The Effects of Auditory and Olfactory Cues on Visual Attention Toward Food Images Under Acute Stress

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Citation
The Effects of Auditory and Olfactory Cues on Visual Attention Toward Food Images Under Acute Stress

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Food Science

by

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Gorgan University of Agricultural Sciences and Natural Resources
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This thesis is approved for recommendation to the Graduate Council.

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ABSTRACT

Psychological stress has been shown to increase preference for high calorie foods containing high levels of sugar and fat. Since excessive intake of high calorie foods may increase potential risk of obesity and other relevant health issues, relieving psychological stress may help in maintaining a balanced diet and good health status. Although a variety of strategies for relieving psychological stress has been suggested, little attention has been paid to regarding whether such strategies can result in balanced diets. Since music therapy and aromatherapy have proven popular approaches to relieving psychological stress, this thesis aimed at determining whether listening to music (Chapter 3) or smelling pleasant odors (Chapter 4) might decrease acute psychological stress, thereby decreasing visual attention toward and desire to consume high calorie foods. In Study 1, participants, after taking an intellectual quotient (IQ) test (acute stressor), were exposed to five minutes of one of three auditory conditions: (1) no music, (2) a classical musical piece (Air on the G string), and (3) a self-selected musical piece. Participants experiencing the no-music condition were given a break from music listening. Both positive and negative emotions were measured at three stages: before the IQ test (Pre-Stress), immediately after the IQ test (Post-Stress), and following the treatment (music or break) (Treatment). Using an eye tracker at both the Pre-Stress and the Treatment stages, participants’ visual attention toward high-calorie food images was measured, along with their desire toward eating high calorie foods shown in the images. The results showed that, under all three auditory conditions, while negative emotions were significantly increased at the Post-Stress stage, they were significantly decreased with no difference found between the Pre-Stress and Treatment stages. The three auditory conditions exhibited no significant differences with respect to visual attention toward high-calorie food images in terms of entry time, fixation count, and fixation time.
However, as participants more intensively felt negative emotions, especially “distressed” and “nervous”, they looked at the high-calorie food images more quickly. In Study 2, participant positive and negative emotions, visual attention to high-calorie food images, and liking and desire to eat directed toward the high-calorie food images were measured before and after the IQ test under one of the three olfactory conditions: (1) no scent, (2) lavender scent, and (3) menthol scent. Negative emotions increased after the IQ test under all three olfactory conditions. With respect to visual attention, participants under the lavender scent condition looked at the high-calorie food images longer than those under the no-scent condition. In addition, as participants more intensively felt a “distressed” negative emotion, they looked at the high-calorie food images more quickly. Participants in the lavender scent condition exhibited less desire to eat the high calorie foods shown in the images than those in the no-scent or menthol-scent conditions. In conclusion, smelling a pleasant scent, especially lavender, can relieve psychological stress-induced visual attention toward high-calorie food images. While listening to musical pieces produced no significant differences with respect to reducing the stress-induced visual attention toward high-calorie food images from just taking a break without listening to music, further study should be conducted to determine how to optimize effective music treatment for stress reduction. The findings of this thesis provide better understanding of how to use either scent or music to maximize relief of psychological stress-related visual attention to high calorie foods.

**Keywords:** Psychological stress, acute stress, eye-tracker, visual attention, music therapy, aromatherapy, high calorie food
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Chapter 1. General Introduction

Individuals today live in an increasingly competitive world, and psychological stress is globally prevalent for a number of reasons. Stress is the natural reaction of the body and mind to environmental challenges, and long-term exposure to stress can lead to both short- and long-term health problems, manifested not only in terms of psychological diseases such as depression, but also in a number of physical disorders. Kendler et al. (1998) found that individuals who had experienced a stressful event had a higher likelihood of developing depression than those who had not. Stressful conditions may also result in negative emotions, anxiety, and depression, possibly leading to some dysfunction of biological processes and behavioral patterns that can increase the risk of certain diseases (Cohen et al., 1995), including cardiovascular disease and cancer may be related to chronic stress (Cohen et al., 2007).

Because of the increasing prevalence of psychological stress and its associated impact on health, it is critical for psychologists, clinicians, and researchers to identify strategies for coping with it. While medication may be a popular treatment, since some medicines include undesirable side effects, there is an ever-present demand for alternative stress-reduction methods. Some of popular strategies used to help combat psychological stress include exercising, listening to music, smelling pleasant odors, chewing gum, and doing yoga (Martin et al., 2009). Many studies for identifying the most effective strategies for coping with psychological stress have been conducted. Exercising is one common activity suggested to decrease the impact of stress. In fact, the U.S. Preventive Services Task Force (2002) proposed regular exercise as a stress reduction method. Another commonly-suggested method of stress reduction is consuming specific food items thought to improve an individual’s emotional state. For example, Martin et al. (2009) showed that consumption of 40 g of dark chocolate every day for two consecutive
weeks decreased the blood level of urinary cortisol considered an index of physiological stress. Smith and Martins (2012) also found that college students who chewed more than 40 pieces of gum for 14 days exhibited lower levels of stress than those who chewed less or no gum over the same time period. This result is consistent with previous research in which participants reported lower stress levels after chewing gum than those who did not chew gum (Smith et al., 2012). These are just a few of the proposed therapies for reducing stress without medication. Among the variety of methods for relieving psychological stress, this study focused on the application of music therapy and aromatherapy.

The use of music as a form of stress reduction is a very popular method that has been around for a long time. In previous studies, Burns et al. (1999, 2002) and Labbé et al. (2004) found that listening to relaxing music, especially music from the classical genre, can be useful in helping individuals to experience more positive emotions and enhance the function of their parasympathetic nervous systems. Other studies have sought to determine whether only specific types of “relaxing” music are effective in relieving stress. For example, Anderson et al. (2003) proposed a design that involved both violent and non-violent music and found that violent musical pieces caused more aggressive thoughts and hostile feelings compared to non-violent pieces (Anderson et al., 2003). Other studies have found music to be an effective way to reduce psychological stress during surgery and medical treatments (Leardi et al., 2007; Nilsson, 2009), and research has proven music therapy useful in reducing stress and anxiety related to pregnancy (Chang et al., 2008; Shin and Kim, 2011; Yang et al., 2009).

Another common method for relieving stress is to smell certain aromas, i.e., aromatherapy. When a selected aroma is inhaled, its volatile organic compounds enter the limbic system through the nasal cavity and affect the hypothalamus and autonomic nervous system,
impacting blood circulation, respiration regulation, heart rate, and blood pressure, all of which play a role in stress reduction (Wendy & Jenny, 2004; Krantz et al., 2005). Many studies have been conducted based on the idea that olfactory cues such as pleasant odors can be helpful in reducing stress. Aromatherapy has also been proposed as a basic, convenient, and non-invasive approach to stress relief. Buckle’s (2001) research found that aromatherapy is more effective than various other stress reduction methods. Tseng (2005) used aromatherapy to enhance the physiological and psychological states of the subjects, decreasing their levels of anxiety and stress. In another study, McCaffrey et al. (2009) found that graduate students who had inhaled essential oil prior to and during a test exhibited stress reduction.

Individual everyday activities such as eating are modulated by emotional state. Because of the growing prevalence of psychological stress, considerable research has been conducted to study the effect of stress on food perception, eating behavior, and food choice. Research has shown that stress itself can play a role in modulating our perception of taste (Ileri-Gurel et al., 2012). For example, Singh (2014) showed that negative emotions associated with stress can motivate or trigger eating of foods high in sugar, salt, carbohydrate, and fat. Other research studies have also found that shifting emotions from positive to negative can lead to repeated consumption of food with higher levels of sweetness (Macht and Mueller, 2007; Macht, 2008). This suggests that exposure to stress can lead to repeated consumption of high calorie food, potentially resulting in health-related problems.

This thesis included two different studies that examined the effects of auditory and olfactory stimuli on reducing psychological stress through altering visual attention to high calorie foods. Study 1 (Chapter 3) was designed to determine whether listening to musical pieces can decrease psychological stress and divert attention from high-calorie food images. Specifically,
participants were divided into groups subjected to three auditory conditions: no music, classical music (Air on the G string), and self-selected music. Using eye-tracking methodology, participants’ visual attention toward high-calorie food images were compared under these auditory conditions both before inducing an acute stressor (IQ test) and after experiencing the music. Study 2 (Chapter 4) sought to determine whether smelling pleasant odors can reduce psychological stress and visual attention toward high-calorie food images. Participants were divided into groups experiencing three olfactory conditions: no scent, lavender scent, and menthol scent. Participants’ visual attention toward high-calorie food images were compared among these olfactory conditions both before taking an IQ test and after completing the test (in the absence/presence of scent stimulus). Based on previous findings that (1) psychological stress increases preference for high calorie foods and (2) music or aroma treatment reduces psychological stress, it was expected that listening to music or smelling a pleasant scent could relieve psychological stress and negative emotions, thereby decreasing individuals’ visual attention toward high-calorie food images. Therefore, the results from this study were therefore expected to provide better understanding of how auditory or olfactory stimuli can play a role in stress reduction and potentially-available balanced diets.
References


Labbe, E., Booth, K., Jimerson, M., & Kawamura, N. (2004). The sound of music: Evaluating responses to different music genres, to be presented at the annual meeting of the Southeastern Psychological Association, Atlanta, GA.


Chapter 2. Literature Review

1. Sense of vision

1.1. Anatomy and physiology

As one of the human senses, sight plays an important role in improving the quality of life and helping humans to enjoy the beauty of the world. The mechanism by which vision works is through a complex and complicated structure of rods, cones, optic nerves, and the retina. All these parts work together to help humans visualize their surroundings by taking a picture of the environment and constructing a signal, which is then sent to the occipital lobe in the back of the brain. When light enters the eye, it passes through the ocular media which is composed of tear film, the cornea, anterior chamber, lens and the posterior chamber vitreous. After passing through the ocular media, light enters the retina, the amount of light entering being controlled by the pupil aperture. Once these steps have occurred, the image becomes projected upside down and backward on the retina (Fishman, 1973). Within the retina, the light is absorbed through the rods and cons, activating the pigments in these parts and converting to nerve impulses in the membranes of vesicles (Zeki, 1993). These nerve impulses are then transmitted within the rods to the synaptic knobs and bipolar nerve cells, finally reaching the optic nerves (Zeki, 1993). Here, the optic neurons are responsible for carrying the nerve messages through the retina to the brain (Zeki, 1993).

As previously mentioned, the occipital lobe is responsible for visual perception. However, since the eye structure is concave, perceiving visual cues from both eyes is a complex system. For example, the nasal retina of the left eye and the temporal retina from the right eye are responsible for the left perspective of view, while the nasal retina of the right eye and temporal retina from the left eye are responsible for the right view (Zeki, 1993). The muscles of
the eye are supplied with oxygen and nutritional materials by blood nerves. Most of this blood
supply to the structure of the eye comes through the ophthalmic artery, which is called the first
branch of internal carotid artery (Hayreh, 2006). According to the review by Koch (2004), there
are two cortical routes which are responsible in vision. The first route is attention deployment,
which is related to the back of the head and called the dorsal pathway. It goes through the
primary visual cortex (V1) in the occipital lobe, moves through the posterior parietal cortex, and
finally ends at the dorsolateral prefrontal cortex. The second route is related to the identification
of the object and passes through the ventral pathway which involves V1, the inferior temporal
cortex and the ventrolateral prefrontal cortex. The sense of vision also plays an important role in
our reaction toward different objects and our surroundings, enabling us to be safe in case of
accident. Eye movement plays an interesting role in this mechanism. There are five kind of eye
movements, including 1) optokinetic responses, 2) vestibule ocular, 3) saccades, 4) smooth
pursuit, and 5) convergence (Buttner et al., 1986).

All five senses work together to allow humans to interact with, receive stimuli from, and
perceive their surroundings. In this regard, visual-olfactory interactions can be interesting in
terms of food perception. One of the ways these interactions are demonstrated is in flavor
recognition, which affects the liking of the food or beverage consumed. For example, color is
one of the most important visual cues that can play a role in modulating the interaction of visual-
olfactory interaction. Morrot et al. (2001) has showed that changing the color of a specific
solution can alter the perception of odor, flavor intensity and pleasantness, along with odor
identification.
1.2. Factors influencing visual perception

1.2.1. Gender

Males and females are different in terms of the emotions they feel toward their surroundings (Canli et al., 2002), a discrepancy that can be extended to their visual perception as well (Karama et al., 2002; Wrase et al., 2003; Montagne et al., 2005). Canli et al. (2002) found that when shown unpleasant images, the right amygdala is more activated in males and the left amygdala in females. Similarly, Wrase et al. (2003) showed that different parts of the brain in males and females are responsible for visual cues. For example, in reaction to pleasant pictures, the frontal lobe was activated more in males than females, while with unpleasant pictures, the frontal lobe, especially the anterior and medial cingulate gyrus, was more activated for females than males (Wrase et al., 2003). This gender difference can also be extended to the discernment of color, as measurable differences in color perception have been found among people with normal color vision (Backhus et al., 1998). Hurlbert, (1987) found that males prefer stifled and soft colors, while women like brighter and more gratifying colors. Similarly, Guilford and Smith (1959) discovered that men are more tolerant of achromatic colors than women. Additionally, they also suggested that females have a more flexible and diverse taste for color.

1.2.2. Age group

It is undeniable that the functions of the human body change with aging (Lich & Bremmer, 2014). With the sense of sight specifically, visual perception and eye movement is often negatively affected by aging (e.g., Morgan, 1993; Billino et al., 2008; Lich & Bremmer, 2014). These problems of the eye have been investigated extensively since the 1970s (Kline & Birren, 1975; Walsh et al., 1979). Older people are slower than their younger counterparts in detecting, discriminating and realizing visual cues, which is related to features of cognitive aging.
such as working memory and inhibition (Salthouse, 1991; Salthouse, 1993; Salthouse, 1994; Salthouse & Meinz, 1995). In addition, older adults frequently have problems processing temporal data, which is an obstacle to being able to perform visual tasks, such as finding an object like a piece of paper (Ball et al., 2002; Edwards et al., 2002; Owsley et al., 2001). Elderly drivers often have difficulty identifying road signs and hazards as well (Wood, 2002; Wood et al., 2008). This decline in visual processing rate increases the danger of vehicle accident involvement, even if other factors like impaired visual acuity, contrast and visual field sensitivity are not issues (Cross et al., 2009; Owsley et al., 1998; Rubin et al., 2007). The population of people in the US and other countries around the world who are over 60 is increasing, making it critically important to focus on research about the effect of aging on vision.

1.2.3. Cultural background

Culture can be a modulating factor in altering visual attention and perception. Research (Nisbett & Masuda, 2003; Nisbett & Muyamoto, 2005) has shown that in eastern countries, people are more holistic, meaning they pay more attention to the whole rather than focusing on one specific part, while their counterparts in western countries are more analytic. This difference between eastern and western cultures can be extended to scene processing as well. In fact, while eastern people tend to concentrate on background context, western individuals focus on focal objects (Nisbett et al., 2005). For example, when asked to watch two different images (the second a slight variant of the first) in a blindness condition, Americans identified more changes in objects, while Japanese identified more changes in the background of the images (Masuda & Nisbett, 2006). Culture can also modulate eye movements for people from various ethnic backgrounds. In a recent research study done by, American and Chinese were found to have differences in visual attention regarding their eye movements.
A similar trend with discrepancies between cultures can also be seen in the food industry. In research conducted by Zhang and Seo (2015), when table decorations became noticeable to Chinese people, the individual’s attention toward the foods declined. Additionally, as in the research done by Masuda and Nisbett (2006), it took longer for Chinese subjects to look at the food items than the American participants, showing that Chinese are more affected by the background of their food than other cultures. This demonstrates that visual attention toward food and non-food items can modulate the perception and liking of food. Thus, visual cues may alter the expectation of food perception and liking based on sensory perception and acceptance of food (Cardello et al., 1985; Cardello & Sawyer, 1992; Seo et al., 2008).

1.2.4. Personality traits

One of the most important factors that can modulate visual perception and vision is personality traits. In fact, the way individuals see the world and their surroundings can be affected by their personality. Therefore, individuals with varying personalities may have different visual perceptions of their environment. For example, people are often divided into two categories of being either introverted or extroverted. It should be noted that this aspect of personality may not only affect behavior but may also alter visual function (Newton et al., 1992). Newton et al. (1992) showed that individuals who are extroverted are usually fast in performing visual functions, such as searching capabilities, while those who are higher in neuroticism, are slower in visual work. It is also interesting to note that the visual attention toward the images that individuals look at can be related to personality traits. According to research done by Perlman et al. (2009), people who have higher scores in neuroticism spend more time in looking at fearful faces, showing a positive correlation between personality traits and visual attention. The finding of this research is in harmony with the trait congruency model suggested by Eizenman et al.
(2003), which claimed that individuals look at the information which linked to their personality traits, ignoring the incongruent data. In another study, Mathews et al. (2003) showed that fearful cues or expressions can influence individual’s visual perception in anxious groups, while it did not have a significant effect on people in non-anxious groups. His results showed that people with high anxiety were more influenced by visual cues from a fearful origin than people who are less anxious (Mathews et al., 2003).

1.2.5. Emotion

Emotion plays an important role in our feelings toward different aspects of daily life. It can be a crucial factor in modulating our senses toward the events and objects around us. Emotional states can impact many parts of life, including the way things are perceived visually. Fredrickson (1998) showed that positive feelings like interest, elation and love can temporarily broaden thoughts, improving attention toward objects. In a similar way, research by Gasper and Clore (2002) found that people with a negative emotional state, such as being sad or nervous, are less likely than neutral or happy people to identify figures on global characteristics. Emotional states can also modulate the attention of people toward positive and negative objects or visual stimuli. Mogg et al. (2000) demonstrated that negative cues usually get more attention than positive stimuli in depressed or stressed individuals because these subjects show negative emotion when paying attention to both positive and negative stimuli at the same time. It has also been shown that negative emotional states, such as anxiety, can affect the participant’s attentional concentration (Derry et al., 1994; Mogg et al., 2000; Mogg et al., 2002). Eye-tracking studies have shown that individuals who are stressed prefer threatening stimuli rather than encouraging ones (Hermans et al., 1999; Bradley et al., 2000; Mogg et al., 2000).

1.2.6. Contexts
The context we look at objects in can play a major role in our perception of both the article and its surrounding. Context modulates the eye movements that can fixate the most relevant features of scenes with foveal vision (Yarbus, 1967). Yarbus (1967) showed that people primarily focus their fixations on the most important feature of visual stimuli, such as people’s faces. In a study by Najemnik and Geisler (2005), it was found that when an individual is looking for an object at a scene, the observers fix their gaze on the location that has the highest probability of including the specific object being looked for. The context in which we are looking at an object can provide us better information to be able to identify and perceive the object. Research done by Eckstein et al. (2006) showed that the context objects are presented in can impact the individual’s ability to detect the object. Context may also affect visual perception in various levels like semantic (e.g., a table and chairs around it are in one picture while a cup or elephant is not), spatial configuration (e.g., the keyboard is predicted to be below a monitor) and also pose (e.g., chairs are oriented towards the table) (Hock et al., 1974).

2. Eye tracker

2.1. Concept and terminology

Eye tracking is usually implemented in order to investigate eye movement and its position. It has been used widely in many research areas such as medical, food science and nutrition. Eye tracking allows things such as consumer’s visual attention toward the nutritional facts on food packages to be assessed. Since people usually focus on nutritional labels on food packages, this technology allows manufacturers and researchers to study which sections people pay the most attention to when they are selecting products. In eye tracking, cameras with higher speed and resolution record subject’s eye movement in order to evaluate visual attention
(Duchowski, 2007). The cameras are located on a flat, stable place, such as a desk. However, like other technologies, this equipment has both benefits and limitations. The most important benefit of using this specific technology in research is that it is less salient, and the behavior is instinctively assessed. Nevertheless, the main limitation of this technology is its lack of realism which sometimes makes it difficult to use for evaluating eye movements. Indeed, realizing that eye position and movement is being controlled or assessed could influence the expected result, thus impacting subject behavior. The eye tracking methodology is developed according to the characteristics of eye movements and the eye-mind hypothesis based on Just and Carpenter (1980) which explained that eye movement is a dynamic trace when the concentration is being directed. The measurement of eye tracking is based on three scales including temporal, spatial and count (Lai et al., 2013). Based on temporal measurement, definitions related to the eye tracking measures can include total fixation duration, gaze duration and average fixation duration. The total time spent on fixation is referred to as total fixation duration. Gaze duration is defined based on total fixation duration within a word or an area of interest (AOI). Average fixation duration is based on the mean of fixation duration on each AOI. In spatial measurement, fixation position is the location of fixation, and fixation sequence is the sequence of fixation allocations on AOIs. Finally, in count measurement, total fixation count is the total number of fixations counted in an AOI or in a task. The average fixation count is described based on average fixation count on each AOI.

2.2. Types of eye movement

There are four types of eye movements: saccades, smooth pursuit, vergence, and vestibulo-ocular (Rayner, 2009). Each type of eye movement has its own function and
mechanism (Rayner, 2009). While saccades is a type of eye movement for rapidly moving from one point to another, fixation is where the eye is staring at a point for a specific period, which in turn will be helpful for processing the images. The most important characteristics of saccades can be summarized in being triggered both voluntarily and involuntarily, and with both eyes always being in the same direction. Additionally, while the average duration of saccades is between 20-40 ms, the duration for fixation can be varied between 50-600 ms. Fixation includes slower and minute movements which can help the eye to keep aligned with the target.

In dynamic conditions where both our eyes and the object are moving, other types of eye movement are helpful to keep the fovea focused on the interested point. For example, the vergence movement is implemented in order to enable us to concentrate on an object at various distances. In fact, the left and right eye movement is not in the same direction and is usually slower than with saccades movement. Additionally, smooth pursuit movement is useful for keeping aligned with moving objects. The last type of eye movement, vestibular ocular reflex is useful when the head and body is moving while looking at an object. In this type of eye movement, the eye moves in the opposite direction of the head (Rayner, 2009).

2.3. Factors influencing visual attention in eye tracking studies

Eye-tracking is a method which can make it possible for researchers to study the movements of the eye. It defines the points where an individual is looking at a specific time along with the sequence in which the eyes are moving from one position to another (Poole & Ball, 2005). Eye-tracking methodology provides a domain of variables that make it possible to evaluate the gazing behavior of a participant. The studies of eye-tracking can be divided into two groups: human-computer interaction and uncovering what a participant is looking at.
Additionally, the fixation of the eyes can play an important factor in indicating the visual attention of a participant. For example, in a free viewing performance, the number of fixation counts or the total number of times an individual fixes their gaze on an AOI can be an indication of high interest, or perhaps mean that the AOI is complicated and difficult to follow (Jacob & Karn, 2003; Just & Carpenter, 1976). However, in some research studies, the number of fixation counts is considered an indication of uncertainty (Jacob & Karn, 2003). Additionally, the fixation time is considered to be another factor to indicate the difficulty of processing information. It is generally accepted that representation related to long period fixations are meaningless to individuals with short fixations (Goldberg & Kotval, 1999). The length of time to the first fixation is like measuring time beginning with the display of the stimulus until the individual’s gaze is fixated on the AOI for the first time. This indicates AOI capture and the order in which the person processes the information needed to accomplish the task (Holmqvist et al., 2011).

3. Psychological stress

3.1. Chronic psychological stress

Humans today are living in a competitive and stressful environment which leads to higher rates of anxiety and depression. These stressful surroundings not only have negative effects in terms of psychological problems but can also lead to many physical diseases such as heart attack and high blood pressure. Unfortunately, levels of stress have increased over the last decades, especially in western countries. Based on a survey done in 2013, 78% of respondents in the US reported that their life has been stressful over the last month (American Psychological Association, 2014). Psychological stress can be classified as either acute or chronic, both of which are defined by the origin of the stressor and have different mechanisms and effects on a
person. For example, people who identified that they had been exposed to poison and felt that their health was threatened would have a long perception of threat, which could lead to chronic stress. However, if a reaction to the stressor is brief and short-term, then this would be considered an acute stress. It is thought that acute threats are likely to be experienced more intensively than chronic ones. Chronic threats usually don’t include a prediction period, but it can be categorized as uncertainty.

Chronic stress can show itself in various forms, such as losing a loved one, being in an accident, or living with daily stress for a long period of time. According to Cohen et al. (2007), depression, cardiovascular disease, human immunodeficiency virus (HIV) infection/AIDS, and cancer are strongly related to psychological chronic stress. However, one important issue that can be considered as a health issue is the relationship between chronic stress and eating behavior or food choice.

One way in which stress impacts people is regarding eating behavior and food choices. There is a general point of view that people who are more stressed seem to accept food less than individuals who are less stressed. Luckett et al. (2015) demonstrated this when they found that hedonic ratings of the appearance and overall flavor of low-calorie chips were significantly lower in a high stress group than in a low stress group. In a study by Groesz et al. (2012) where 561 women were selected for studying the relationship between stress and drive-to-eat, the results revealed that there is a strong relationship between these two factors, especially for foods high in fat and sugar. Additionally, stress itself not only plays a role in decreasing the acceptance of food and increasing amount of consumption, but also affects chemoperception (Nakagawa et al., 1996; Dess & Edelheit, 1998; Al'abisi et al., 2012; Ileri-Gurel et al., 2013). For example, Dessand and Edelheit (1998) found that acute stress potentially increases sensitivity to bitterness.
Additionally, Nakagawa et al. (1996) showed that sweetness and sourness were suppressed in people when they were given a stressful mental task. In a similar way, Al'absi et al. (2012) showed that acute stress, such as a math test, can reduce the perception of sweet taste.

Stress can also lead to the development of problems with sexual function, especially in women (Hamilton & Meston, 2013). Increased tension can result in higher levels of cortisol being released, which can be dangerous over a long period. Research has shown that hormones released from the hypothalamic–pituitary–adrenal (HPA) axis in response to stress can interfere with hormonal secretion from the hypothalamic–pituitary–gonadal (HPG) axis, which is responsible for the reproduction and sexual function (Hamilton & Meston, 2013).

3.2. Acute psychological stress

Experiencing stress is an unavoidable part of our daily life. However, unlike chronic stress which people experience over long periods of time, acute stress can happen in a short time. This could be something like taking an exam or having a job interview. Due to increased busyness and more challenging lives, acute stress has been increasing over the last decades. Unfortunately, these higher levels of acute stress are negatively impacting people’s quality of life. Not only is daily life affected, but the quality of activities like speaking in front of an audience can also be impacted. For example, Christenfeld and Creager (1996) showed that anxiety is highly associated with using pauses during a public speaking task.

Stress can also be extended to children who are not responsible for life like their parents. Being in a stressful atmosphere can affect children’s reaction toward facial expressions. Children who are abused and ignored are more susceptible to recognizing sad faces. In an fMRI study,
children raised in an environment of chronic family stress exhibited atypical neural responses to fearful and angry faces (Taylor et al., 2006).

Emotional eating is described as a desire to overeat in reaction to negative emotions, such as anxiety (Van Strien et al., 2007), and as a way of dealing with stress (Bruch, 1973). Stress also affects eating behavior. Earlier studies done by O’Connor et al. (2008) and Wardle et al. (2000) showed an increase in fat and sugar consumption and a decrease in overall calorie intake, main meal, and vegetable consumption when individuals were stressed. Another way stress impacts eating behavior is by increasing the tendency to eat foods through involving several systems like metabolism, cognition and reward (Adam & Epel, 2007). The relationship between stress and eating is regulated by the hypothalamic pituitary adrenal (HPA) axis release of cortisol (Wilson et al., 2008; Nieuwenhuizen & Rutters, 2008; Dallman, 2010; Razzoli et al., 2015), a major stress hormone associated with food intake in humans and animals (Adam & Epel, 2007; Torres & Nowson, 2007; Warne, 2009).

3.3. Methods for reliving stress

Although the human life has been under heavy pressure, leading to both acute and chronic stressors, many methods have been introduced in order to help relieve stress. Coping mechanisms can vary, depending on the type of stress experienced. While some methods of coping with stress are appropriate for long-term threats, other types are more effective in relieving short-term stressful situations (Mullen & Suls, 1982; Collins et al., 1983). One strategy for coping with stress is listening to music. However, there are many argumentative discussions based on music’s ability to decrease stress. Listening to music supports the emotional and spiritual needs of people by promoting a relaxing environment and helping to decrease stress and
tension. Music has also been used to control stress levels in surgical settings and hospital care (Cooke et al., 2005). For example, listening to music has been implemented as a tool for pregnant women in their second and third trimesters, in order to reduce stress. However, there are some issues that arise when using music as a stress relief, including whether the person is interested in that genre or not. It is also important to note that the individual’s state of arousal or calm can be important factors in impacting whether the music helps relieve stress for them. There is currently a lack of research looking at what type of music helps to reduce stress. This study will help to fill in this gap by focusing on the effects of different types of music on stress reduction.

As mentioned previously, food selection can play a role in mediating stress. A recent study done by Osdoba et al. (2014) showed that people with acute stress can be affected positively when they have no pressure to select food. Eating food regularly can also be effective in relieving stress (Martin et al., 2009; Osdoba et al., 2014). Martin et al. (2009) found that eating 40 g of dark chocolate per day for two weeks decreased urinary cortisol (an indicator of physiological stress levels) in participants with chronic stress. In another study, three days of dark chocolate consumption led to a reduction in the amount of psychological stress (Lua & Wong, 2011). Pecoraro et al. (2004) also discovered a reduction in stress hormone amount after individuals ate palatable food during stress.

Other methods of coping with stress include chewing gum (Princeton Review and Wrigley, 2005) and exercising (Coulter et al., 2009). People who regularly exercise have more confidence in dealing with problems in their life, which is effective in decreasing tension and stress. Women who exercised regularly showed feelings of well-being and coping with personal stress (Coulter et al., 2009).
4. Influences of psychological stress on food perception

People eat their food in a variety of emotional states. These emotional states can range from being extremely happy or sad to being highly stressed or calm. Due to the growing percentage of people who are suffering from acute and chronic stress, research has been done regarding the effect of stress on food perception, eating behavior, and food choice. The perception of taste is not only based on genetics, but can also be defined by several other factors such as body mass index and eating certain types of food (Donaldson et al., 2009; Ileri-Gurel et al., 2012), smoking and alcohol consumption Fisher et al. (2013), aging (Bartoshuk et al., 1986; Duffy, 2007), gender (Duffy, 2007; Fisher et al., 2013) and exposure to pathogens (Duffy, 2007). Besides these factors, acute stress itself can also play a role in modulating our perception of taste (Ileri-Gurel et al., 2012). Stress itself can be one of the most important factors in obesity. For example, Singh (2014) showed that negative emotions can motivate or trigger the eating of foods high in sugar, salt, carbohydrate and fat. Thus, exposure to stress can lead to the repetition of eating high calorie food, which can result in individuals becoming overweight or obese. Psychological stress can also be a critical factor in changing the perception of basic tastes like sweet, bitter, umami and sour. Several research studies have worked on finding a cross-modal interaction between stress and perception of basic tastes. Since stress is highly connected with negative emotions, (Watson et al., 1988), after experiencing the same condition, subjects rate umami and sweet solutions lower in intensity (Al'absi et al., 2012). Similarly, an experiment by Dess and Edelheit (1988) found that people who are experiencing mild stressors rate bitterness more intense than sweetness.

In addition to affecting the perception of basic tastes, stress can also influence hedonic ratings and food preferences (Lyman, 1982; Willner & Healy, 1994). In fact, positive emotions
can increase the hedonic rating of food while negative emotions, such as stress, can decrease the overall rating of liking (Macht, 2008; Willner & Healy, 1994). Additionally, research studies have found that shifting emotions from negative to positive can lead to the consumption of food with higher levels of sweetness (Macht, 2008; Macht & Mueller, 2007). Science has shown that stress can shift food selection in individuals who are suffering from psychological stress. In a recent investigation by Zellner et al. (2006), subjects with a certain level of stress changed their food choice from a healthy low-fat food to less healthy with a higher proportion of fat. Thus, this shows that the food choice or preference can be changed under stressful conditions. However, stress responses, such as eating behavior, might differ by gender. For example, Oliver and Wardle (1999) found that stressed females preferred to eat more snacks with high sugar content than males. Females also reported that they were less interested in eating fruits or vegetables when they were stressed (Oliver & Wardle, 1999).
References


Chapter 3. Effect of auditory cues on visual attention under acute stress

1. Introduction

Psychological stress has been described as a major contributor to many health issues such as heart attack, depression, and anxiety (McEwen, 1998). There has been a significant increase in diagnosed psychological stress over the last several years. (Cohen et al., 2007). Exposure to severely stressful conditions can affect children’s response to different context. When children are growing in an environment where can easily be neglected and abused (like inducing stressful condition), they are able to detect angry faces quicker than those who did not experience the same condition (Pollak & Sinha, 2002; Pollak & Kistler, 2002). In another study using functional Magnetic Resonance Imaging (fMRI) technique, it was also found that children who grew up in an environment of chronic family stress showed abnormal neural reaction toward the angry and sad faces (Taylor et al., 2006). Chronic stress can show itself in various forms, such as losing a loved one, being in an accident, or living with daily stress for a long period of time. According to Cohen et al. (2007), depression, cardiovascular disease, human immunodeficiency virus (HIV) infection/AIDS, and cancer are strongly related to psychological chronic stress.

In general, psychological stress occurs when a person perceives that environmental conditions exceed their capacity (Cohen et al., 1995). The psychological stress can affect health by changing some behaviors like the eating behavior which has direct effect on obesity and weight (Greeno & Wing, 1994; Baum & Posluszny, 1999). When individuals are stressed out, their food consumption increases significantly, leading to obesity and health issues. On the other hand, others decrease their intake when they are stressed out (Willenbring et al., 1986; Streere & Cooper, 1993). Indeed, stress may influence health by changing people's attitude toward selecting their food. Based on a survey study, people are more willing to choose to eat higher
caloric sweet and fatty foods when they are stressed out (Steptoe et al., 1998; Oliver & Wardle, 1999; Wardle et al., 2000; Cartwright et al., 2003). For example, Oliver and Wardle (1999) found out that stressed individuals, specially females, reported consumed more sweet foods like chocolate. Also, the same subjects reported a decline in consumption of fruits and vegetables. Epel et al. (2001) also reached this conclusion that women who had higher levels of cortisol in response to stressful condition, ate more sweet high fat foods compared to those women who did have lower level of cortisol in their blood. Stress and diet relation are especially complex. Stress is related to biological changes that may be expected to decrease food intake, for example in short-term, like the adrenaline-induced glycogenolysis, slowing gastric emptying, autonomic pushing blood from stomach to musculature, the activation of the hypothalamic-pituitary-adrenal axis. Stress and diet associations are particularly complex. Stress is associated with biological changes that might be expected to reduce food intake, at least in the short-term, such as adrenaline-induced glycogenolysis, slowed gastric emptying, autonomic shunting of blood from gut to musculature, and activation of the hypothalamic-pituitary-adrenal axis (Johnson et al., 1992; York, 1992).

The high prevalence and impact of psychological stress have made it necessary to find the most beneficial as well as most cost-effective strategies to use as treatment and therapy. One of the most popular therapies used to treat stress aside from medication is music (or sound) therapy. There has been a large amount of research focusing on the stress reducing effects of music, and the results from numerous studies both in experimental laboratory and clinical centers indicate that listening to music can help decrease anxiety and stress levels psychologically. For example, Sandstrom and Russo (2010) found that the type of music listened to, in terms of its valence and arousal, impacts its ability to reduce stress. Indeed, they showed that music which
was high in valence and low in arousal resulted in the recovery of heart rate and skin conductance levels after a period of stress. Other studies have confirmed the result that listening to high valence and low arousal music can assist in reducing stress, while some studies have found that the context factor should also be considered, such as whether the music was selected by the experimenter or participant (Chanda & Levitin, 2013). This is likely due to the familiarity with the piece and the participant feeling more in their natural habitat, and this should be considered when using music for stress reduction. Physiologically, music listening has been related to regulation of the hypothalamic-pituitary-adrenal (HPA) axis, which has been shown to decrease the level of cortisol concentration in both experimental and clinical contexts (Kreutz et al., 2012). However, the results from numerous studies on the ability of music to relieve the effects of stress have not been consistent. For example, Chalen et al. (2013) did not find music to have a significant effect on reducing the level of cortisol in blood circulation, while Han et al. (2010) found a positive effect of music listening on patient’s nervous systems. In addition, a plethora of research studies have found inconsistent findings when comparing the self-reported stress level and physiological indications of stress (Gerra et al., 1998; DeMacro et al., 2012; Thoma et al., 2013). For example, Thoma et al. (2013) found that rippling water is more effective in reducing the level of cortisol in blood than listening to music, while there were no significant differences between these stimuli on participants self-reported stress levels. A similar trend was also reported by DeMarco et al. (2012), in which music decreased reported level of stress, while it did not influence heart rate or blood pressure of patients who were about to have surgery.

People eat their food in a variety of emotional states, and furthermore individual’s experience in doing instinctual tasks like eating, drinking, can be modulated by their emotional
states. Due to the growing percentage of people who are suffering from acute or chronic stress, research has been done regarding the effect of stress on food perception, eating behavior, and food choice. Ileri-Gurel et al. (2012) showed that stress itself can play a role in modulating our perception of taste. Additionally, stress can be one of the most important factors in obesity, with Singh (2014) showing that negative emotions can motivate or trigger the eating of foods high in sugar, salt, carbohydrate, and fat, which all are dietary factors for obesity.

There is a key link between stress and negative emotions (Watson et al., 1988), and we know that emotions alter food perception in regard to taste and liking. Al’absi et al. (2012) showed that participants rated umami and sweet solutions less intense after stress. Similarly, a study by Dess and Edelheit (1998) found that people who were experiencing mild stressors rated bitterness more intense than sweetness. In addition to affecting the perception of basic tastes, stress can also influence hedonic ratings and food preferences (Lyman, 1982; Willner & Healy, 1994). In fact, positive emotions can increase the hedonic rating of food while negative emotions, such as those caused by stress, can decrease the overall rating of liking (Willner & Healy, 1994; Macht, 2008). Additionally, previous studies have found that shifting emotions from negative to positive led to the consumption of food with higher levels of sweetness (Macht & Mueller, 2007; Macht, 2008). Zellner et al. (2006) found that participants with a certain level of stress changed their food choice from a healthy low-fat food to less healthy (e.g., higher fat) food. There may however be a gender effect for the effect of stress on food, for example, Oliver and Wardle (1999) found that stressed females preferred to eat more snacks with high sugar content than males, and females also reported that they were less interested in eating fruits or vegetables when they were stressed.
To consider the effects of the type of music used for stress reduction participants were in one of two test groups, either listening to classical music samples (with proven relaxing qualities) or listening to a selected music sample. This study aimed to determine whether music can be helpful in reliving the urge to consume or desire for high calorie food by examining attention to visual stimulus. The attention to high calorie food was measured using eye-tracking studies. Specifically, we measured visual attention toward high calorie food images before and after inducing stress and using musical piece to reduce any effects of the stressful states.

2. Materials and Methods

2.1. Ethics statement

This study was conducted based on the declaration of Helsinki for studies on human subjects. The protocol (#1810154212) was approved by the University Institutional Review Board of the University of Arkansas (Fayetteville, Arkansas, U.S.A.). The experimental method was thoroughly explained to all subjects and a written consent form was obtained from each participant before their participation in the study.

2.2. Participants

Ninety volunteers (45 females and 45 males) with an age range of 18-35 years old took part in this study. The participants were selected based on specific criteria with respect to their health, ability to see, and sense of smell. All respondents reported having neither color blindness, nor issues seeing. If they had corrected vision, they were encouraged to wear contact lenses to minimize a lack of tracking visual attention because of eyeglasses frame. Participants also reported having neither a history of major disease such as heart disease or cancer, nor any food
allergies. Finally, to avoid any potential effect of chronic stress on visual attention toward food images, volunteers who showed either too low or high scores on the Perceived Stress Scale questionnaire (Cohen 1994) were not included.

Participants were randomly attributed to one of three treatment groups: (1) no music (NM; N = 31), (2) Air on the G string (AG; N = 29), and (3) selected music (SM; N = 30). Three groups did not differ with respect to gender ratio ($\chi^2 = 0.07$, $P$-value = 0.97), mean age ($F$-value = 0.41, $P$-value = 0.66), ethnicity background ($\chi^2 = 0.14$, $P$-value = 0.93), and educational background ($\chi^2 = 3.35$, $P$-value = 0.50) (Table 3.1).

<table>
<thead>
<tr>
<th>Table 3.1. Comparisons among three groups with respect to demographic profiles and Dutch Eating Behavior Questionnaire (DEBQ) subscales</th>
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<tbody>
<tr>
<td>Demographics</td>
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<tr>
<td>Gender ratio</td>
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<tr>
<td>Mean age (± SD)(^2)</td>
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<tr>
<td>Ethnicity background</td>
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<td>Educational background</td>
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<td>2-year college or lower</td>
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<td>4-year college</td>
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<td>Graduate or higher</td>
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<td>DEBQ scales (mean ± SD)</td>
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<tr>
<td>Restrained eating</td>
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<tr>
<td>Emotional eating</td>
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<tr>
<td>External eating</td>
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</table>

\(^1\)F: female; M: male
\(^2\)SD: standard deviation
\(^3\)C: Caucasian; NC: Non-Caucasian

2.3. Sound samples

Two music treatments were used in this study: (1) Air on the G String, a classical arrangement by Johann Sebastian Bach which was purchased from website amazon (https://www.amazon.com) and (2) A musical piece selected by each participant. Participants
who were attributed to the selected “selected music” group (see below) were asked to bring a musical piece they considered “relaxing” and that they enjoy listening to. The participants selected a wide range of music (mostly Rock: 6, Pop: 5, Classical: 2, Folk: 2, Country: 2, Indian classical: 2 and etc.) and were able to choose their preferred volume level (40-85 dB range). All music samples were played through the same pair of commercially available headphones (Model MDR-V150, Sony, Tokyo, Japan).

2.4. Visual stimuli

A total of 64 pictures were used as a part of the eye-tracking studies. Four pictures were presented at a time in a slide to each participant, on a total of 16 slides. The pictures were selected based on four categories: “nature”, “activity”, “high-calorie food”, and “low-calorie food”. All the pictures were purchased from public web provider (https://www.dreamstime.com).

2.5. Intelligence Quotient (IQ) questionnaire (Stressor)

An IQ questionnaire was used to induce acute stress. This questionnaire included 19 questions testing general problem solving, and participants were asked to complete it within 8 minutes. To induce psychological stress, participants were told that they will receive $25 dollars as a monetary reward if they score all 19 questions correctly. However, if they miss even one question, there will be a penalty and they will only receive $20. Additionally, the test administrator gave a time update every two minutes to simulate a high stress situation.
2.6. Dutch Eating Behavior Questionnaire (DEBQ)

The eating behavior of individual participants was measured using the DEBQ. The DEBQ is a 33-item self-report questionnaire developed by Van Strien (1986) to evaluate three eating behaviors: (1) emotional eating, (2) external eating, and (3) restrained eating. Items on the DEBQ ranged from 1 (never) to 5 (very often), with higher scores showing greater endorsement of a specific eating behavior. As shown in Table 1, the three groups did not differ with respect to scores in restrained eating ($P = 0.28$), emotional eating ($P = 0.19$), and external eating ($P = 0.22$).

2.7. Positive and Negative Affect Schedule (PANAS) questionnaire

The PANAS questionnaire consists of 20 items (words or phrases) that describe different emotions and feelings (for details, see Watson & Clark, 1994). Participants were asked to rate their specific affective impression (20 items) on that time based on a 5-point scale ranging from 1 (very slightly or not at all) to 5 (extremely).

2.8. Procedure

The main components of this study were the two eye-tracking sessions, one before and one after induced stress, in order to evaluate the effect of different musical condition (i.e., Air on the G string versus preferred music) on participant’s attention to high-calorie food images. Before the study, all participants were asked to refrain from consuming any food or beverages for approximately two hours. In addition, the study was not conducted during lunch time (between 11:00am and 1:00pm). Before the test began, the experimental procedure was completely explained and clarified to the participant and a written consent form was completed. After the consent form was filled out, the participant was given their first PANAS questionnaire.
to record their baseline, pre-test emotions. The first eye-tracking experiment was then conducted to record the “pre-stress” attention to the eight slides including four different images on each. Participants were asked to sit on a chair 60 cm from the 22-in. monitor integrated with the eye-tracker (Model: RED, SensoMotoric Instruments GmbH, Teltow, Germany). The sampling rate of the eye-tracker is 60 Hz and tracking spatial resolution is 0.03°. By using a five-point calibration method, the eye-tracker was calibrated for each person with a low tracking error (less than 0.4°). Before starting, the general instructions for the eye-tracking procedure were explained to the participant. On each slide they would look at four images, and they were asked to keep their attention on the monitor at all times. The eye-tracking study began with two warm-up slides, followed by eight slides featuring four pictures, one from each of the specific topics: “activity”, “nature” and “high-calorie food”, and “low-calorie food”. The order of the eight test slides was randomly presented via stimulus presentation software (Experiment Suite 360°TM, SensoMotoric Instruments GmbH, Teltow, Germany). Each slide was presented for 10,000 ms on the monitor. An inter-stimulus interval (ISI) was shown for 5,000 ms on average in between every test slide. Since the eye-tracking test was conducted both pre-stress and post-stress, there were two sets of eight slides for a total of 16.

After finishing the first eye-tracking study the participants were given the IQ test, and they were asked to complete it within eight minutes. After completion of the IQ test, participants were again given the PANAS questionnaire to measure their emotions immediately post stress. For the next five minutes, the participants were instructed based on their test group. More specifically, participants in either the Air on the G-string or the selected music group were asked to listen to either musical piece. Those in the no music group were asked to sit and take a rest with wearing a headphone. Following the he treatment, the participants were again asked to
answer the PANAS questionnaire. The second part of eye-tracking started once the PANAS questionnaire was completed. The procedure for eye tracking was the same as discussed above, except the eight test slides.

Following the second measurement of eye-tracking, additional four images of high calorie foods were presented on the computer monitor. They were asked to rate their liking and desire to eat each food shown in the images on 10-cm line scales ranging from 0 (I don’t like it at all) to 10 (I like it extremely). Participants were then asked to answer the DEBQ. Regarding the music stimuli the participants were asked to answer questions regarding their liking, perceived pleasantness, familiarity, and arousal based on nine-point scales ranging 1 (Extremely dislike, extremely unpleasant, extremely unfamiliar, extremely calm) to 9 (Extremely like, extremely pleasant, extremely familiar, extremely arousal). If the participants selected their own music samples, they were asked to write the title of song, the singer or performer (if applicable), and the sound level was measured in dBA using sound level meter (Model R8080, Reed Instruments, Wilmington, NC).

2.9. Data analysis

Statistical analysis was performed using XLSTAT statistical software (Addinsoft, New York, NY). The Shapiro-Wilk Normality test concluded that the null hypothesis stating that the data came from a normally distributed population, was rejected in most data obtained from this study. Therefore, non-parametric statistical methods were executed for data analysis. Prior to data analysis, from the slides used in the eye-tracking tests, the images were designated as different area of interest (AOI) and labeled either “high-calorie food”, “low-calorie food”, “nature”, and “activity” using BeGaze™ software (SensoMotoric Instruments GmbH, Teltow,
Germany), as shown in Figure 3.1. Three parameters of visual attention to each AOI images were collected and used for analysis: (1) entry time, (2) fixation count, and (3) fixation time. Entry time refers to the latency passed until the first fixation onto that specific AOI, i.e. how long it took the participant to look at that specific image, once the slide was shown. Fixation count refers to the total number of fixations onto the specific AOI. Finally, fixation time is the sum of the fixation duration to the specific AOI, i.e., the total time the participant looked at that specific image. The data of individual slides whose recording time was less than 70% (< 7,000 ms) were regarded as incomplete data. The incomplete data were not included in the data analysis. Data of three participants who showed extremely incomplete data across visual slides were also not included in the data analysis. To determine whether visual attention to individual AOIs differed among the three music conditions, Kruskal-Wallis test was conducted.

To compare the mean scores of eating behavior questionnaires (DEQB) among three music conditions, Kruskal-Wallis test was conducted. When there was a significant difference, multiple pairwise comparisons using Nemenyi’s procedure were performed. In addition, to examine whether the emotions change during the experiment, Freidman test was conducted. When there was a significant difference, multiple pairwise comparisons using Wilcoxon Signed Rank tests were performed. To determine the effects of the three factors: 1) session, 2) image type as within participants factors, and 3) gender as between-participants factors on participants’ implicit visual attentions to the images of given during the experiment, Kruskal-Wallis tests were also performed. To compare the music stimuli in terms of liking, valence, stimulation, and familiarity, Mann-Whitney U-test was used. Finally, Spearman’s correlation analysis was used to measure the correlation between emotions and visual attention parameters to high calorie food images. A statistically significant difference and correlation were defined as $P < 0.05$. 
Figure 3.1. An example of visual slide used in this study. Each slide includes four images of the four different categories: low-calorie food (top-left), nature (top-right), activity (bottom-left) and high-calorie food (bottom-right). The locations of the four different categories were randomized across 16 visual slides.

3. Results

3.1. Characteristics of musical stimuli

Mann-Whitney U-test revealed that two musical stimuli (i.e., Air on the G string and selected music) differed significantly with respect to liking ($P < 0.001$), valence ($P < 0.001$), stimulation ($P < 0.001$), and familiarity with music stimuli ($P < 0.001$). More specifically, when individuals selected their own music samples, they were more familiar, find the music samples more pleasant and arouse (Table 3.2).
Table 3.2. Comparisons between the two musical stimuli used in this study with respect to liking, valence, stimulation, and familiarity

<table>
<thead>
<tr>
<th></th>
<th>Air on the G string (N = 24)</th>
<th>Selected music (N = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liking of musical piece</td>
<td>7.3 ± 1.3</td>
<td>8.7 ± 0.5</td>
</tr>
<tr>
<td>Valence of musical piece</td>
<td>7.7 ± 0.8</td>
<td>8.7 ± 0.5</td>
</tr>
<tr>
<td>Stimulation (arousal) of musical piece</td>
<td>3.5 ± 2.5</td>
<td>4.8 ± 2.9</td>
</tr>
<tr>
<td>Familiarity with musical piece</td>
<td>5.3 ± 2.3</td>
<td>8.5 ± 1.0</td>
</tr>
</tbody>
</table>

1All participants did not complete these ratings.

3.2. **Effect of music conditions on positive and negative emotions**

Each participant’s positive and negative emotions were measured three stages over this study: pre-stress (Pre-Stress), immediately following induced stressor (Post-Stress), and following treatment (Treatment). Using Freidman test, the difference among the three stages (Pre-Stress, Post-stress, and Treatment) were compared for both positive and negative emotions, separately for the three different music conditions. In the no music (NM) group, there was a significant difference in reported positive emotion among the three stages ($P < 0.001$). More specifically, positive emotions reported in the Treatment stage were significantly lower than those reported in the Pre-Stress ($P < 0.001$) and the Post-Stress ($P = 0.002$) stages. There were also significant differences in reported negative emotion among the stages ($P < 0.001$). Negative emotions reported in the Post-Stress stage were significantly higher than those reported in the Pre-Stress ($P = 0.01$) and the Treatment ($P < 0.001$) stages (Fig. 3.2).

In the Air on the G String (AG) group, significant differences among the three stages were observed in positive ($P < 0.001$) and negative ($P < 0.001$) reported. Positive emotions reported in the Treatment stage were significantly lower than those reported in the Pre-Stress ($P < 0.001$) and the Post-Stress ($P = 0.02$) stages. Negative emotions reported in the Post-Stress stage were higher than those reported in the Pre-Stress ($P < 0.001$) and the Treatment ($P < 0.001$) stages (Fig. 2).
In the selected music (SM) group, while positive emotions reported during the three stages did not differ ($P = 0.51$), negative emotions differed significantly ($P < 0.001$). Negative emotions reported in the Post-Stress stage were higher than those reported in the Pre-Stress ($P < 0.001$) and the Treatment ($P < 0.001$) stages (Fig. 3.2).

Taken together, for all three of the treatment groups, there was a similar pattern observed for reported negative emotions across the three stages. From the baseline emotions reported during Pre-Stress stage, negative emotions significantly increased at the Post-Stress stage for all three groups. Additionally, there was a significant decrease from the Post-Stress stage the Treatment stage for all three treatment groups, with no differences between the Pre-Stress and Treatment stages. For positive emotions, a similar trend was found in the NM and AG groups where there was a gradual decrease in positive emotions from the Pre-Stress through Treatment stages. However, for the SM group, there was no difference in positive emotions among the three stages.

![Figure 3.2](image-url) **Figure 3.2.** Comparisons among positive (A) or negative (B) emotions measured at the three stages: Pre-Stress, Post-Stress, and Treatment, as a function of music condition: no music (NM), Air on the G string (AG), and selected music (SM). *** represents a significant difference at $P < 0.001$. Mean scores with different letters within each music condition represent a significant difference at $P < 0.05$. N.S. represents no significant difference at $P < 0.05$. 
3.3. Effects of music condition on stress-induced visual attention toward high-calorie food images

Overall, there were no significant differences among the three music conditions in terms of entry time, fixation count, and fixation time measured either before stress or after treatment as follows:

*Entry time*

Kruskal-Wallis test revealed no significant differences among the three music conditions with respect to entry time to high-calorie food images when measured before stress (Pre-Stress; $P = 0.29$) and after treatment (Treatment; $P = 0.28$) (Fig. 3.3).

![Figure 3.3](image.png)

**Figure 3.3.** Comparisons among the three music conditions with respect to entry time measured at either Pre-Stress or Treatment stage. *N.S.* represents no significant difference at $P < 0.05$. 
**Fixation count**

Kruskal-Wallis test showed there were no significant differences among the three music conditions with respect to fixation count toward high-calorie food images when measured before stress (Pre-Stress; \(P = 0.90\)) and after treatment (Treatment; \(P = 0.39\)) (Fig. 3.4).

![Figure 3.4. Comparisons among the three music conditions with respect to fixation count measured at either Pre-Stress or Treatment stage. N.S. represents no significant difference at \(P < 0.05\).](image)

**Fixation time**

There were no significant differences among the three music conditions with respect to fixation time for the high-calorie food images in both the Pre-Stress (\(P = 0.53\)) and Treatment (\(P = 0.62\)) (Fig. 3.5).
Figure 3.5. Comparisons among the three music conditions with respect to fixation time measured at either Pre-Stress or Treatment stage. N.S. represents no significant difference at $P < 0.05$.

3.4. Relationships between emotions and visual attention toward high-calorie food images

Spearman correlation analysis revealed no significant relationships of positive emotions measured at the Post-Stress and Treatment stages, with eye-tracking parameters: entry time ($\rho_{87} = 0.007, P = 0.95$; $\rho_{87} = 0.002, P = 0.98$), fixation count ($\rho_{87} = -0.02, P = 0.82$; $\rho_{87} = 0.02, P = 0.85$), and fixation time ($\rho_{87} = 0.03, P = 0.77$; $\rho_{87} = 0.05, P = 0.65$). However, there were significant relationships of negative emotions with eye-tracking parameters: entry time
(\rho_{87} = -0.29, \ P = 0.007; \ rho_{87} = -0.28, \ P = 0.01), \ fixation \ count \ (\rho_{87} = 0.02, \ P = 0.88; \ rho_{87} = -0.05, \ P = 0.62), \ and \ fixation \ time \ (\rho_{87} = -0.04, \ P = 0.71; \ rho_{87} = -0.07, \ P = 0.51) \ (Table \ 3.3).

Table 3.3. Spearman correlation coefficients (P-value) that show relationships of positive or negative emotions with eye-tracking parameters: entry time, fixation count, and fixation time

<table>
<thead>
<tr>
<th>Stages</th>
<th>Emotions</th>
<th>Eye-tracking parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Entry time</td>
</tr>
<tr>
<td>Post-Stress</td>
<td>Positive</td>
<td>0.007 (0.95)</td>
</tr>
<tr>
<td></td>
<td>emotions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>-0.29 (0.007)</td>
</tr>
<tr>
<td></td>
<td>emotions</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>Positive</td>
<td>0.002 (0.98)</td>
</tr>
<tr>
<td></td>
<td>emotions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>-0.28 (0.01)</td>
</tr>
<tr>
<td></td>
<td>emotions</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.4 shows relationships of individual positive (or negative) emotions measured at the Treatment stage, with eye tracking parameters. Ten positive emotions were found to have no significant relationships with any of the three eye tracking parameters (for all, \( P > 0.05 \)). However, two negative emotions, “distressed” (\( \rho_{87} = -0.35, \ P < 0.001 \)) and “nervous” (\( \rho_{87} = -0.28, \ P = 0.008 \)), were found to negatively associate with the parameter of entry time for high-calorie food images.
Table 3.4. Spearman correlation coefficients (P-value) that show relationships of individual positive or negative emotions measured at the Treatment stage, with eye-tracking parameters: entry time, fixation count, and fixation time

<table>
<thead>
<tr>
<th>Stages</th>
<th>Emotions</th>
<th>Eye-tracking parameters</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Entry time</td>
<td>Fixation count</td>
<td>Fixation time</td>
</tr>
<tr>
<td>Positive</td>
<td>Interested</td>
<td>0.06 (0.55)</td>
<td>-0.04 (0.71)</td>
<td>0.06 (0.58)</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>Excited</td>
<td>0.05 (0.64)</td>
<td>0.01 (0.92)</td>
<td>0.06 (0.60)</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>Strong</td>
<td>0.00 (1.00)</td>
<td>-0.07 (0.54)</td>
<td>0.01 (0.91)</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>Enthusiastic</td>
<td>-0.01 (0.91)</td>
<td>0.03 (0.80)</td>
<td>0.02 (0.83)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Proud</td>
<td>0.06 (0.60)</td>
<td>-0.10 (0.35)</td>
<td>0.03 (0.77)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Alert</td>
<td>0.13 (0.21)</td>
<td>0.17 (0.11)</td>
<td>0.05 (0.65)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Determined</td>
<td>0.00 (1.00)</td>
<td>0.11 (0.33)</td>
<td>0.14 (0.19)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Attentive</td>
<td>-0.11 (0.29)</td>
<td>0.12 (0.25)</td>
<td>0.06 (0.58)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Active</td>
<td>-0.05 (0.68)</td>
<td>0.03 (0.80)</td>
<td>0.02 (0.88)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Inspired</td>
<td>-0.02 (0.83)</td>
<td>-0.10 (0.36)</td>
<td>-0.02 (0.86)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Distressed</td>
<td>-0.35 (&lt; 0.001)</td>
<td>-0.01 (0.91)</td>
<td>-0.04 (0.74)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Upset</td>
<td>-0.12 (0.27)</td>
<td>-0.04 (0.71)</td>
<td>-0.07 (0.55)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Guilty</td>
<td>-0.10 (0.37)</td>
<td>-0.03 (0.79)</td>
<td>-0.01 (0.95)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Scared</td>
<td>-0.18 (0.10)</td>
<td>0.01 (0.94)</td>
<td>0.003 (0.98)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Hostile</td>
<td>-0.04 (0.68)</td>
<td>0.02 (0.82)</td>
<td>-0.03 (0.79)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Irritable</td>
<td>-0.12 (0.28)</td>
<td>-0.06 (0.61)</td>
<td>-0.01 (0.95)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Ashamed</td>
<td>-0.10 (0.35)</td>
<td>0.07 (0.50)</td>
<td>0.02 (0.83)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Nervous</td>
<td>-0.28 (0.008)</td>
<td>-0.02 (0.87)</td>
<td>-0.03 (0.78)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Jittery</td>
<td>-0.08 (0.45)</td>
<td>0.04 (0.68)</td>
<td>-0.05 (0.67)</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Afraid</td>
<td>-0.19 (0.07)</td>
<td>-0.14 (0.20)</td>
<td>-0.10 (0.38)</td>
<td></td>
</tr>
</tbody>
</table>

3.5. Effect of music condition on ratings of liking and wanting toward high-calorie food images

Kruskal-Wallis test revealed no significant differences among the three music conditions in the ratings of liking (P = 0.18) and wanting (P = 0.07) with respect to high-calorie food images. No significant differences among the three music conditions in both ratings were also observed in the individual four images (P > 0.05) (Fig. 3.6).
Figure 3.6. Comparisons among the three music conditions with respect to ratings of food liking and food wanting. N.S. represents no significant difference at $P < 0.05$.

4. Discussion

With respect to reported emotions, we found a similar trend in all three music conditions with an increase in negative emotion immediately following the IQ test used to induce stress. However, for all three groups (NM, AG, and SM), we found that reported the increased negative emotions return to the baseline measured before the stressor was given. In previous studies, it has been found that selecting music would be effective in relieving the stress by decreasing the anxiety (Lai et al., 2008; Lilley et al., 2014). Based on previous studies that showed the stress relieving effect (Lai et al., 2008; Snyder, 2010), classical music was selected as one of musical treatments. Additionally, in previous studies, participants showed increase positive emotions,
while decreasing the anxiety level (Lesuik, 2010; Ince & Cevik, 2017). Therefore, it was hypothesized that this would happen for both the Air on the G String and selected music groups, but not for the control. In addition, the results of the eye-tracking measurement showed little difference between the three test groups at the three stages (Pre-Stress, Post-Stress, and Treatment). For the three parameters of entry time, fixation count, and fixation time, there were no significant differences found among the music conditions in either the Pre-Stress or Treatment eye-tracking measurement. We expected there to be no differences between treatments in the pre-stress test and it was good confirmation to find this result. However, we hypothesized that there would be differences in the post-stress eye-tracking, specifically that for the control group any of the three parameters measured would be different. Although the music treatments did decrease reported negative emotions, the same pattern was noticed in the control (NM) group, and furthermore there were no differences in the eye-tracking results. These results do not give a conclusive answer as to if listening to music can be used as a method to alter emotions and decrease desire for high-calorie foods.

Certain aspects of the research did confirm our assumptions. We found, as expected, that there were higher reported negative emotions indicative of stress immediately following the given IQ test. Additionally, with regard to the music samples there was a significant difference between Air on the G String and participant selected musical pieces. The selected music samples were liked more, and they were more familiar with, as well as more pleasant and stimulating. We did find that in the control and Air on the G String groups there was a common trend that positive reported emotions decreased throughout the experiment. However, for the selected music group, positive emotions were at the same levels at the beginning and end. The higher positive emotions at the end of the experiment may have been due to the higher liking and
familiarity of the selected music compared to Air on the G String. Research in health psychology showed that the perceived control is critical factor for inducing more stressful condition (Brannon & Fiest, 2007). Self-selected rather than provided music can be more effective in decreasing the level of stress as it gives the person the chance to control some aspect of their context by allowing to select their music. As the result shows, people found their selected music to be more relaxing, pleasant, and familiar. For example, Anderson et al. (2003) found that when students listened to their favorite music samples, they were more relaxed compared to violent or prescribed music.

One takeaway from this study is that time alone may be an effective way to combat short-term stress. In our experiment the participant did not immediately complete the post-stress eye-tracking experiment after the IQ test, there was a 5-minute treatment period, where the control (NM) group was instructed to just sit there. During this time, it is reasonable to hypothesize that one’s stress could significantly decrease, especially after an acute stressor such as an 8-minute IQ test. Other research studies focus on monitoring the level of stress such as through screening the heart rate which makes it easier to see the effectiveness of stressful condition. However, as described in the Introduction section, previous studies exhibited mixed results in aspect of changes in physiological changes (e.g., heart rate) (Burns et al., 1999; Labbé et al., 2004).

One assumption that was made during this study was that the IQ test would induce meaningful and significant stress. The manner the instructions were given attempted to create the most stressful situation possible. One method that could have improved this research would have been to use pupil diameter to ensure we induced a stressful state for the participants. This could have included measuring heartbeat during specific time points of the study, or even looking at pupil dilation during eye-tracking. Future studies could expand upon this research by using real
food samples, and either looking at food selection or using facial recognition software to analyze emotions. In addition, although we did not include participants who had common food allergies, we did not select participants based on their liking of every high-calorie food image that was shown. It is possible that unfamiliarity or disliking of certain food images played a role in the eye-tracking studies. Future studies could recruit specifically for people with neutral to positive feelings toward the specific either visual or food samples.

5. Conclusion

In conclusion, this study shows that listening to musical pieces did not outperform in reducing visual attention toward high-calorie food images. However, the results suggest that after exposure to a stressful condition it is possible that a waiting period (for 5 minutes) is a good enough remedy for relieving stress, while the study certainly does not say that music listening is not useful. A further study should be done to generalize the effects of music listening both on relieving psychological stress and modulating stress-induced visual attention toward high calorie-food images.
References


Chapter 4. Effect of olfactory cues on visual attention under acute stress

1. Introduction

As described in Chapter 3, stress is defined as a state of psychological, physiological, and physical strain that is usually perceived by an individual who encounters an instable situation which is difficult to adapt to (Schneiderman et al., 2005). While stress can be categorized as either acute or chronic, in this study we specifically focused on acute stress, and specifically reducing it. Acute stress has been identified to have psychological impacts such as causing anxiety, and physiological changes such as increasing the level of catecholamine in blood circulation, and inducing high blood pressure (Schneiderman et al., 2005; Vlachopoulos et al., 2006). From this medical standpoint stress is recognized as a common factor for many diseases, thus making stress relief necessary in order to prevent further medical issues (Schneiderman et al., 2005). As previously discussed, several methods outside of medication have been identified as effective ways to alleviate acute and chronic stress including exercising, listening to music, consumption of specific foods, and the use of specific odors or aromatherapy. In the previous chapter our research had focused on using music stimulus as a treatment for stress reduction, and in this chapter, we focused on the use of aroma stimuli for stress reduction.

Aromatherapy is characterized as the therapeutic use of essential oils, especially oils extracted from plants. Essential oils can be extracted from various different plants such as tea tree, cinnamon, clove, thyme, eucalyptus, rosemary, lavender, and pine (Lawless, 1995). These essential oils can be used for aromatherapy either by being absorbed through contact with the skin or aromatically through the olfactory system (Ernst, 2005). Some of the common methods for dispersion of essential oils are through a diffuser, during a bath, or a massage. The mechanism of aromatherapy through inhalation is complex. When the essential oils are inhaled,
the aromatic molecules begin to involve the brain’s limbic system through the nasal cavity. From there, the aromatic compounds affect the hypothalamus, autonomic nervous, and endocrine systems which then help to improve blood circulation and regulate respiration, heart rate, and blood pressure, all of which can play a role in stress relief (Wendy et al., 2004; Liu et al., 2008). While the use of essential oils has been suggested to have antimicrobial, preservative, anti-depressive, anti-inflammatory, and immune-improving effects (Lawless, 1995), we are only interested in its effectiveness at helping relaxation and reducing stress in this chapter.

The stress relieving abilities of essential oils, as well as additional effects they can have on emotions, has been thoroughly researched. The aromas which were used in this study are Menthol and Lavender essential oils, two common odors in aromatherapy. First, the menthol is widely used with other components for the purpose of relieving psychological stress. There is evidence that volatile compounds of peppermint, menthol, menthone, or pulegone would have psychoactive effects and may activate the dopamine system in nervous system (Umezo, 2009; Umezo, 2010). Tang and Tse (2014) evaluated the stress relieving effects of the essential oils of lavender and bergamot on pain, depression, anxiety, and stress in elderly people. They found a slight decrease in the level of pain and stress reported, and additionally a significant reduction in negative emotions in the treatment groups. McCaffrey et al. (2009) also found that graduate students who were asked to breathe lavender essential oil prior to and during a test, showed lower levels of stress. They demonstrated their lowered anxiety levels through self-reporting of their perceived stress. In another study, Kuttu et al. (2008) investigated the stress alleviating effect of aromatherapy using lavender essential oil on students. One group of students were asked to sit in a class where they were exposed to lavender essential oil for 60 minutes, while another group of students were placed in class without any intervention. Based on the students’
self-reported anxiety, the level of anxiety of those who were exposed to the essential oil was found to be significantly lower than the control group. A similar trend was reported in another study by Pemberton and Turpin (2008) in which the level of job-related stress in nurses decreased remarkably through aromatherapy.

This study aimed at investigating the use of aroma stimuli in relieving acute psychological stress, thereby specifically decreasing visual attention to high-calorie food images. We used an IQ test and a realistic testing situation to induce stress. This gave us the opportunity for the aroma treatment to be given during the stressful situation. In Chapter 3, the connection between stress and eating behavior was thoroughly discussed, and in a similar way the study of this chapter looked to increase positive emotions and decrease negative emotions to alter food attention behavior. This study was designed to use eye-tracking method to observe if an olfactory cue could be useful in decreasing visual attention to high calorie food images when an acute stressor was given.

2. Materials and Methods

2.1. Ethics statement

This study was conducted based on the declaration of Helsinki for studies on human subjects. The protocol (#1810154212) was approved by the University Institutional Review Board of the University of Arkansas (Fayetteville, AR, USA). The experimental method was thoroughly explained to all subjects and a written consent form was obtained from each participant before their participation in the study.
2.2. Participants

Ninety volunteers (67 females and 23 males) with an age range of 18-35 years took a part in this study. The participants were selected based on specific criteria with respect to their health, ability to see, and sense of smell. All respondents reported having neither colorblindness, nor issues seeing. If they had corrected vision, they were encouraged to wear contact lenses to minimize difficulty tracking visual attention caused by eyeglasses frames. Participants also reported having no significant health conditions, such as heart disease or cancer. Finally, to avoid any potential effect of chronic stress on visual attention toward food images, volunteers who showed either too low or high scores on the Perceived Stress Scale questionnaire (Cohen 1994) were not included.

Participants were randomly attributed to one of three treatment groups: (1) No Scent (control; \(N = 30\)), (2) Lavender (\(N = 30\)), and (3) Menthol (\(N = 30\)). The three groups did not differ with respect to gender ratio (\(\chi^2 = 0.12, P\text{-value} = 0.94\)), mean age (\(F\text{-value} = 0.30, P\text{-value} = 0.74\)), ethnicity background (\(\chi^2 = 0.11, P\text{-value} = 0.95\)), and educational background (\(\chi^2 = 6.72, P\text{-value} = 0.15\)) (Table 4.1).
Table 4.1. Comparisons among three groups with respect to demographic profiles and Dutch Eating Behavior Questionnaire (DEBQ) subscales

<table>
<thead>
<tr>
<th></th>
<th>No Scent (N = 30)</th>
<th>Lavender (N = 30)</th>
<th>Menthol (N = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender ratio</td>
<td>8 M / 22 F(^1)</td>
<td>7 M / 23 F</td>
<td>8 M / 22 F</td>
</tr>
<tr>
<td>Mean age (± SD)(^2)</td>
<td>26 (± 5) years</td>
<td>27 (± 4) years</td>
<td>27 (± 6) years</td>
</tr>
<tr>
<td>Ethnicity background</td>
<td>21 C : 9 NC(^3)</td>
<td>21 C : 9 NC</td>
<td>22 C : 8 NC</td>
</tr>
<tr>
<td>Educational background</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-year college or lower</td>
<td>10</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>4-year college</td>
<td>14</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Graduate or higher</td>
<td>6</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>DEBQ scales (mean ± SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restrained eating</td>
<td>28.0 ± 7.9</td>
<td>31.7 ± 7.1</td>
<td>27.8 ± 7.8</td>
</tr>
<tr>
<td>Emotional eating</td>
<td>35.6 ± 11.0</td>
<td>36.3 ± 11.6</td>
<td>34.6 ± 10.2</td>
</tr>
<tr>
<td>External eating</td>
<td>29.1 ± 5.6</td>
<td>27.0 ± 6.8</td>
<td>30.2 ± 5.8</td>
</tr>
</tbody>
</table>

\(^1\)F: female; M: male  
\(^2\)SD: standard deviation  
\(^3\)C: Caucasian; NC: Non-Caucasian

2.3. Odor stimuli

There were two odor stimuli used in this study: (1) essential oil of lavender (Plant Therapy Essential Oils Corp., Twin Falls, ID, USA) and (2) essential oil of menthol (Plant Therapy Essential Oils Corp., Twin Falls, ID, USA). For each participant, 20-µL of either essential oil were measured and dispensed using a pipet onto a fabric pad for 90 seconds before given to the participant. The fabric pad was placed inside a portable aroma dispenser (necklace type; RoyAroma) and hung from the end of a lanyard adjusted for each participant. At the end of the test, the participant was asked about the intensity, pleasantness, arousal, liking and familiarity of the aroma based on nine-point scale ranging from 1 (extremely dislike) to 9 (extremely like). Mann-Whitney U-test revealed no significant odor differences with respects to intensity (U = 472.00, P = 0.53), liking (U = 335.50, P = 0.13), valence (U = 344.50, P = 0.16), stimulation (U = 374.50, P = 0.36), and familiarity with odor stimuli (U = 364.00, P = 0.28) (Table 4.2.).
Table 4.2. Comparisons between the two odor stimuli used in this study with respect to intensity, liking, valence, stimulation, and familiarity

<table>
<thead>
<tr>
<th></th>
<th>Lavender (N = 29)(^1)</th>
<th>Menthol (N = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity of odor stimuli</td>
<td>6.3 ± 1.3</td>
<td>6.0 ± 1.4</td>
</tr>
<tr>
<td>Liking of odor stimuli</td>
<td>6.5 ± 1.5</td>
<td>7.0 ± 1.6</td>
</tr>
<tr>
<td>Valence of odor stimuli</td>
<td>6.4 ± 1.7</td>
<td>7.0 ± 1.4</td>
</tr>
<tr>
<td>Stimulation (arousal) of odor stimuli</td>
<td>5.3 ± 1.9</td>
<td>5.7 ± 2.0</td>
</tr>
<tr>
<td>Familiarity with odor stimuli</td>
<td>6.3 ± 1.9</td>
<td>6.8 ± 1.8</td>
</tr>
</tbody>
</table>

\(^1\)All participants did not complete these ratings.

### 2.4. Visual stimuli

A total of 64 pictures were used as a part of the eye-tracking studies. Four pictures were presented at a time in a slide to each participant, on a total of 16 slides. The pictures were selected based on four categories: “nature”, “activity”, “high-calorie food”, and “low-calorie food”. All the pictures were purchased from web providers (https://www.dreamstime.com).

### 2.5. Intelligence Quotient (IQ) questionnaire (Stressor)

An IQ questionnaire was used to induce acute stress. This questionnaire included 19 questions testing general problem solving, and participants were asked to complete it within 8 minutes. To induce psychological stress, participants were told that they will receive $25 dollars as a monetary reward if they score all 19 questions correctly. However, if they miss even one question, there will be a penalty and they will only receive $20. Additionally, the test administrator gave a time update every two minutes to simulate a high stress situation.

### 2.6. Dutch Eating Behavior Questionnaire (DEBQ)

The eating behavior of individual participants was measured using the DEBQ. The DEBQ is a 33-item self-report questionnaire developed by Van Strien (1986) to evaluate three
eating behaviors: (1) restrained eating, (2) emotional eating, and (3) external eating. Items on the DEBQ range from 1 (never) to 5 (very often), with higher scores showing greater endorsement of a specific eating behavior. As shown in Table 1, the three groups did not differ with respect to scores in restrained eating ($P = 0.15$), emotional eating ($P = 0.92$), and external eating ($P = 0.15$).

### 2.7. Positive and Negative Affect Schedule (PANAS) questionnaire

The PANAS questionnaire consists of 20 items (words or phrases) that describe different emotions and feelings (for details, see Watson & Clark, 1994). Participants were asked to rate their specific affective impression (20 items) on that time based on a 5-point scale ranging from 1 (very slightly or not at all) to 5 (extremely).

### 2.8. Procedure

There were two eye-tracking sessions, one before and one after induced stress, in order to evaluate the effect of different scent conditions (i.e., no scent, lavender, and menthol) on participant’s visual attention to high-calorie food images. Before the study all participants were asked to refrain from consuming any food or beverages for approximately two hours. In addition, the study was not conducted during lunch time (between 11:00am – 1:00pm). Before the test began, the experimental procedure was completely explained and clarified to the participant and a written consent form was completed. After the consent form was filled out, the participant was given their first PANAS questionnaire to record their baseline, pre-test emotions. The first eye-tracking experiment was then conducted to record the “pre-stress” attention to the eight slides, including four different images on each. Participants were asked to sit on a chair 60 cm away from the 22-in. monitor integrated with the eye-tracker (Model: RED, SensoMotoric Instruments...
GmbH, Teltow, Germany). The sampling rate of the eye-tracker was 60 Hz and tracking spatial resolution was 0.03°. By using a five-point calibration method, the eye-tracker was calibrated for each person with a low tracking error (less than 0.4°). Before starting, the general instructions for the eye-tracking procedure were explained to the participant. On each slide they looked at four images, and they were asked to keep their attention on the monitor at all times. The eye-tracking study began with two warm-up slides, followed by eight slides featuring four pictures, one from each of the specific topics: “activity”, “nature” and “high-calorie food”, and “low-calorie food”. The order of the eight test slides was randomly presented via stimulus presentation software (Experiment Suite 360°™, SensoMotoric Instruments GmbH, Teltow, Germany). Each slide was presented for 10,000ms on the monitor. An inter-stimulus interval (ISI) was shown for 5,000ms on average in between visual slide presentations. All participants were presented with the same stimuli (i.e., two warm-up slides + eight test slides). Since the eye-tracking test was conducted in both pre-stress and post-stress conditions, there were two sets of eight slides for a total of 16 visual slides.

After finishing the first eye-tracking session, the participants were moved to the room where they would be given the IQ test. Approximately two minutes before starting the IQ test, the scent was prepared by taking 20-µL of either lavender or menthol and pour into a pad. For the No Scent group, no odor stimulus was added into the pad. The participant was then asked to wear the necklace which the pad was put in it and they could smell the odor during the IQ test. They were then asked to complete the IQ test within eight minutes. After completion of the IQ test, participants were again given the PANAS questionnaire to measure their emotions immediately after the IQ test. Following the PANAS questionnaire, the second session of eye-tracking measurement was started. The procedure for eye tracking measurement in the second
session was the same as discussed above; different visual slides were not used in the second session.

Following the second eye-tracking measurement, participants were asked to rate their liking and desire to eat high-calorie foods shown in four different pictures, on nine-point scales ranging from 1 (I don’t like it all) to 9 (I like extremely). Participants were also asked to rate perceived intensity, liking, valence, stimulation, and familiarity with respect to odor stimulus given during the study, on 10-cm line scales.

2.9. Data analysis

Statistical analysis was performed using XLSTAT statistical software (Addinsoft, New York, NY, USA). The Shapiro-Wilk Normality test concluded that the null hypothesis stating that the data came from a normally distributed population, was rejected in most data obtained from this study. Therefore, non-parametric statistical methods were executed for data analysis. As described in Chapter 3, prior to data analysis, from the slides used in the eye-tracking tests, the images were designated as different area of interest (AOI) and labeled either as “high-calorie food”, “low-calorie food”, “nature”, and “activity” using BeGaze™ software (SensoMotoric Instruments GmbH, Teltow, Germany). Three parameters of visual attention to each AOI image were collected and used for analysis: (1) entry time, (2) fixation count, and (3) fixation time. Entry time refers to the latency passed until the first fixation into that specific AOI, i.e., how long it took the participant to look at that specific picture, once the slide was shown. Fixation count refers to the total number of fixations onto the specific AOI. Finally, the fixation time is the sum of the fixation duration to the specific AOI, i.e., the total time the participant looked at that specific image such as high-caloric food images. The data of individual slides whose
recording time was less than 70% (< 7,000 ms) were considered as incomplete data. The incomplete data were not included in the data analysis. Data of twelve participants who showed either poor performance in odor identification test or extremely incomplete data across visual slides were also not included in the data analysis. To determine whether visual attention to individual AOIs differed among the three scent conditions, Kruskal-Wallis test was conducted.

To compare the mean scores of eating behavior questionnaires (DEQB) among three scent groups, Kruskal-Wallis test was conducted. When there was a significant difference, multiple pairwise comparisons using Nemenyi’s procedure were performed. In addition, to examine whether the positive or negative emotions changed between the Pre-Stress and Post-Stress sessions, Wilcoxon signed-rank tests were used to determine whether positive or negative emotions changed between Pre-Stress and Post-Stress sessions in each of the three scent conditions. To compare the odor stimuli in terms of intensity, liking, valence, stimulation, and familiarity, Mann-Whitney U-tests were used. Finally, Spearman’s correlation analysis was used to measure the correlation between emotion changes (i.e., Post-Stress – Pre-Stress) and visual attention parameters to high calorie food images. A statistically significant difference and correlation were defined as $P < 0.05$.

3. Results

3.1. Effects of odor conditions on positive and negative emotions

Each participant’s positive and negative emotions were measured using PANAS two times over this study: before (“Pre-Stress”) and immediately after (“Post-Stress”) inducing the stressor (IQ test). Wilcoxon signed-rank tests revealed that the positive or negative emotions differed between the Post-Stress and Pre-Stress stages in the No Scent condition. More
specifically, while positive emotions decreased ($P = 0.03$), negative emotions increased ($P < 0.001$). Similarly, the same trend was observed in the Menthol condition: positive ($P = 0.047$) and negative ($P = 0.001$) emotions. In the Lavender condition, while negative emotions increased after stressor induction ($P = 0.04$), positive emotions did not change ($P = 0.28$) (Fig. 4.1).

![Graphs showing changes in positive and negative emotions](image)

**Figure 4.1.** Comparisons among positive (A) or negative (B) emotions measured at the two stages: Pre-Stress and Post-Stress, as a function of odor condition: No Scent, Lavender, and Menthol. *, **, and *** represent a significant difference at $P < 0.05$, $P < 0.01$, and $P < 0.001$, respectively. N.S. represents no significant difference at $P > 0.05$.

### 3.2. Effects of odor condition on stress-induced visual attention toward high-calorie food images

Overall, there were no significant differences among the three odor conditions in terms of entry time, fixation count, and fixation time measured either before stress or after treatment as follows:

**Entry time**

Kruskal-Wallis test revealed a significant difference among the three odor conditions in terms of entry time to high-calorie food images when measured before stress induction (Pre-Stress; $P = 0.01$). Participants in the Lavender group looked at the high-calorie food images sooner than those in the Menthol group ($P = 0.01$). Similarly, when measured after stressor
induction, participants in the Lavender group looked at the high-calorie food images than those in the No Scent ($P = 0.046$) and Menthol ($P = 0.005$) groups (Fig. 4.2).

![Figure 4.2](image)

**Figure 4.2.** Comparisons among the three odor conditions with respect to entry time measured at either Pre-Stress or Post-Stress stage. * and ** represent a significant difference at $P < 0.05$ and $P < 0.01$, respectively. Bars with different letters within each category represent a significant difference at $P < 0.05$.

**Fixation count**

Kruskal-Wallis test showed no significant differences among the three odor conditions in terms of fixation count toward high-calorie food images when measured before (Pre-Stress; $P = 0.91$) and after (Post-Stress; $P = 0.73$) stressor induction (Fig. 4.3).
Figure 4.3. Comparisons among the three odor conditions with respect to fixation count measured at either Pre-Stress or Post-Stress stage. N.S. represents no significant difference at $P < 0.05$.

Fixation time

Kruskal-Wallis test showed no significant difference among the three odor conditions in terms of fixation time toward high-calorie food images when measured before stressor was given (Pre-Stress; $P = 0.24$). However, there was a significant difference among the three odor conditions when measured after the stressor was induced (Post-Stress; $P = 0.048$). More specifically, participants in the Lavender group looked at high-calorie food images longer than those in the No Scent group ($P = 0.04$) (Fig. 4.4).
Figure 4.4. Comparisons among the three odor conditions with respect to fixation time measured at either Pre-Stress or Post-Stress stage. * represents a significant difference at $P < 0.05$. Bars with different letters within each category represent a significant difference at $P < 0.05$. N.S. represents no significant difference at $P < 0.05$.

3.3. Relationship between emotions and visual attention toward high-calorie food images

Using Spearman correlation analysis, it was determined whether stressor-induced emotion changes (i.e., Post-Stress – Pre-Stress) could be associated with visual attention parameters, i.e., entry time, fixation time, and fixation count, for high-calorie food images. The emotion changes in “distressed” ($\rho_{78} = -0.29$, $P = 0.01$) and “excited” ($\rho_{78} = -0.24$, $P = 0.03$) were found to have negative correlations with entry time toward high-calorie food images. In other words, as the stressor evoked more distressed or excited emotions, visual attention toward high-calorie food images were sooner. No other significant correlations were observed (Table 4.3).
Table 4.3. Spearman correlation coefficients (P-value) that show relationships of stressor-induced individual emotion changes (“Post-Stress” – “Pre-Stress”) with eye-tracking parameters: entry time, fixation count, and fixation time.

<table>
<thead>
<tr>
<th>Stages</th>
<th>Emotions</th>
<th>Eye-tracking parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Entry time</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>Interested</td>
<td>-0.08 (0.50)</td>
</tr>
<tr>
<td>emotions</td>
<td>Excited</td>
<td>-0.24 (0.03)</td>
</tr>
<tr>
<td></td>
<td>Strong</td>
<td>0.00 (0.99)</td>
</tr>
<tr>
<td></td>
<td>Enthusiastic</td>
<td>-0.04 (0.73)</td>
</tr>
<tr>
<td></td>
<td>Proud</td>
<td>-0.13 (0.27)</td>
</tr>
<tr>
<td></td>
<td>Alert</td>
<td>-0.11 (0.32)</td>
</tr>
<tr>
<td></td>
<td>Determined</td>
<td>-0.03 (0.77)</td>
</tr>
<tr>
<td></td>
<td>Attentive</td>
<td>-0.09 (0.45)</td>
</tr>
<tr>
<td></td>
<td>Active</td>
<td>0.01 (0.96)</td>
</tr>
<tr>
<td></td>
<td>Inspired</td>
<td>-0.18 (0.11)</td>
</tr>
<tr>
<td>Negative</td>
<td>Distressed</td>
<td>-0.29 (0.01)</td>
</tr>
<tr>
<td>emotions</td>
<td>Upset</td>
<td>0.00 (0.98)</td>
</tr>
<tr>
<td></td>
<td>Guilty</td>
<td>-0.11 (0.32)</td>
</tr>
<tr>
<td></td>
<td>Scared</td>
<td>0.03 (0.77)</td>
</tr>
<tr>
<td></td>
<td>Hostile</td>
<td>-0.01 (0.94)</td>
</tr>
<tr>
<td></td>
<td>Irritable</td>
<td>-0.14 (0.21)</td>
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<td></td>
<td>Ashamed</td>
<td>0.01 (0.96)</td>
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<tr>
<td></td>
<td>Nervous</td>
<td>0.09 (0.46)</td>
</tr>
<tr>
<td></td>
<td>Jittery</td>
<td>-0.06 (0.61)</td>
</tr>
<tr>
<td></td>
<td>Afraid</td>
<td>0.16 (0.15)</td>
</tr>
</tbody>
</table>

3.4. Effect of odor condition on ratings of liking and wanting toward high-calorie food images

Kruskal-Wallis test revealed that the three odor conditions did not differ with respect to liking ratings of high-calorie food images (P = 0.27). However, there was a significant difference among the three odor conditions in terms of ratings of desire to eat the high-calorie foods shown in the images (P < 0.001). Participants in the Lavender group showed less desire to eat the high-calorie foods than those in the No Scent (P = 0.003) or Menthol (P = 0.004) group (Fig. 4.5).
Figure 4.5. Comparisons among the three odor conditions with respect to ratings of food liking and food wanting. *** represents a significant difference at $P < 0.001$. Bars with different letters within each category represent a significant difference at $P < 0.05$. N.S. represents no significant difference at $P < 0.05$.

4. Discussion

This study used two common odors, lavender and menthol essential oils, which are helpful in decreasing the level of acute stress. Panelists evaluated that the two odors did not differ in terms of intensity, liking, valence, stimulation, and familiarity. The critical point for this preparation was mainly related to the intensity of odorants. The experimenter used the similar amount of both for the experiment and this is a positive point that the two odors were not significantly different in terms of intensity. Also, to screen participants’ olfactory performance, the odor identification test was used after the eye-tracking measurement at the Post-Stress stage.
Since some participants had poor performances in the odor identification task (< 10 out of 16 points), their data were not included for the data analysis.

In this study, the positive and negative emotions were monitored using PANAS questionnaire two times, i.e., before and after inducing the stressful condition. As we expected, the positive and negative emotions were different between two sessions, showing that individuals’ emotions are affected by the stressful condition. Aromatherapy has been mainly used for treating the different diseases like psychological disorders for many decades specially in western countries (Martin, 1996). Lavender and bergamot essential oils are antidepressants and can induce relaxation in individuals (Battaglia, 2003). The essential oils are usually inhaled by entering to the olfactory pathway and to the brain, the limbic system which is responsible for learning, emotions and memory (Price, 2012). Pleasant odors may induce a positive emotion in an individual. The essential oils used in aromatherapy are extracted from the plants like lavender, rose, jasmine by steam distillation method (Kose et al., 2007; Ozdemire & Oztunc, 2013). When the essential oils are inhaled, they lead to different effects by entering to some centers like the hypothalamus and the hippocampus which ultimately go to the limbic system through the olfactory pathway (Kose et al., 2007).

This study showed that the time pressure may play a role in inducing the short-term stressful condition. Despite the previous chapter, the participant immediately completed the post-stress PANAS questionnaire and eye-tracking studies after the IQ test; i.e., there was no 5-minute waiting period. Thus, the stressor-induced positive and negative emotions could be measured. This study was based on self-reported emotions before and after stressful condition. However, since other research studies screened the level of stress based on the level of cortisol or...
heart rate through the experiment, physiological measurements need to be considered in a future study.

Regarding the eye-tracking measurement, the results of this study showed that visual attention toward high-calorie food images were significantly different in terms of entry time. More specifically, participants in the Lavender group looked at the high-calorie food images sooner than did those in the Menthol and/or the No Scent group. However, since this trend was observed in both Pre-Stress and Post-Stress stages, this observation might not be deeply related to psychological stress induced in this study. Interestingly, participants in the Lavender group looked at the high-calorie food images shorter than did those in both Menthol and No Scent groups, suggesting that lavender odor might be effective in reducing visual attention toward high-calorie foods or their images. In addition, this study showed that negative emotions are related to visual attention toward high-calorie food images, which is in agreement with the result of Chapter 3.

5. Conclusion

In conclusion, the study showed the effect of odor stimulus, especially lavender essential oil, on relieving stress and changing the visual attention toward to high-calorie food images. In addition, the stressor-induced negative emotions were found to be associated with visual attention toward the high-calorie food images. A further study is needed to explore whether odor stimuli (e.g., lavender odor) can reduce individuals’ visual attention toward real high-calorie foods in the context of food consumption.
References


Chapter 5. General Discussion

This study was designed to determine whether or not listening to music or smelling pleasant odors can relieve psychological stress, thereby reducing visual attention toward high-calorie food images. Music therapy and aromatherapy have been found effective in relieving psychological stress (Labbé et al., 2004; Wendy & Jenny, 2004; Krantz et al., 2005). Burns et al. (1999, 2002) and Labbé et al. (2004) reported that listening to relaxing music (e.g., classical music) could help listeners experience positive emotions and parasympathetic increases in nervous system arousal. In a previous study by Anup et al. (2017), the effects of both music and scent in mitigating stress were investigated, and they concluded that aromatherapy was more helpful in improving emotional states and decreasing anxiety of participants. Although numerous studies have shown the effect of music therapy and aromatherapy on stress reduction, little is known about whether music therapy (or aromatherapy) can also reduce individuals’ visual attention and preference toward high calorie foods whose excessive intake may increase the potential occurrence of obesity and related health issues (Rosenheck, 2008).

In Study 1, two different music treatments and a control (i.e., no music treatment) condition were used to evaluate changes in visual attention toward high-calorie food images after a stressful event. With respect to emotions experienced by participants, a similar trend was found in all three treatment conditions, with negative emotions increasing immediately following the IQ test used to induce stress. However, in all three treatment conditions there was also a decrease in negative emotions when moving from a post-stress stage to a post-music-treatment stage. It was hypothesized this would happen for both music treatment conditions (i.e., the Air on the G string and self-selected music), but not for the control (i.e., a 5-minute break without music listening). The eye-tracking measurement results showed little difference between the three test
conditions. For the three parameters of entry time, fixation count, and fixation time, there were no significant differences found among the music conditions either in the pre-stress stage or post-music-treatment stage. These results do not provide a conclusive answer as to whether listening to music can be used as a method to alter emotions and decrease desire for high calorie foods. One takeaway from this study is that simply taking a break for 5 minutes may be an effective way to combat short term stress, but it should be noted that the participants did not immediately complete the eye-tracking measurement immediately after the IQ test and there was a 5-minute treatment period during which the control group was instructed to just sit quietly.

Study 1 focused on whether or not individual self-reported emotional states during the experiment and their visual attention toward the food images, specially the high calorie ones, would be different before and after the stressful condition. Although other previous studies in this regard had focused on physiological changes such as heart rate and cortisol level along with self-reported emotion changes (Burn et al., 1999, 2002; Labbé et al., 2004; Demarco et al., 2011) those results have been inconsistent between the two different types of measurement. However, it would be interesting to conduct further study to determine whether listening to music can reduce psychological stress as reflected in measurement of physiological parameters.

Another factor to note is the time at which listening to the music occurs. Although listening to music is most often reported in the late afternoon or evening (Linneman, 2015), it is still open to discussion as to whether choice of time of day may be effective with respect to the impact of music on decreasing levels of anxiety. Results from the effect of music on inducting positive emotions may vary depending on many factors, including familiarity with music therapy and duration of music listening (Khalfa et al., 2003; Thoma et al., 2013). Musical properties such as arousal (low versus high arousal) and valence (low versus high pleasantness) should also be
considered when interpreting the effect of music therapy on stress reduction. In fact, Jiang et al. (2016) suggested that low-arousal music is considered to be better than high-arousal music in mediating tension or state of anxiety (Fisher & Greenberg, 1972; Iwanaga & Moroki, 1999; Iwanaga et al., 2005; Lingham & Theorell, 2009; Sandstorm & Russo, 2010; Gan et al., 2015). Listening to highly pleasant musical pieces has also been found to be effective in decreasing psychological stress (Sandstorm & Russo, 2010) and trained listeners have exhibited lower rates of anxiety than untrained listeners (Smith & Morris, 1977); familiar music can also induce more positive emotions (Sung et al., 2012).

The current research can be applied in university settings. For example, Wu (2002) investigated the impact of music therapy on self-efficacy, anxiety, and stress level of students and found that these levels decreased significantly after music therapy. In fact, the music was found to decrease the activity of the sympathetic nervous systems and neuroendocrine, and this decrease reduces corticotropin release, called adrenocorticotropin and stress response.

In Study 2, two different scent treatments and a control (i.e., no odor treatment) condition were used to determine changes in visual attention toward high-calorie food images after a stressful event. With respect to participants’ reported emotions, there was no significant difference between reported pre-stress and post-stress positive emotions for the lavender condition, while there were significant decreases for both the control and menthol conditions. In terms of negative emotions, there was a significant increase from pre-stress to post-stress in all three conditions. The finding that positive emotions did not decrease in the lavender condition is a good indication that the odor treatment (using lavender essential oil) may have been effective in maintaining positive emotions during stressful events. With respect to eye-tracking measurement, while participants in the lavender condition looked at the high-calorie food images
sooner than did those in the menthol and/or the no scent conditions. However, since this trend was observed in both pre-stress and post-stress stages, this observation should be carefully interpreted. Participants experiencing the lavender condition also looked at the high-calorie food images for shorter times than those in both menthol and no scent conditions, suggesting that lavender scent might be effective in reducing visual attention toward high calorie foods or their images.

An important factor when considering of aromatherapy effects is duration of exposure to scents. In this study, we provided the scent for 8 minutes during the stressful condition, while other research studies provided scent cues for a longer period of time. For example, in the study conducted by Sahebalzamani et al. (2010), aromatherapy using rose or lavender scent was applied to 240 students for two to four weeks. This suggests that further study should be conducted to maximize the effect of scent cues on stress reduction by optimizing the duration of scent exposure.

There were some consistent findings between the two studies with respect to using musical pieces or scent cues for stress reduction. As expected, negative emotions increased immediately following the given stressor (IQ test), indicating that the IQ test indeed induced psychological stress. In addition, in both studies, negative emotions indicative of stress were highest immediately after the IQ test. Finally, both studies showed through correlation analysis that negative emotions are related to visual attention toward high-calorie food images.

As mentioned previously, to further validate that participants were in a higher state of stress after the treatment than before, it would be interesting to measure physiological changes (e.g., pupil-diameter data) before and after the stressor induction. In addition, because of the findings in Study 1 that revealed that a break itself to be an important factor in stress reduction,
further study should be conducted to compare whether visual attention toward high-calorie food images can differ with respect to the presence and absence of break without music listening. Finally, it would also be interesting to investigate the synergistic effect of music and aroma treatments in fostering relaxation. In fact, Sarah et al. (2018) found that a combination of music and aroma treatments was helpful in improving emotional states by decreasing the anxiety level. Future studies could expand on this research by using real food samples, either looking directly at food selection or consumption, and using facial recognition software to analyze emotions rather than relying solely on reported valued.
References


Appendix

To: Han-Seok Seo  
FDSC N-216  
From: Douglas James Adams, Chair  
IRB Committee  
Date: 11/06/2019  
Action: Expedited Approval  
Action Date: 11/06/2019  
Protocol #: 1810154212R001  
Study Title: Variation in the visual attention toward images of food and non-food stimuli  
Expiration Date: 10/28/2020  
Last Approval Date: 11/06/2019

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution’s IRB.

It is the Principal Investigator’s responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Kyle J Buffin, Investigator  
Thadeus L Beekman, Investigator  
Reza Moltaji, Investigator  
Victoria J Hogan, Investigator