity, behavioral intervention is an additional avenue for obesity treatment. Interventions targeting overconsumption can be applicable for many individuals struggling with obesity particularly if it is simple and easily self-manageable. This study focused on understanding the effects of varying durations of smell exposure on food consumption. If a specific duration of smell exposure was found to have a decreasing effect on food consumption, then it would have been a seemingly simple intervention that can be implemented by anyone looking to curb their diet. Unfortunately, no statistically significant differences were found across the four different smell exposures. However, it is possible that longer durations of smell exposure may have had an impact on amount of pizza eaten. Future research addressing the limitations above may also lead to significant findings. It is undeniable that smell exposure has an effect on food consumption but more research is needed to further examine the specificities between the two sensory modalities. When the interplay between duration of smell exposure and quantity of food consumption has been understood, it may open up exciting new tools for individuals to utilize in their fight against obesity.
REFERENCES


APPENDICES
APPENDIX A: 9-POINT HEDONIC SCALE OF FOOD PREFERENCE
Appendix A: 9-Point Hedonic Scale of Food Preference

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<tr>
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<th>2</th>
<th>3</th>
<th>4</th>
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<th>6</th>
<th>7</th>
<th>8</th>
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<tbody>
<tr>
<td></td>
<td>Dislike Extremely</td>
<td>Dislike Very Much</td>
<td>Dislike Moderately</td>
<td>Dislike Slightly</td>
<td>Neither Like Nor Dislike</td>
<td>Like Slightly</td>
<td>Like Moderately</td>
<td>Like Very Much</td>
<td>Like Extremely</td>
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</table>
APPENDIX B: CONSENT FORM
You are invited to participate in a study conducted by Kellee Chi and Dr. Marianne Jackson at California State University, Fresno. The present study examines the effects of wait time and food consumption. Eating pizza will be part of the study. You were selected as a possible participant in this study because you are a student at CSU, Fresno.

If you decide to participate, you will be asked to complete a brief questionnaire about your weight, height, gender, age, food preference, and identify the foods eaten within the last 24 hours. You will then be provided with pizza and asked to eat it but you may consume as little or as much as you would like. Some individuals may consume more than others and some may consume less. There is not a specified amount which participants are expected to consume. Water will also be offered. The study is expected to last approximately two hours. This experiment will expose participants to minimal risk. If you complete the entire study, you will be given two course credits. There are no foreseeable benefits for individuals participating in this study.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. If you give us your permission by signing this document, we plan to disclose your participation to your instructor so that you may receive class credit. In addition, if the results of the study are published and/or presented, any identifying information will be removed.

Your decision whether or not to participate will not prejudice your future relations with California State University, Fresno. If you decide to participate, you are free to withdraw your consent and to discontinue participation at any time without penalty.

If you have any questions, feel free to ask or if you have additional questions later, please contact Kellee Chi at (559) 916-7742 and/or Dr. Marianne Jackson in Science II 336 at (559) 278-2757. You will be given a copy of this form to keep at the end of the study.

YOUR SIGNATURE INDICATES THAT YOU HAVE READ THE INFORMATION ABOVE AND HAVE DECIDED TO PARTICIPATE.

Signature of Participant

______________________________

Date

______________________________

Signature of Investigator
APPENDIX C: QUESTIONNAIRE AND 24-HOUR FOOD RECALL
Appendix C: Questionnaire and 24-hour food recall

1. What is your age (in years)? __________
2. What is your weight? ______feet and _______ inches
3. What is your current weight? _______ lbs.
4. What is your year in college? _______
5. What is your gender? Male Female
6. Do you have an impaired sense of smell? Yes No
7. Are you currently taking any medication affecting your appetite? Yes No
8. Are you on a calorie restricting diet? Yes No
9. On the scale below, indicate your liking of pizza by circling the corresponding number:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dislike Extremely</td>
<td>Dislike Very Much</td>
<td>Dislike Moderately</td>
<td>Dislike Slightly</td>
<td>Neither Like Nor Dislike</td>
<td>Like Slightly</td>
<td>Like Moderately</td>
<td>Like Very Much</td>
<td>Like Extremely</td>
</tr>
</tbody>
</table>

Participant ID#____________
24-Hour Food Recall

Please indicate the foods you consumed within the last 24 hours.

<table>
<thead>
<tr>
<th>Time of Consumption</th>
<th>Food and Quantity</th>
<th>Time of Consumption</th>
<th>Food and Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Example- 9:00 AM</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cereal-1 bowl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>24</td>
<td></td>
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<tr>
<td>5</td>
<td></td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>28</td>
<td></td>
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<tr>
<td>9</td>
<td></td>
<td>29</td>
<td></td>
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<td>10</td>
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<td>30</td>
<td></td>
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<td>11</td>
<td></td>
<td>31</td>
<td></td>
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<tr>
<td>12</td>
<td></td>
<td>32</td>
<td></td>
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<tr>
<td>13</td>
<td></td>
<td>33</td>
<td></td>
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<tr>
<td>14</td>
<td></td>
<td>34</td>
<td></td>
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<td>15</td>
<td></td>
<td>35</td>
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<td>16</td>
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<td>36</td>
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<td>17</td>
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<td>37</td>
<td></td>
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<tr>
<td>18</td>
<td></td>
<td>38</td>
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</tr>
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<td>19</td>
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<td>39</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D: SETUP OF THE EXPERIMENT
Appendix D: Setup of the Experiment

Setup of Room 2

<table>
<thead>
<tr>
<th>Participant #25</th>
<th>Participant #20</th>
<th>Participant #15</th>
<th>Participant #10</th>
<th>Participant #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant #24</td>
<td>Participant #19</td>
<td>Participant #14</td>
<td>Participant #9</td>
<td>Participant #4</td>
</tr>
<tr>
<td>Participant #23</td>
<td>Participant #18</td>
<td>Participant #13</td>
<td>Participant #8</td>
<td>Participant #3</td>
</tr>
<tr>
<td>Participant #22</td>
<td>Participant #17</td>
<td>Participant #12</td>
<td>Participant #7</td>
<td>Participant #2</td>
</tr>
<tr>
<td>Participant #21</td>
<td>Participant #16</td>
<td>Participant #11</td>
<td>Participant #6</td>
<td>Participant #1</td>
</tr>
</tbody>
</table>

Front of Room
APPENDIX E: POST-CONSUMPTION PREFERENCE RATING
Appendix E: Post-Consumption Preference Rating

1. On the scale below, indicate your circle liking of pizza by circling the corresponding number:

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dislike Extremely</td>
<td>Dislike Very Much</td>
<td>Dislike Moderately</td>
<td>Dislike Slightly</td>
<td>Neither Like Nor Dislike</td>
<td>Like Slightly</td>
<td>Like Moderately</td>
<td>Like Very Much</td>
<td>Like Extremely</td>
</tr>
</tbody>
</table>
APPENDIX F: PROCEDURE TASK ANALYSIS CHECKLIST
Treatment Integrity Checklist for Pizza Thesis

Date: ___________________                       Name: ___________________

☐ Passed out Consent Form
☐ Passed out Questionnaire
☐ Assigned Participant ID #s
☐ Implemented appropriate wait time in Room 1 after all participants finished filling out forms
☐ Led participants to the correct room (Ed. 390)
☐ Participants sat down at the appropriate desk
☐ Correct Setup: bottom plate, magazine, water, green/red card, divider, napkins
☐ Placement of pizza to the left, right, back and front of room
☐ Implemented correct wait time in the Pizza smell room after all participants sat down
☐ Slices of pizza varied in size
☐ Each plate of pizza weighed by 2 different individuals
☐ Pizza distributed simultaneously
☐ Handed out extra plate of pizza without participant needing to raise his/her hands
☐ Correctly recorded the time each participant was finished
☐ Handed out post-questionnaire
☐ Each finished plate measured by 2 different individuals and recorded
☐ Each water bottle measured by 2 different individuals and recorded
Using the scale above, indicate the intensity of the pizza smell around the group of participants by writing the appropriate number next to each position.

**FRONT of the group:**

**BACK of the group:**

**LEFT of the group:**

**RIGHT of the group:**

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Smell</td>
<td>Barely Perceptible Smell</td>
<td>Faint Smell</td>
<td>Easily Perceptible Smell</td>
<td>Strong Smell</td>
<td>Extremely Strong Smell</td>
</tr>
</tbody>
</table>
Fresno State

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Kellee Chi

Type full name as it appears on submission

[ ] March 15, 2013

Date