

**IMPLICIT AND EXPLICIT EMOTIONAL RESPONSES TO LIGHT INDUCED MILK
OXIDATION AND BREAKFAST MEALS**

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ACADEMIC ABSTRACT

Emotional responses, whether approach or withdrawal motivated, are fundamental factors in all food-related experiences. In this research project four experiments were completed with the goal of contributing to the growing body of research related to food and emotions. Implicit (unstated) measures of attention, emotional expression, and motivational behavior tendencies were assessed as additional supportive information for explicit (cognitive) measures of acceptability and emotional response to food and attributes of food with quality and safety concerns. Differences in explicit responses were evaluated using a 9-point hedonic scale, check-all-that-apply (CATA) emotion term questionnaire, and a six basic emotion intensity ratings scale. Implicit responses of emotion, attention and motivational behaviors were measured using automated facial expression analysis (AFEA), eye-tracking technology, electrocardiography (ECG) and electroencephalography (EEG). An initial study on light-induced milk oxidation flavor quality indicated reliable explicit measures of emotion and consumer acceptability, while AFEA showed a wide range of facial expression. In a following study, five different control breakfast meal videos were created; three were matched with a nearly identical video that contained one of three food concerns, food spoilage quality, hygiene quality and safety. Explicit measures provided solid support for the expected explicit response differences between food concerning and control breakfast meal types. Implicit measures of heart rate, facial motor expressions and frontal cortex asymmetries (brain activity) were only minimally informative

across each measure or conclusive across meal types. The use of time series statistical analyses illustrated temporal changes in emotions when compared to a control condition, which was not evident using traditional analysis of variance approaches. A visual attention study investigated use of eye tracking as an indicator of the emotional responses elicited. Eye tracking technologies, as well as the other implicit measures (ECG, EEG, and AFEA), encountered similar limitations pertaining to participant variability due to personal preferences and characteristics, as well as a need for standard methodologies with food as stimuli and appropriate control conditions. With further research in this area of study, implicit measures of emotion, attention and motivational behaviors may provide additional valuable information to more traditional explicit affective methodologies for a greater understanding of the overall consumer food experience.

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GENERAL AUDIENCE ABSTRACT

Emotional responses are fundamental in all food-related experiences. The understanding of the relationship between emotions and food is valuable for food companies to create desirable products, but also plays an important role in our perception of the nutrition, health and safety of our food. In this research, four experiments were completed with the goal of exploring unconscious measures of attention, facial motor expression, and motivated behaviors as truer indicators of emotional responses; these methods provide support to self-expressed measures of liking and emotions to food and attributes of food with quality and safety concerns. Self-expressed responses were assessed for product acceptability, emotional word choices associated with the product, and identified intensity of six basic emotions. Unconscious responses of emotion were measured using automated facial expression analysis (AFEA) software, eye-tracking technology, heart (ECG) and brain activity (EEG). An initial study on flavor quality of milk related to light-protective packaging indicated milk samples exposed to light for extended periods were characterized with the term disgust and were rated lower in acceptability compared to the light-protected milk; AFEA showed a wide range of facial expression among all milk samples. In a following study, five different control breakfast meal videos were created; three were matched with a nearly identical video that contained one of three food concerns, food spoilage quality, hygiene quality and safety. Written measures provided solid support for the expected liking and emotional response differences between food concerning and control

breakfast meal types. Unconscious measures of heart rate, facial expressions and brain activity were not informative across each measure nor conclusive across meal types. A visual attention study using eye tracking technology, assessed consumer awareness of quality and safety issues in relation to expressed emotions using these videos. Participant variability due to personal preferences and characteristics, as well as a need for standard methodologies with food as stimuli and appropriate control conditions were limitations to the outcomes of unconscious responses. With further research, unconscious measures of emotion, attention and motivational behaviors may provide additional valuable information for a greater understanding of consumers' wants, needs, and overall food experience. This understanding has the potential to broadly impact and inform medicine, psychology, nutrition, health, and advertising/marketing communications.

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CHAPTER 1: INTRODUCTION

In the food science industry, the means for understanding consumer-based affective responses through extensive product development and sensory testing is an important element for success. Large food companies are most often responsible for this consumer research; however other areas of the food industry such as food service settings in school and business cafeterias, hospitals, restaurants, etc., would greatly benefit from understanding their consumers and the relationship they have with food. More specifically, deeper knowledge of what attributes of food cause positive food experiences is essential for consumer satisfaction. Learning to reduce or eliminate attributes that cause negative food experiences is a basic concept that is arguably as important and often overlooked in food studies; adverse food experiences can lead to brand distrust, consumer dissatisfaction and even reduced sales (Kubberod, Ueland, Digstad, Risvik & Henjesand, 2008; Wardy, Sae-Eaw, Sriwattana, No, & Prinyawiwatkul, 2015). Published literature and methods for this type of affective testing with food is limited. The traditional use of the hedonic scale, which estimates the degree of a product's acceptability, has been the primary method of predicting what products will be liked and thus what should be released into the market/food establishment. However, this type of consumer sensory testing is not always successful. Many factors can affect this type of response and issues of accuracy arise because of variability within panelist consistency, uniformity, memory, perception and rationality (Köster, 2009). It is clear that emotions play a significant role in food experiences (Meiselman, 2015; Köster & Mojet, 2015); yet traditional sensory techniques, such as acceptability, do not give adequate insight into how the consumer truly feels about a product or food (Köster, 2003). With the majority of new products failing in the market place and the fact that not all food service institutions are well-liked or successful (Stanton, 2013), developing superior methods for

evaluating food items and their attributes for improved assessment of positive/negative emotional food experiences would be advantageous to all areas of the food industry. The relatively recent addition of emotions literature to sensory science research, building on the psychology field of affect, provides a new avenue for observing and understanding how a consumer reacts to food through a nontraditional perspective.

In psychology literature, emotions have been studied extensively. With dozens of emotion based theories and many methods of measuring emotions, incorporating this area of research is important for food scientists delving into work on emotional responses to food stimuli. Although many theories are accepted in psychology literature, the Approach-Withdrawal Motivational Behavior Tendency theory is of particular interest due to its support from neurological studies. This theory describes emotional responses as either an ‘approach,’ having a natural inclination towards the stimuli, or as a ‘withdrawal’, having a propensity away from the stimuli. This distinction is important to recognize as more traditional positive/negative approaches to emotional responses are not always appropriate for emotion terms that cannot be distinctly categorized. For example, surprise cannot be classified as either negative or positive (Alves, Fukusima & Aznar-Casanova, 2008). In the approach/withdrawal model, approach emotions include (but are not limited to) happy, surprise and anger, while withdrawal emotions include fear, sadness and disgust (Demarree, Everhart, Youngstrom & Harrison, 2005; Alves, et al., 2008). These emotions (anger, disgust, fear, happy, sad and surprised) are considered the six universal (basic) emotions (Ekman, Friesen, O'Sullivan, Chan, Diacoyanni-Tarlatzis, Heider, Krause, LeCompte, Pitcairn, Ricci-Bitti, Scherer, Tomita, & Tzavaras, 1987). The six basic emotions are believed to be recognized throughout different cultures and thus are important to identify for communicative purposes between different research studies and emotion

methodologies. Even though the difference in emotion categorization may seem rudimentary, identifying evoked ‘approach’ and ‘withdrawal’ emotions have the potential to better predict product acceptance and pleasing food experiences, particularly when entering areas of research that include cognitive and unconscious (unstated) responses.

To further understand the consumer-food relationship, it is valuable to consider methods for assessing both explicit and implicit emotional responses (Jiang, King, & Prinyawiwatkul, 2014; Köster & Mojet, 2015; Meiselman, 2015). The term, explicit, describes responses made when one is consciously aware. Hedonic scoring and preference questionnaires are widely used non-emotion explicit responses, while a Check-All-That-Apply (CATA) emotional terminology selection questionnaire, such as the EsSenseTM Profile (King & Meiselman, 2010) is an emotion-based explicit tool (King, Meiselman & Carr, 2010). Emotion-based explicit consumer response approaches are designed to provide fast and unlabored emotional responses. The key is eliciting the quickest response in hopes of revealing the most unaffected reaction to the stimuli. In theory, this method provides an accurate representation of the immediate emotions one feels towards a food (King & Meiselman, 2010). However, in reality this type of response is influenced by many factors that are often difficult to control. Factors that influence emotional response to food include: 1) the sensory attributes of the food, 2) past experiences and memories, 3) personal or cultural significances 4) anticipation, and 5) actions associated with food (cooking, preparation, etc.) (Desmet & Schifferstein, 2008, Köster & Mojet, 2015). The challenge of overcoming these factors when making conclusions about explicit emotional responses to food provides support for the use of implicit emotional responses or responses made when not consciously aware (Köster & Mojet, 2015). Implicit responses include physiological measurements of brain and heart activity, facial motor expressions, skin conductance, eye movements, etc. Implicit responses are

arguably less cognitively influenced and have the potential to provide food scientists, restaurant owners, food service managers and food companies with additional important information about their consumers and their interactions with food.

Methods for assessing implicit responses in food science research is in its infancy. Heart rate, sweat response, skin temperature, eye-tracking and automated facial expression analyses (AFEAs) are a few of the methods in the latest food-related literature (Danner, Sidorkina, Joechl & Duerrschmid, 2013; Danner, Haindl, Joechl & Duerrschmid, 2014; de Wijk, Kooijman, Verhoeven, Holthuysen & de Graaf, 2012; de Wijk, He, Mensink, Verhoeven & de Graaf, 2014; He, Boesveldt, de Graaf & de Wijk, 2016; Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015; Mawad, Trias, Gimenez, Maiche & Ares, 2015; Walsh, Duncan, Potts, & Gallagher, 2015; van der Laan, Hooge, Ridder, Viergever & Smeets, 2015). Brain activity is also of interest, but a study assessing this measurement's use has yet to be published in a food journal (Köster & Mojet, 2015). Responses from the brain, heart, face and eyes are often (but not always) unconscious and arise directly from the central nervous (CNS) or autonomic nervous systems (ANS). The CNS and ANS work together to integrate response signals for important functions in the body, measuring reactions from these systems are conceivably more representative of true emotional response than cognitively determined explicit responses. More recent technology developments have made measuring emotions more feasible and practical in research settings. Automated computer software containing algorithms designed to measure specific movements in the face has made measuring facial expressions of the six basic emotions (and a neutral state) possible with little training (Noldus Information Technology, 2012). Visual processing patterns is a related implicit measure. Eye-tracking technology can provide information on an individual's attention by measuring the number of fixations and fixation durations on a particular

subject or element of interest (van der Laan, et al., 2015). This information provides insight into what potentially influences consumer's decisions or thought processes by interpreting their focus (Armel, Beaumel & Rangel, 2008; Jantathai, Danner, Joechl & Durrschmid, 2013). An electrophysiological response of the ANS that measures the rhythmic relaxation and contractual activity of the heart is called electrocardiography (ECG) (Becker, 2005). Although it is debated as to whether this method is emotion specific, heart rate changes can provide additional information about emotions felt or/and the direction (dimension) of the emotional response (pleasantness/unpleasantness or positivity/negativity) (Kreibig, 2010). Brain electrical activity measured by an electroencephalograph (EEG) uses electrical potentials transferred to the scalp to determine frontal cortex asymmetry; the approach/withdrawal motivational behavior theory has been directly related to this method (Kaiser, 2005; Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Davidson, 2004). The combined use of these different implicit response modalities (facial expressions, eye-tracking, heart rate and brain activity) with explicit emotional questionnaires, has the potential to advance sensory techniques by uncovering true, sincere emotional responses. Enhancing our understanding of emotional responses to food will provide superior consumer insight knowledge, potentially leading to greater brand loyalty, product/food establishment success and overall food experiences.

The findings of this research project are the first steps in advancing how sensory and product development scientists critically analyze emotional responses and provides further evidence for a transformation of consumer-based food evaluation. Four studies were conducted which include the following topics: 1) the evaluation of two emotional response measures (emotional questionnaires and AFEA) to assess quality changes in milk due to light-induced oxidation, 2) the use of implicit (EEG, ECG and AFEA) and explicit response measures to

evaluate emotion and motivational behaviors to quality and safety concerns in breakfast meals, 3) the use of implicit (EEG, ECG and AFEA) and explicit response measures to assess emotion and motivational behaviors to different breakfast meal types, and 4) eye tracking technology use for interpretation of attention and its relation to emotional responses to food.

1. OVERALL OBJECTIVES

- 1.) Determine if specific emotion terminology selection can be correlated to hedonic scoring for potential use in improving traditional consumer sensory testing.
- 2.) Determine if automated facial expression analysis (AFEA) can be used as an additional unbiased method to traditional sensory techniques and explicit emotional assessments for a greater understanding of emotional reactions to food.
- 3.) Determine if other implicit emotional responses, frontal cortex asymmetry and heart rate will provide informative additional evidence to understanding explicit emotional response measures to food.
- 4.) Evaluate if emotional responses can be related to visual processing and attention patterning through the use of eye tracking technology.

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CHAPTER 2: FROM BRAIN TO BEHAVIOR: LINKING EMOTIONS TO RESEARCH APPLICATIONS IN FOOD SCIENCE

ABSTRACT

Limited success in understanding food choice and behavior has initiated interest in measures of emotional response to foods. The relevance to food science and consumer insights has led to increased use of self-reporting tools of emotions. Emotions are complex, however, and self-reporting methods are deficient at capturing the implicit basis from which food choice and behavior may be derived. Neurological, physiological and motor expression measures of implicit emotions are complex and challenging to interpret yet the brain is central to the study of emotion. While there is a vast research literature base on emotions provided through psychology, interpretation related to food choice and behavior is limiting and often confusing. This article integrates information on current food and emotions research with established psychology literature to bridge the gap. This paper clarifies what emotions are, the theories of emotion processing, as well as provides a general description of the emotional brain. Additionally, critique of value, limitations, and uses of current techniques and focus on the need for integrated methods, illustrates how to consider the measurement of emotional response to food.

KEYWORDS

Emotions, EEG, food

1. INTRODUCTION

Food is an integral part of our daily lives (Cardello, Meiselman, Schutz, Craig, Given, Leshner & Eicher, 2012; Plutchik, 2001), contributing sustenance as well as enrichment. The food industry acknowledges this importance with its dedication to understanding consumer response to products and their use. Food companies recognize that the success of new food products depends on the consumer (Leonard, 2002; van Kleef, van Trijp & Luning 2005). The industry invests significant effort, time, and money in developing and designing products targeted to meet consumer wants and needs. However, current consumer-driven approaches are not broadly effective, as evidenced by a 70-80% new product failure rate (Gutjar, de Graaf, Kooijman, de Wijk, Nys, Horst & Jager, 2014; Stanton, 2013). Jiang, King & Prinyawiwatkul (2014) argue that the consumer liking assessment, characteristically measured with overall acceptability or preference methodology, may not be predictive of product success or sales. Considering information about consumer emotions may be helpful in providing additional evidence of the processes involved in differentiating similar food products (Chaya, Pacoud, Ng, Fenton & Hort, 2015; Gutjar et al., 2014; Jiang et al. 2014; King, Meiselman & Carr, 2010).

Commonly used approaches to understanding consumers and their emotion-based decision making processes have yielded disappointing results. Not only is it difficult for individuals to describe their emotional responses [to food products], it is also difficult for consumers to distinguish between similar emotions (Plutchik, 2001). Ulwick (2002) suggests that consumers do not really know what they want; asking them directly provides little concrete information (Leonard, 2002; van Kleef et al., 2005). Despite this difficulty, it has long been an accepted method to listen to “the voice of the consumer.” Research at the fuzzy front end provides guidance for product development with consumer emotions in mind (Brown and Eisenhardt,

1995; Leonard, 2002; van Kleef et al., 2005). However, food product development and sensory scientists have difficulty producing and validating new products that effectively meet consumer expectations, partially because such expectations are not well articulated (Leonard, 2002; van Kleef et al., 2005; Ulwick, 2002). Improved understanding of how consumers perceive a product on multiple levels (taste, texture, use, and convenience) can enhance consumer-driven product planning but may not ensure product success (Ulwick, 2002; van Kleef et al., 2005).

Incorporating theory and research on emotions and how emotions influence food choices may prove fruitful in developing new products that become consumer favorites.

The study of human emotion has been a cornerstone of the discipline of psychology (James, 1884). The field of food science has likewise acknowledged the value of emotion in consumer research, with a rapidly expanding food science literature base in the area of emotion (Jiang et al., 2014; Meiselman, 2015; Koster and Mojet, 2015). However, inconsistencies in use of terminology, application of theories, and description and use of methods between psychology and food science research literature are confusing. These inconsistencies confound the application and interpretation of emotion-related testing methods as applied to food. There is consensus that food product sensory characteristics and the product experience evoke emotions, that these emotions help steer decision making, and that emotions contribute to product experience. Research on food as a stimulus for emotion is still limited. Most methods for measuring the emotional experiences associated are not well developed for application to food. Statistical approaches and interpretation of integrated implicit and explicit responses are challenging.

The recent application of self-reporting emotion questionnaires in food science studies has added additional information when assessing product acceptability and consumer choice

behaviors (Chaya et al., 2015; Cardello et al., 2012; Desmet & Schifferstein, 2008; Gutjar et al. 2014; King & Meiselman, 2010; King et al., 2010; Spinelli, Masi, Dinnella, Zoboli & Monteleone, 2014). Many food science researchers develop their own emotion lexicons (list of emotion terms) based on consumer feedback, which effectively increases the discrimination capabilities of the tool for that specific product (Ng, Chaya, & Hort, 2013; Jiang et al., 2014). This is, however, a time and resource intensive endeavor, making product specific tools less feasible for smaller or time restricted research projects (Jiang et al., 2014; Ng et al., 2013; Spinelli et al., 2014). To further complicate the measurement of emotion in food science research, the field of psychology continues to debate the definition of emotion. A current approach is to describe emotions as behavioral motivations. This approach utilizes natural propensities (or aversions) to stimuli; these behavior motivations are reflective of brain activity during emotion and are often used to characterize complex feeling states (to be discussed later; Davidson, & Irwin 1999; Davidson, Ekman, Saron, Senulis & Friesen, 1990; Scherer, 2000). This approach may prove beneficial for food science emotion-based research.

In psychology research, six emotion components (to be discussed in detail later), as well as idiosyncratic variation in general intensity of emotion response, termed individual granularity, are known to contribute to differences in emotional response (Barrett, 2008; Fontaine, Scherer, Roesch & Ellsworth, 2007; Valenzi, Islam, Jurica, & Cichocki, 2014). Jiang et al. (2014) identified eight factors that affect how individuals respond emotionally to food: (1) nutritional/physical condition, (2) involvement with the particular food, (3) psychological state, (4) familiarity with the food, as well as (5) gender, (6) liking, (7) age, and (8) cultural importance to the individual. Desmet and Schifferstein (2008) identified five similar factors affecting food emotions including: (1) sensory characteristics of food, (2) cultural/personal importance, (3) past

experiences (memories), (4) potential consequences, and (5) actions of involved individuals.

The diversity of these influencing factors emphasizes the complexity of emotional responses to food and the need for a deeper understanding of consumer response to food (Gibson, 2006). This complexity also necessitates questions as to whether even the most meticulously chosen lexicons (or other emotion tools) will sufficiently characterize the extent of possible emotions one may feel about a food. Thus, apparently simple questionnaire assessments of consumer emotion reactions to food products are actually not simple at all. These questionnaires are attempting to measure complex reactions, interactions, and attitudes.

Given the complexity of the well-established psychology literature on emotion and the need to clarify basic knowledge in emotions and the emotional brain for the food scientist and nutritionist, the objectives of this paper are to:

- 1.) Identify gaps, contradictions, and inconsistencies in the assessment of emotion in food science research, with the addition of literature from the psychology research field to define and clarify;
- 2.) Describe basic brain functions related to emotion, behavior, and cognition; and
- 3.) Provide context for needed advancements in emotion assessment methodologies and techniques, as well as offer guidance for future research endeavors in the area of food and emotion with the intent of improving the rate of product success and consumer satisfaction.

It is not our intent to argue for a particular definition or theory of emotion. Rather we present commonly accepted theories in psychology research to assist food and sensory science researchers in understanding the dynamic and rapidly expanding field of food and emotions research.

2. EMOTION TERMINOLOGY, MODELS, AND THEORIES AND THE CONNECTION TO FOOD SCIENCE

2.1 What is emotion?

Emotion is a complex topic. Its definition is thought to be described in more than 90 different ways with no authoritative definition (Izard, 2007, Plutchik, 2001). Commonly, and for the purpose of this paper, emotion is described as an individual's fleeting state of mind, elicited by internal or external stimuli, and shaped by a complex combination of specific individual influences (Ekman, 1994; Harrison & Critchley, 2007; Jiang et al., 2014; Scherer, 2000). Thus, evaluation (appraisal), arousal of neurophysiological reactions, motor expressions, and the subjective state of feeling are some of the influences that contribute to the construct of what is an emotion (Fontaine et al., 2007; Ng et al., 2013; Scherer, 2000; Harrison & Critchely, 2007). Fontaine et al. (2007) describes six 'emotion components' that are known to contribute to emotional response. These components include: (1) cognitive evaluation of significance (appraisal), (2) facial, vocal and bodily expressions, (3) changes in one's physiological state, (4) feelings from past experiences, (5) propensity to act in response to the stimuli (action tendencies) and (6) an individual's censoring or choice of displaying their emotions. Thus the adjectives often used to describe emotions (for example, angry) should be considered as a "label" for an emotional experience (Izard, 2007; Scherer, 2000; Spinelli et al., 2014), and not as a steadfast term, due to many factors influencing an individual's interpretation of a term (King & Mieselman, 2010).

Many established theories bring greater contextual meaning to emotion or feeling terms by grouping them into categories (Barrett, 2008). To illustrate this point, anger can be described both as intense and aggressive feeling (wanting to approach your stimuli), while conversely can

be internal and more reserved (wanting to withdraw from your stimuli). Representing a complex and varying emotion using a single feeling term may not be the most appropriate technique (Jiang et al., 2014; Spinelli et al. 2014). This complexity and diversity in emotion differentiation contributes to the challenges of interpreting the emotion literature in the psychology field, and extends to the food science domain. It is important to acknowledge that there are many other significant definitions of emotion, but the intent of this paper is not to critically analyze all potential meanings. In an effort to explain the complexity of emotion response to food, we designed Figure 1 to emphasize the multiple factors influencing perception, the many modes of perception, and the many communicative activities (physiological, cognitive, motor and neurological) that continually feed back and feed forward to create an emotional response. Food scientists with limited formal training in psychology can benefit from recognizing the complexity of emotion response and, by extension, the difficulty with using emotion term lexicons in a research setting.

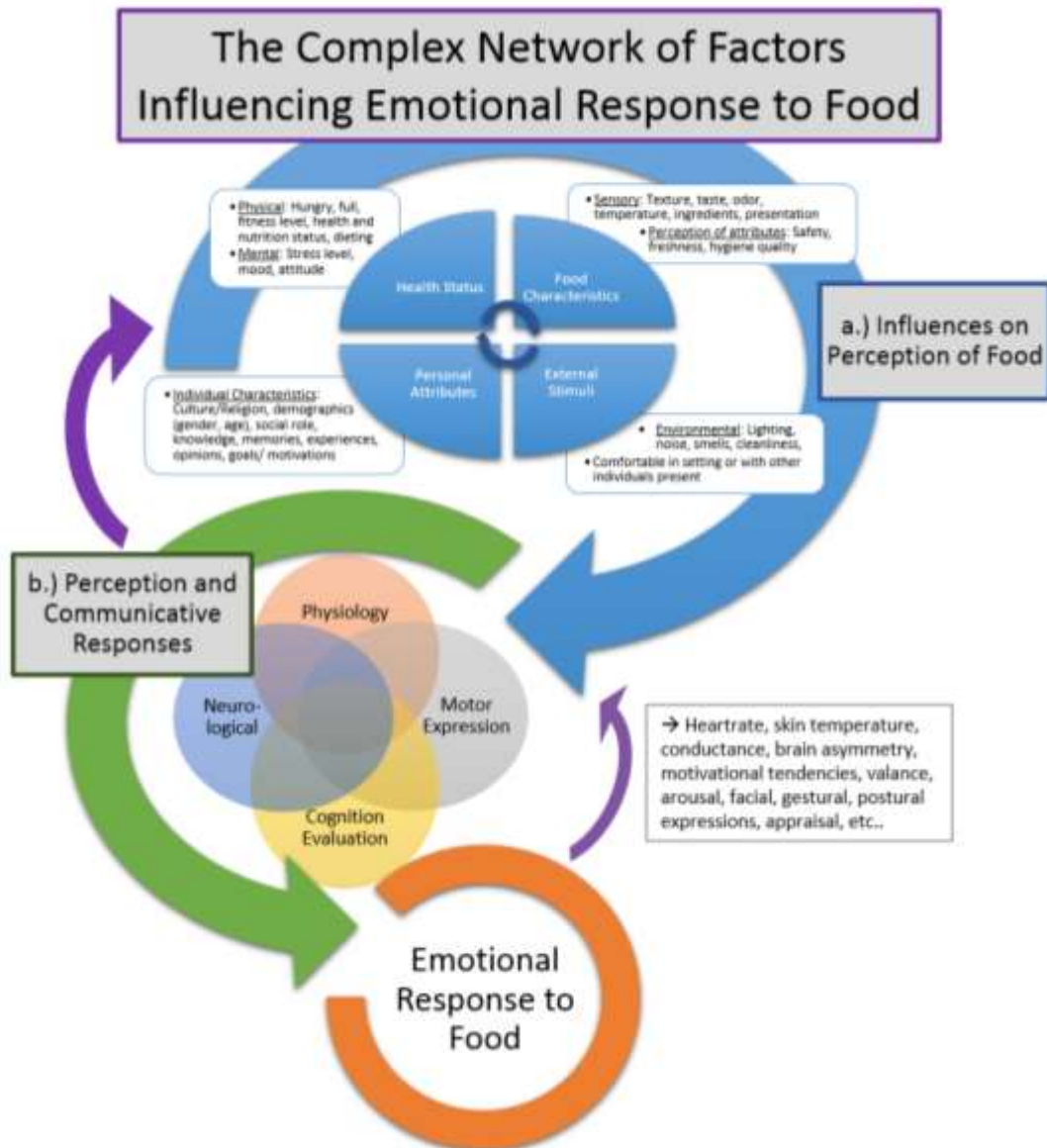


Figure 1: The complex network of factors influencing emotional response to food; a.) Four categories of stimuli that influence how food is perceived; b.) Four ways in which the perception of the food is communicated within oneself and outwardly, which leads to an emotional response to food; blue, green and orange arrows illustrate feed forward activity, purple arrows illustrate feedback loops.

2.2 Important Related Terminology and Common Misconceptions

To further understand the definition of emotion, it is important to recognize the distinctions between other commonly used, and often misinterpreted, terms related to emotion:

feeling, mood, expression, and attitude (see Table 1 for a complete list of definitions). A *mood* is less intense and has a longer duration than an emotion. A mood can last hours or even days, while an emotion's duration can be as short as a second or could last for a few minutes (Ekman, 1994; Robbins & Judge, 2013, Scherer, 2000). Also, an emotion is often directed at someone or something (stimuli), whereas a mood does not usually have a specific stimulus (Ekman, 1994; Robbins & Judge, 2013; for a complete review see Scherer, 2000). The term *feeling*, although more commonly used interchangeably with emotion, is subtly differentiated (Garrett, 2015). A feeling is the personal conscious experience of an emotion that is often articulated through facial expressions or verbalized with emotion terms (de Wijk, Kooijman, Verhoeven, Holthuyzen & de Graaf, 2012; Scherer, 2000). An *expression* is the communicative action or response of one's internal state, which is an important concept for the basic function of humans interacting and living together (de Wijk, et al., 2012; Scherer, 2000). Facial motor movements, vocalization, and/or physical actions can all be modes of expression that provide evidence for a feeling experience of emotion (Scherer, 2000). An *attitude* emphasizes a response with an evaluative component that can change depending on emotional state (Jiang et al., 2014; King & Meiselman, 2010). Definitions assist in understanding the subtle distinctions in terminology, as well as assist in interpreting the psychology literature, and in accurately applying the basic science principles to food and emotion research.

While careful use of terminology helps reduce misinterpretation of emotion literature, the challenges that exist in classifying emotions and understanding the theories behind emotions are complex. We present a brief synopsis of the common emotion theories and models as an introduction.

Table 1: Emotion and neuroscience terminology

Term	Definition
<i>Emotion</i> ^{7,12,18,19}	A fleeting and often intense state of mind caused by an internal or external stimuli and shaped by a complex combination of specific individual influences. An emotion is often directed at someone or something and lasts for a few seconds to a couple minutes.
<i>Mood</i> ^{8,18,19}	A less intense and longer lasting state of mind that is not necessarily caused by a known stimuli and can last for hours to days.
<i>Expression</i> ^{5,19}	The outward response or communicative action of one's state of mind (emotion or mood) which includes modes such as facial movements, vocalization and other physical actions that provide evidence for a feeling experience of an emotion.
<i>Feeling</i> ^{5,10,19}	The personal conscious experience of an emotion that is often articulated through facial expressions, verbalized with emotion terms or through other communicative means.
<i>Cognition</i> ^{10,16}	The mental processes that allows for the acquisition of knowledge, decision-making, perception of experiences and the senses, as well as for understanding and comprehension.
<i>Attitude</i> ^{14,15}	A response with an evaluative component that can change depending on emotional state and is usually directed at a stimuli.
<i>Emotion Schema</i> ¹³	Emotion schemas illustrate a non-basic dynamic feeling state that is influenced by the perception of emotion and cognition. They are also culturally formed, influenced by appraisal, affect motivational processes, and are individualistically based on one's motivations and need for coping with a significant stimuli based on their specific experiences and memories.
<i>Basic Emotions</i> ^{8,13,17, 19}	Evolutionarily developed states of mind (emotions) that have fixed boundaries or characteristics that originate from nature providing recognizable and common properties across populations.
<i>Big Six</i> ^{8,17}	The six commonly accepted basic emotions: anger, disgust, happy, sad, scared, and surprise.
<i>Appraisal</i> ^{6,9,16,19}	The cognitive interpretation of an event that helps define one's emotions by providing a perception of responsibility in a circumstance, also inferred to as personal meaning analysis.
<i>Action Tendency</i> ⁹	A behavior propensity that is connected to a feeling (or emotion), and is often described as a motivation to approach or withdrawal from a stimuli.

<i>Affect</i> ^{1,13,19}	The condition that one experiences from a stimuli or how their state of being is influenced by a stimuli. Hedonic quality (pleasantness), positive/negative, or stimulation effect (arousal) are all aspects that contribute to affect.
<i>Core Affect</i> ¹	Core affect is an individual's most elementary state of valence and arousal. In the core affect theory, individuals have a universal "core knowledge" that is influenced by appraisal (evaluation) and an ever changing environment causes constant fluctuations/variations in one's emotional state.
<i>Valance</i> ^{1,9,19}	The amount to which one is attracted (positive) or averse (negative) to a specific stimuli. Often associated with degree of pleasantness (or unpleasantness).
<i>Arousal</i> ^{9,19}	The state of activation or inactivation stimulated by a specific stimuli, often described as the degree of alertness.
<i>Frontal Cortex</i> ¹⁰	The most anterior and superior lobe, which contributes to the division of the brain into 4 main lobes: frontal, parietal, occipital and temporal.
<i>Prefrontal Cortex</i> ¹⁰	An anterior area of the frontal lobe that is important for emotion processing.
<i>Lateralization/Asymmetry</i> ^{2,3,4}	The structural difference between the right and left hemispheres of the brain, which helps explain the control of different functions on opposing sides of the brain
<i>Electroencephalography (EEG)</i> ^{4,10}	A brain activity monitoring system that measures changes in electrical current of all brain neurons between pairs of corresponding electrodes on the surface of the scalp.
<i>Functional Magnetic Resonance Imaging (fMRI)</i> ^{4,10,11}	A brain activity monitoring system that measures oxygen levels and changes in blood flow, which provides a spatial image of the entire brain by implementation of a complete head (or body) scan.
<i>Brain Activation</i> ^{2,10}	The change in brain activity in response to stimuli or in response to cognitive processing.

Barrett, 2008¹; Coan & Allen²; Davidson et al. 1990³; Davidson, 2004⁴; de Wijk, et al., 2012⁵; Ellsworth & Scherer, 2001⁶; Ekman, 1994⁷; Ekman, 1999⁸; Fontaine, 2007⁹; Garrett, 2015¹⁰; Harmon-Jones, et al., 2010¹¹; Harrison, & Critchley, 2007¹²; Izard, 2007¹³; Jiang et al., 2014¹⁴; King & Meiselman, 2010¹⁵; Lazarus and Folkman, 1987¹⁶; Prinz, 2004¹⁷; Robbins & Judge, 2013¹⁸; Scherer, 2000¹⁹

2.3 Introduction to Emotion Theories and Models

Theories are an important part of psychologists' efforts to present their ideas and as explanation of a phenomenon. Theories may be supported by general principles and/or some indirect scientific evidence and are important for developing models of behavior which researchers can test. Questionnaires, scales, and other measures are developed to interpret the theories and ultimately provide support for or rejection of the theory. A brief summary and discussion of basic, discrete, dimensional, and more complex emotion theories is warranted to assist in understanding the psychology literature on emotion.

2.4 Basic Emotions, the Discrete Model and the Food Science Connection

The basic emotions framework proposes that there are six primary emotions (anger, disgust, happy, sad, scared, surprise), often referred to as the 'Big Six' (Ekman 1999; Prinz, 2004). This idea of primary emotions originated from the work of Darwin, and has been supported by studies in the area of facial expressions (Ekman 1984; Izard, 2007; Plutchik, 2001; Scherer, 2000).

The discrete model of emotion advocates for preexisting specific neurological and physiological reaction mechanisms for these basic emotions; these mechanisms are initiated by their corresponding emotional arousal and provoked by certain stimuli (Izard, 2007; Scherer, 2000). Discrete emotions describe a response with definite characteristics that are observed naturally and are recognized by the human mind (Barrett, 2008). Specific motor expressions and physiological reaction patterns are based on the specific emotion elicited, often defining these universal emotional responses as basic emotions (Scherer, 2000). The discrete model, and its relation to basic emotions, is the foundation for facial expression analysis and many emotion questionnaires.

Recent research in food science is studying the use of automated facial expression analysis (AFEA) software as a means of capturing a less consciously controlled response (facial movements) and reporting the corresponding discrete emotion (Danner, Sidorkina, Joechl & Duerrschmid, 2013; Danner, Haindl, Joech & Duerrschmid, 2014; de Wijk et al., 2012; de Wijk et al., 2014; He, Boesveldt, de Graaf & de Wijk, 2016; Leitch, Duncan, O’Keefe, Rudd, & Gallagher, 2015; Walsh, Duncan, Potts, & Gallagher, 2015). AFEA software programs, such as Noldus’s FaceReader and the Computer Expression Recognition Toolbox (CERT), are based on Ekman and Friesen’s Facial Action Coding System (FACS) for identification of emotions (Littlewort, Whitehill, Wu, Fasel, Frank, Movellan & Bartlett, 2011; Loijens & Krips, 2012; Noldus Information Technology, 2015; Anonymous, 2015). Newest updates in AFEA software advertises for the use of a circumflex model (to be discussed later) by utilizing two dimensions; valance, which is a measure of pleasantness (pleasant to unpleasant), and arousal, the degree of activity (active to inactive) (Noldus Information Technology, 2015). However, in food science research, only the discrete model technique had been applied. Facial expressions are monitored for basic emotions (and a neutral state) through automatic coding of facial motor movements (Littlewort et al., 2011; Loijens & Krips, 2012; Noldus Information Technology, 2015). AFEA software is beginning to be used to better understand consumer food choices; however, it remains more common to study the discrete model using emotion questionnaires.

Established discrete emotion questionnaires are used in areas such as clinical nutrition (e.g., Multiple Affect Adjective Check List – Revised (MAACL-R), Profile of Mood States (POMS)). These questionnaires typically are targeted towards disordered or restrained eaters (King & Meiselman, 2010). In food science research, however, where the target population is often the general public or a specific demographic, as opposed to a specific group of people in

search of medical treatment, a standardized emotion questionnaire has not been developed (Cardello et al., 2012; Jiang et al., 2014; King & Meiselman, 2010; Meiselman, 2015). Private companies such as Nestle (and likely many others) have produced their own emotion lexicons, but a standard method available to all professionals is an important step in remedying evaluation discrepancies between studies (Jiang et al., 2014). The emotion lexicons that have been developed identify many more emotion-based terms than Ekman's six basic emotions (Cardello et al., 2012; King & Meiselman, 2010). Published and commercialized emotion term lists used in the field of food science range anywhere from 36 to 316 words (Cardello et al., 2012; Jiang et al., 2014; King & Meiselman, 2010). Although a long list provides depth to the term list, the advantages of the check-all-that-apply tool may be self-defeating. The advantages of these questionnaires include quick and easy instruction for participants, rapid collection, relatively simple statistical analyses, and little expense (Cardello et al., 2012; King & Meiselman, 2010; Meiselman, 2015; van Kleef et al., 2005). With a recent emerging importance of emotion to food and sensory science, food science researchers are often caught up in wanting to quantify emotional responses to food in order to produce statistically significant results and concrete evidence for the successful release of a product in the market place (Cardello et al., 2012; Jiang et al., 2014). However, the complexity of emotional response and individual variation in emotion experience may suggest the need for a more individualized approach (Valenzi et al., 2014). The use of emotion research in the field of food science has added additional knowledge to understanding consumers, but emotional analysis may not be as simple as the current methods portray (Jiang et al., 2014; King & Meiselman, 2010; King et al., 2010; Cardello et al., 2012). The discrete emotions theory is important for supporting the application of emotion tools such as check-all-that-apply list of terms, but there are some important concerns with these tools.

Limitations of discrete model tools are important to identify when developing a research question and procedure. There are four main arguments against the use of the discrete emotions model as the basis for an emotion research tool for food science: (1) there is no standardized methodology; (2) there is debate on emotion term list length; (3) individual interpretation of terms and experience affect responses to the product; and (4) basic emotions may not be representative of more complex emotional responses or blends of emotions associated with food perceptions and preferences. These arguments are discussed in further detail in the following paragraphs.

One concern with the discrete model is the lack of standard method for producing an emotion lexicon (Jiang et al., 2014; Spinelli et al., 2014). The lack of standardized protocols for methodology development and use provides a broad range of emotion lexicon tools with limited ability for comparison of outcomes. Some emotion questionnaires use prescreening and consumer feedback when producing their lists (EsSence ProfileTM: King & Mieselman, 2010; EmoSemio: Spilleni et al, 2014; Jiang et al., 2014). However, Cardello and colleagues (2012) shared concern for comparing findings between studies without research standards. Some researchers endorse a longer list of terms because using condensed lists may fail to reveal valuable information (Cardello et al., 2012; King & Mieselman, 2010; Mieselman, 2015). Conversely, caution should be given to longer lexicon lists, as shorter lists may be more conducive for rapid, efficient, and less tiresome data collection (Cardello et al., 2012; Gutjar et al., 2014; Mieselman, 2015; Spinelli et al., 2014). Longer lists may be associated with participant mental fatigue, causing increasingly poor testing results as the sensory testing session proceeds. Longer lists may decrease the immediacy of the response due to unrecognized terms on the list and thus allows for potential reevaluation of the experienced emotional response.

Longer lists run the risk of having overlapping terms in an effort to include all possible responses. This redundancy can also convolute results when individual interpretation of terms renders different item choices (Jiang et al., 2014; Meiselman, 2015). Further bias is created when unequal positive and negative terms are presented (Chaya et al., 2015; Meiselman, 2015; Ng et al., 2013). Meiselman (2015) emphasized the importance of investigating the most fitting lexicon and/or response method for a specific research question and then develop a standard method for data collection to have an effective balance between brevity and being all encompassing (Chaya et al., 2015; Jiang et al., 2014; Spinelli et al., 2014).

Another argument against application of the discrete model is the influence of individual interpretation. The use of discrete emotions assumes that participants understand each emotion-related term on the questionnaire or have the same interpretation of the term. Particularly when testing food, some terms can have two meanings. For example, the term “warm” is often incorporated in emotion word lexicon (King & Meiselman, 2010); however “warm” can be interpreted as having a sense of comfort and assurance, while at the same time “warm” can describe the temperature of the food. Spinelli et al. (2014) argues that context needs to be included for more consistent word interpretation across individuals and ethnic groups. EmoSemio captures full sentence descriptions, based on product user interviews, for each emotion term in an effort to lessen the severity of ambiguity (Spinelli et al., 2014). On the other hand, Gutjar et al. (2014) argues for non-verbal emotion representations by using cartoon figurines in a tool called the Product Emotion Measurement Instrument (PrEmo®). Both of these methods may provide greater discriminatory capabilities by reducing interpretation opacity compared to a basic lexicon listing (Gutjar et al., 2014; Spinelli et al., 2014).

The last argument against using the discrete emotion theory for the development of emotion tools is the concept of emotion blends (Plutchik, 2001). Psychologists who do not embrace the discrete emotions model argue there are infinite numbers of emotions and emotion combinations due to the numerous factors affecting emotions (Barrett, 2008; see Figure 1 for illustration). These psychologists question whether a discrete list of terms would ever sufficiently cover the broad range of possible feelings a consumer may have (Davidson et al., 1990; Liao, Corsi, Chrysochou & Lockshin, 2015). Emotions may have as many as fifteen dimensions, if not more (Plutchik, 2001). A recent study on emotions elicited by odor incorporated six dimensions (Porcherot, Delplanque, Planchias, Gaudreau, Accolla & Cayeux, 2012; Jiang et al., 2014). Although the discrete model is the basis for many emotional assessment tools already in use, the dimensional model of emotion presents opportunity for further explanation of choice and behavior.

2.5 The Dimensional Model of Emotions

Although discrete model theorists describe six basic emotions, they also acknowledge that an emotional response can be more complex and may be a combination of emotions (e.g., Ekman et al., 1987). Plutchik (2001) describes the idea of “mixed emotions” and there is considerable debate as to whether there is a one-to-one system between emotion and behavior. These observations further support a more multifaceted system for emotion construct (Barrett, 2008; Blascovich & Hartel, 2008).

In an effort to better explain the complexity of emotions, the dimensional model was formulated for comparing and categorizing emotions. This model provides objectivity for measuring the individual’s affective condition. Affect, which is often used synonymously with emotion, describes the condition change that one experiences from stimuli or how one’s state of

being is influenced by that stimuli (Barrett, 2008; Scherer, 2000). Some psychology literature distinguishes affect (or “core affect”) as being directly connected to the valence feature of the response, measuring change in hedonic quality or pleasantness, the positive/negative characteristics of the stimuli, or its stimulation effect or arousal (Barrett, 2008; Scherer, 2000). There are different beliefs as to the number of dimensions that describe emotions. Most often, in different research projects, two or three dimensions; however additional theories describe anywhere from four to eight dimensions (Cardello et al., 2012; Fontaine et al., 2007; Jiang et al., 2014; Scherer, 2000). Fontaine and colleagues (2007) propose that three dimensions may be enough for some research questions but at least four dimensions, if not more, are needed for a comprehensive approach. Valence, the dimension of pleasure and displeasure (often described as positive or negative or degree of agreeableness/pain) is almost always included (Barrett, 2008; Fontaine et al, 2007; Scherer, 2000). Arousal is the second most commonly accepted dimension; it describes the amount of physiological activation or inactivation stimulated by the emotional event. These two dimensions are presented on a coordinate plane with the level of low/high arousal on the y-axis and pleasantness/unpleasantness level on the x-axis. Collectively, this categorizing method is called the Valence-Arousal model (Fontaine, 2007; Scherer, 2000). In other models, such as Plutchik’s Circumplex model (2001), a third dimension, intensity (tension/relaxation), is added. Alternative models argue four dimensions (potency-control/unpredictability) are needed to distinguish similar terms. Some established food industry tools, such as the Geneva Emotion and Oder Scale (GEOS) use six dimensions for odor evaluation, but as many as eight and even fifteen dimensions have been identified (Fontaine, 2007; Jiang et al., 2014; King et al., 2010; Plutchik, 2001).

In food science, simple dimensional models, in the form of emotional intensity ratings scales, are argued to be more accurately accessed by participants (Jiang et al, 2014; Ng et al., 2013). Rating scales of emotion require more cognitive processing by the consumer, thus rendering results that are more discriminating than non-scaled emotional assessments (Ares, Bruzzone, Vidal, Cadena, Gimenez, Pineau, Hunter, Paisley & Jaeger, 2014; Jiang et al, 2014; King & Meiselman, 2010; Ng et al., 2013). King and Meiselman (2010) found their emotion intensity rating scales (rate-all-that-apply; RATA scales) to be more effective in adding additional information to understanding acceptability than their discrete models when evaluating food and emotions (Cardello et al., 2012). Arousal, engagement, valance, motivation, and unique food category characteristics are a few of the additional dimensions identified in food studies (Cardello et al., 2012; Chaya et al., 2015; Evers, Adriaanse, de Ridder & de Witt Huberts, 2013; Liao et al. 2015; Jiang et al., 2014; Spinelli et al. 2014). While other questionnaires with varying amounts of dimensions do exist (refer to Meiselman (2015) for a comprehensive review of emotion research methods in product development), just as there is no standardization for discrete methods, there is no standard method between dimensional methods. Scherer (2000; p. 185) makes an excellent point when he writes: “If the subjective feeling is restricted to the conscious experience of emotion, then it would seem that the verbal expression we use to describe this state is the closest we can come to defining it”. It is clear that the dimensional model is important for improved communication as it is arguably a more thorough method for emotion classification than a discrete model.

Automated facial expression analysis software includes elements of the dimensional models. Software, such as the Noldus FaceReader, measures the “activation” of emotions, providing a metric of intensity for each of the six basic emotions and neutral (Noldus

Information Technology, 2015). Although the newly updated software (FaceReader 6™, Noldus Information Technology, Wageningen, The Netherlands, 2015) does directly acknowledge two dimensions (valence and arousal), no published AFEA studies in food science have utilized this feature. Food science literature utilizes older versions of AFEA where scaling features act as a “dimension” by providing a percentage to which an emotion is expressed in comparison to other emotions. In effect, when multiple emotions are activated, this could indicate a blend of emotions, but the software was not designed to identify new emotion blends in this manner. Further research is needed to explore the newly developed dimensional elements of the software.

There are some concerns with the dimensional model. More understated emotions and less obvious differences are often overlooked (Scherer, 2000). Interestingly, hedonic and emotional scoring are sometimes but are not always correlated, raising questions about rating emotional intensity reliability (Cardello et al., 2012; King & Meiselman, 2010). Another concern is participant fatigue. The broad range of potential dimensions presented to the consumer can be challenging when including a wide variety of terms, but alternatively a limited list of emotions brings concern for accuracy and usefulness (Barrett, 2008; Cardello et al., 2012; King & Meiselman, 2010). The potential for fifteen dimensions brings forth the additional questions: Are there a countable number of dimensions? Is there an infinite number? Although there are many aspects of concern for this model, its use in providing a more advanced communication tool for emotion supports the dimensional model’s further use (Scherer, 2000). The concept of an emotional model with even greater complexity created the framework for Core Affect and Appraisal theories.

2.6 More Complex Models: Core Affect and Appraisal Theories

Even though Fontaine et al. (2007) is a dimensional model theorist, he presents 6 components of emotions: a) appraisals of events, b) psychophysiological changes, c) motor expressions, d) action tendencies, e) subjective experiences, and f) emotion regulation. These components further the discussion about emotion complexity and the effort to find an effective model. Theorists Magda B. Arnold, Richard Lazarus and Lisa Feldman Barrett explain that there is a cognitive evaluation component in the course of emotion processing (Barrett, 2008; Lazarus & Folkman 1987; Scherer, 2000). The Core Affect Theory and the Appraisal Theory include these additional components.

Core affect is one's state of valence and arousal at the most elementary level. The core affect theory is described as the constant variation in one's physical and mental being in response to an ever-changing environment (Barrett, 2008). Individuals have a universal "core knowledge" that is influenced by evaluation (personal meaning analysis). Often equated to a barometer, core affect monitors stimuli and fluctuations in response to different circumstances (Barrett, 2008). Evaluation, also called appraisal evaluation, is the cognitive assessment of a stimulus, such as an event, object, or a person's action. Evaluation develops meaning and results in understanding the importance of achieving goals, which produces a response emotion or coping action (Lazarus & Folkman, 1987; Scherer, 2000).

The appraisal theory is different from the core affect theory in that there is no identified status of emotional knowledge. Combinations of responses and evaluations to a stimulus (or stimuli) continuously build the characteristic emotion during the specific appraisal episode (Ellsworth & Scherer, 2001). Initial evaluation of valence (advantageous or harmful) to a stimulus is thought to be the preliminary process and the course of reappraisal (reevaluation)

begins thereafter (Barrett, 2008; Ellsworth & Scherer, 2001; Lazarus & Folkman, 1987; Mesquita, 2003; Scherer, 2000). Reevaluating a stimulus and changing the emotion that follows renders infinite possibilities of emotions (Ellsworth & Scherer, 2001; Lazarus & Folkman, 1987; Scherer, 2000).

The core affect and appraisal theories emphasize emotions as “blends.” All emotions may not be described as absolute or be accurately described when projected on a dimensional scale (Jiang et al., 2014; Plutchik, 2001; Scherer, 2000). Further complicating the study of emotion is another factor that only more recently has been addressed in the discrete model but not in dimensional models: the time course of the emotion experience. Leitch et al. (2015), in studying sweetener effects in tea, developed a method for monitoring emotional response over time through AFEA by creating a time series of emotional response. He and colleagues (2016) have similarly observed facial expressions to odors to understand how emotions progress over time. Different emotions are elicited at different time intervals over exposure to a stimulus, making self-report questionnaires that target specific emotions a challenge (Davidson et al., 1990). Some assessments in the food science emotions literature may actually be reporting a mood or feeling rather than emotion (Jiang et al., 2014). Jager, Schlich, Tijssen, Yao, Visalli, de Graaf, and Stieger (2015) recently developed an emotional time course method based off of a sensory technique called temporal dominance of sensations (TDS) (Meiselman, 2015). This method, temporal dominance of emotion (TDE), has potential for providing insightful information on emotion change throughout the eating experience (Jager et al., 2015). However like other questionnaire techniques, the cognitive nature still provides some bias due to thinking and rationality; further research on its use is needed. Thus, it may be necessary to utilize the term ‘emotion schema’ for clarity, especially as research methods become more complex (Izard,

2007). Emotion schemas illustrate a non-basic dynamic feeling state that is influenced by the perception of emotion and cognition (Izard, 2007). They are also culturally formed, influenced by appraisal, affect motivational processes, and are individualistically based on one's motivations and need for coping with a significant stimuli based on their specific experiences and memories (Izard, 2007). The term emotion schema provides an all-encompassing explanation of many emotion theories, while incorporating the possibility of an infinite number of emotional responses.

As can be seen, the measurement of emotion is a complex task, and the experimental design differences between recording emotion perception and induction, as well as differences in verbal descriptors of emotion, make comparisons among research studies challenging (Davidson et al., 1990; Davidson, 2004; Jiang et al., 2014). A brief review of how the brain is involved in emotions and how this affects both cognitive responses and behavioral choices in relation to food provides additional foundational knowledge for the food science researcher.

3. THE BRAIN: MEASURING TECHNIQUES AND EMOTION STRUCTURES

3.1 The Basics in Emotion-Related Parts of the Brain

The brain is divided into four lobes: frontal, parietal, occipital, and temporal (Figure 2). The brain can be further divided into the outer area called the cerebral cortex, and everything beneath the cerebral cortex, called the subcortical area. These areas have many established functions, but for the extent of this review, the focus is on areas involved with sensory, memory, emotions, and behavior important for food science research.

The frontal lobe has a vast number of functions that play a critical role in both cognition and emotion. These functions range from attention, goal-oriented behaviors, language, memory,

personality, as well as awareness of own and others' feelings, emotions, and moods (Chayer & Freedman 2001). Within the region of the frontal lobe, the prefrontal cortex is located most anterior, with the premotor and primary motor cortexes located posterior. The prefrontal cortex is associated with emotion processing. The emotion asymmetry theories (to be described in detail later) are associated with regions of the prefrontal cortex (Chayer & Freedman 2001; Pessoa, 2008), including the dorsolateral, ventromedial, and the orbitofrontal regions (Davidson & Irwin, 1999; Garrett, 2015).

In addition to the prefrontal cortex, the limbic system structures, and to a lesser extent the parietal lobe, are recognized for contributions to emotions. Although the limbic system is not a separate anatomical region from the subcortical region, it is a complex system of many brain structures, such as the amygdala, clustered around the brain stem, and located medial to the temporal lobe (Figure 2). The limbic system's location below the cerebral cortex allows it to be highly involved in emotion due to its particular connections to the prefrontal cortex. The limbic system is significant in emotion processing and it takes part in many emotion-related tasks also associated with the frontal cortex function, including cognition, memory, sensory, learning and motor actions (Garrett, 2015; Pessoa, 2008). The emotion-related functions of these areas of the limbic and frontal cortex are extensively explored and discussed in psychology literature. Methods for measuring emotional responses in these regions of the brain are being applied in the examination of the emotional response to food. A brief summary of the methods used and related themes helps characterize the influence of food as a stimulus for emotion.

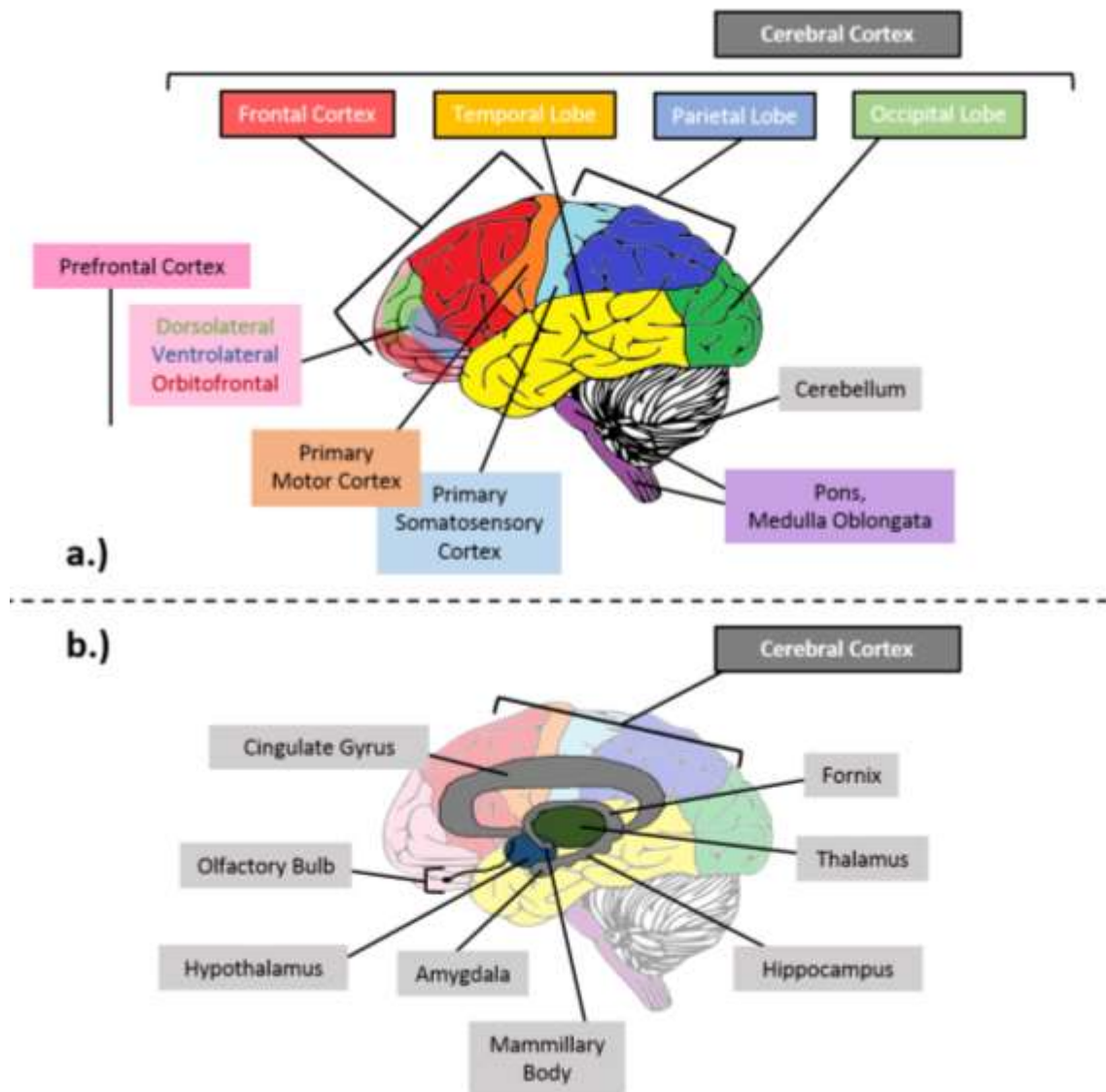


Figure 2: Parts of the Brain; a.) The four lobes of the cerebral cortex and other major parts of the brain; b.) Major parts of the limbic system (Image created by Alexandra Walsh)

3.2 Measuring Emotion in the Brain: A short description of two common methods and their advantages and disadvantages

The electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI) are the most common techniques for identifying and measuring emotion-related responses. These

methods measure different brain functions, areas of the brain, and use different sources of signal, making neuroscience emotion work somewhat difficult to compare across studies (Davidson, 2004). EEG systems measure changes in electrical current of brain neuron networks between pairs of corresponding electrodes on the surface of the scalp (Garrett, 2015). EEG measures small groups of neurons mainly from cortical areas and thus is not the complete representation of all synaptic actions in the brain associated with emotion. EEG recordings do not just measure the electrical current at the site of the electrode; they also have the potential to measure electrical activity from subcortical areas of the brain. EEG provides an indication of the temporal nature of brain activity with millisecond precision, but the spatial resolution of the source of the brain electrical activity is much less precise.

fMRI measures oxygen levels and changes in blood flow, providing an accurate spatial image of the entire brain (Davidson, 2004; Garrett, 2015; Harmon-Jones, Gable & Peterson, 2010). fMRI can detect the precise location of brain activation during emotion experience, but the timing resolution is imprecise (Davidson & Irwin, 1999; Harmon-Jones et al., 2010). Thus, EEG and fMRI measures offer advantages and disadvantages for research. fMRI requires expensive equipment that requires extensive training and personnel. In most research settings fMRI equipment must be shared with a medical facility, requiring any non-medical research activities to occur during low-use times, often at night. Like fMRI methodology, EEG research also requires trained staff and experienced researchers for data collection, analysis, and interpretations. EEG equipment is more affordable and tends to be associated with a specific research lab or shared by a small group of researchers. Thus, EEG methodology is more widely available and accessible within the research community.

In food sensory testing, environmental controls play a large role in people's interactions with and responses to food stimuli. Individuals are easily influenced by external factors, affecting their perceptions of many qualities of the food (Meilgaard, Civille & Carr, 2007). All methods of assessing brain activity reduce the natural engagement with the food stimuli, producing an environmental influence on the human subject (Valenzi et al., 2014). However, EEG is a much more feasible technique in a food science research setting. Participants sitting quietly in a comfortable environment wearing an EEG electrode cap can directly focus on observing or interacting with food stimuli, allowing for a more natural environment with food. In contrast, fMRI necessitates lying down in a scanner tunnel and having one's head immobilized to control for movement. Current publications with food related stimuli in fMRI studies are limited to images, liquid or odorant stimuli (de Araujo, Kringelbach, Rolls & Hobden, 2003; Grabenhorst, Rolls, Bilderbeck, 2007; Kuikka, 2011; Rolls, McCabe, 2007; Kringelbach, O'Doherty, Rolls & Andrews, 2003). Studies have shown that body position influences brain hemisphere activation, especially anger responses (Harmon-Jones et al., 2010; Harmon-Jones & Peterson, 2009) as well as motivational behaviors to food (Brunyé, Hayes, Mahoney, Gardony, Taylor & Kanarek, 2013). The body positioning and the scanner environment limit interaction with the stimuli, such that images of food are typically used. Additional limitations for fMRI can affect data collection. Issues can arise with image distortion, signal losses, and particular concern comes with measuring the orbitofrontal cortex; its location near the sinus cavity can cause misinterpretation of data due to the presence of air (Kringelbach, 2005).

Further consideration should be taken when choosing a system for measuring brain activity depending on the type of information desired. EEG can measure the electrical activity from all areas of the cerebral cortex and thus is a reliable indication of emotional response

happenings in the four cortical regions (Davidson, 2004). However, as Davidson (2004) explained, the dorsolateral section of the prefrontal cortex is most involved in emotion processing but is least likely to be measured by EEG. EEG systems are restricted to more generalized scalp-recorded electrical activity. They are unrepresentative of specific prefrontal cortex or other subcortical areas that fMRI systems may be able to detect more accurately (Davidson, 2004; Harmon-Jones et al., 2010). However, EEG systems can be used to measure frontal and prefrontal asymmetric cortical activation (to be discussed later) for emotion processing and behavioral motivation response observations. Traditionally fMRI studies do not focus solely on cortical asymmetries for emotional response analysis, but rather fMRI observes activity of more specific prefrontal cortex areas in combination with subcortical areas such as the amygdala, insular cortex, and ventral striatum (Davidson & Irwin, 1999). In this manner, fMRI methods can detect different areas, which may not be distinctly evaluated by EEG measurements, through their spatial imaging (Harmon-Jones et al., 2010). Although EEG measurements may lack a complete view of both cortical and subcortical brain regions that fMRI procedures can provide, EEG is a useful and functional tool. EEG provides a different piece of information that can be used as supporting evidence in combination with other measures for a more complete understanding of an emotional response (Davidson, 2004).

3.3 The Brain Basis of Emotion: A brief history

One of the biggest debates, and probably the most important concept mediating future emotion research, is the manner in which emotion is processed. Older emotion models proposed that emotions are linear (Scherer, 2000). Charles Darwin, who published his book *The Expression of Emotions in Man and Animals* in 1872, believed that an individual observes an event, to which an emotion is elicited which then becomes felt, and causes an array of different

physiological responses that are expressed through the body as that particular emotion feeling (Barrett, 2008; Scherer, 2000). Later in 1885, William James and Carl Lange individually posed what turned out to be similar theories and the combined James-Lange theory shaped much of modern emotion psychology in attempts to uncover the mystery behind the nervous system (Barrett, 2008; Scherer, 2000). James and Lange described a slightly reversed theory than Darwin, in which an event is perceived causing different physiological responses; the perception of these bodily change responses is recognized and a specific emotion is elicited, causing a feeling (Barrett, 2008; Scherer, 2000). Then, in the 1960s, an emergence of many new emotion topics appeared, introducing appraisal and meaning evaluation, as well as new twists on basic emotions (Barrett, 2008). The James-Lange theory of the emotional response sequence was revised by the Schachter-Singer model, which introduced the idea of cognitive processes involved in emotion. A cognitive component interprets nonspecific sensations/or bodily responses elicited by the event stimuli, which are then perceived and cause an emotion followed by a feeling (Scherer, 2000). Although none of these theories have been completely discredited, none has been chosen as superior. The more modern models present emotion-processing systems in a more complex manner, without a definitive sequence due to the advancement in our understanding of cognitive contributions to emotion and sophisticated measurement techniques. Brain anatomy and function provide additional insight into the theoretical view of emotion processing.

3.4 Brain Lateralization and Emotion Categorization

The brain is physically divided by the longitudinal fissure separating the cerebral cortex into right and left hemispheres. These separate sides are involved in some unique functions but are connected and thus communicate via a bundle of nerve tissues called the corpus callosum

(Garrett, 2015). Asymmetry (or lateralization) is used to describe the structural and functional differences between the right and left hemispheres. Brain asymmetry models of emotion have generated a great deal of research information about brain-behavior relations in the area of emotion. These brain asymmetry models include simple Positive/Negative or Pleasantness/Unpleasantness categorizations as well as motivation-driven dichotomies such as: Approach/Withdrawal (avoidance), Aversive/Attractive, Behavior Activation/ Behavioral Inhibition, Appetitive/Defensive and Appetitive/Aversive categories (Spielberg, Stewart, Levin, Miller, & Heller, 2008). Most current research emphasizes the importance of motivation in emotion processes, and thus the Approach/Withdrawal model dominates the research literature (Harmon-Jones et al., 2010). For the purpose of this paper, the slight differences between the motivational models will not be discussed in detail and the interested reader is referred to Spielberg et al. (2008); instead, our focus will be placed on the Approach/Withdrawal model (refer to Spielberg et al. (2008); for additional information on other emotional models and their neural processes).

The Approach/Withdrawal model describes two different systems. First, the approach system involves the act of moving towards (approaching) a stimulus or a sought-after goal, controlling appetitive behavior, and is often associated with positive affect (Coan & Allen, 2004; Davidson & Irwin, 1999; Spielberg et al., 2008). Comparatively, the withdrawal system describes the act of removing or moving away (withdrawing/avoiding) from an aversive stimulus, and is often associated with a negative affect (Coan & Allen, 2004; Davidson & Irwin, 1999; Spielberg et al., 2008). In relation to the brain, the left frontal lobe is involved with approach responses and the right frontal lobe is involves with the opposing withdrawal responses (Coan & Allen, 2004; Davidson, 2004; Harmon-Jones et al., 2010). Typically withdrawal-

related emotions are mostly negatively valenced terms (sadness, fear, anxiety, disgust and fear), while approach-related emotions are usually regarded as positively valenced terms (happiness, love, enthusiasm, pride and surprise) (Davidson & Irwin, 1999; Spielberg et al., 2008).

Typically, anger is associated with negative valence, such as in the Positive/Negative models or Pleasant/Unpleasant models. However, the Approach/Withdrawal model categorizes anger as an approach emotion, surfacing the debate on whether anger is negative or positive affect (Alves, Fukusima, & Aznar-Casanova, 2008; Davidson et al., 1990; Harmon-Jones et al., 2010; Spielberg et al., 2008). Harmon-Jones et al. (2003) explain that there are different types of anger; the neurobiological response depends on context because both the situation and individual's traits affect the response (Pessoa, 2008). Asymmetry studies suggest there is also a difference in brain activity between approach-related anger and withdrawal-related anger (Harmon-Jones et al., 2003; Harmon-Jones et al., 2010; Spielberg et al., 2008). The argument is that valence (positive or negative) does not necessarily have an effect on Approach/Withdrawal tendencies, discrediting the idea that anger can be placed in a positive or negative category (Harmon-Jones et al., 2003). Similar to the anger debate, Davidson et al. (1990) discusses variations in positive affective states and illustrates differences in happy feelings. He differentiates between the terms "approach happiness" and "non-approach forms of positive affect" to describe other happy emotions like amusement (Davidson et al., 1990). Ekman, Friesen, & Davidson (1990) also discuss the inconsistencies in positive expressive emotions when distinguishing different types of smiles. True enjoyment is associated with a smile containing specific eye wrinkling postures, termed the "Duchenne Smile" (Ekman et al., 1990). These postures differentiate the Duchenne smile from other smiles such as painful or deceitful smiles, called "masking smiles", which cover up other emotions (Ekman et al., 1990). Even

though smiling may be associated with positive affect, infant studies have shown that smiles expressed in either approach or withdrawal feeling situations cause different areas of the brain to be activated (Fox & Davidson, 1988). Thus, inconsistencies in brain activity in both anger and happy emotions suggest caution when categorizing emotions into specific groups, such as Positive/Negative or Approach/Withdrawal, for interpreting an individual's feelings or behaviors. These inconsistencies also provide evidence that all emotions may not be as discretely described as many theories suggest (Harmon-Jones et al., 2010; Jiang et al., 2014).

To alleviate some of these inconsistencies, alternative models have been developed. The Appetitive/Aversion model adds a cognitive element to reward/punishment evaluations. This cognitive element involves monitoring, reevaluating, and adjusting an emotion accordingly to adapt one's behaviors. This model includes appraisal (meaning evaluation), memory and past experiences, and decision-making, in combination with motivation, as critical for emotion (Spielberg et al., 2008). The application of the Approach/Withdrawal model is most highly accepted in psychology literature but mindfulness of other viewpoints such the Appetitive/Aversive model provides a more informed knowledge base in the ever growing emotions research. Since interaction with food occurs daily and diversity in food character and quality as well as the environment of the eating situation is high, it is likely that appraisal, decision-making, and motivation results in the alteration of food-related emotions.

3.5 Emotional Brain Behavior

The measurement technique influences the region and functions of the brain that are measured. It is important to determine and to use appropriate (electrical or metabolic) methods for the research question (Davidson, 2004). Evidence from both EEG and spatial imaging assists

in revealing the important connectivity between these cortical regions and structures of the limbic system and help describe emotional behavior of the brain.

The orbitofrontal region of the prefrontal cortex is believed to be most directly connected to affective value in emotions (Davidson 2004). Sensory information from all five systems (olfactory, auditory, visual, gustatory and somatosensory) is received in the orbitofrontal cortex (Kringelbach, 2005). Furthermore, the orbitofrontal region is directly linked to at least nine other regions of the brain (amygdala, cingulate cortex, insula/operculum, hypothalamus, hippocampus, striatum, periaqueductal grey and dorsolateral cortex), which provides support for a complex interaction in emotional processing (Kringelbach, 2005). Unfortunately, EEG techniques are unable to specifically record the orbital region's activity due to the system's surface recording limitations, still, EEG studies have been able to identify evidence of activity due to the proximity to other frontal regions where EEG recordings can be made (Davidson, 2004). The dorsolateral region is believed to be most reflective of EEG measures and due to neuronal connectivity, EEG measures of the dorsolateral region can be reflective of the orbitofrontal region, but lack the specificity to measure these smaller areas of the prefrontal cortex (Davidson et al., 1990; Davidson, 2004; Pessoa, 2008). Because of this limitation, it is not uncommon that a more general approach in measuring asymmetries in the "frontal cortex area" is used as a broader overview of the brain's lateralized activity (Davidson, 2004; Davidson et al. 1990; Harmon-Jones et al., 2009). With the addition of brain metabolic measurement tools such as fMRI, spatial images illustrating connectivity between cortical and subcortical regions have allowed for further functional and behavioral discoveries in emotions research.

The prefrontal cortex is believed to act as a moderator of activity patterns and thus is influenced by many connected networks contributing to emotional responses; in this manner, the

prefrontal cortex plays only a part in the more complex circuit brain circuit (refer to Coan & Allen (2004) for a review on EEG Asymmetry of emotion; Davidson, 2004). To illustrate the complexity of the emotional brain network, Kringelbach (2005) notes that the orbitofrontal cortex receives information from the specific area of the magnocellular medial thalamus of the mediodorsal thalamus, while other areas of the prefrontal cortex receive information from the same structure (thalamus), but from different sections. The parvocellular lateral region is where the dorsolateral region receives information from, while visual information input from anterior region is received in the paralamar region (Kringelbach, 2005). This illustrates that specific structures in the brain that are thought to be active in emotion processing may be connected to numerous other regions creating a larger network (Chayer & Freedman (2001); Davidson, 2004; Davidson & Irwin, 1999; Kringelbach 2005; Pessoa, 2008). Because of this connectivity, not only has hedonic response or affective values been connected to the frontal areas of the brain, other functions important in emotion determination and processing have been linked to the prefrontal region. Decision-making, motivation (both to reach goals and in response to aversive stimuli), fear responses, anger, control, punishment/ reward, attention, working memory, expectation and many more functions related to cognition are associated with the prefrontal region (Alves et al., 2008; Davidson & Irwin, 1999; Harmon-Jones et al., 2010; Kringelbach, 2005; Pessoa, 2008; Phillips, Drevets, Rauch & Lane, 2003). It is apparent that many areas of the brain have effects on emotion processes, providing a complex network, but with particular focus in the prefrontal cortex and the amygdala.

fMRI studies have allowed for a deeper visual representation of the brain's emotion network. Specifically, neuroimaging techniques have uncovered that the amygdala is believed to regulate attention, primary visual cortex stimuli, associative learning, affective significance

(especially negative affect), expression perception (auditory and visual of faces), recognition of emotionally salient stimuli (appraisals), cognitive control and depression behaviors (Alves et al., 2008; Harrison & Critchley, 2007; Pessoa, 2008; Phillips et al., 2003). Areas of the prefrontal cortex such as the ventrolateral region (particularly the right hemisphere) are associated with punishment and inhibition behavior. The ventromedial region is believed to be involved in anticipation and emotion-based decision making processes, whereas damage in this area leads to risky choices (Davidson, 2004; Davidson & Irwin, 1999; Kringelbach, 2005). The ventromedial prefrontal cortex has also been linked to anticipatory consequences and the dorsal lateral prefrontal cortex with working memory (Davidson & Irwin, 1999). In addition, psychologists including Chayer & Freedman (2001) and Davidson and colleagues (1990) similarly identified the prefrontal cortex and the dorsal anterior cingulate, as well as the inferior parietal area, as significant in emotional response.

To help explain the working network of areas that include the amygdala and the prefrontal cortex in emotion perception, Phillips et al. (2003) suggests two separate systems. First, a ventral system for rapid automatic meaning evaluation and regulation of response, which consists of amygdala, insula, ventral striatum and other ventrally-located areas of the prefrontal cortex and anterior cingulate gyrus (Phillips et al., 2003). Second, a dorsal system is suggested consisting of the hippocampus and other dorsally located areas of the prefrontal cortex and anterior cingulate gyrus, which control cognitive affect or “effortful regulation of resulting affective states” (Phillips et al., 2003).

The complexity of the emotional brain is still beyond understanding and an established emotional processing system of the brain still does not exist. While the brain is central to the emotional relationship to food, deciphering the logic and motivation of food choice, preference,

and food-related behaviors based on the brain is not readily accomplished. However, awareness of the emotional brain is important as food science researchers pursue the role of emotions in the affective response to food.

4. FOOD SCIENCE CONNECTION

Health specialists, nutritionists, medical doctors, and food scientists alike are concerned with the health of individuals and populations and are looking for new ways to understand associations among food, emotions, and subsequent behaviors. Historically, most emotion and food studies related to health are concerned with disordered eaters and most food science research focuses on the role of arousal or mood valence from the consumption of food. Emotion-induced variation among individuals classified as “normal” and “restrained eaters” is well studied in the areas of food restraint, intake and motivation. These studies are important for the body of literature on food and emotions, and especially significant for health professionals to better understand eating behaviors in patients needing medical assistance or intervention. Understanding of emotional responses to food is also important for understanding eating behaviors and food choice in the broader population.

In the food industry, sensory and product development research is targeted at increasing their knowledge on consumer needs/wants to produce desired products. Understanding how to improve existing products and produce new successful products are essential for companies to grow and remain successful. Population categories such as children or elders, certain ethnicities or people with a certain lifestyle are large groups of interest to food companies. Populations with needs for medical attention, are not typically the aim of a company unless otherwise specialized in that area. Implicit tools of emotional measurement (neurological or physiological) have yet to be fully developed for these more general demographics in product development.

Transferring these technologies and methods from the medical profession, and adapting them to the needs of the food industry is essential to advancing sensory science research. Although implicit tools necessitate further research, explicit emotional response tools have been studied in recent years in these populations. However, explicit tools may not provide the complete answers the food industry is looking to for.

Most emotion research relating to food is based on verbal self-reporting methodologies. In such approaches, the individual is asked to characterize their emotional state related to the food stimuli. However, self-reports require that the individual is sensitive to and can describe their emotional state in relation to the food (stimulus). The challenge lies in reporting the food-related emotions in the context of the other influences (environment, personal/cultural meanings, etc). Self-reports may not be sufficient in understanding emotion due to cognitive biases from rational thinking, which only provides subjective feelings states (Jaeger, Cardello & Schutz 2013; Jiang et al., 2014, Liao et al., 2015). Jiang et al. (2014) explains that choice behaviors [to food] are irrational and that emotional questionnaires necessitate cognitive thinking and reason to determine a response. This provides an inconsistency between what we do in actuality and what we are asked in sensory testing. To further complicate the understanding of emotional responses, individual interpretation of questionnaires and their emotion terms can lead to inconsistent results. While the expansion of food and emotion research based on self-reporting methodologies is valuable, integration of self-reports with objective measures of emotion can provide additional perspective to understanding emotional response to foods.

The emergence of food studies using non-verbal, physiological responses such as heart rate (de Wijk et al., 2012), skin conductance (de Wijk et al., 2012; Liao et al., 2015), finger temperature (de Wijk et al., 2012) and respiration as well as automatic facial expressions

analyses (Danner et al., 2013; Danner et al., 2014; de Wijk et al., 2012; de Wijk et al., 2014; He, et al., 2016; Leitch et al., 2015; Walsh et al., 2015) are evidence of the evolution and the need for new and more objective tools of measuring emotions (Liao et al., 2015; Jiang et al., 2014; Koster & Mojet, 2015). Although physiological mechanisms are important to study, the literature on their use and relation to emotions is not as comprehensive as neurobiological (i.e., EEG, fMRI) studies. Autonomic nervous system measures including various cardiovascular, electrodermal (skin conductance) and respiratory measures have been shown to correlate with many emotions. Currently, individual physiological responses cannot readily identify emotions because their automatic nature is highly variable among individuals, rendering emotions difficult to differentiate (Ng et al., 2013; Koster & Mojet, 2015; Kreibig, 2010). A combination of implicit response measurements may, however, provide more specificity to the emotion response interpretation (Koster & Mojet, 2015). Interpretation of these methods in relation to understanding emotional response to foods is still evolving. Integration of neurobiological and physiological measures with self-reporting methods is needed.

5. CONCLUSION

Continued research on neurobiological responses and other physiological responses, in conjunction with self-reported questionnaires, is likely to provide the most complete picture of emotional response to foods. By thoughtfully integrating these techniques it is possible to infer if a food elicits: 1) an approach or withdrawal response by using EEG to measure one's motivated intentions using prefrontal cortex asymmetries; 2) uncover the food's effect on a consumer's valence and arousal activity with EEG and heart rate (or another measure of physiology) studies; and 3) understand expressed or communicative emotions through facial motor movements. By combining implicit tools with the more traditional affective measures of

eating behavior, acceptability, and/or intention to purchase may provide a more profound translation to consumer choice and behavior intentions. This integration will provide observations on many emotional influences that are often neglected when using only one method; providing greater depth to food and emotions research to advance the fields of product development and sensory science.

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CHAPTER 3: COMPARING QUALITY AND EMOTIONAL RESPONSES AS RELATED TO ACCEPTIBILITY OF LIGHT-INDUCED OXIDATION FLAVOR IN MILK¹

ABSTRACT

Off-flavors in fluid milk often result from light exposure during retail display if milk packaging does not provide light-blocking protection. There is no direct evidence that light-induced oxidation affects milk acceptability. In this 2-part study, effects of fluorescent light exposure (375 lux at the package) on fluid 2% milk packaged in HDPE without and with a (foil) light blocking overwrap for periods of 8, 72, and 168 hr (4°C) were determined. Study 1 evaluated oxidative stability of milk, as well as consumer acceptability (hedonic 9-pt scale) and explicit emotional response (check-all-that-apply terminology selection) at 8 and 168 hr (n=41). Oxidative stability was measured by riboflavin (Rb) and thiobarbituric reactive substances (TBARS) assays. Rb, a photo-initiator of the oxidation reaction, decreased significantly, with 71% loss by 168 hr. TBARS assays showed significant increases in oxidative by-products by 168 hr. Within 8 hr of light exposure, acceptability decreased significantly from 7.20 (“like moderately”) to 5.85 (below “like slightly”) and decreased further to 3.46 (between “dislike moderately” to “dislike slightly”) by 168 hr. Light-protected milk (control) maintained a score of 7.0 over 168 hr. Emotion term selection reflected acceptability response; the term disgust was used more frequently for both the 8 hr (17.1%) and 168 hrs (46.3%; $p < 0.05$) light-exposed milk

¹ Walsh, A.M, Duncan, S.E., Potts, H., & Gallagher, D. (2015). Characterization of implicit and explicit emotions as related to acceptability of light induced oxidation flavor in milk. *Food Research International; Food and Emotions*, 76, 293-300.

compared to both light-protected milks (2.4% 8 hr; 12.2% 168 hr). Light-protected milk had higher frequency of positive emotion term selection (content, calm, good, happy, and pleased) than did light-exposed milk (168 hr). In study 2, automated facial expression analysis was completed (n=12) at 72 hr light exposure. Automated facial expression analysis provided evidence for great variety of unique responses from individuals. Light-induced reactions in fluid milk affect emotional response and flavor acceptability of milk, which may be contributing to the reduction in fluid milk sales and decreased milk consumption.

KEYWORDS

Riboflavin, thiobarbituric reactive substances, sensory, acceptability, CATA, facial expression analysis, emotion

1. INTRODUCTION

Consumption of fluid milk and milk products is decreasing in all age groups. The most significant difference is among adolescents, where milk consumption has declined about 25% since 1977, putting this age group at increased risks of osteoporosis later in life. Adolescents who are consuming milk are drinking only half as much milk as 28 years earlier (Sebastian, Goldman, Enns & LaComb, 2010). Competition against other beverages in the market place may be one cause of declining milk consumption.

Flavor quality of fresh milk, which is affected by light exposure in retail dairy display cases, may also be a contributor to declining milk sales and consumption. Quality standards are primarily based on microbial assessment as an indication of shelf life (Chandan, Kilara, & Shah, 2008). Industry standards for milk quality, as well as retailer efforts for marketing milk using bright retail lighting, do not consider the rapid changes in fresh milk flavor that occur between display storage prior and consumer purchase.

In retail refrigerated dairy cases, fluorescent and/or LED lights are used to display milk products. It is well documented that light exposure causes oxidative chemical changes to milk proteins, fats and other nutrients, leading to off-flavors, as reviewed by Duncan & Webster (2010). These chemical changes are initiated when riboflavin (Rb) and other photosensitive molecules in milk are activated by light energy. Light energy is transferred from these photosensitive molecules to other molecular species in milk, with the subsequent production of volatile aldehydes and other flavor compounds. The increase in flavor-contributing volatiles overrides the bland, slightly sweet flavor of high quality milk (Alvarez, 2009). In addition, many vitamins can be degraded during light exposure, reducing nutritional value (Duncan & Webster,

2010; Duncan & Chang, 2012). Light protection of photosensitive molecules in milk is needed to protect milk flavor and nutrient quality.

Commonly used plastic milk packaging, such as natural (translucent) high density polyethylene (HDPE) and clear polyethylene terephthalate (PET), do not sufficiently protect milk from light-induced oxidation reactions during retail storage conditions (Johnson, Duncan, Bianchi, Chang, Eigel, & O'Keefe, 2014). Flavor changes due to light exposure occur rapidly and off-flavors can be detected within 54 min to 2 hr of light exposure by untrained panelists (Chapman, Whited & Boor, 2002). From the point of processing until retail purchase, milk may receive 7 or more days of light exposure (Senyk and Shipe, 1981). About 50% of milk packages remain in the retail lighted dairy case for 8 hr or more, providing ample time for flavor and nutrient degradation. The incentive for the dairy industry to identify optimized packaging options to protect fresh milk quality is related to improving milk sales, which corresponds to increasing consumer acceptability and motivation for consuming milk. However, there is limited evidence that describes the effect of retail dairy case lighting on consumer acceptability.

Consumer acceptability, traditionally measured using the hedonic scale, is not always successful at predicting consumption or product success (Schroder, 2003). Acceptability does not give adequate insight into how the consumer truly feels about a product (Köster, 2007). The 70-80% failure rate of new products on the market suggests that better techniques for evaluating product acceptability would be advantageous (Stanton, 2013). The addition of emotion assessment is an emerging area of research, as it provides information to better understand how to differentiate between similar consumer responses to a product (Cardello, Meiselman, Schutz, Craig, Given, Leshner & Eicher, 2012).

In psychology literature, six universal emotions are identified and classified as either “approach” (happy, surprise and anger) or “withdrawal” (fear, sadness and disgust) (Alves, Fukusima & Aznar-Casanova, 2008; Ekman, Friesen, O’Sullivan, Diacoyanni-Tarlatzis, Heider, Krause, LeCompte, Pitcairn, Ricci-Bitti, Scherer, Tomita & Tzavaras, 1987). In literature outside of the psychology domain, these emotions are often classified as positive (happy) and negative (anger, fear, sadness and disgust) (King & Meiselman, 2010); surprise can be either negative or positive (Alves et al., 2008). Even though this categorization is rudimentary, identifying evoked “approach” and “withdrawal” emotions may help predict product success.

To further increase market success, evaluating cognitive (explicit) and subconscious (implicit) expression of emotions for understanding product acceptability may have value (Cardello et al., 2012). Explicit, or conscious responses, to a product, such as hedonic scoring, are widely used (Peryam, 1957). An example of an explicit emotion-based tool used for evaluating potential new products is the check-all-that-apply (CATA) emotional terminology selection approach (King & Meiselman, 2010; King, Meiselman & Carr, 2010). Implicit emotions are more difficult to understand and measure but may also describe underlying emotional influences on product acceptability. Automated facial expression analysis (AFEA) technology monitors many points on the face to determine the expression of the 6 universal emotions (as well as a neutral state) using differences in facial movements and textures (Loijens & Krips, 2012). Movement of the eyes, eyebrows, lips, head orientation, gaze, nose and cheeks are monitored. Using software to integrate the movements into emotional categorization, identification of and intensity of each of the universal emotions is computed (Loijens & Krips, 2012; Noldus Information Technology, 2012). This technology potentially provides value for understanding unstated emotional response to a food or beverage product and reduces the

influence of thoughts and external factors on participant response. Only one study has applied AFEA analysis to assessing emotional response to fluid milk (Arnade, Duncan, Rudd, Dunsmore, & O’Keefe, 2013a). The combined understanding of both implicit and explicit emotions has potential for greatly enhancing traditional sensory methods for greater consumer insight and the possibility of improved market success.

Milk, having many nutritional benefits, is particularly important to consume within the young adult population when bone structure is in its final stages of being established (Heaney et al., 2000). It is thus important to understand flavor influence on acceptability and emotions of young adults to improve purchasing and consumption behaviors. The objective of this project was to evaluate the influence of light exposure on milk quality, acceptability and emotional responses in a young adult (college) population. We hypothesize that light exposure of milk for as little as 8 hr causes sufficient oxidation to reduce consumer acceptability and negatively affect emotional response, providing significant evidence for the need to improve milk packaging.

2. MATERIALS AND METHODS

2.1 Overview of Design

This project consisted of two studies. Study 1 focused on analytical measures of milk quality, acceptability and explicit emotions in response to milk stored for two lighting durations (8 hr and 168 hr; 4°C) compared to light-protected control conditions. Study 2 added implicit emotional responses relate to acceptability of light-protected and light-exposed fluid milk over 72 hr.

2.2 Experimental Storage Conditions

High temperature short time (HTST) pasteurized fluid milk (2% milk fat; 3.78L; natural (translucent) high density polyethylene (HDPE) packages; Study 1: n=12; Study 2: n=6) was obtained directly from the dairy manager at the local grocery store (Kroger, Blacksburg, VA) within an hour of product delivery to obtain the freshest, highest quality milk available and minimize potential for light exposure. Each package was immediately wrapped in aluminum foil to prevent incidental light exposure and transported on ice to the research laboratory (Food Science and Technology Department (FST), Virginia Tech, Blacksburg, VA). Milk was stored in a refrigerated walk-in cooler (4°C; Study 1: Tonka, Hopkins, MN; Study 2: Harris Environmental Systems, MA) equipped with fluorescent lights (Study 1 and 2: Sylvania Designer cool white 30W, F30T12/DCW/RS, Ontario, Canada). Two 2-bulb lighting units (4 ft length) were positioned horizontally (12.7 cm) above the milk packages from the shelf above to mimic environmental conditions in a retail dairy case. During storage, milk in HDPE packages was exposed to light (light-exposed (LE); no foil overwrap) or was light-protected (LP; control treatment) by retaining the foil overwrap. Lights over the packages remained on 24 hr/d and had a mean measured light intensity of 1,738 lux (model 407026, Heavy Duty Light Meter with PC Interface, ExTech Instruments, Nashua, NH). Products were protected from incidental lighting in the environment by creating a foil shield over the shelving unit. Light intensity (lux) received by each package was measured in between each bottle at the package shoulder (average lux = 375). Gallon packages were rotated daily to avoid differences due to variability in light intensity within the storage unit. In Study 1, milk (LE: n=6; LP: n=6) was stored for 8 hr or 168 hr, yielding 3 packages per treatment per lighting duration. In Study 2, six milk packages (LE: n=3; LP: n=3) were exposed to light for 72 hr.

2.3 Analytical Evaluation of Quality

2.3.1 Sampling and Conditions for Sample Storage

Samples for microbial analyses were collected under aseptic conditions for microbial analyses from each milk package for immediate analysis. Samples (30 mL per package) for milk composition analyses were transferred to sterile glass vials and refrigerated until delivered (within 5 hr) to the United Dairy Herd Information Association (United DHIA) extension laboratory on campus (Department of Dairy Science, Blacksburg, VA). Samples for assessing the light effects on oxidation (Rb, 12 mL per vial/treatment, multiple vials per treatment; thiobarbituric acid reactive substances (TBARS), 7 mL per vial/treatment, multiple vials per treatment) were collected and immediately frozen (-75°C) from each milk package until analytical analyses could be completed.

2.3.2 Microbial Quality

Aerobic plate counts were completed by standard methods for dairy products using petrifilm method (Laird, Gambrel-Lenarz, Scher, Graham & Reddy, 2004); samples were incubated at $37 \pm 1^\circ \text{C}$ for 48 hr. One aliquot per package was analyzed.

2.3.3 Milk Composition

Gross composition (protein, fat, lactose, solids-not-fat (SNF)), and somatic cells were analyzed by infrared (IR) methods (Foss instruments, Hillerød, Denmark) following standard protocols at the United DHIA Extension lab (study 1 only) (Arunvipas, VanLeeuwen, Dohoo & Keefe, 2003).

2.3.4 Thiobarbituric Acid Reactive Substances

Two frozen aliquots from each treatment were thawed and comingled. Samples were extracted and TBARS completed as described by Johnson et al. (2015). Analyses were completed in triplicate.

2.3.5 Riboflavin

Riboflavin analyses were completed under green light and using a spectrofluorometer (450-520 nm; model RF-1501, Shimadzu Scientific Instrument, Inc., Columbia, MD) based on AOAC method 970.65 (Bradley, 2000) as described by Webster, Duncan, Marcy & O'Keefe (2009). Three vials per treatment were thawed and comingled and analyses completed in triplicate.

2.4 Evaluation of Sensory Acceptability and Emotional Response

2.4.1 Human Subjects Approval

Institutional Review Board (Virginia Tech, Blacksburg) approval was obtained prior to human testing began. Informed consent was obtained from each participant; in Study 2, video recording permission was also obtained.

2.4.2 Sample Preparation

One hour prior to sensory evaluation, packages within a treatment were comingled into large foil-wrapped dispensers and portioned (30 mL) into two ounce cups with lids and labeled appropriately with their codes (Study 1: 3-digit codes). Alternatively, a color identifier was used in Study 2 to aid with video recording identification as color coding does not influence hedonic scores in beverages (Beckman, Chambers & Gnagi, 1984). Portioned samples were covered and refrigerated in the sensory laboratory to prevent incidental light effects and to standardize the temperature among samples before sensory testing began.

2.4.3 Study 1: Test Conditions and Population

Participants evaluated two coded samples (LE, LP), presented sequentially in balanced order, in each sensory test for each time duration (8 hr, 168 hr). Crackers and water were provided to cleanse the palate between samples. Unlimited time was provided for evaluation.

Initially, participants were seated in a classroom, equipped with white lighting and tables, and directed to face forward and to make no verbal expression. There was a range of 1 to 5 participants in the room at any given time. After informed consent was provided, participants evaluated the samples using a modified CATA emotional terminology selection questionnaire (EsSense™ ballot, King & Meiselman, 2010), modified as described by Arnade (2013). One term, glad, was removed from the original ballot and five terms, angry, content, fearful, sad and safe were added. The term glad was removed because of similar meaning to happy. To better compare results to prior emotional research, angry, sad and fearful were added so all universal emotions were represented (Ekman et al., 1987; Arnade et al., 2013). The term safe was added to reflect the sense of security provided by the product. For the 8 hr treatment assessment, a demographic (age, gender, education status, beverage intake) survey was completed.

Participants then moved into the sensory evaluation laboratory to be seated in the sensory booth. Booths were equipped with white lighting and touchscreen monitors for electronic data collection, utilizing the Sensory Information Management System (SIMS) data collection software (SIMS2000, version 6, Sensory Computer Systems, Berkeley Heights, NJ). Participants were presented with the same samples, using different 3-digit codes, in a sequential, balanced presentation, with the palate cleanser as previously described. Acceptability of each sample was rated, following instructions provided on the monitor, using a 9-point hedonic scale (1=dislike extremely; 9=like extremely). Participants were asked to return the following week to complete

the same procedure for the second light treatment milk (168hr light exposure) samples (demographic and beverage intake questionnaires were not collected a second time).

Forty-one college age participants (8 males, 33 females, age range of 18-25) completed all evaluations for both time durations. Twelve participants were excluded from the data analysis as they failed to return for the 168 hr analyses. Most participants were undergraduates in the Departments of Food Science and Technology or Dairy Science.

2.4.4 Study 2: Test Conditions and Population

In the second study, participants were mostly female, and within the age range of 18-25 years (n=27) and had not participated in study 1. Most students were enrolled in the undergraduate sensory evaluation course. Participants with full beards and/or mustaches were asked to refrain from participating and those with glasses were asked to remove them during sensory evaluation for better video capture. Instructions were provided to improve video capture as described by Arnade (2013), prior to beginning sample evaluation. Instructions emphasized body and face/head position and to look directly and continuously at the monitor so as to optimize video capture of the face. Hands were to be kept away from the face. Participants were instructed to sit forward and upright, looking at the monitor while taking in the complete sample from the cup, then quickly drop the hand and cup below the chin. If needed, an expectorant cup was provided, but participants were asked to refrain from expectorating if possible.

Two sensory booths were used for sample analyses and video capture in order to minimize variation related to lighting conditions. Overhead lighting within the sensory booth as well as white lighting in the room were used to illuminate the face. Cameras were placed above eye-level and were angled down at participant's face.

Participants were seated within the two light-controlled sensory booths at the same time and asked to sign a consent form and provide permission for video-recording. Cameras were turned on only after consent/permission was received. Participants then received a tray containing the first color-coded sample and a color-matched index card with the panelist number, as well as a paper ballot with the CATA and acceptability questionnaires as used in Study 1. Participants held the index card up to their face prior to sampling, as an indicator in the video recording of both the sample being tasted and participant number. Participants were then asked to complete the ballot. Next, a demographics questionnaire was provided. Then the second sample was presented and subsequent CATA and hedonic ballot completion followed.

2.4.5 Automated Facial Expression Analysis (Study 2 only)

Participants' facial reactions to the 72 hr LE and LP samples were recorded using Axis M1054 Network cameras (Axis Communications, Lund, Sweden). Noldus Media Recorder software saved the videos to an external hard drive through a computer equipped with media-recording software (Media Recorder, Noldus Information Technology, Wageningen, The Netherlands). Recorded videos were edited using software (Final Cut Pro X, Apple, California) to remove extraneous footage, retaining video immediately before and 5 sec after consumption. Several videos (n=15) were not usable because of failure to follow instructions, hand interference, or insufficient readable video footage during the targeted 5 sec interval post-consumption. Edited videos (n=12) were analyzed by automated facial expression analysis software (FaceReader 5.0, Noldus Information Technology, Wageningen, The Netherlands). Video analysis was completed using the continuous calibration setting at 30 frames per second.

2.5 Data and Statistics

2.5.1 Summary Statistics of Analytics

Means and standard errors of the concentration of Rb and TBARs were calculated. A one-way Student's T test (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC.) was used to compare LE and LP samples for the 8 hr and 168 hr treatments ($\alpha=0.05$).

2.5.2 Summary Statistics of Explicit Sensory Data

Normality of distribution for acceptability scores for all milk samples was calculated using the Shapiro-Wilk goodness-of-fit test (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC.). A comparison of means using a Tukey-Kramer test was completed to determine the significance ($\alpha= 0.05$) between acceptability scores among all milk samples within study 1. The distribution of hedonic responses was graphed (histograms). A one-way analysis of variance (ANOVA) was completed to determine confidence intervals and median hedonic scores between all pairs of LE and LP samples (Study 1).

CATA emotion terminology categorization for frequently selected emotion terms and acceptability segmentation (liked, disliked) was determined as described by Arnade et al. (2013b). Frequently selected emotional terms were defined as “20% selection for at least one milk treatment”. Hedonic scores were categorized into “liked” (score between 6 and 9) and “disliked” (score between 1 and 4) segments and related to CATA emotion terminology selection. Cochran's Q test was completed for each frequently selected term in Study 1 to determine differences by treatment (XLSTAT, 2015, Addisonsoft, New York, NY). Separate paired t-tests for hedonic scores and CATA emotion terminology were conducted for Study 2 results ($\alpha= 0.05$).

2.5.3 Summary Statistics of Implicit Sensory Data (Study 2 only).

Automated facial expression analysis data was exported as a text document, converted with an algorithm into numeric data, then all statistics were analyzed in R, version 3.1.1 (R Core Team, 2014). Means of intensity (0 = not expressed; 1= fully expressed) of each emotion (angry, happy, disgusted, sad, scared, surprised) and the neutral state for LE and LP treatments were calculated. Means were then transformed into pie charts for each participant to illustrate the variation in emotion responses.

3. RESULTS AND DISCUSSION

3.1 Milk Quality

Milk used for this study was of high microbial quality and met compositional standards. Light-protected milk retained Rb concentrations and maintained low TBARS values throughout the 168 hr lighted storage, indicating that any development of off flavors can be attributed to light exposure (Figure 1; Figure 2). LE milk Rb quality was affected ($p < .001$) at 168 hr. As reviewed in Duncan & Webster, 2010, light activation of Rb contributes to production of volatile oxidative end-products leading to off-flavors. Additionally, a TBARS value of 1.3mg/L or higher is associated with a noticeable sensory quality difference due to light exposure (Johnson et al., 2015). In LE milk, the mean TBARS value exceeded the noticeable value within 8 hr, indicating that changes in flavor may be observed. At intense levels, light-induced off-flavors and odors in milk are described as burnt feathers, burnt protein, scorched, cabbage and mushroom flavors with an aftertaste and may also be associated with wet cardboard, metallic, or tallowy characteristics (Alvarez, 2009). Such off-flavor notes quickly override the pleasant, bland and slightly sweet flavor of fresh milk, but can be tempered with packaging advances. Milk is most commonly packaged in unpigmented, translucent HDPE packages, which do not provide

adequate protection of milk quality during retail display. Light-protective packaging is needed to protect milk quality (Johnson et al., 2015; Duncan & Webster, 2010; Duncan & Hannah, 2012) over the first seven or more days of storage prior to consumer purchase.

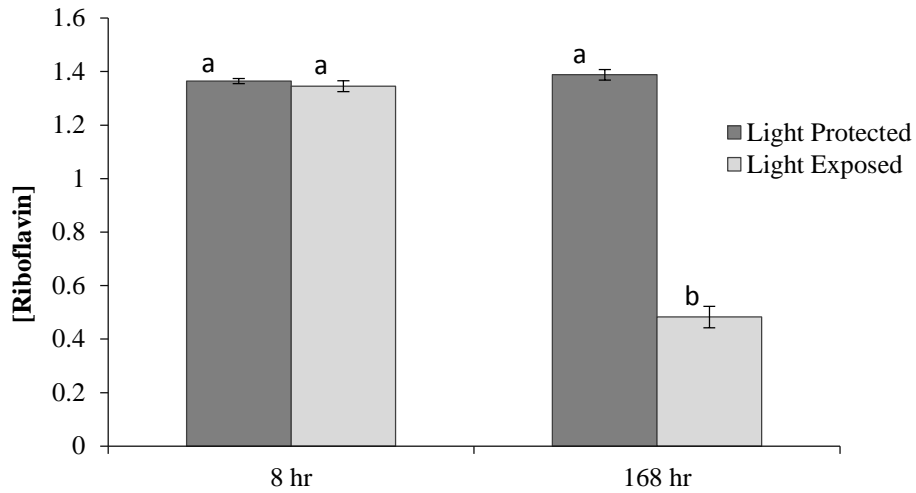


Figure 1: Concentration of riboflavin at 8 hr and 168 hr light exposure (4°C) in milk (2% milkfat; a,b Bars with different letters are significantly different ($p < 0.05$)).

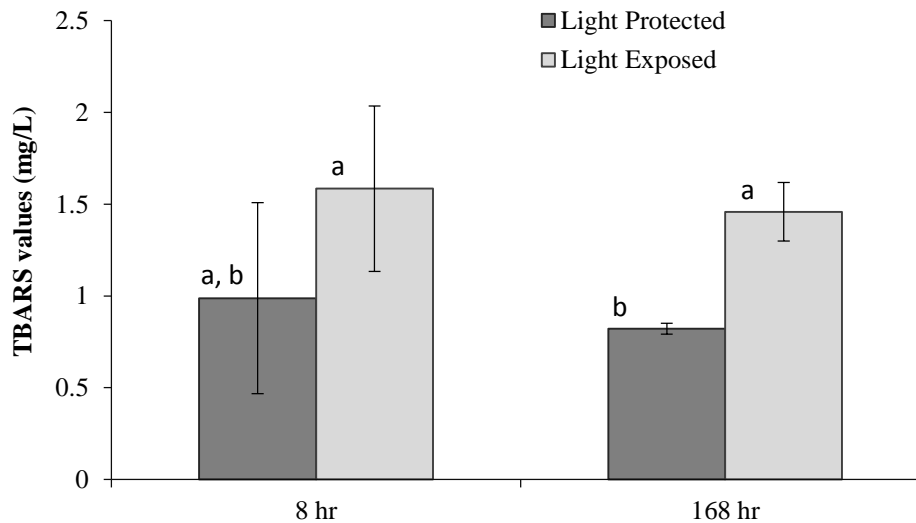


Figure 2: Thiobarbituric acid reactive substances values (TBARS; mg/mL) as indication of light-induced oxidation at 8 hr and 168 hr light exposure (4°C) in milk (2% milkfat; a,b Bars with different letters are significantly different ($p < 0.05$)).

3.2 Acceptability of LP and LE Milk

While the relationship of light exposure to differences in flavor quality is well recognized, its relationship to consumer acceptability of milk is not well documented. Heer et al, (1995) reported that college students rated LE milk (for less than 3 hr) as ‘neither like nor dislike’ compared to ‘like slightly’ for milk that was packaged in paperboard cartons (LP) but the difference was not significant ($p > .05$). This suggests light exposure’s relationship to a decreased milk acceptability with longer light exposure, but this relationship has not been fully established.

On a 9-point Hedonic scale, most foods receive scores between 5.5 and 7.5, where a score above a 7 is considered to be good, 7.5 is very good and 8 or above is above expectations (Peryam, 1957). In Study 1, LP milk was liked moderately (mean > 7.0) throughout the refrigerated storage, indicating that fresh fluid milk flavor is highly acceptable by young adults through the first 7 days of retail storage if adequately protected (Table 1). In contrast, within 8 hr of light exposure, fluid milk acceptability decreased ($p < .05$) to below ‘like slightly’; by 168 hr, mean acceptability was less than ‘dislike slightly’. Hedonic scores (Study 1) were not normally distributed, based on Shapiro Wilk goodness-of-fit ($p < 0.05$) (Figure 3). Mean scores in Study 2 were slightly lower than observed in Study 1 but reflected about the same spread and were also statistically different between LP and LE samples (72hr; Student’s T test). These slight differences may be attributed to many external factors, but a different pool of participants in Study 2 as well as biological variability (seasonal influence) for the milk supply are more likely (Alvarez, 2009). Industry testing using this scale has found that scores at 7.5 or higher would be predicted to do well on the market (Peryam, 1957). While scores below 5.5 would be rejected; which supports the idea that more ideally light protected milk will be successful, where in reality the milk found under retail lighting will not be accepted in its current packaging. As

liking to a product is correlated to likelihood-to-buy (Rosas-Nexticapa, Angulo & Mahony, 2005) providing additional concern for milk flavor quality. Thus with TBARS > 1.3 mg/L as well as significantly lower hedonic scores in the neutral to dislike range of the scale, we have confirmed that volatiles in LE milk were noticeable and affected product acceptability. Light protective packaging is important in maintaining high degree of milk acceptability over 7 days of light exposure and helps protect against a decrease in acceptability during retail storage refrigerated retail storage.

Table 1: Average hedonic scores¹ (\pm std. dev) light exposure in milk (2% milkfat).

Treatment	Mean	\pm SD	95% Confidence Interval		Median
			Lower	Upper	
<i>Study 1</i>					
	(n=41)				
Light Protected, 8 hr	7.20 ^a	\pm 1.05	6.86	7.53	7
Light Exposed, 8 hr	5.85 ^b	\pm 2.23	5.15	6.56	7
Light Protected, 168 hr	7.10 ^a	\pm 1.92	6.49	7.70	8
Light Exposed, 168 hr	3.46 ^c	\pm 1.93	2.86	4.07	3
<i>Study 2 (72 hours)</i>					
	(n=25)				
Light Protected	6.40 ^d	\pm 1.55	5.76	7.04	8
Light Exposed	5.16 ^e	\pm 2.11	4.29	6.03	3

^{a,b,c} (Study 1) and ^{d,e} (Study 2) Means within a study with different superscript letters are significantly different ($p < 0.05$).

¹ 1=dislike extremely; 9=like extremely

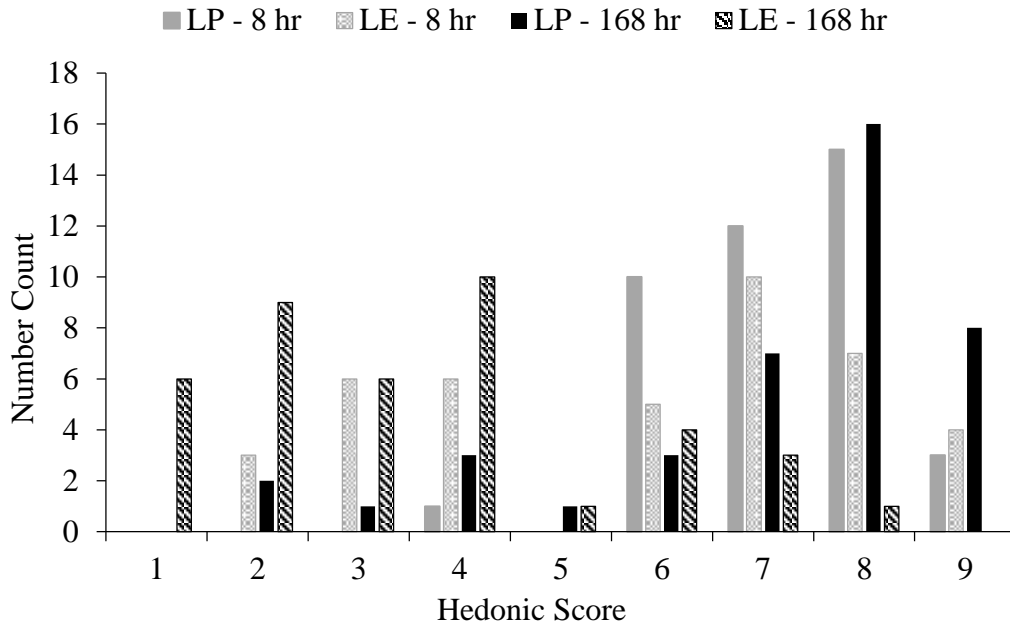


Figure 3: Histogram of acceptability scores (1=dislike extremely; 9=like extremely) for light-protected and light-exposed 2% bovine milk at 8 hr and 168 hr (4°C).

3.3 Explicit Emotions for LP and LE Milk

Assessing acceptability using hedonic scoring methods are not always a predictor of consumer behavior or product success (Schroder, 2003). Consequently, there has been increased venture to use emotional responses to distinguish between products with similar acceptability ratings (Cardello et al., 2012). Our investigations of explicit emotions, using the CATA emotional terminology check sheet, illustrated some concrete support for the changes in hedonic scores for LE milk compared to LP milk. Of the 43 terms on the scorecard, 16 were frequently selected for at least one of the milk products (Table 2; Figure 4). Calm, content, good and satisfied were frequently selected (greater than 20% of participants selected this term) for all milk treatments. All frequently selected terms for both 8 hr samples (n=14) and the LP 168 hr milk sample (n=13) were positive, suggesting that participants had positive emotional responses to these products (Table 2). Only 5 terms (content, calm, good, satisfied, disgust) met the criteria

for frequently selected LE milk at 168 hr. No terms were shared solely between both 8 hr and 168 hr LE samples, illustrating that there were important differences in how participants responded to LE milk at the two time durations. In a separate comparison, for 72 hr milk (Study 2), four terms (peaceful, pleased, warm, whole) did not appear and two terms (tame, quiet) were frequently selected.

Table 2: ‘Frequently’ selected emotional terms¹ for light-protected and light-exposed milk (2% milkfat) at 8 hr and 168 hr of refrigerated (4°C) storage at 375 lux².

	<i>Light Protected, 8 hr</i>	<i>Light Exposed, 8 hr</i>	<i>Light Protected, 168 hr</i>	<i>Light Exposed, 168 hr</i>
Content	0.829 ^a	0.585 ^{ab}	0.707 ^{ab}	0.439 ^b
Calm	0.683 ^a	0.585 ^{ab}	0.585 ^{ab}	0.317 ^b
Disgust	0.024 ^b	0.171 ^{ab}	0.122 ^b	0.463 ^a
Friendly	0.268	0.293	0.390	0.195
Good	0.659 ^a	0.537 ^{ab}	0.634 ^a	0.244 ^b
Good-Natured	0.293	0.341	0.293	0.146
Happy	0.366 ^{ab}	0.366 ^a	0.439 ^a	0.098 ^b
Interested	0.366 ^{ab}	0.439 ^a	0.195 ^{ab}	0.146 ^b
Peaceful	0.390	0.293	0.341	0.146
Pleased	0.537 ^a	0.366 ^{ab}	0.488 ^a	0.122 ^b
Pleasant	0.439	0.341	0.366	0.195
Quiet	0.171	0.268	0.220	0.195
Safe	0.366	0.171	0.244	0.098
Satisfied	0.512	0.390	0.537	0.268
Warm	0.390	0.220	0.293	0.171
Whole	0.317	0.220	0.122	0.171
Number of frequently selected terms	n=14	n=14	n=13	n=5

^{a,b} Frequency values within a row with different letters are different (p<0.05)

¹ Frequently selected is defined as frequency greater than 0.20.

² As measured at the shoulder of the bottle; lighting provided 1738 lux.

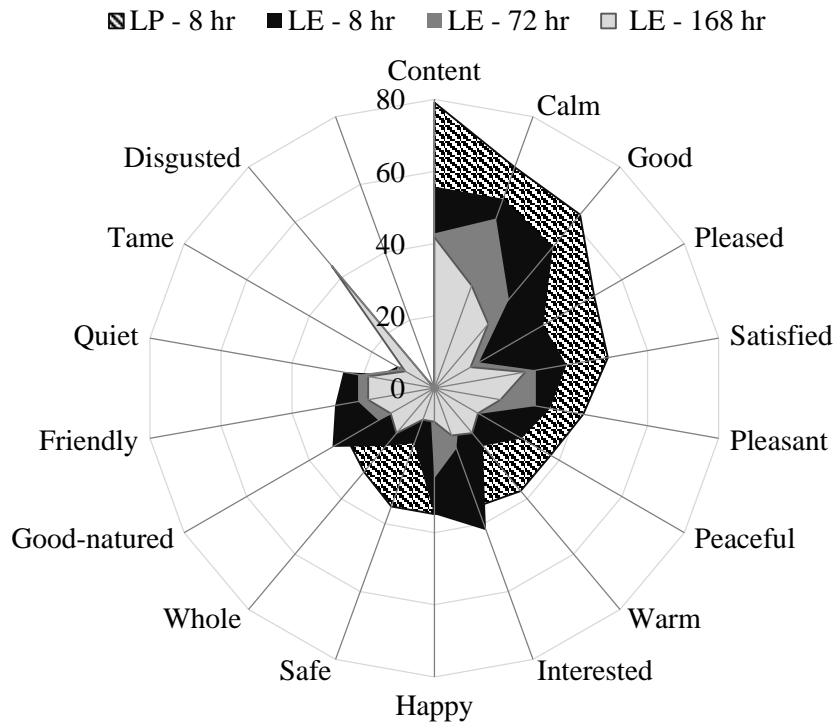


Figure 4: Percent frequency for frequently selected emotion terms for light-exposed and light-protected milk (2% milkfat) up to 168 hr of light exposure (4°C).

Based on a Cochran's Q test (study 1), seven emotion terms (content, calm, good, happy, interested, pleased, disgust) were significantly different ($p < 0.05$) among milk treatments, primarily for LE milk at 168 hr (Table 2). Positive terms were chosen with significantly less frequency and disgust was chosen significantly more frequently for LE milk at 168. LP milk, regardless of time duration, and LE milk at 8 hr were not different for these seven terms. Although there is evidence for the usefulness of this emotional tool, significant limitations are also evidence for continuing research to determine the most optimal and balanced term list, and developing project specific methodologies (Desmet & Schifferstein, 2008; King & Meiselman 2010; King, Meiselman & Carr, 2013; Cardello et al., 2012). Desmet & Schifferstein (2008), as well as King & Meiselman (2010), describe a variety of different factors that influence emotional responses associated with food. Unique sensory perceptions, the environment, personal or social

meanings, expectations and past experiences, physiological differences (energy levels or sickness), and consumer usage of the product, all affect emotional response (Desmet & Schifferstein, 2008; King & Meiselman 2010). Additionally, we believe our modified list begins to assuage participants' varying understanding of emotional terms (King & Meiselman, 2010), but the need of a balanced, yet complete list of terms is still a challenge (Desmet & Schifferstein, 2008; Cardello et. al, 2012).

As suggested by mean hedonic scores and histograms, most "liked" samples (scores between 6 to 9) were LP but not exclusively; the "disliked" category (scores from 1 to 4) consisted primarily of LE samples and a few LP samples at 168 hr. Therefore, most frequently selected emotion terms were the same as in the previous discussion. However, the term worried appeared for "disliked" products, which is different (Figure 5). The terms friendly, pleasant, polite and secure also begin to appear for "liked" samples, while good-natured is removed from the list for disliked milk. The EsSense™ ballot (King & Meiselman, 2010) with an intent to measure emotional responses to test food products by incorporating more positive terms (Cardello et al. 2012), as opposed the more negatively skewed clinical ballots it originated from (King & Meiselman, 2010). Food is supposed to be a generally positive for healthy individuals and products in the market place are developed to appeal to consumers and elicit pleasant experiences (Desmet & Schifferstein, 2008; Schifferstein, Fenko, Desmet, Labbe & Martin, 2013). As milk has been in retail for decades, positive emotional responses are expected, making this tool optimal for evaluation in this study. However, the concluded negative responses, expose the issue of potential word bias due to the low number of negative terms exacerbating their usage. Conversely, this evident negative response to a common product on the market,

emphasizes the need for a change in milk handling after leaving the processing plant and before consumer consumption.

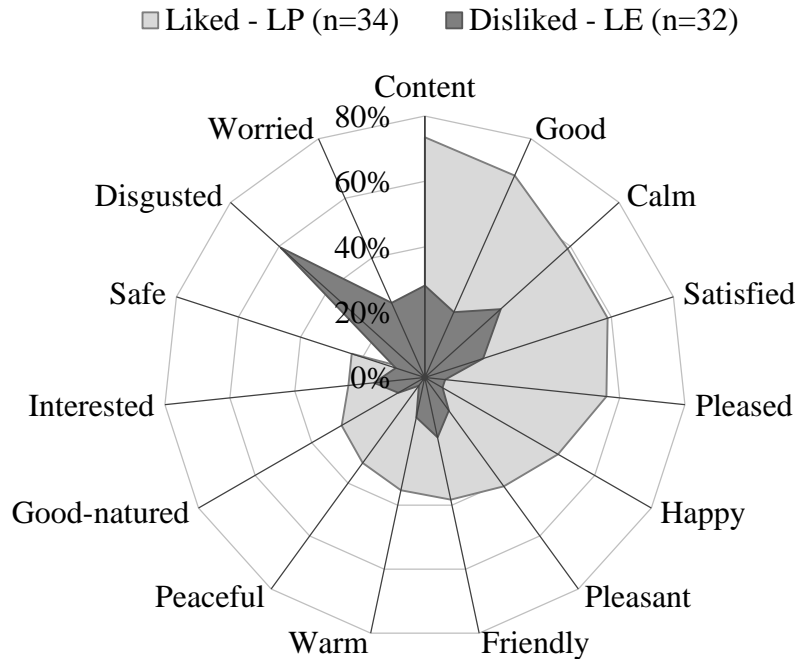


Figure 5: Percent frequency of emotion terms for “liked” and “disliked” milk (2% milkfat) at 168 hr of light exposure (4°C).

In a previous study, unflavored milk in translucent HDPE packages elicited frequent selection of the terms calm, good and disgusted (Arnade, et al., 2013b). Milk for both the Arnade et al (2013b) and our current study was processed by the same manufacturer and purchased from the same retail store; however, milk in the Arnade et al. (2013b) study was purchased from the retail display case with no specific knowledge of the duration of light exposure; the frequent selection of the term disgust suggests the milk may have been exposed to light for 8 hrs or more. We purchased milk that had just been received at the store, thus allowing us to protect milk quality for the light-protected treatments. Interestingly, the use of the negative emotion term “disgusted” is used in response to LE milk (17.1% and 46.3% relative frequency at

8 hr and 168 hr) compared to LP milk, with less than 3% selection frequency for LP milk at 8 hr and 12% at 168 hr.

The quality of milk after departing the processing plant is not monitored by the dairy industry unless complaints are received. The milk processor distributes milk that meets quality standards, as measured by microbial counts and other quality checks (Chandan et.al, 2008). However, as this study illustrates, fresh milk quality can be adversely affected by retail storage conditions that are selected to optimize product marketing. For consumers', at the buying stage, taste is an important aspect of a product; indicating consumers' expect a certain quality of flavor, even before consumption (Schifferstein et al., 2012). We believe that the discrepancy between industry's safety concern and consumer's flavor quality expectations is the cause for consumer distrust, leading to negative impression of milk products; further explaining the steady decrease of milk consumption. Rozin 2007, explains disgust creates repulsion and a nausea effect, discouraging consumption. The use of negative emotion terminology in this study, particularly disgust, suggests withdrawal from or rejection to the product (Rozin, 1996). Vidal, Barreiro, Gomez, Ares & Gimenez (2013) explain that expectations of a product are important for product success. Consumers have expectations of a product and if their expectations are met they will revisit (purchase, consume) that item again. Conversely, if the expectation is not met, the likelihood of one buying the product again is severely reduced (Vidal et. al, 2013). As we hypothesized, flavor changes from light exposure of "fresh" milk potentially caused negative consumer experiences with the product, reducing their confidence for a positive product experience and trust in fresh milk quality, leading to diminishing purchase behaviors.

3.4 Implicit Emotions Expressed through Automated Facial Expression Analysis (Study 2; 72 hr)

We investigated the potential of AFEA, as a measure of implicit emotions, for augmenting our understanding of the explicit emotional response methods. We visually displayed the automated facial expression analysis data by individual (Figure 6). The area of each emotion in each pie chart reflects the mean intensity value for each expression over 5 seconds post-consumption. We observed that some individuals had low to moderate levels of expressed universal emotions relative to the neutral state (neutral > 50%) whereas others expressed emotions at much higher levels. We subsequently categorized the individual participants, based on the estimated percent of neutral state in the LP samples, to search for relationships. We also compared the individual participant's hedonic scores to their facial expressions.

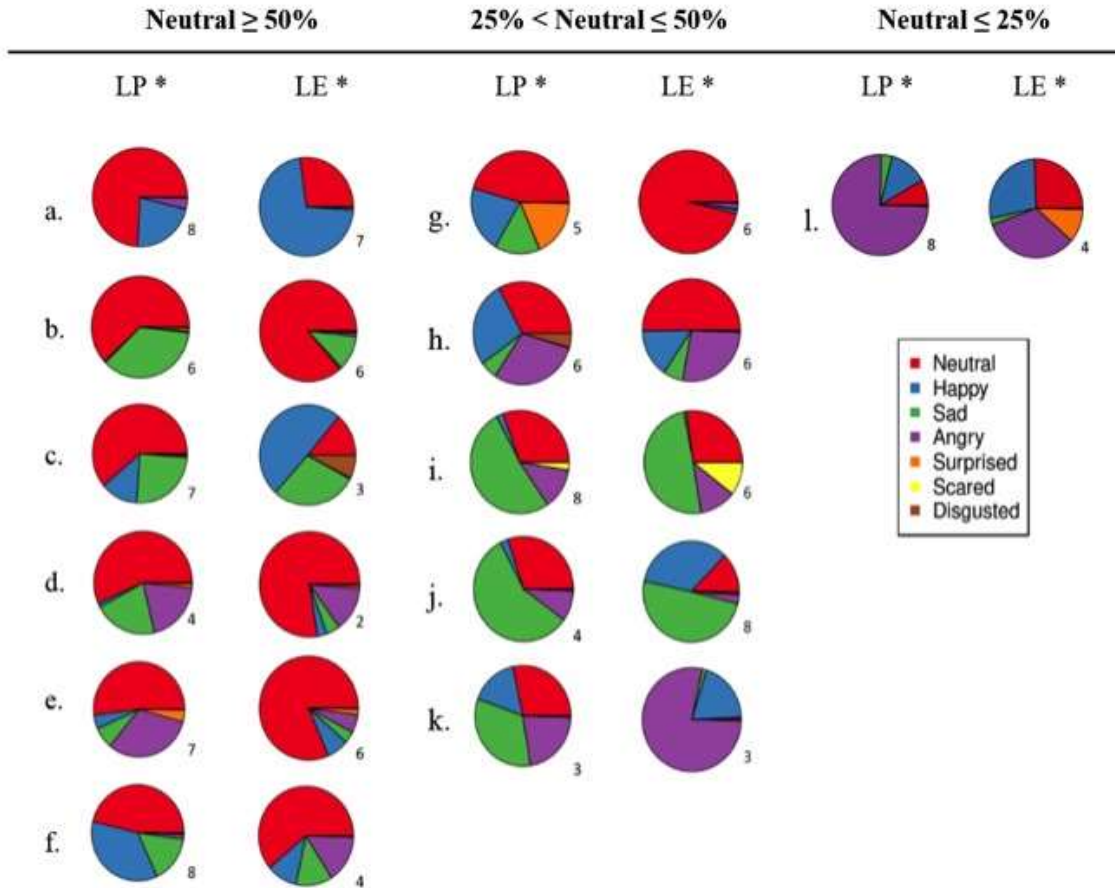


Figure 6: Automated facial expression analysis responses for light-exposed and light-protected milk (2% milkfat) at 72 hr (4°C).

Of those participants for whom we were able to capture facial expression, only 3 (panelists c, f, l) had acceptability scores for LP sample in the liked category and LE acceptability scores in the disliked portion of the scale. Five participants responded to both products with acceptability scores of 6 or higher and two participants responded to both products with scores of 4 or less (Figure 6); this sub-segment of our studied population had lower mean acceptability scores, 6.1 and 5.0 for LP and LE milk, respectively. This suggests that the participants who successfully completed the facial expression analysis were not representative of the larger population we studied.

It is interesting to note that facial expression identified as happy by the automated software was often found at higher intensity for LE samples than for LP samples, whereas sad was expressed more intensely in LP than in LE samples. We cannot determine if this is a real relationship to the LP and LE treatments. The variability in AFEA response among individuals in this study is high, reducing the potential of finding real effects using summary statistics and diminishing the potential of interpretation of individual response. Emotional expression (intensity) in response to food presented in a laboratory setting may be minimal. In sensory laboratory testing, we attempt to limit environmental and social influences to reduce the influence of these biases on the individual responses (Meilgaard, Civille & Carr, 2007) whereas in typical consumption situations, the environment and social setting influences our emotions (Desmet & Schifferstein, 2008; King & Meiselman 2010) and potentially influences the intensity of emotion expression. Many emotions were expressed at very low intensity, thus indicating that management of laboratory conditions for video capture and software settings for analysis is critical to finding and measuring subtle expressions (Arnade, 2013). In addition, the relationship of emotions, both in sequence and intensity, is an important consideration (Leitch, Duncan, O'Keefe, Rudd & Gallagher, 2015); qualitative and quantitative statistical approaches for understanding and modeling these relationships are being explored.

4. CONCLUSION

Industry standards of satisfactory quality of milk and what is acceptable to consumers do not align. Consumers like milk and express positive emotions when fresh milk is of high quality and protected from the detrimental effects of light. In contrast, fresh milk that is not protected from light effects has lower acceptability and increased expression of disgust; consumers withdraw from the product flavor and experience. Milk that is protected from light maintains

flavor, nutrients, a high level of acceptability, and provides a positive emotional experience. The incorporation of emotional measures with traditional acceptability helps convey the importance of milk packaging selection. Addressing an obvious disconnect between industry measures of milk quality and consumer preferences helps explain declining milk consumption patterns.

5. ACKNOWLEDGEMENTS

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CHAPTER 4: INTEGRATING IMPLICIT AND EXPLICIT EMOTIONAL ASSESSMENT OF FOOD SAFETY AND QUALITY CONCERNS

ABSTRACT

More accessible technologies and the inclusion of psychology literature are opening doors for more advanced research on food and emotions. Tools for automatic facial expression analysis (AFEA), frontal cortex (EEG) and cardiac electrical activity (ECG) may bring additional support to traditional sensory techniques for a better understanding of consumer response to food. To enhance the understanding of consumer emotional response to food, participants (age: 18-29 years; n=40, female=31) were presented with videos (average 40 sec) of food concerns (safety, hygiene and spoilage) and matched control (no food concern) videos, while implicit emotional responses (AFEA, EEG and ECG) and expressed explicit emotional responses were measured concurrently. AFEA analyzed facial expressions for the six basic emotions (0 = not expressed; 1= expressed); EEG measured frontal cortex asymmetry motivational behavior tendency (right hemisphere activation = withdrawal: scared, sad and disgust; left hemisphere activation = approach: happy, surprised and angry; 10/20 system, 32 channels, 512 Hz), while ECG measured heart rate (bpm) changes. Explicit emotions were assessed using a list of emotional terms (n=43) in a check-all-that-apply method and acceptability was rated on a 7-point hedonic scale (1=dislike extremely; 7=like extremely). Withdrawal emotions, disgust and worried, were significantly chosen more for evented videos, while approach emotions (content, good, good-natured, interested, pleasant, pleased and satisfied) were significant for all control videos ($p < 0.05$). Acceptability scores were significantly

lower ($p < 0.05$) for the evented meals. Significant differences in HR indicate emotional response. AFEA results for quality (spoilage, hygiene) concerns found greater variety of emotion expression compared to the safety concern, while frontal cortex asymmetries were inconsistent. More research is needed to validate the use of implicit measures (EEG, ECG and AFEA) in providing information for understanding differences in emotional response to food safety, hygiene and spoilage events. The evaluation of displeasing or unpleasant characteristics of food, through the integration of implicit and explicit responses will lead to a greater understanding of the consumer-food relationship.

KEYWORDS

Emotion, EEG, ECG, facial expression, food quality, food safety, meal

1. INTRODUCTION

In good product design, it is understood that limiting unwarranted negative emotional ‘side effects,’ experienced by the consumer, is just as important as understanding the positive responses (Desmet & Hekkert, 2009). In many areas of the food industry, food service and retail establishments, food companies and restaurants, this same concept is essential for success. Predominantly, the idea of establishing consumer confidence in quality and safety is important for brand loyalty, satisfactory customer service as well as for motivating customer return and purchasing behavior (Desmet & Hekkert, 2009; Lassoued & Hobbs, 2015). Recent interest in consumer experience has led to the understanding that emotions influence decision making and behaviors toward products and foods (Desmet & Hekkert, 2009; Gutjar, de Graaf, Kooijman, de Wijk, Nys, ter Horst & Jager, 2015). Kubberod, Ueland, Digstad, Risvik & Henjesand (2008), emphasize the reduction of undesirable emotions, such as with disgust, to ensure positive food-associated emotional experiences. Barriers to consumption and purchase can arise when associations are made between negative feelings and food, or even food advertisements (Kubberod et al., 2008; Shimp and Stuart, 2004). Most research on emotions in food science literature focuses on the discriminating capabilities of high quality foods using traditional written ballot methodologies (Jiang, King & Prinyawiwatkul, 2014; King, Meiselman & Carr, 2010). However, little attention has been given to understanding the attributes of food that may cause negative effects that influence consumer dissatisfaction, customer complaints, brand damage or even sales that are low or reduced (Kubberod et al., 2008; Shimp & Stuart, 2004; Wardy, Sae-Eaw, Sriwattana, No, & Prinyawiwatkul, 2015). Furthermore, recent interest in understanding true, sincere emotional responses, advancements in technology and the inclusion of psychology literature in food sensory research, are leading to use of nontraditional methods for measuring

emotions and motivational behavior tendencies; non-verbal responses, such as facial expressions and brain activity, as well as physiological measures of heart activity, skin conductance and skin temperature are beginning to be explored for food science questions. Observing emotional responses and motivation behaviors to displeasing food experiences may be valuable in understanding a more complete understanding of the relationship between the consumer and food.

Emotions research is a rapidly growing area of food science; how emotions affect responses to food acceptability, intent to purchase, food choice, attitudes and food behaviors are a few of the areas already studied (Jiang et al., 2014; Wardy et al., 2015). However, it is especially important for product developers to understand what specific attributes of their products have negative effects (Wardy et al., 2015). Studies on emotional response to food hazards and concerns are limited, but this is a great avenue for better understanding food characteristics that have the potential for both lowering consumer acceptability and increasing consumer association of negative emotions with food. Wardy et al. (2015) found that unwholesome eggs, defined as eggs lacking a safety attribute, received significantly lower liking scores as well as lower 'safe' emotion selection and higher 'worried' and 'disgusted' term selection. Similarly, Olsen, Rossvoll, Langsrud & Scholderer (2014) determined that 'fear' and 'disgust' responses safeguarded individuals against potential risky foods such as undercooked hamburgers. Of particular influence to food is the withdrawal emotion, disgust. The feeling of disgust originated from the rejection of a bad taste to protect against unsafe or contaminated food; it is defined as the "fear of (oral) incorporation of an offensive object..." (Rozin and Fallon, 1987; Rozin, 1996; Rozin, 1999; Rozin, 2007). Tastes recognized as disgust are associated with illness and the feeling of nausea, separating its meaning from dislike or distaste

to a food (Rozin, 1996). Thus obstacles to purchasing and/or consumption of a food can be created not only from one's preference, but when the feeling of disgust is associated with the product or brand (Kubberod et al., 2015). Specifically, foods from animal origins that have begun to decay or spoil or have been tainted by poor hygiene are all disgust elicitors and can be identified by the universal facial expressions of disgust (Rozin, 1996; Rozin and Fallon, 1987; Rozin 2007); an upper lip raise, a wrinkle of the nose and the bottom lip lowering in a gaping fashion bear importance for communicating a revulsion or withdrawal response to a food (Rozin, 1996; Rozin and Fallon, 1987; Rozin 2007; Zeinstra, Koelen, Colindres, Kok, & de Graaf, 2009). Wendin, Bredie & Tan (2014) further explain these communicative facial expressions are either a warning signal to others for a potential danger or designate a distaste response. Conversely, positive facial expressions serve as an affirmation for safe consumption or of sensory pleasure (Wendin et al., 2014). Facial expressions are not the only means of communication of disgust; Shimp & Stuart (2004), found food advertisements of undercooked meat products elicited strong written disgust responses. Phrases such as "gross," "obnoxious," "... not appealing," and "... looked nasty," were all used to describe meat in the meal presented in the advertisement, and emphasize the importance of understanding all attributes of a food to reduce unintentional negative affects that could influence purchasing intention (Shimp & Stuart, 2004). Written responses and facial expressions are just a couple of measurement tools that can signal important emotions or motivational behaviors; by studying other measures such as heart and brain activity to concerning attributes of food, important knowledge could be uncovered about consumers and their preferences.

Emotions and emotional responses are a complex network of responses that can be described as either explicit or implicit (Koster & Mojet, 2015). Emotions that result from

thought and reason and expressed in a verbal, written or physical (gestures or intentional facial expressions) manner are considered as explicit. On the other hand, implicit measures occur at the time of the event, thought or action and occur without conscious awareness (Koster & Mojet, 2015). Current food science research uses traditional explicit methodologies for emotional assessment. Because these explicit methods provide additional discriminating information for high quality products, the emotion lists are comprised mostly or entirely of positively valenced terms (Ng, Chaya & Hort, 2013). The current technique is not designed to capture unexpected negative attributes. Valuable information on the consumer-food interaction is lost by not evaluating potentially unpleasing attributes, motivations for withdrawing behaviors, or disgust feelings (Kubberod et al., 2008). This information is particularly significant for establishing quality and safety credence among consumers for establishing purchase behaviors and product preferences through brand confidence (Lassoued & Hobbs, 2015). Revision of explicit questionnaires to include a more balanced list of terms will decrease biases (Jiang et al., 2014). Adding more appropriate terminology for disagreeable food experiences is likely to provide more telling information; however the combination of explicit and implicit emotional responses and motivational behavior tendencies has even greater potential.

Explicit emotional response methods run the risk of being affected by cognitively determined factors (Jiang et al., 2014). Introducing implicit measures as additional supportive information to explicit measures provides a more holistic approach. The incorporation of implicit measures necessitates the understanding of the Approach/Withdrawal Motivational Behavior theory. This theory describes an approach behavior as a natural action propensity toward the stimuli, while a withdrawal behavior as a natural action propensity away from the stimuli (Davidson, & Irwin 1999; Davidson, Ekman, Saron, Senulis & Friesen, 1990; Scherer,

2000; Spielberg et al., 2008). Basic approach-related emotions include happy, surprise and anger; withdrawal emotions include disgust, scared and sad (Alves, Fukusima & Aznar-Casanova, 2008; Coan & Allen 2003; Ekman, Friesen, O'Sullivan, Diacoyanni-Tarlatzis, Heider, Krause, LeCompte, Pitcairn, Ricci-Bitti, Scherer, Tomita & Tzavaras, 1987). With the understanding of the Approach/Withdrawal Motivational Behavior theory, research tools for measuring automatic nervous system (ANS) responses, such as skin conductance, skin temperature, facial expressions and heart rate, as well as measures of brain activity, can be more effectively used in developing a deeper understanding of a true emotional response (Danner, Sidorkina, Joechl & Duerrschmid, 2013; Danner, Haindl, Joech & Duerrschmid, 2014; de Wijk, Kooijman, Verhoeven, Holthuysen & de Graaf, 2012; de Wijk, He, Mensink, Verhoeven, & de Graaf, 2014).

Automatic Facial Expression Analysis (AFEA) software tools analyze the face for muscle movements that can be translated into physically expressed emotions. AFEA software works by measuring movements of the lips, eyes, cheeks, mouth, etc. and translates the combinations of facial movements to classify and provide the intensity of the six basic emotions (Loijens & Krips, 2012; Noldus Information Technology, 2012). AFEA has been used in a few food science studies, providing inconclusive results on its application (Arnade, 2013; Danner et al., 2013; Danner et al., 2014; de Wijk et al., 2012; de Wijk et al., 2014; He, Boesveldt, de Graaf, de Wijk, 2014; He, Boesveldt, de Graaf, de Wijk, 2016; Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015; Walsh, Duncan, Potts, & Gallagher, 2015). Although current AFEA research has provided unclear results, no research has focused on understanding withdrawing aspects of food experiences; rather, the focus has been on specific products or product attributes to determine if liking differences could be detected. These studies do provide some valuable information.

Danner et al. (2014) and He et al. (2016) found neutral expressions to be more greatly associated with “liked” or “positively valanced” samples, while Leitch et al. (2015) found significant variation in responses between panelists tasting sweetened teas. These studies support other literature on facial expressions that conclude negative responses as more easily identifiable, and neutral and positive expressions as not being easily distinguishable (Zeinstra et al., 2009). Because of this limitation in positive valanced experiences, deepening the understanding of expressed emotional responses to negatively valanced or withdrawing food experiences, such as with quality and safety concerns, would be a logical next step. Further research on AFEA and other physiological responses will provide valuable knowledge to food companies, retailers, restaurants and food service establishments to reduce unwanted negative responses and lead to greater consumer satisfaction.

Physiological responses of the autonomic nervous system (ANS) are another emerging method for providing additional information about implicit emotion processing to food. In a review article by Kreibig (2010), cardiac electrical activity, measured as heart rate (HR), is described as being both emotion specific as well as being variable amongst individuals. Fernandez, Pascual, Soler, Elices, Portella, & Fernandez-Abascal, (2012) show ANS measurements can be used to measure arousal or used with dimensional (positive/negative or pleasant/unpleasant) differences, when the context is known (Kreibig, 2010). Emotion specificity literature present happiness, joy, disgust (contamination), surprise and others, to typically result in an increase in HR, while sadness (non-crying or acute), contempt (visual), anticipatory pleasure and others, to cause a decrease in HR (Kreibig, 2010). In food science literature, HR findings are inconsistent. The focus of this literature, is similar to AFEA studies in that they relate to acceptability for product development questions, and provide some

insightful information for the understanding of HR responses to displeasing food experiences. de Wijk et al. (2014) found that liking was positively related to higher HR when tasting breakfast drinks; however a study on food odors found that liked smells resulted in a decrease in HR (He et al., 2014). Conversely, another earlier study by de Wijk et al. (2012) found a trend for higher HR to disliked foods, whereas other researchers saw no significant correlation between ANS measures and liking (Danner et al., 2014). The inconsistent HR results in food science literature suggests further research is needed for understanding HR as an indicator of response to food (Danner et al., 2014). At this point, measures of electrocardiography (ECG) should be used as supportive information in combination with explicit emotional responses and other physiological measures of emotions as opposed to concrete evidence in emotion processing of food.

Another physiological method, electroencephalography (EEG), is a measure of electrical current of the brain from the surface of the scalp through systematically placed electrodes, for measuring activity of the brain's neurons (Garrett, 2015). The structural differences in the right and left hemispheres of the brain explain why the two hemispheres differ in function and response (Bisazza, Rogers & Vallortigara, 1998; Garrett, 2015). For emotion processing, the frontal cortex area is of particular focus (Coan & Allen, 2003; Coan & Allen, 2004; Davidson et al., 1990; Diaz & Bell, 2011). Activation of the right hemisphere of the frontal cortex, has been associated with withdrawal motivational tendencies, while the left hemisphere is associated with approach motivational tendencies (Alves et al., 2008; Coan & Allen, 2003; Coan & Allen, 2004; Davidson et al., 1990; Davidson, 2004; Davidson & Irwin, 1999; Diaz & Bell, 2011; Harmon-Jones, Gable, & Peterson, 2010). Psychology literature contains a variety of research measuring brain activity and emotional response to food. However, the attention of these studies are most often targeted towards food behavior and motivations in disordered eating or dieting populations,

as related to food temptations, craved foods, reward/punishment feelings and goal pursuits (Berkman & Lieberman, 2009; Giuliani, Mann, Tomiyama & Berkman, 2014; Siep, Roefs, Roebroek, Havermans, Bonte, & Jansen, 2012; Silva, Pizzagalli, Larson, Jackson, & Davidson, 2002). With the expectation of one study by Silva et al. (2002), who studied normal and restrained eating populations' responses to food, measuring approach/withdrawal tendencies using frontal asymmetries from EEG data in response to food is not well studied. No studies have been completed using EEG to measure emotional asymmetry responses in a general normal eating population as a tool for measuring aversive attributes to food for a greater understanding of emotional and motivational responses in food experiences. Because brain activity is part of the larger complexity of the emotional and motivational behavior response systems; its incorporation with other implicit and explicit emotional responses will provide a more complete and dynamic image of the relationship between emotion and food.

Desmet & Hekkert (2009) emphasize the importance of anticipating potential unwanted emotional responses by exploring both the positive and the negative sides of an user's probable emotional response. In order to better understand the consumer-food relationship, this study compared responses to positive and negatively valenced food experiences, using multiple implicit and explicit measures of emotion and behavior motivations. Purposely withdrawal-eliciting stimuli of food containing off-putting quality (spoilage and hygiene) and safety characteristics were used as commonly encountered food concerning attributes. By combining AFEA software with brain and heart rate activity, as well as cognitive emotion questionnaires, the goal of this study was to develop a comprehensive approach to measuring multiple types of responses for a more complete observation of emotional and motivational behaviors to foods and food concerns.

In the assessment of emotional and motivational behavior measures of food concerns, we hypothesize:

A. Explicit measures:

1. Hedonic ratings for food concerning stimuli (evented) will be lower than the (matched) control.
2. Withdrawal (negatively valanced) emotions will be more prevalent for the evented stimuli and approach (positively valanced) emotions will be more prevalent for control stimuli.

B. Implicit measures:

1. AFEA will show greater withdrawal emotional expressions for the evented stimuli following the event, compared to a neutral/positive emotional expression for the control, post-event occurrence.
2. Pre-event AFEA for both the evented and control stimuli will be neutral (or positive).
3. ECG analysis will support AFEA and show differences in HR (bpm) to illustrate emotion specificity (anger, disgust, scared, happy and surprise - increase HR; sad - decrease HR). No difference in HR will be observed prior to event occurrence.
4. EEG analysis will determine an approach or withdrawal motivational behavior tendency through frontal cortex asymmetries; evented stimuli will have a greater withdrawal response (right hemisphere activation), and control stimuli will have a greater approach response (left hemisphere activation). No

difference in frontal asymmetry scores will be observed prior to event occurrence between control and evented stimuli.

2. MATERIALS AND METHODS

2.1 Participants


Institutional Review Board (Blacksburg, Virginia) approval was obtained prior to human testing began (IRB *Approval #*: 14-020). The Psychology department's SONA Experimental Management System at Virginia Tech was used to recruit students who were seeking extra credit. Informed consent was obtained for the forty students who participated (18-29 years; female=31). Exclusion criteria included excessive facial hair, eyeglasses, contact lenses, and left handedness. The former two were exclusion criteria because of potential interference with AFEA. The latter two were exclusion criteria specific to the EEG recordings. Contact lens wearers tend to have a higher blink rate, which interferes with the amount of usable EEG data. Right-handed participants are typical for EEG studies because cortical hemispheric specialization is different for left-handed individuals. Lastly in order to help reduce learned biases, Food Science and Technology, Human Nutrition Foods and Exercise, and other related majors were excluded from participation.

2.2 Video Stimuli: Food Hygiene, Safety, and Spoilage

Eight different color videos averaging 40 seconds in length were recorded using a Sony PMW-EX1R high definition video camera (Sony Corporation, MinatoFpa, Tokyo). No sound was recorded. Three breakfast meal videos containing emotion eliciting events ("evented" with food hygiene, safety, and spoilage concerns) were matched with their nearly identical control (no concern) videos making three sets of two videos. Videos were chosen as stimuli in order to

reproduce a dynamic situation, while providing standardization across participants and the ability for replication of results (Fernandez et al., 2012). Real food was not used in order to control for movements associated with consumption, as well as control for other sensory characteristics (smell) that could influence results if not uniform across all participants. The category of breakfast meals was chosen for the variety of meal types that offered apparent food concerns, while providing some cohesion to the types of food presented. Two additional unmatched video meals (without a food concern) were also developed in order to distract the participant from learning the matched pattern of videos. A neutral white wall served as the back drop, while a maroon table cloth, white or clear dishes and basic silver utensils were used as a common setting for all videos. Each video began with an empty plate/bowl and/or utensil in place. Hands for preparing the meal were included as minimally as possible. Once the meal was prepared and to simulate consumption, the food was carried (bite-size) to the front of the screen toward the participant. The camera was placed at a distance with the angle positioned as if the viewer was seated at the table. An additional non-food (beach scene) video was used to induce a calming effect in an effort to return the participant’s emotional state back to baseline between food videos. A short description of the videos follows (Table 1).

Table 1: Image representation of control breakfast meal and distractor videos, and a description of the corresponding “evented” videos presented.

Stimuli Type	Control: Example Image	Evented Description
Emotional Evaluation Stimuli	<p>a. Milk and cereal</p> 	<p>Food spoilage quality concern: Poor product quality from bacterial fermentation; curdled milk chunks pour out of milk package onto the cereal.</p>

b. Pancakes and fruit



Food hygiene quality concern:

Poor product quality from improper food handler hygiene; a hand pulls a contaminating hair out of the syrup in a stack of pancakes and fruit after the pancake bite is picked up by the fork.

c. Sausage sandwich



Food safety concern:

Improper preparation for food safety; the red color of raw meat is visible when the cut sandwich is turned toward the viewer.

d. Yogurt and fruit parfait



No concerning event

e. Biscuits and gravy



No concerning event

Distractor
Stimuli

f. Beach scene



No concerning event

Palm tree on a beach with waves ebbing.

2.3 Emotional Measures

Two different emotional response types were recorded: implicit and explicit. Implicit responses, for this study, are defined as responses that are not verbalized or written by the participant. Brain activity and heart rate are considered implicit because they are not cognitively determined; they are physiological reactions. Facial expressions, although they can be cognitively controlled, have been grouped into the implicit results because facial responses are not a written or verbal response. Explicit responses are defined as written (or verbal) responses that have been subject to thought and/or reason and can be recorded through questionnaires.

2.3.1 Implicit Measures: EEG, ECG and AFEE

Brain activity was measured using electroencephalography (EEG). Collection was completed continuously throughout the research visit using Snapshot-SnapStream (HEM Data Corp.; Southfield, MI) and Instrumentation Bioamps (San Diego, CA) systems. Electrical response was recorded at 512 Hz. The high pass filter was 0.1 Hz and the low pass filter 100 Hz with a gain of 5,000 Hz. The location of the electrodes followed a 10/20 system and 32 EEG channels were collected, using a midline reference (Cz) and a scalp ground reference anterior to the Fz electrode. Omni-Prep abrasive gel was first applied to the scalp at each electrode with a blunt syringe for preparation of the scalp. Then a conductive gel, Electro-Gel, was applied. Electrode impedances were under 5K ohms to ensure a high quality recording. An acquisition computer displayed and stored raw data for future analysis. The alpha bandwidth was used to detect brain activity at a frequency of 8-to-13 Hz (Ahern & Schwartz 1985; Coan & Allen, 2004).

Heart rate activity was measured using electrocardiography (ECG). By placing two disposable electrodes on the participant, one on the lower left rib and the other on the right collar

bone, cardiac electrical impulses were measured. The ground electrode was anterior to Fz on the scalp. To amplify the electrical activity, the SA Instrumentation Bioamp was used with a bandpass filter set at 0.01 - 1000 Hz. The same acquisition computer that displayed the EEG, also displayed the ECG data. The heart rate signal was recorded at 512 Hz. The Snapshot-Snapstream (HEM Data Corp., Southfield, MI) was used to record and store the raw data. Cardiac electrical activity was recorded throughout the testing.

Participants were also video recorded after receiving their consent and EEG/ECG set up was complete. A discrete video camera (Panasonic North America, Newark, NJ) was located above the TV monitor used for viewing the breakfast meal videos. The zoom and toggle features allowed the camera to be adjusted squarely and tightly on each participant's face. Video recordings were taken to be later evaluated with AFEA software (FaceReader 6.0, Noldus Information Technology, Wageningen, The Netherlands).

2.3.2 Explicit Measures

Three different questionnaires were used to collect explicit responses to the breakfast meal videos. Acceptability was rated on a 7-point hedonic scale scorecard (1= "dislike extremely," 4 = "neither like nor dislike," 7= "like extremely"). Intensity for each of the six basic emotions (happy, sad, surprised, angry, disgusted and fearful), was also rated on a 7-point intensity scale. A score of 1 was defined as the emotion was "not at all," felt, a 4 was "somewhat" felt and score of 7 was "very much" felt. A Check-All-That-Apply (CATA) emotional terminology selection questionnaire (EsSenseTM Profile; King & Meiselman, 2010), was modified to a list of 42 terms, as described by Arnade et al. (2013). Three additional emotion terms (angry, fearful and sad) were added to compare this explicit response to AFEA responses as well as include all six basic emotions. 'Safe' was also added because the study was

designed to evaluate food concerns that may affect one's sense of security and acceptability of the meal presented (Arnade et al., 2013; Olsen et al., 2014). Additionally, 'glad' was removed from the list due to its similarity in meaning to happy (Arnade et al., 2013; Ekman et al., 1987). These three affective questionnaires were completed after watching each food video. Following all stimuli, an additional questionnaire was given to assess food preferences about the specific types of breakfast meals presented.

2.4 Overview of Design

The goal of this project was to determine if implicit responses (EEG, ECG, AFEA) can be used to complement and add additional interpretation for explicit emotional responses as measures for understanding emotion, motivational behaviors and food. Through comparisons of different types of responses to videos of food concerns (food spoilage, safety and hygiene) and their matched control videos, approach/withdraw motivations and associated emotional responses have been studied. This work adds to the understanding of consumer response to food through novel and non-traditional methods.

2.4.1 Test Conditions

Upon scheduling a two-hour appointment and obtaining informed consent, the EEG and ECG application began, taking about 30 mins for each participant. The two ECG electrodes leads were placed first, followed by the EEG cap. Capping and machine calibration was accomplished by the trained lab technician. During this preparation, the participants were instructed to fill out a demographics questionnaire as well as to familiarize themselves with the three explicit emotional response questionnaires. They were also directed to sit facing the video screen and minimize movements to ensure quality video, ECG and EEG recordings. Once setup was complete, all recordings (EEG, ECG and video) began. A technician controlled the

equipment from the adjacent room, as well as marked previously determined “emotion eliciting events” (safety, hygiene and spoilage concerns) in each “evented” video and corresponding “non-emotion eliciting events,” in the “control” videos for reference during the analysis phase. Each participant’s session began with baseline EEG/ECG recordings; participants were asked to sit quietly for two minutes with their eyes open and two minutes with eyes closed (Coan & Allen, 2003). A moderator quietly sat at the back of the room and controlled the video presentation. The moderator allowed the participant to fill out the scorecards at their own pace following each of the nine videos. To minimize repulsion to the food from the food concern presented, the control video always preceded the evented video. The beach scene video was shown directly before each separate video in order to reduce carry over of emotions and to help minimize potential anticipatory effects. The unmatched distractor videos were inserted between matched video sets. An example schematic of a set of videos is presented below (Figure 1). Additionally, due to researcher perception that the sausage sandwich video was the least obvious issue in internal beta testing, it was always presented last. The other videos were presented in a balanced manner. Following completion of all videos and emotion scorecards, the final questionnaire on food preference was given and each participant was aided with the removal of the EEG cap and ECG electrodes.

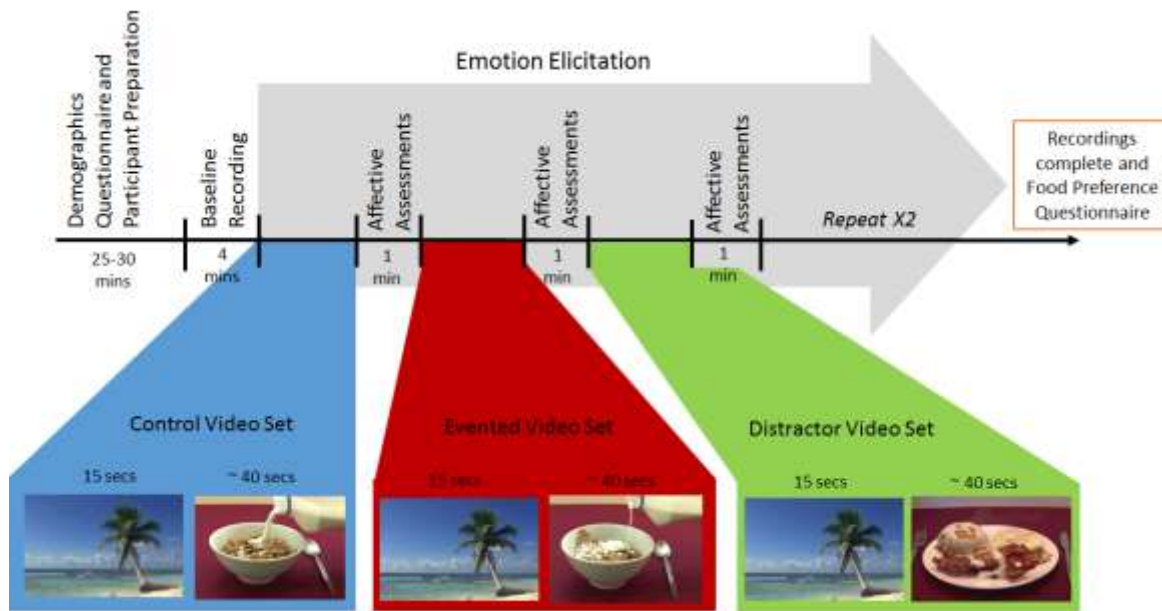


Figure 1: Single scheme of video presentation sequence.

2.5 Data Analysis/ Statistical Technique

2.5.1 Data Analysis for Implicit Responses: EEG, ECG and AFEA

ECG data was analyzed using IBI Analysis System software (James Long Company, Caroga Lake, NY). First, some areas of the raw data were removed, artifact-scored epochs. Once edited, artifact-free R waves were converted into interbeat intervals (IBIs) and further converted into equal 125 ms time intervals and beats per minute (bpm) was calculated. Event times manually marked during each session served as a point to split each video into two segments: “pre-event” and “post-event”. Because emotions are believed to last anywhere between 0.5 - 4 seconds (de Wijk et al., 2014; Fox, Kirwan & Reeb-Sutherland, 2012; Leitch et al., 2015; Scherer, 2008), we chose five seconds prior to the event (safety, hygiene and spoilage) occurrence and five seconds following in order to capture all emotion around the event. Independence, normality and equal variance were validated for ECG data. Pairing was completed within participant. The mean (M) heart rate (HR; bpm; n=40) and standard deviations

(SD) for the pre- and post- event five second segments were found for each participant (n=40; Excel 2013, Microsoft Corporation, Inc., Redmond, WA). Then paired Student's t-tests ($\alpha=0.05$) were calculated for both the pre- and post- event time segments; comparisons were completed between the control and evented videos.

Collected brain activity data was analyzed using EEG Analysis Software (James Long Company; Caroga Lake, NY) to manually remove individual participant's artifacts (eye blinks and gross motor movements). The EEG data were analyzed with a discrete Fourier transform (DFT) with a 50% overlap and a Hanning window of 1-s width. The data was transformed with a natural log to normalize the distribution for data analysis, as per standard EEG procedures. For the emotion processing analysis of the brain activity, frontal cortex asymmetry scores were found. The mean value for each electrode was found for the same pre- and post- event five second segments as the HR analyses for each participant. Validation of independence, normality and equal variance were tested. Pairing was completed within participant (Microsoft Corporation, Inc., Redmond, WA). To find individual frontal cortex asymmetry score, the value of an electrode measuring the left hemisphere (F3, F7 or Fp1 electrodes) was subtracted from the mean value of an electrode measuring the right hemisphere (F4, F8 or Fp2 electrodes) for the same five second duration (right - left = frontal asymmetry; Coan & Allen, 2004). Paired Student's t-tests ($\alpha=0.05$) of the average asymmetry difference for both pre- and post- event time segments were compared between the control and evented videos. When an electrode failed to record activity, the corresponding electrode pair for that participant was removed from analysis.

Prior to AFEA, video recordings were edited (Final Cut Pro X, Apple, California) to remove extraneous footage (n=40). Edited videos were analyzed using the individual calibration setting within the AFEA software (FaceReader 6.0, Noldus Information Technology,

Wageningen, The Netherlands), at approximately 30 frames per second. Footage of each participant during the baseline EEG recordings (eyes open) were used to create individual calibrations (two seconds); no stimuli was present and the participants were in a relaxed state (Danner et al., 2013; Danner et al., 2014). Events were manually marked within the software program and automatically analyzed facial recognition data was exported as text files for further analysis. Text files contained means of intensity (0 = not expressed; 1= expressed) of the six basic emotions (anger, happy, disgusted, sad, scared and surprised) for each videos presentation. Two separate analyses were performed, 1) mean emotion expression intensity (5 sec) comparison between and within emotion using a two-way analysis of variance (ANOVA) and Tukey's HSD test for significance (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC), and 2) time series analysis for significant differences in occurrence of emotion expression over time (R, version 3.1.1; R Core Team, 2013). The second method performed sequential paired Wilcoxon Test between breakfast meal and the control stimuli and were transformed into time series graphs for 20 seconds ($\alpha = 0.05$). Previous studies evaluated responses post five seconds of event occurrence (Leitch, et al., 2015); however de Wijk, et al. (2014) found different emotions initiate at different times and have varying durations. Due to our stimuli being a video, the duration of ten seconds after the emotional event was chosen to provide sufficient time for emotional development on the face. Lastly, dot diagrams, included in the time series analysis, show significant differences in expressed emotions through paired sequential Wilcoxon signed-rank tests (non-normal data; Shapiro Wilks test) over equivalent times between the control and breakfast meal stimuli ($\alpha = 0.05$; R, version 3.1.1; R Core Team, 2013).

2.5.2 Data Analysis for Explicit Responses: Acceptability, Emotion Term Selection and Food Preference Questionnaires

Explicit responses included acceptability scores, CATA emotional terminology selection (EsSense™ Profile; King & Meiselman, 2010) and the basic emotion intensity rating questionnaire. Demographic and food preference questionnaires were also collected and were tabulated in an electronic spreadsheet (Excel 2013, Microsoft Corporation, Inc., Redmond, WA).

For each stimuli, normality of acceptability scores was determined using the Shapiro-Wilk Goodness-of-Fit test (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC). A comparison of mean hedonic scores a using Tukey-Kramer test (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC) determined the significance ($\alpha = 0.05$) between control and evented videos. The distribution of hedonic responses was graphed (Figure 2). A one-way analysis of variance (ANOVA) test (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC) was completed to determine confidence intervals and median hedonic scores for all pairs ($\alpha = 0.05$; Table 2).

CATA emotion terminology categorization was based on frequency of selection of emotion terms. Terms that failed to be chosen greater than or equal to 20% for at least one breakfast meal were removed from further analysis (Arnade et al., 2013; King & Meiselman, 2010). Spider graphs present the percent frequency of choice for these frequently selected emotional terms (Figure 3). Multiple Cochran's Q tests were completed for frequently selected terms to determine their significance across all videos (XLSTAT, 2015, Addisonsoft, New York, NY).

The six basic emotional intensity rating results were tabulated to find the mean scores of the six emotions (Excel 2013, Microsoft Corporation, Inc., Redmond, WA). Mean intensity scores are represented by histograms (Figure 4). Two graphs were used to illustrate felt intensities of the emotions. To create uniformity within reporting of implicit and explicit measures, the six terms were segmented based off of emotion terminology associated with physiological and neurobiological motivational behavior responses, instead of by a semantic rationale. The top graph illustrates the intensity felt of the approach (angry, happy and surprised) emotions and the bottom graph illustrates felt intensities of the withdrawal (disgust, sad and scared) emotions. For analysis, one-way analysis of variance (ANOVA) tests with emotion across all events was completed; Tukey-Kramer HSD Tests were used to compare all possible pairs for comparison (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC).

3. RESULTS

3.1 Explicit Response Results

The control videos always received a greater mean acceptability than the evented videos ($\alpha = 0.05$; Figure 2). The control pancake and fruit breakfast meal was “liked moderately” and received the highest average score ($p < 0.05$; 5.8 ± 1.34). The evented pancake and fruit breakfast meal (hygiene) video was “slightly disliked” and received a significantly lower score ($p < 0.05$; 3.4 ± 1.72 ; Table 2). The control cereal and milk breakfast meal was “like[d] slightly” and the evented stimuli (spoilage) was “disliked moderately,” receiving significantly different mean scores ($p < 0.05$; 4.7 ± 1.24 and 2.0 ± 1.15 respectively). Lastly, the sausage sandwich breakfast meal received the lowest acceptability overall for the different breakfast videos. The control was “neither liked nor disliked,” while the evented (safety) video was “disliked

extremely.” Like the other sets, the control sausage sandwich video received a significantly higher score than the evented video ($p < 0.05$; 3.8 ± 1.73 ; 1.8 ± 1.30).

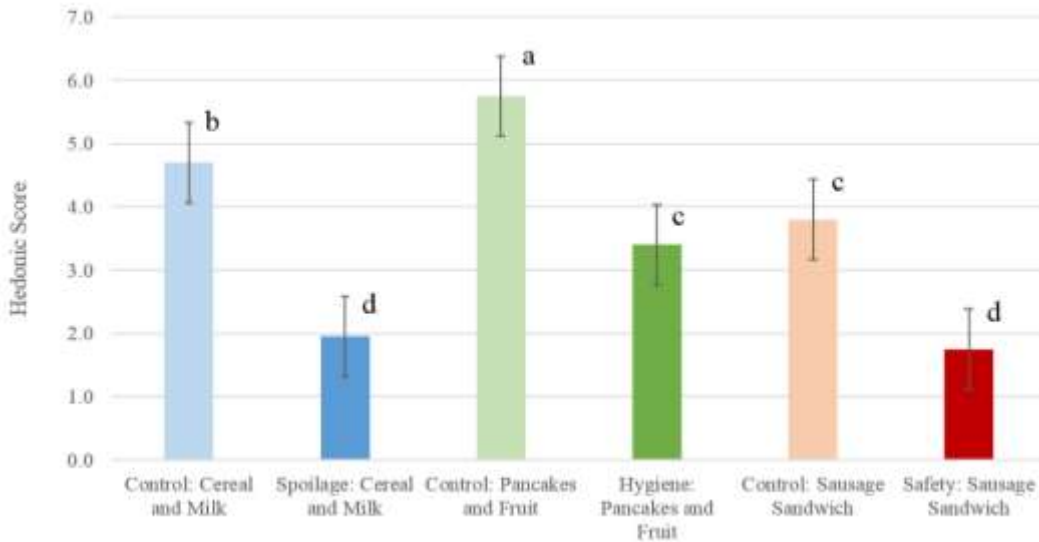


Figure 2: Acceptability scores (mean \pm s.d.) for control and evented breakfast meals ($n=40$; 1= "dislike extremely"; 7= "like extremely"); ^{a,b,c,d} bars with different superscripts significantly differ in mean score ($p<0.05$).

Table 2: Statistical summary for acceptability scores for breakfast meals (matched control and evented videos) illustrating quality and safety differences.

Video	Event Category	M	SD	95% CI		Median
				Lower	Upper	
Cereal and Milk	Control	4.7 ^b	1.24	4.30	5.10	5.0
	Spoilage	2.0 ^d	1.15	1.58	2.32	2.0
Pancakes and Fruit	Control	5.8 ^a	1.34	5.32	6.18	6.0
	Hygiene	3.4 ^c	1.72	2.85	3.95	3.0
Sausage Sandwich	Control	3.8 ^c	1.73	3.25	4.35	4.0
	Safety	1.8 ^d	1.30	1.34	2.16	1.0

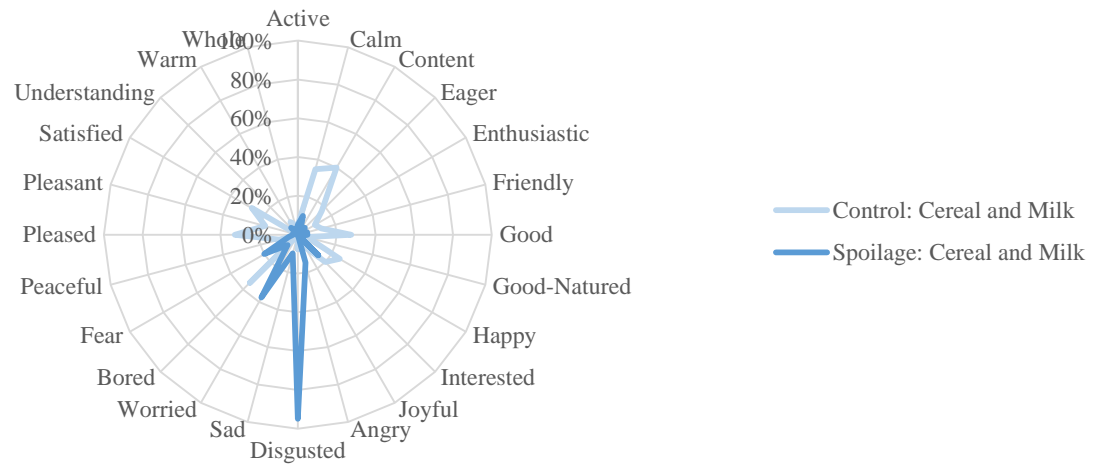
^{a, b, c, d} Means with different superscripts are significantly different ($p<0.05$).

Nine terms were chosen less than 20% of the time for all videos (including the beach scene). These infrequently chosen terms were removed from further analysis: affectionate, aggressive, daring, energetic, guilty, merry, polite, tame and wild. Ten additional terms were

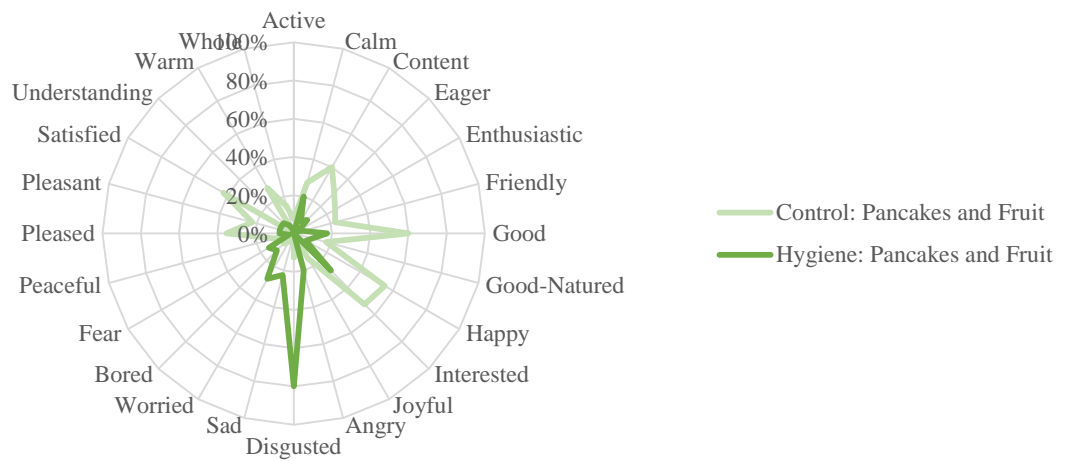
removed from analysis of the breakfast meals due to their infrequency of usage in food only comparisons. These terms included: adventurous, free, loving, mild, nostalgic, quiet, secure, safe, steady and tender. Everted meals received very high disgust responses; over 80% of the population chose disgust for all of the everted videos (Figure 3).

Based on a Cochran's Q analysis (XLSTAT, 2015, Addisonsoft, New York, NY), all three control videos were significantly similar in choice for approach emotions: content, good, good-natured, interested, pleasant, pleased and satisfied ($\alpha = 0.05$). Two withdrawal emotions were significantly chosen for all three everted videos: worried and disgusted ($\alpha = 0.05$). Interestingly, the term worried was used frequently for the control sausage sandwich breakfast meal (safety) video (20% relative frequency); this term was statistically similar in relative frequency to the everted hygiene (pancakes and fruit breakfast meal; 27.5%) video. The control pancakes and fruit (hygiene), and cereal and milk breakfast meal (spoilage) videos received 5% and 0% relative frequency for worried, respectively. For disgust, the control safety video received a 45% relative frequency making it significantly similar to the everted hygiene video (80% relative frequency). The other two control videos, pancakes and fruit (hygiene) and cereal and milk breakfast meal (spoilage), received relative frequencies of disgust at 12.5% and 7.5% (respectively). The everted spoilage and safety videos both received 95% term usage for disgust (also significantly similar to the everted hygiene video at 80% relative frequency).

a.) Spoilage:



b.) Hygiene:



c.) Safety:

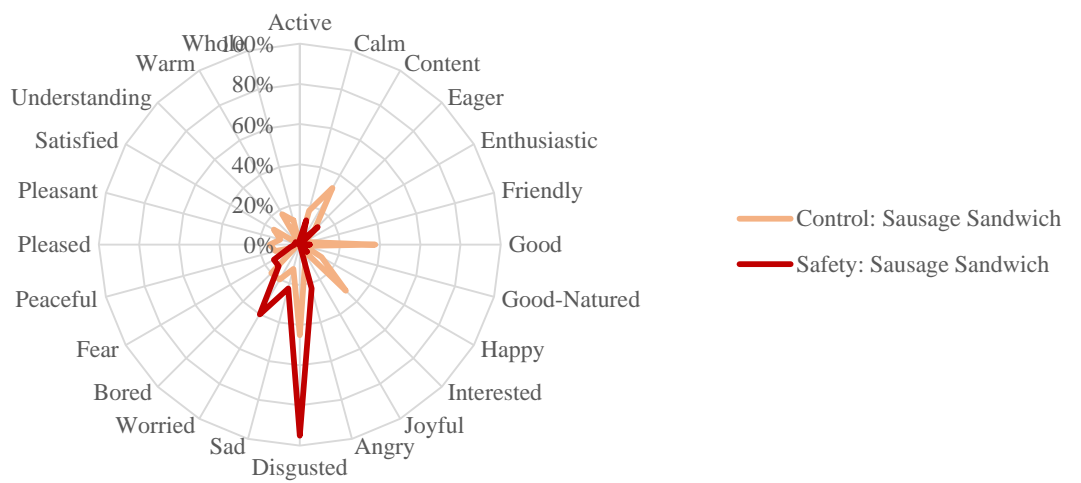
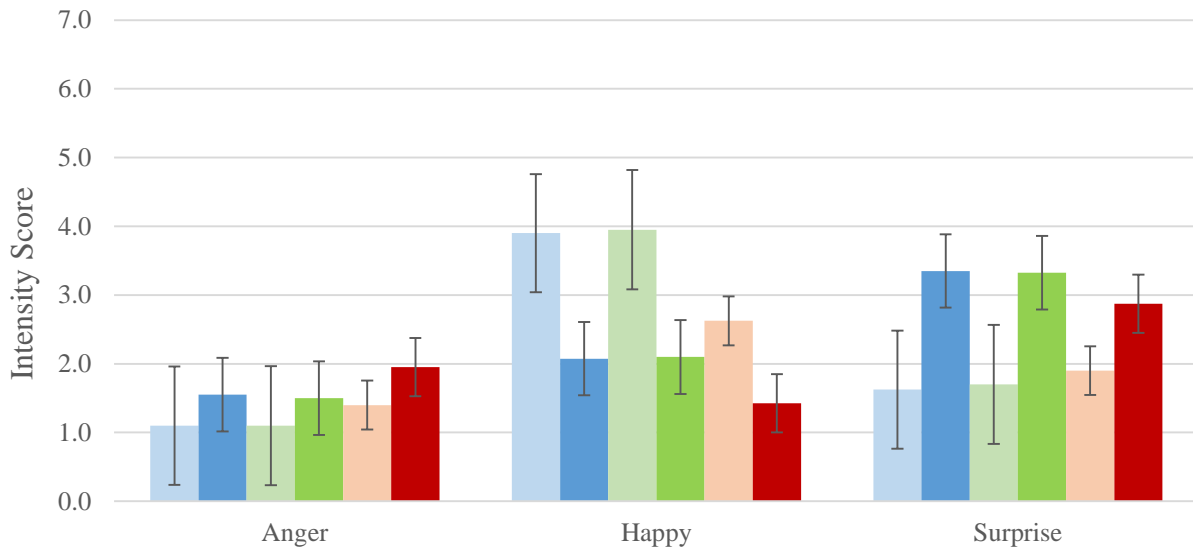


Figure 3: Emotional term selection for control and evented breakfast meals (n=40); a.) Cereal and milk, b.) Pancakes and fruit, c.) Sausage sandwich breakfast meals.

Using the emotional intensity rating questionnaire developed specifically for this study, we were able to cognitively determine how intensely each individual felt about each of the six basic emotions for each video presented. ANOVA analyses showed angry and fearful were significantly higher for the evented sausage sandwich breakfast meal than any other breakfast meal ($p < 0.05$; 2.00 ± 1.747 and 2.46 ± 2.15 , respectively). Disgusted was rated significantly higher in intensity for all three of evented videos. The evented sausage sandwich breakfast meal received the most intense disgust score ($p < 0.05$; 4.90 ± 1.945), with the evented cereal and milk breakfast meal close behind ($p < 0.05$; 4.58 ± 1.647) and lastly the evented pancakes and fruit breakfast meal ($p < 0.05$; 4.30 ± 1.682). It is also important to note that the control sausage sandwich breakfast meal was rated significantly higher in disgust ($p < 0.05$; 2.775 ± 1.928) compared to all other control videos. For the term happy, all control videos received higher average intensities compared to the evented videos ($p < 0.05$; control pancakes and fruit: 3.95 ± 1.709 , control cereal and milk: 3.90 ± 1.722), except the control sausage sandwich breakfast meal ($p < 0.05$; 2.692 ± 1.592). All three of the evented videos were significantly similar in their low intensity rating for happy ($p < 0.05$; evented pancake 2.154 ± 1.709 , evented cereal: 2.13 ± 1.260 , evented sausage: $1. \pm 0.756$). The intensity rating of sad was fairly consistent. The evented sausage sandwich breakfast meal ($p < 0.05$; 1.79 ± 1.301) had a slightly greater mean intensity for sad, while the control pancakes and fruit breakfast meal had a small, but significantly lower intensity for sad intensity compared to all other videos ($p < 0.05$; 1.026 ± 0.160). Lastly, all three evented breakfast meals received significantly higher intensities for surprised ($p < 0.05$; spoilage: cereal and milk, 3.35 ± 1.916 , hygiene: pancakes and fruit, 3.33 ± 1.791 , safety: sausage sandwich, 2.949 ± 1.791), compared to all other videos (control pancakes

and fruit: 1.70 ± 1.398 , control cereal and milk: 1.67 ± 1.284 , control sausage sandwich: 1.90 ± 1.429).

a.) Approach



b.) Withdrawal

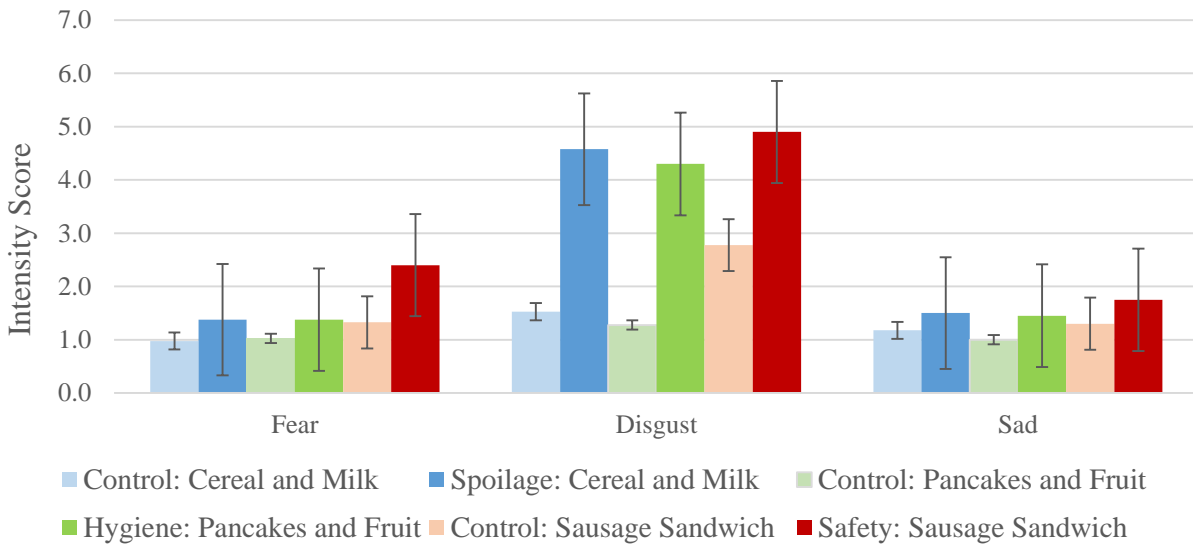


Figure 4: Intensity scores (mean \pm s.d.) for control and evented breakfast meals (n=40); a.) Approach emotion responses, b.) Withdrawal emotion responses

3.2 Implicit Response Results

Heart rate (bpm) data was analyzed between sets of evented and control stimuli for both the pre- and post- event occurrence (Table 3). As expected, no differences were found in mean five second heart rates between the evented and control videos prior to the stimuli ($n=40$, $p>0.05$). Post-event comparisons saw significant differences in heart rate between sets of evented and control videos ($p<0.05$). The evented hygiene concern ($p=0.041$) and safety concern ($p=0.017$) videos had a statistically significant increase in heart rate ($t=2.111$, $t=0.2484$; respectively) following the event occurrence. Conversely, the evented spoilage concern ($p=0.018$) video had a statistically significant decrease in heart rate ($t= -2.481$) compared to the control.

EEG analysis of motivational behavior response was determined by finding the frontal cortex asymmetry score for the F3/F4 electrodes (asymmetry scores for electrodes F7/F8 and Fp1/Fp2 can be found in the Appendix B). P-values (Table 4) show if differences in mean response between control and evented videos occur, while the t-statistics show direction. A negative t-statistic (negative asymmetry score) indicates greater relative activation of the F4 electrode (right hemisphere of the frontal cortex) compared to the F3 electrode (left hemisphere). A positive t-statistic (positive asymmetry score) indicates greater activation of the F3 electrode or the left hemisphere of the frontal cortex compared to the right (F4 electrode). It was expected that no difference would be found for the pre-event comparison between the control and evented videos ($p>0.05$). Post-event analysis found a significant difference between only one stimuli set, the cereal and milk (spoilage) videos ($p=0.037$). A negative t-statistic for the spoilage concern comparison presents a greater activation of the F4 electrode (right hemisphere), indicating a

withdrawal response for the evented video after the event occurred. No differences were found for the hygiene ($p= 0.580$) and safety ($p=0.438$) concern video sets for the post-event analysis.

Table 4: Student's t-test comparison of mean heart rate (HR) between control and evented videos for five seconds pre- and post-event ($n=40$, $\alpha=0.05$).

HR	Food Concern	Event	Control		Evented		Mean Diff.	SD	t	p
			M (bpm)	SD	M (bpm)	SD				
Five sec pre-event	Spoilage	Cereal and Milk	73.680	10.349	74.063	10.773	0.891	5.624	1.002	0.322
	Hygiene	Pancakes and Fruit	72.114	11.223	73.263	11.401	1.148	4.536	1.601	0.117
	Safety	Sausage Sandwich	74.646	11.034	74.992	11.186	0.346	4.465	0.491	0.626
Five sec post-event	Spoilage	Cereal and Milk	73.172	10.906	71.657	10.756	-2.023	5.158	-2.481	0.018
	Hygiene	Pancakes and Fruit	71.282	11.082	72.593	10.820	1.311	3.927	2.111	0.041
	Safety	Sausage Sandwich	71.914	11.227	73.651	10.963	1.736	4.421	2.484	0.017

Table 3: Student's t-test comparison of mean frontal cortex asymmetry scores (F4-F3) between control and evented videos for pre- and post-event ($\alpha=0.05$).

Frontal Cortex Asymmetry Scores: F4 - F3	Food Concern	Event	Control		Evented		Mean Diff.	SD	n	t	p
			M	SD	M	SD					
Five sec pre-event	Spoilage	Cereal and Milk	0.039	0.411	0.033	0.376	-0.009	0.523	39	0.631	0.532
	Hygiene	Pancakes and Fruit	0.128	0.455	-0.001	0.381	-0.143	0.491	39	-1.820	0.077
	Safety	Sausage Sandwich	0.021	0.429	0.039	0.484	-0.018	0.571	38	-0.038	0.970
Five sec post-event	Spoilage	Cereal and Milk	0.063	0.420	-0.118	0.346	-0.175	0.503	39	-2.168	0.037
	Hygiene	Pancakes and Fruit	0.052	0.400	0.013	0.348	-0.039	0.439	40	-0.558	0.580
	Safety	Sausage Sandwich	0.014	0.347	0.068	0.388	0.054	0.435	40	0.784	0.438

Evaluation of mean intensities of emotions expressed over five seconds pre- and post-event occurrence (Tables 5 and 6, respectively) for both the control and the evented videos were completed. Within emotion and across stimuli, no significant differences in expressed emotional intensity were found for either the pre- or post- event analysis ($p > 0.05$). Differences are seen within stimuli and across emotions. Pre-event and post-event analysis indicate neutral as uniquely being the most intense expression for the five second duration for all videos ($p < 0.05$). Similarly, although not unique, anger received the second highest intensity scores for both pre- and post- event occurrence analysis as well as for all videos ($p < 0.05$). Aside from the neutral state and anger expressions, all other expressed emotion intensities were different across emotions and within food stimuli.

Table 6: Mean intensities (\pm s.d.) pre-event occurrence of expressed emotions identified by automated facial expression analysis and multiple comparisons within emotion and across video stimuli (five seconds; $n=40$, $p<0.05$).

Food Stimuli		Neutral		Happy		Sad		Anger		Surprise		Scared		Disgust	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Cereal and Milk	Control	0.459 ^a	0.316	0.013 ^c	0.049	0.052 ^c	0.169	0.214 ^b	0.357	0.130 ^{bc}	0.289	0.012 ^c	0.060	0.039 ^c	0.120
	Spoilage	0.465 ^a	0.336	0.009 ^c	0.035	0.061 ^{bc}	0.180	0.178 ^b	0.306	0.194 ^b	0.362	0.013 ^c	0.058	0.032 ^c	0.111
Pancakes and Fruit	Control	0.482 ^a	0.278	0.032 ^{bc}	0.118	0.038 ^{bc}	0.118	0.159 ^b	0.297	0.119 ^{bc}	0.268	0.028 ^c	0.083	0.030 ^{bc}	0.079
	Hygiene	0.470 ^a	0.316	0.007 ^c	0.047	0.039 ^c	0.123	0.212 ^b	0.341	0.141 ^{bc}	0.293	0.016 ^c	0.064	0.048 ^c	0.159
Sausage	Control	0.452 ^a	0.307	0.031 ^c	0.132	0.066 ^{bc}	0.197	0.205 ^b	0.328	0.130 ^{bc}	0.282	0.008 ^c	0.041	0.044 ^{bc}	0.116
Sandwich	Safety	0.421 ^a	0.305	0.011 ^d	0.061	0.036 ^{cd}	0.120	0.235 ^b	0.338	0.163 ^{bc}	0.324	0.022 ^{cd}	0.100	0.023 ^{cd}	0.066

*Means within each emotion (column) had no significant differences ($p>0.05$).

^{a, b, c} Means within each event (row) with different superscripts are significantly different ($p<0.05$).

Table 5: Mean intensities (\pm s.d.) post-event occurrence of expressed emotions identified by automated facial expression analysis and multiple comparisons within emotion and across video stimuli (five seconds; $n=40$, $p<0.05$).

Food Stimuli		Neutral		Happy		Sad		Anger		Surprise		Scared		Disgust	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Cereal and Milk	Control	0.462 ^a	0.314	0.007 ^c	0.029	0.048 ^c	0.164	0.216 ^b	0.350	0.132 ^{bc}	0.300	0.005 ^c	0.020	0.033 ^c	0.093
	Spoilage	0.394 ^a	0.331	0.027 ^{cd}	0.116	0.090 ^{bcd}	0.230	0.195 ^b	0.326	0.171 ^{bc}	0.347	0.006 ^d	0.034	0.073 ^{bcd}	0.207
Pancakes and Fruit	Control	0.464 ^a	0.288	0.037 ^b	0.121	0.042 ^b	0.148	0.159 ^b	0.297	0.124 ^b	0.278	0.032 ^b	0.107	0.031 ^b	0.090
	Hygiene	0.423 ^a	0.300	0.032 ^c	0.134	0.048 ^c	0.140	0.215 ^b	0.345	0.115 ^{bc}	0.271	0.023 ^c	0.082	0.063 ^c	0.186
Sausage	Control	0.453 ^a	0.317	0.031 ^c	0.133	0.079 ^{bc}	0.214	0.203 ^b	0.330	0.130 ^{bc}	0.285	0.008 ^c	0.045	0.031 ^c	0.098
Sandwich	Safety	0.394 ^a	0.299	0.034 ^c	0.114	0.056 ^c	0.141	0.210 ^b	0.334	0.169 ^{bc}	0.332	0.026 ^c	0.119	0.048 ^c	0.132

*Means within each emotion (column) had no significant differences ($p>0.05$).

^{a, b, c} Means within each event (row) with different superscripts are significantly different ($p<0.05$).

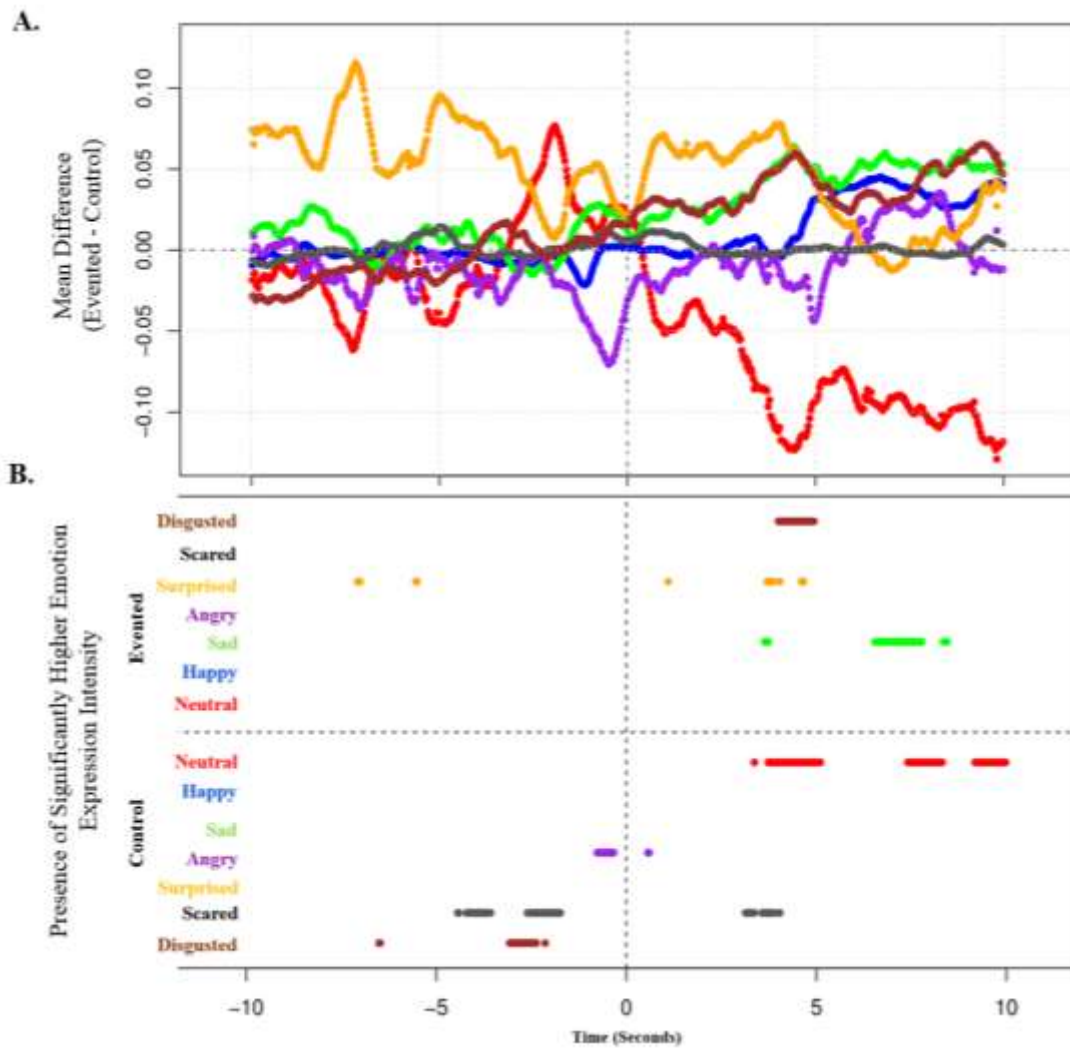
AFEA time series graphs are represented in two panels per figure (Figure 5, a-c). In both graphs, time zero indicates when the event occurred and ten seconds pre-event and ten seconds post-event were analyzed. This moment in time the event occurs is specific to each video, but comparable in the progression of the meal preparation across all videos. The continuum of mean differences of expression intensity for each emotion is plotted between the control (no concern) and the evented breakfast meal set over time (20 sec; evented - control) (Figure 5, Top Graph, Panel A). Sequential paired nonparametric Wilcoxon tests were performed between the control and the corresponding treatment to identify significant positive and negative emotional differences over time (20 sec) ($\alpha=0.025$ for positive and for negative differences; $n=40$). Results were summarized and plotted into time series graphs where the stimuli for each expressed emotion was of higher intensity (Figure 5, Bottom Graph, Panel B). The time series graphs illustrate where significant differences in emotion expression intensity exist between the matched control and evented breakfast meals within 20 sec. In other words, these graphs (Figure 5, Bottom Graph, Panel B) are not illustrating the intensity value of the emotion expressed, but the presence (or absence) of an emotion expression intensity that is statistically significantly different in one treatment video compared to the matched control.

Time series comparisons of the facial expressions between the control and evented videos support some patterns seen with the other implicit measures. In the comparisons of the cereal and milk breakfast meals (spoilage), the evented video observed significantly more expressions of the emotions disgusted (~4 – 5 sec), surprised (~1; 3 – 4.5 sec), and sad (~3; 6.5 – 8.5 sec) post-event occurrence compared to the control; small instances of greater surprised expressions occurred pre-event (~-6; -7.5 sec; $\alpha = 0.05$; Figure 5a) for the evented video. When looking at where the control video received greater occurrence of emotion expression, a majority of neutral

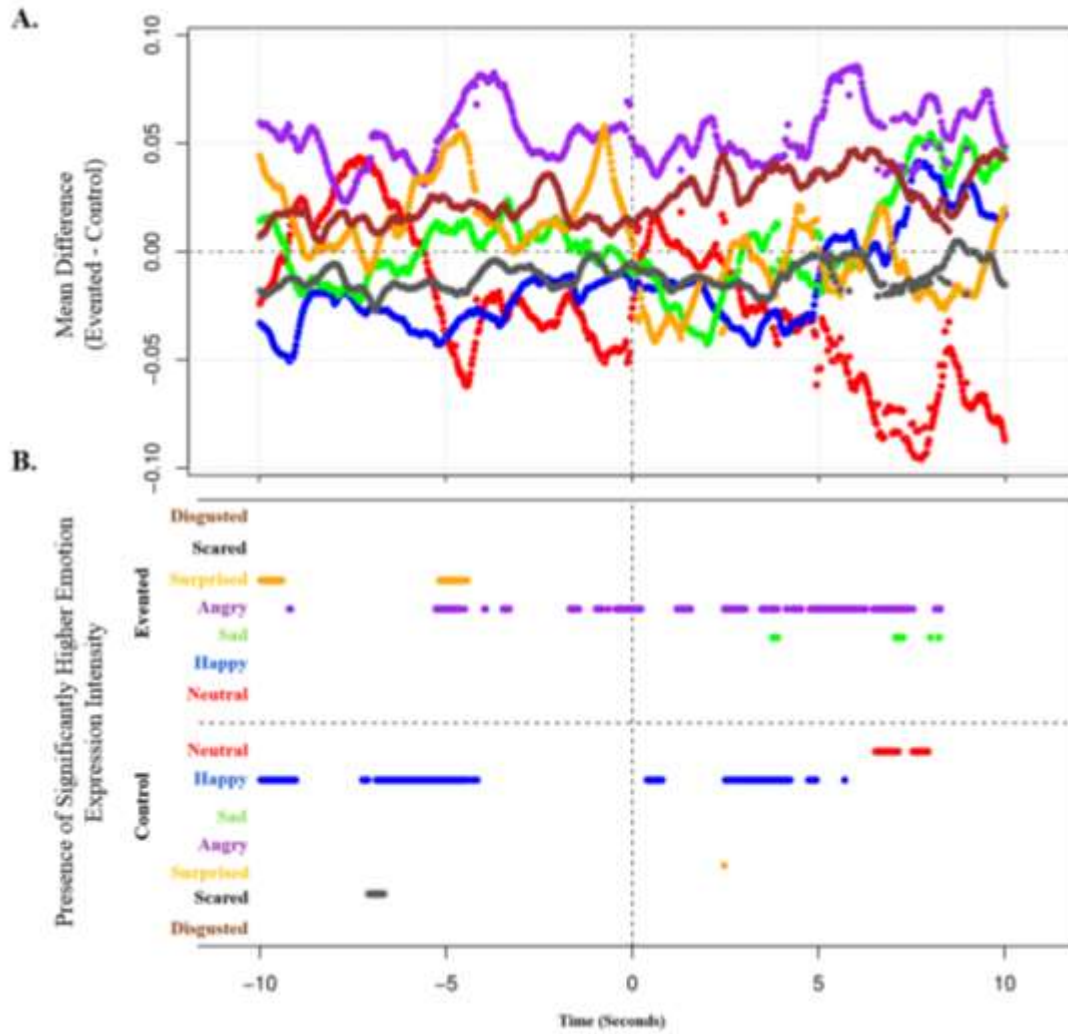
expression was observed post-event occurrence (~3 – 5.25; 7.5 – 8.5; 9 – 10), with some response of scared (~3 – 4 sec) and anger (~1sec), post-event occurrence. However, scared (~-1.5 – 3; -3.5 – -4.5 sec), disgust (~-6.5; -2 – -3 sec) and anger (~-1 – -1.5 sec) were also significantly greater prior to the event for the control. Comparing the pancakes and fruit breakfast meals (hygiene), greater pre-event emotion expression significance include: anger (~-9.5; -3.5 – -6; 0 – -3 sec) and surprised (~-9.5-10; -4.5 – 5.5 sec) for the evented video. Post-event emotions include: anger (~1.5 – 2; 2.5 – 8 sec) and sad (~4; 7 – 8 sec) for the evented video. Happy was significantly observed pre-event (~-9 – -10; -4 – -7.5 sec) and post-event (~0.5 – 1; 2.5 – 5.5 sec) occurrence for the control pancakes and fruit breakfast meal; neutral (~-6.5 - 8 sec) was also present in minor, post-event for the control ($\alpha = 0.05$; Figure 5b).

Overall, the sausage sandwich video comparisons (safety) indicate the least significant expression of emotion compared to the other video sets (Figure 5c). Happy was significantly expressed post-event occurrence for the evented stimuli (~2.5; 3 – 3.5; 6.5; 7.5 – 10 sec). A very small incidence of disgust (-4 sec) can be seen for the control, pre-event occurrence. In particular, the happy response for the evented sausage sandwich video following the event occurrence, brings forth concerns for the accuracy of this implicit measurement tool (AFEAS software). However, short periods of expression may not be representative of the true emotional experience due to an insufficient duration; in the same manner no difference in emotion expression may provide valuable information. Comparisons of mean intensities of expressed emotions bring further context to the AFEAS results.

a.) Spoilage Quality:



b.) Hygiene Quality:



c.) Safety:

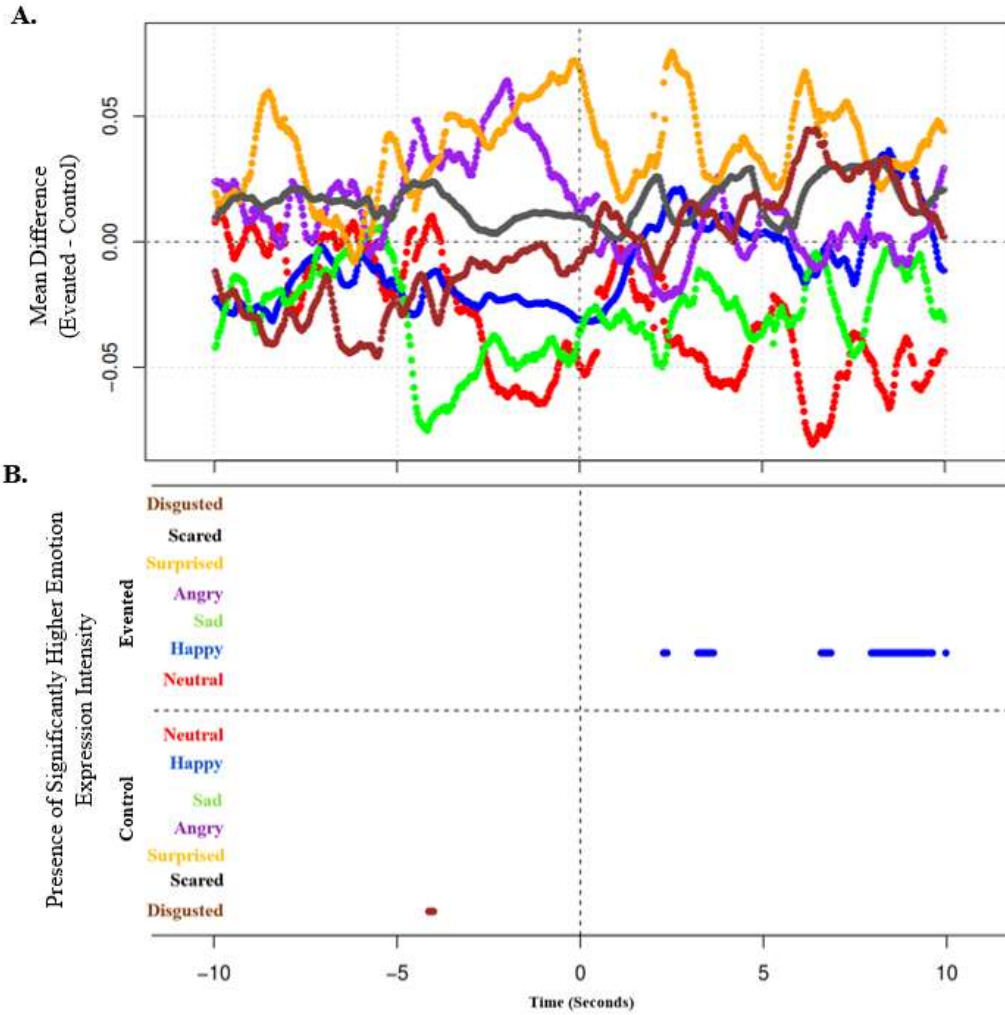


Figure 5: Time series comparison of the six basic emotions expressed and a neutral state between the three sets of control and evented breakfast meals; Top graph, Panel A: Sequential mean difference of intensities of emotion expression; Bottom graph, Panel B: Time series indicating the presence and directionality of statistically significantly greater emotion expression intensities from sequential paired nonparametric Wilcoxon tests ($\alpha=0.025$; $n=40$); a.) spoilage quality (cereal and milk), b.) hygiene quality (pancakes and fruit), c.) safety (sausage sandwich).

4. DISCUSSION

Explicit responses support the hypotheses. Significantly lower hedonic scores for all evented videos, compared to the control videos, provides a strong indication that the quality or safety food challenges were observed in the three evented videos. Additional supportive evidence was found from the emotional terminology selection; withdrawal emotions were more frequently chosen for evented videos, while control videos overwhelmingly received greater approach emotion selection. With statistically significant differences in explicit measures between the control and evented videos, it is clear that participants consciously identified the concerns and determined the difference between the stimuli.

The cereal and milk breakfast meal (spoilage) stimuli showed the most promising implicit results to support the explicit measures. As expected, the AFEA time series illustrated withdrawal emotions for the evented video; disgust and sad (as well as surprised (approach)), were the predominant emotions expressed for the evented video following the post-event occurrence. Time series analysis also found neutral as the predominant expression in the control video post-event occurrence. These findings support previous research on food and facial expression analysis that describe negative facial expressions are more identifiable than positive expressions (Wendin et al., 2009), and positively valenced responses are most often identified as a neutral facial expression (Danner et al., 2014; de Wijk et al., 2012; de Wijk et al., 2014; Wendin et al., 2014; Zeinstra et. al., 2009). Interestingly, the mean intensity scores the expressed emotions from AFEA show both sad and disgust with very small mean intensities (0.090 and 0.073; respectively) in comparison to other emotions such as anger and surprise (0.195 and 0.171; respectively). It is important to emphasize that the time series analysis is valuable in displaying differences in expression over time between stimuli sets, however there is no

indication of the degree to which the emotion is expressed. The ANOVA analysis puts the differences found in the time series into perspective to the other emotions expressed and identifies limitations to using one analysis method. In the same manner, the ANOVA analysis also sheds light on the unexplainable emotions expressed in the pre-event occurrence analysis for the cereal and milk comparisons; intensity values for disgust and scared are only minimally different between the evented and control video suggesting that these responses may be trivial. Although there is statistical significance in emotion expression differences using the time series analysis, some differences may not be noteworthy for consideration in the overall emotional experience. Explicit emotional responses reveal the use of the withdrawal terms, disgust and worried, for the evented meal; there no significant use of sad. HR response saw a significant decrease ($t = -2.481$) in the post-event analysis for the evented spoilage stimuli compared to the control; this is supportive of the time series analysis of facial expressions as hypothesized. Kreibig (2010) explains sad (non-crying) feelings are identified by a decrease in HR. Because sad was a significant facial expression in the post-event analysis of the spoilage concern stimuli, it can be suggested that they were related. However, lack of specific emotion identification in HR responses does not allow for a steadfast conclusion, especially without explicit support. Disgust was also significantly expressed in the post-event analysis of the time series results for the spoilage video. Disgust (contamination) is known to increase HR responses (Kreibig, 2010). The opposing directions of the response found and what is expected provides question of how to determine which emotion/s are more influential on the overall result. Frontal cortex activity further supports the AFEA and HR findings. The spoilage stimuli comparison showed a significant difference in the frontal cortex asymmetry score ($p=0.037$; $t=-2.168$) between the evented and control videos following the event occurrence. Greater right hemisphere activity

was expected for the evented video as it is associated with a withdrawal motivational behavior. Support is evident across all implicit measures for a withdrawing effect from the spoilage concern and additional evidence for this accuracy lies in the food preference questionnaire. Because the majority of participants (82.5%) said they liked both the cereal and the milk, there is less discrepancy between effects from potential distaste of the product and the response from the actual food concern. Because other meals saw a less cohesive response on liking the specific parts of the breakfast meals, it is likely the responses from the sausage sandwich and pancakes and fruit breakfast meals were more biased by preference.

The pancakes and fruit (hygiene) breakfast meal results for AFEA and HR data were marginally consistent with the explicit responses. Frontal cortex asymmetry scores were not significant; however, the direction of response ($t = -0.558$) indicates an accurate withdrawal reading for the evented video. When looking at the post-event time series analysis for the hygiene concern, an extended anger expression (and brief sad) was observed for the evented stimuli whereas the control had a happy and neutral expression response. When taking into account the mean intensities for neutral, happy and sad expressions, they were very close in value between control and evented pancakes and fruit breakfast means. More differing mean values for anger expression intensity between the control and evented video, as well as the significant anger response seen in time series analysis, could be argued as supported by the significant increase in HR for the evented video post-event occurrence. However, caution should be taken in stating this conclusion as anger was not significantly used to describe the evented pancakes and fruit meal, explicitly. Although implicit response seemed to present a negatively valenced and withdrawing response over all, it is difficult to determine if anger is the source of these responses. It should also be noted that anger can be considered as a withdrawal emotion,

however it is typically considered as approach emotion (Ekman, Friesen, & Davidson, 1990).

The food preference questionnaire found over half of participants (60%) recorded that they liked all aspects of the pancake and fruit breakfast meal. There were a few participants who indicated that they disliked syrup and/or powdered sugar (10% for each) and 15% indicated they disliked butter on their pancakes. Together, these differences of preference could explain why implicit responses were only partially supportive of the explicit responses.

The sausage sandwich (safety) breakfast meal comparisons provided no implicit support for a withdrawal response to the event video, through measures of AFEA, HR or frontal cortex asymmetry. The time series analysis presented very limited differences in facial expressions for this condition. Happy was identified as significant post-event occurrence for the event video compared to the control, but no other expressions were identified as significant. When looking at the mean intensity of expression for happy, post-event occurrence, the values are very close in value, indicating that this happy response may not be accurate in the overall difference in emotional experience. Again, this difference points out the limitations of the different AFEA methods. The event video sausage sandwich breakfast meal had a significant increase in heart rate, post-event occurrence. This finding supports the happy facial expression observed. However, a happy expression is not to be expected in response to a safety threat (de Wijk et al., 2012; Kreibig, 2010; Wardy et al., 2015). The food preference questionnaire reported that only 50% of the population agreed to liking everything in the sausage sandwich breakfast meal. Some participants did not like sausage (17.5%) and some did not like the breakfast meal at all (25%; three participants reported only consuming white meats and one was a vegetarian). Differences in preference are a likely explanation for implicit responses being inconclusive and provides discussion for study limitations.

Implicit results were subject to two limitations which can help explain some of the inconsistent results. First, the choice of medium used to display the stimuli is a concern. Food is a multi-sensorial experience. Although, videos and images are common stimuli types in psychology literature, in a food experience having only the visual may not have been able to elicit the emotional and motivational behavior responses expected. Other senses, such as taste and smell are particularly important in the food experience. Videos were chosen due to laboratory limitations and for control purposes between participants; the videos allowed for all participants to be subject to the same experience. However, it is likely that a combination of sensory aspects of food will elicit a more real response than when just using the visual. Secondly, the nature of the stimuli is likely a limitation to the implicit responses. In psychology literature, the stimuli used in emotions studies are often on extreme ends of the spectrum. Stimuli aim to produce experiences of complete bliss to graphic revulsion in order to be certain the intended response is elicited. For example, puppies playing in flowers or a gorilla taking a bath are some positive valanced video stimuli, while videos of amputations or burn victims are some negatively valanced stimuli (Davidson et al., 1990). With food as the subject, eliciting the same extreme responses is nearly impossible because food is generally positive as well as an everyday item. The ordinary nature of food as stimuli makes eliciting detectable emotional and motivational behavior tendencies difficult. With the effort of this research focused on better understanding consumer preference in an effort to be used in a product development setting, it is important to realize that the implicit tools may not currently be sensitive enough to detect small differences in acceptability. Although food is known to be emotional, its intensity is much less dramatic compared to other types of stimuli and thus is likely contributing to the inconclusive implicit findings in this study.

The food preference survey provides important information that helps to explain some of the variability in implicit and explicit emotion responses by understanding some external personal factors that may have affected the results. Selecting participants who are product users is a common practice in many food sensory studies. Pre-screening participants and pre-testing stimuli may have helped reduce the inconsistencies observed in this study. Pre-screening will ensure effectiveness of the stimuli, while having more cohesive groups would help remove specific personal preferences that may bias results (Berkman & Lieberman, 2009; Giuliani et al., 2014). Consideration of other factors such as past experiences, memories, frequency of consumption/exposure to food, physical or nutritional state, cultural importance and other personal characteristics/preferences, also come into play (Desmet & Schifferstein, 2008; Jiang et al., 2014). Consideration for individuality of responses to food by grouping more common backgrounds may reduce effects from personal influences. However, the intention of this study was to observe responses to unpleasant food experiences in a general population. By screening for specific types of people, this reduces the understanding of emotional effects in the overall population.

Experimental limitations result from lack of establishment for equal perception of each stimuli. The setting of the video and the general actions of each stimulus were similar, but no preliminary tests for coloring, brightness, contrast, resolution and size were made (Berkman & Lieberman, 2009). Internal beta testing had recognized the sausage and sandwich breakfast meal's safety concern as most difficult to identify and concern arouse for it not eliciting a strong emotional reaction. Subsequently, this video was always placed last in video presentation sequence in an effort to ensure adequate attention to the other stimuli. As a result, the safety video was always subject to the most participant fatigue. Participant fatigue may contribute to

the inconsistent and minimally significant facial expressions, as well as lack of significant brain activity findings. The responses found for the safety stimuli were farthest from what was hypothesized. With the safety concern video being the least liked stimuli and received all happy expressions, this finding is incongruent with published studies (de Wijk et al., 2014), as well as with the rest of the experimental findings. Explicit responses provide excellent evidence for participants being able to cognitively identify a concern present, but variability in implicit responses renders further research on the methodology and deeper exploration into more personal and individual preference differences that could have influenced these findings.

Further limitations of explicit measures must be addressed in relation to this study. While the EsSense ballot has been identified as a value-added tool in traditional affective testing (Jiang et al., 2014; Ng et al., 2013), there are some aspects of the tool to be aware of when determining its use. Depending on the stimuli, unequal approach/withdrawal (or positive/negative) terms can unintentionally skew the result (Chaya, Pacoud, Ng, Fenton & Hort, 2015; Meiselman, 2015; Ng et al., 2013). For example, in the term list there are five withdrawal (or negative) terms out of 42 terms. With disgust being the only option if one is repulsed by the stimuli, the options for expressing this feeling are limited. This limited selection explains why the term disgust was much more pronounced than any of the other negative (or positive) terms used. If participants had more options of negatively valenced or withdrawal terms, the explicit responses would likely be less stark for the evented stimuli. Because this tool was designed to test the emotions of potential products in the market place, negatively valenced and withdrawal terms are not usually needed and often removed. In the case of this study, a list with equal amounts of approach/ withdrawal emotion terms would have been more fitting and would have provided an unbiased result.

5. CONCLUSION

This study was designed to capture implicit and explicit responses to foods in order to better understand emotional responses and motivational behaviors to different food products and food issues. In an effort to create the most acceptable and pleasurable food experience, positive emotional affects are the usual focus of food study. However, it is arguably just as or even more important, to all areas of the food industry, to have knowledge about both the approach and withdrawal eliciting attributes of one's product or service for the greatest customer satisfaction. The combination of physiological and neurological (implicit) reactions with cognitive (explicit) responses is a growing interest area in sensory science. Results of this study indicate variable and unique responses among individuals creating the indefinite pattern observed. However the results also suggest the potential for the combination of implicit and explicit measures to be used to better understand consumers through approach/withdrawal motivations and emotions. Further research on methodology and validation efforts to define food specific responses is needed to advance this body of work in anticipation for its continued use in the food industry.

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CHAPTER 5: INTEGRATING IMPLICIT AND EXPLICIT EMOTIONAL ASSESMENT OF PLEASURABLE MEAL EXPERIENCES

ABSTRACT

Creating pleasurable experiences with food is essential for the success of food service and restaurant institutions for establishing loyal customers, as well as for food companies to establish brand allegiance. However, the workings of what constitutes a purely positive and approachable food experience is not fully understood. With new technology and a new emphasis on incorporating established research in psychology, food science researchers are looking for more advanced evaluative techniques for measuring implicit (unconscious) responses of emotions and motivational behavior tendencies. Automatic facial expression analysis (AFEA), electroencephalography (EEG) and electrocardiography (ECG) may provide further information for better understanding consumer response to food. Participants (age: 18-29 years; n=40, female=31) were presented with eight different videos (5 videos intended to elicit positive approach responses; average 40 sec) of breakfast meals and were concurrently measured for implicit responses (AFEA, EEG and ECG) and expressed explicit emotional responses. AFEA analyzed facial expressions for the six basic emotions (0 = not expressed; 1= expressed), EEG (10/20 system; 32 channels, 512 Hz) measured frontal cortex asymmetry to provide motivational tendency (right hemisphere activation = withdrawal, scared, sad and disgust; left hemisphere activation = approach, happy, surprised and angry), while ECG measured heart rate (bpm) for changes in arousal. Explicit emotions were assessed using a check-all-that-apply list of emotional terms (n=43), an emotion intensity questionnaire (n=6; 7-point scale), and

acceptability was rated on a 7-point hedonic scale (1=dislike extremely; 7=like extremely). The withdrawal emotion, disgust, was significantly chosen more for videos less liked, while approach emotions, good and happy were significantly chosen for videos liked more ($p < 0.05$).

Acceptability scores were significantly different ($p < 0.05$) across meal types. Implicit measures, EEG, ECG and AFEA, found little supportive data to more traditional explicit measures for understanding pleasurable meal experiences.

KEYWORDS

Emotions, EEG, ECG, automated facial expression analysis, pleasurable meal experience

1. INTRODUCTION

Recent literature on product design emphasizes the importance of user emotions. The idea, “design for emotion,” illustrates the importance of not only knowing what causes unwanted user responses, but also what causes consumer satisfaction (Desmet & Hekkert, 2009). Because all areas of the food industry, including food service/restaurants, consumer packaged goods (CPG) food companies, retail food stores, etc., are consumer driven, developing food products or experiences with an understanding of the relationship between food and emotion will provide important consumer insight knowledge. Current literature recognizes that research beyond the product, in areas such as user and product experience, as well as emotional design are subjects that marketers, designers, engineers, product developers and others, must integrate into their research to enhance consumer satisfaction and make their product or service most desirable (Desmet & Hekkert, 2009). Guaranteeing a positive and approachable food experience is essential for success in the food industry as it contributes to creating brand-loyalty, customer service satisfaction, ensuring customer return, influencing positive purchase behavior and much more. However, pleasurable food experiences are a result of a complexity of factors that are unique to every individual. Making those interactions memorable is even more of a challenge (Piqueras-Fiszman & Jaeger, 2015). Four main factors have been identified as influential in meal satisfaction: 1) the environment, 2) social interaction, 3) physiological outcome, and 4) the experience with the food (Piqueras-Fiszman & Jaeger, 2015). Abundant research is available on how the first three factors influence emotions in food situations. However, as design experts have identified, understanding the experience one has with food and what makes particular foods more pleasurable over others is not fully understood. Advanced research in neuropsychology, physiology, and other related fields such as behavior economics have recognized non-verbal

(implicit) responses, such as facial expressions, brain and heart activity, and other physiological responses, as measures of emotion. Because current sensory literature is beginning to recognize emotions as an important factor in understanding meal gratification, novel integration of implicit emotional response will likely provide a more holistic picture of emotional response to food (Desmet & Hekkert, 2009; Köster & Mojet, 2015; Zurawicki, 2015).

Emotions are a multifarious system that can be described as either explicit or implicit (Köster & Mojet, 2015). Explicit emotions are a result of one's "conscious awareness" and thus can be expressed in a verbal, written or physical (gestures or intentional facial expressions) manner (Köster & Mojet, 2015). Use of explicit emotional measurement tools has become common in sensory science literature, but are limited to research in product discrimination studies (Jiang, King, & Prinyawiwatkul, 2014; Ng, Chaya & Hort, 2013; refer to Meiselman, 2015 for a comprehensive review of current explicit emotional methods). Implicit emotional responses are described as reactions, without conscious awareness, that occur at the time of a specific experience, thought or action. Although the discrimination ability of explicit emotional response measures can be useful (Ng, et al., 2013), they do not determine true emotional response due to the influence of cognitively determined drivers (Jiang et al., 2014; Köster & Mojet, 2015). Potential cognitively determined drivers that may influence explicit responses and cause unreliable results include, but are not limited to: (1) knowledge or specific opinions of the product, treatment, packaging, nutrition, etc., (2), habits and behaviors, (3) scale interpretation or understanding of task, as well as (4) the dynamics of the environment (Jiang et al., 2014; King, Meiselman & Carr, 2010; Köster & Mojet, 2015; Meilgaard, Civille & Carr, 2007). Not only are explicit measures impressionable, but defining and communicating complex emotions is often difficult for consumers (Plutchik, 2001; Ulwick, 2002). It is argued that questioning consumers

cognitively about their emotional experience is unproductive and produces inconclusive results due to cognitive information processing (Plutchik, 2001; Ulwick, 2002; de Wijk, He, Mensink, Verhoeven & de Graaf, 2014). This belief questions the use of explicit responses for emotional assessment and renders the exploration of subjective measures (Zurawicki, 2015). Thus, implicit response research using motor (e.g. facial expression analysis), neurological (e.g. brain activity) and physiological responses (e.g. heart rate) is gaining interest in the field of food science for its potential in providing deeper insight into what constitutes a pleasurable food experience through emotional and motivational behavior responses.

The use of automatic facial expression analysis (AFEA) software tools is increasing, as AFEA offers a practical and accessible automated method to measure expressed emotions (Littlewort, Whitehill, Wu, Fasel, Frank, Movellan & Bartlett, 2011). Such software analyzes the facial movements (lips, eyes, cheeks, mouth, etc.) and textures, by identifying and measuring differences in specific points on the face (Littlewort et al., 2011; Loijens & Krips, 2012). These measurements are assigned intensities and translated into values for the expression of the basic emotions (and a neutral state), endeavoring to identify unspoken emotional responses (Loijens & Krips, 2012; Noldus Information Technology, 2012). Studies using AFEA tools have been used in only a few food-related applications and the wide variation in results provides a need for further investigation of the tool for food experience evaluation (Arnade, 2013; Danner, Sidorkina, Joechl & Duerrschmid, 2013; Danner, Haindl, Joech & Duerrschmid, 2014; de Wijk, Kooijman, Verhoeven, Holthuysen & de Graaf, 2012; de Wijk, et al., 2014; He, Boesveldt, de Graaf, de Wijk, 2016; Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015; Walsh, Duncan, Potts, & Gallagher, 2015). Although no study has specifically studied facial expressions for the intent of exploring what pleasurable and approachable meal experiences look like, the few

studies looking at differences in ‘liked’ and ‘disliked’ foods provide some important evidence. Danner et al. (2014) and He et al. (2016), found similar findings that ‘liked’ or ‘positively valanced’ samples caused little change in facial expressions compared to obvious adverse facial expressions in response to ‘disliked’ or ‘negatively valanced’ samples. “Liked” products are not as easily identifiable; studies have suggested neutral to be undistinguishable from positive expressions and in food experiences neutral faces are more greatly associated with positive responses (Danner et al., 2014; de Wijk et al., 2012; de Wijk et al., 2014; Wendin, Bredie & Tan, 2014; Zeinstra, Koelen, Colindres, Kok, & de Graaf, 2009). These findings are supportive information for understanding how a positive food experience may be expressed through non-verbal means such as motor facial movements. It should be noted that some scientists believe facial expressions may have limited ability for predicting affective experience (Wendin et al., 2014). However, these studies focus on specific tastes or products; facial expression analysis in food science literature has not focused on the expression of emotional experience to complete meal experiences. Thus, inconsistencies where happy expressions from ‘negatively valanced’ samples were seen (He et al., 2016), and inconclusive results found by Leitch et al. (2014), justify the need for further research with other types of stimuli and identify a gap in the literature. AFEA is one of many potential implicit measures for emotional response; other measures of automatic nervous system response (ANS), such as heart rate (HR) activity, may provide additional information for understanding responses in pleasurable food experiences.

An ANS measurement that is gaining interest in emotions and food science literature is cardio-electrical response or electrocardiography (ECG). ANS measures, such as HR, can be used as indicators of emotional response, but emotion specificity is debatable (Kreibig, 2010). Due to the nature of human physiology, which responds to many environmental elements, it is

difficult to isolate emotional responses from external ones (for a complete review on ANS responses and emotions, see Kreibig, 2010). In contrast, some researchers suggest ANS measures can be used for measures of arousal or dimensional (positive/negative) indicators (Fernandez, Pascual, Soler, Elices, Portella, Fernandez-Abascal, 2012). Fernandez et al. (2012) explains an emotion's intensity and one's alertness are reflective of physiological responses as opposed to specific emotions. On the other hand, specific HR patterns have been shown to be indicative of certain emotions. An increase in HR is usually in response to anger, contentment (imaginary), fear, surprise, happiness, joy, sadness (crying) and disgust (contamination) emotions, while a decrease in HR is indicative of other emotions, including sad (non-crying or acute), disgust (mutilation), visual contentment, and anticipatory pleasure. It should be noted that although these HR emotional responses are well studied in psychology literature, the nature of the stimuli can make a significant difference (Kreibig, 2010). In food science literature, like AFEA, HR studies have found mixed findings and are exclusively concerned with specific products or product attributes, as opposed to understanding the complete food experience (Danner et al., 2013; Danner et al., 2014; de Wijk et al., 2012; de Wijk et al., 2014; He et al., 2016). These studies, which are focused on product development questions, present some important evidence for understanding pleasurable food experiences. He et al. (2014) found a decrease in HR in response to 'liked' samples in a study on food odors. In contrast, de Wijk et al. (2014) observed an increased trend in HR associated with sample liking when tasting breakfast drinks (de Wijk et al., 2012); other researchers have found no correlations between liking and ANS measures (Danner et al., 2014). Although contradictions in HR analyses are apparent, there is evidence for its use as supportive information to other implicit responses, such

as brain activity and AFEA, as measures of emotion and motivational behaviors to understand the underlying reactions involved in attractive food experiences.

Another implicit response tool, electroencephalography (EEG) measures the electrical activity of the brain's neurons from the surface of the scalp (Garrett, 2015). Frontal cortex asymmetry, which is the difference between neuro-electrical activity of the right and left hemispheres of the frontal cortex, is often used to describe differing functions and responses due to the structural differences of the two hemispheres (Coan & Allen, 2003). In particular, the approach/withdrawal motivational behavior theory describes differing responses described as either approach or withdrawal (Bisazza, Rogers & Vallortigara, 1998; Garrett, 2015; Davidson, Ekman, Saron, Senulis & Friesen, 1990; Coan & Allen, 2003; Diaz & Bell, 2011). In psychology literature a greater activation of the left frontal cortex is indicative of an approach motivational behavior, which is described as a propensity to move toward the stimuli and suggestive of the emotions happy, surprised and anger. In contrast, a greater activation of the right frontal cortex is indicative of a withdrawal motivational behavior, and is defined as an action propensity to move away from the stimuli. Withdrawal related emotions include disgust, sad and scared (Alves, Fukusima, & Aznar-Casanova, 2008; Coan & Allen, 2003; Coan & Allen, 2004; Davidson, et al., 1990; Davidson, 2004; Diaz & Bell, 2011; Harmon-Jones, Gable, & Peterson, 2010; Scherer, 2000). Psychology literature in the area of emotional responses to food is substantial. However, much of the focus is on issues associated with disordered eating or dieting populations that have health related issues such as reward/punishment behaviors, excessive cravings and/or food temptations (Berkman & Lieberman, 2009; Giuliani, Mann, Tomiyama & Berkman, 2014; Siep, Roefs, Roebroek, Havermans, Bonte, & Jansen, 2012; Silva, Pizzagalli, Larson, Jackson, & Davidson, 2002). Additionally, studies that observe

neurobiological responses most often use extreme stimuli in order to elicit the desired emotion or motivational behavior. Examples of extreme stimuli range from graphic nurse training videos of amputations to beatific videos of baby animals playing (Davidson et al., 1990). Because food is a part of ordinary life, this renders the question of if food stimuli can elicit comparable responses to the extremes studied in psychology literature. It is believed that researchers will be able to use motivational behavior tendencies to provide subjective measurement of behavior and emotional response to answer food science-related questions. The questions in our study will provide further insight into understanding approach motivational responses through implicit reactions to pleasurable meal experiences, have not been directly explored.

Recently food science literature has been greatly expanded on food and emotions topics. It is clear in the literature that food consumption affects mood (Rozin & Gohar, 2011). It is also clear that mood influences the consumption of food (Evers, Adriaanse, de Ridder, de Witt Huberts, 2013; Köster & Mojet, 2015). Research studying gender and cultural differences in emotional response to food also is significant (Dube, LeBel & Lu, 2005). Literature even describes how hormones and neurotransmitters affect perception and sensations in the brain from different sensory modalities and characteristics of food such as odors, temperature, compositions and caloric value (Zurawick, 2015). However, little is actually know about what happens during positive food evaluation after removing the many influential sensory inputs, so that uninfluenced emotional responses can be measured concurrently. The goal of this project was to develop a unified approach for studying frontal cortex asymmetry, AFEA, and HR measures of emotion and motivational behaviors for a comprehensive observation and deeper understanding of subjective responses to pleasurable food experiences. Sensory and food scientists, food service managers of schools, businesses and other facilities, as well as restaurant owners, will then be

better informed on how to elicit pleasurable food experiences, which are important for consumer satisfaction.

In the assessment of emotional and motivational behavior measures of pleasurable food experiences, we hypothesize:

A. Explicit measures:

1. Hedonic ratings of prepared breakfast meals will have small and significant ($p < 0.05$) differences in acceptability, indicating slight preference among the meals. All meals will be rated at or above “neither like nor dislike”, indicating the meals are all positively perceived.
2. Small differences in approach (positively valenced) and withdrawal (negatively valenced) emotion term selection will indicate preference differences, providing additional differentiation among acceptability scores.
3. Intensity scores of the six basic emotions will show differences in approach and withdrawal feelings, which will coincide with acceptability and emotion term selection as further indication of preference.

B. Implicit measures:

1. AFEA will show a greater neutral/approach (positive) emotional expressions reflective of emotion term and acceptability differences.
2. HR analysis will support AFEA and show intensity differences in HR (bpm) to illustrate emotional response differences supported through arousal.
3. Frontal cortex asymmetries will display greater approach motivational behavior tendencies that are reflective of acceptability and emotion term differences.

2. MATERIALS AND METHODS



2.1 Participants

For a description of participants see Walsh (2016), *Chapter 4; Participants*.

2.2 Video Stimuli: Five Breakfast Meals

The focus of this study was to compare five different breakfast meal videos to a control video (beach scene) to observe emotional and motivational differences. Based on the product's nutrition labels and suggested serving sizes, approximate meal nutrition facts were calculated (Appendix B). The meals were within 200 total calories of each other (with the exception of the cereal and milk breakfast meal), but had a wide range of carbohydrate, fat and protein contents, providing a diverse presentation of meal types. Video descriptions follow in Table 1. For further details on the production and descriptions of the videos see Walsh (2016), *Chapter 4; Video Stimuli: Food Hygiene, Safety and Spoilage*.

Table 1: Description and images of breakfast meal videos.

Example Video Image	Descriptions
<p>a. Pancakes and fruit</p> 	<p>A stack of pancakes were set on a plate, followed by butter, fruit, maple syrup and powdered sugar.</p> <p>*Matched with hygiene concern video.</p>
<p>b. Sausage, egg and cheese sandwich</p> 	<p>A kaiser roll is placed on the plate followed by a sausage patty, egg, and cheese.</p> <p>*Matched with safety concern video.</p>

c. Control milk and cereal



Cereal flakes are poured into a bowl and milk is poured over top.

*Matched with a spoilage concern video.

d. Yogurt and fruit parfait



Yogurt is placed in a bowl followed by granola and fruit.

*Unmatched.

e. Biscuits and gravy



A biscuit, fried egg and bacon were placed on a plate and drizzled with gravy.

*Unmatched.

f. Beach scene



Palm tree on a beach with waves ebbing.

*Unmatched.

2.3 Emotional Measures

Implicit and explicit emotional responses were recorded. Implicit responses, for this study, are defined as responses that are not verbalized (or written) by the participant. Brain and heart activity are considered implicit because they are not cognitively determined. Although facial expressions can be cognitively controlled, they have been grouped into the implicit results

because they are neither written nor verbal. Explicit responses are defined as written (or verbal) responses that have been subject to thought and reason, such as questionnaires.

2.3.1 Implicit Measures: EEG, ECG and Facial Affect Coding

For an overview of implicit measures see Walsh (2016), *Chapter 4; Implicit Measures*.

2.3.2 Explicit Measures

For an overview of explicit measures see Walsh (2016), *Chapter 4: Explicit Measures*.

2.4 Overview of Design

The objective was to determine if different types of breakfast meals elicit different implicit responses (EEG, ECG, AFEA) and if these responses were supported by explicit emotional responses. This project advances sensory testing methods by introducing novel tools as well as aiding in better understanding consumers through emotional and motivational behavior responses to food.

2.4.1 Test Conditions

For further descriptions of test conditions see Walsh (2016), *Chapter 4; Test Conditions*.

Figure 1 presents a schematic of how sequencing within the session proceeded and how video sets were presented.

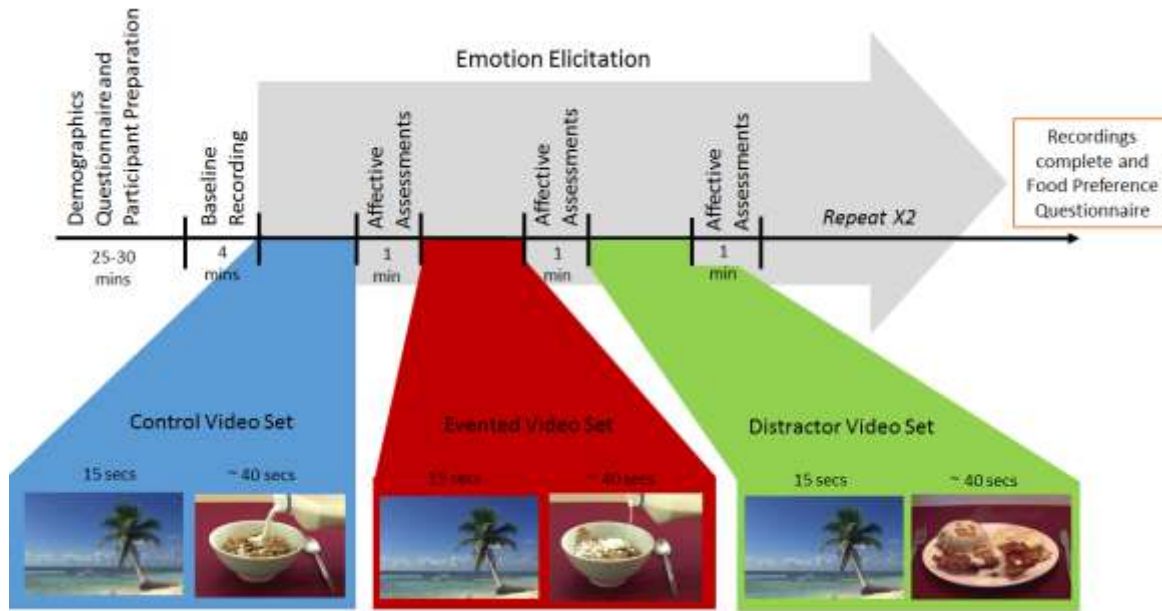


Figure 1: Single scheme of video presentation sequence.

2.5 Data Analysis/ Statistical Technique

2.5.1 Data Analysis for Implicit Responses: EEG, ECG and AFEA

For specific information on data preparation and ECG analysis refer to Walsh (2016), *Chapter 4: Data Analysis for Implicit Responses: EEG, ECG and AFEA*. A corresponding segment of time (five seconds for all analyses except for the time series and ANOVA analyses of AFEA at ten seconds (Appendix B)) was chosen for all stimuli to analyze implicit responses to the breakfast meals. This particular time segment was selected due to its intentional engagement with the viewer occurring a few seconds before meal preparation was complete and as the food was in the process of coming towards the face. Means and statistical comparisons for ECG data was completed in Excel (Excel 2013, Microsoft Corporation, Inc., Redmond, WA). Independence, normality and equal variance were tested and pairing was completed within participant. The mean (M) heart rate (HR; bpm; n=40) and standard deviations (SD) for each

stimuli for the five second segments was found. Paired student's *t*-tests ($\alpha=0.05$) were calculated between each breakfast meal and the control (beach scene) (Table 3; see Appendix B for an additional analysis using Dunnett's method with the beach scene as the control (Tables 10 and 11).

For further information on data preparation of EEG measurements refer to Walsh (2016), *Chapter 4; Data Analysis for Implicit Responses: EEG, ECG and AFEA*. The same five second time segments for the ECG data analysis was used for the EEG analysis of frontal cortex asymmetry scores. Paired student's *t*-tests ($\alpha=0.05$) of the average frontal cortex asymmetry scores (F3/F4 electrode pair) were calculated between each breakfast meal and the control (beach scene) (see Appendix B for frontal cortex asymmetry scores of the F7/F8 and Fp1/Fp2 electrode pairs (Tables 7 and 8, respectively) and for an additional analysis using Dunnett's method (Tables 12 and 13; Excel 2013, Microsoft Corporation, Inc., Redmond, WA). When an electrode failed to record activity, the corresponding electrode pair for that participant was removed from analysis.

For further information on data preparation of AFEA measurements refer to Walsh, (2016), *Chapter 4; Data Analysis for Implicit Responses: EEG, ECG and AFEA*. Participant videos were analyzed at 30 frames per sec using the individual calibration setting within the AFEA software; two seconds of video during baseline (eye-open) readings were used for each participant's calibration. Two separate analyses were performed, 1) mean emotion expression intensity (5 sec) comparison between and within emotion using a two-way analysis of variance (ANOVA) and Tukey's HSD test for significance (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC), and 2) time series analysis for significant differences in occurrence of emotion expression over time (R, version 3.1.1; R Core Team, 2013). The second

method performed sequential paired mean differences between breakfast meal and the control stimuli and were transformed into time series graphs for 20 seconds ($\alpha = 0.05$). Previous studies evaluated responses post-five seconds of event occurrence (Leitch et al., 2015); however de Wijk, et al. (2014) found different emotions initiate at different times and have varying durations. Due to our stimuli being a video, the duration of ten seconds before and ten seconds after the emotional event occurred was chosen to provide sufficient time for emotional development on the face. Lastly, dot diagrams, included in the time series analysis, were used to illustrate significant differences in expressed emotions through paired sequential Wilcoxon signed-rank tests (non-normal data; Shapiro Wilks test) over equivalent times between the control and breakfast meal stimuli ($\alpha = 0.05$; R, version 3.1.1; R Core Team, 2013).

2.5.2 Data Analysis for Explicit Responses: Acceptability, Emotion Term Selection, and Food Preference Questionnaires

For specifics on the methods of data analysis of the explicit responses refer to Walsh (2016), *Chapter 4; Data Analysis for Explicit Responses: Acceptability, Emotion Term Selection, and Food Preference Questionnaires*.

3. RESULTS

3.1 Explicit Response Results

The breakfast meal videos were rated on acceptability on a 7-point hedonic scale (Figure 2). The fruit parfait and pancakes and fruit breakfast meals received significantly higher acceptability scores and were considered “liked moderately” ($p < 0.05$; 6.1 ± 1.42 ; 5.8 ± 1.33 , respectively; Table 2). The cereal and milk meal was “liked slightly” ($p < 0.05$; 4.7 ± 1.24); the biscuits and gravy meal was liked slightly less and was categorized as a “neither liked nor disliked” rating (4.4 ± 1.50). The sausage sandwich meal was also “neither liked nor disliked,”

but received a significantly lower score ($p < 0.05$; 3.8 ± 1.72) than all other breakfast meals. The control video (beach scene; 6.4 ± 0.68) received the highest mean value but was not different in rating to the fruit parfait breakfast meal (6.1 ± 1.42).

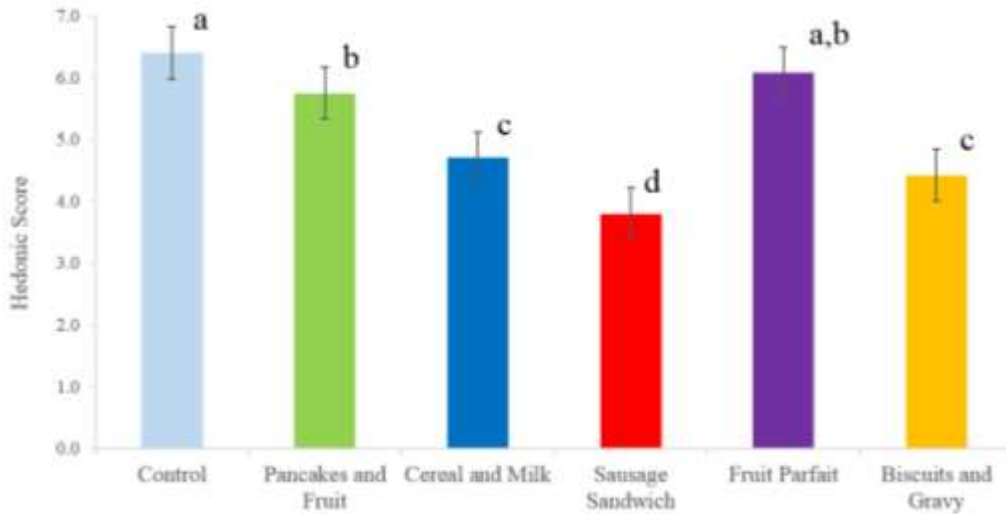


Figure 2: Acceptability scores (mean \pm s.d.) for breakfast meals and the control (n=40; 1= "dislike extremely;" 7= "like extremely"); ^{a,b,c,d} bars with different superscripts significantly differ in mean score ($p < 0.05$).

Table 2: Statistical summary of acceptability scores for breakfast meals and the control.

Video	M	SD	95% CI		Median
			Lower	Upper	
Control	6.4 ^a	0.78	6.15	6.65	6.5
Pancakes and Fruit	5.8 ^b	1.34	5.32	6.18	6.0
Cereal and Milk	4.7 ^c	1.24	4.30	5.10	5.0
Sausage Sandwich	3.8 ^d	1.73	3.25	4.35	4.0
Fruit Parfait	6.1 ^{a,b}	1.42	5.62	6.53	7.0
Biscuits and Gravy	4.4 ^c	1.50	3.95	4.91	5.0

^{a, b, c, d} Means with different superscripts significantly differ ($p < 0.05$).

Twenty-three terms (n=43) were chosen at less than 20 percent frequency for all breakfast meals and were removed from further analysis; the removed terms included adventurous, affectionate, daring, energetic, free, loving, merry, mild, nostalgic, angry,

aggressive, sad, fear, guilty, polite, quite, safe, secure, steady, tame, tender, understanding and wild. With the remaining twenty terms, percent frequency of selection for emotion term selection in response to the breakfast meals and the control are presented in spider graphs (Figure 3).

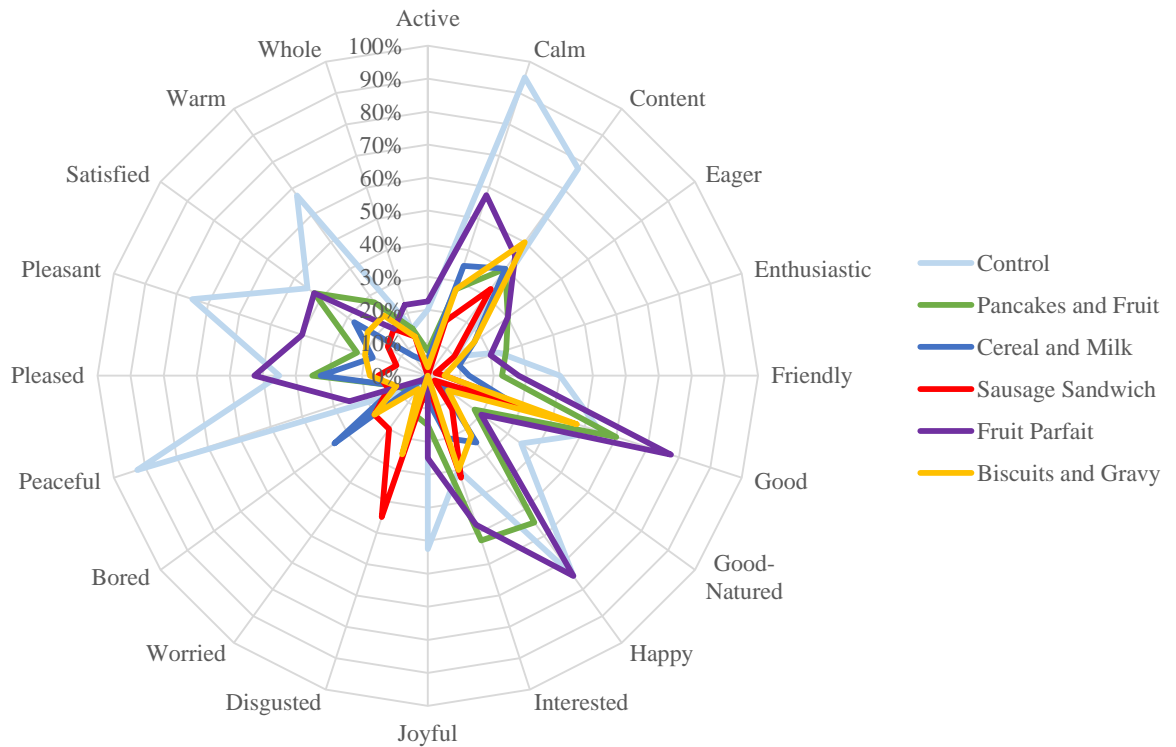


Figure 3: Percent frequency of frequently selected emotional terms for breakfast meals and the control (n=40).

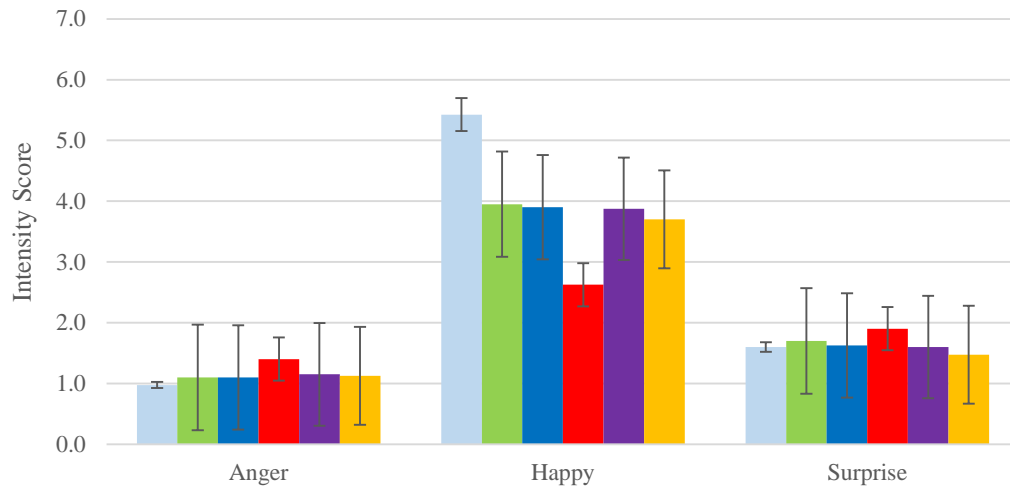
Cochran's Q analysis (XLSTAT, 2015, Addisonsoft, New York, NY) of frequently selected terms (greater than 20% selection for at least one breakfast meal) showed no differences in relative frequencies for many frequently selected emotional terms across all videos, including active, eager, enthusiastic, interested, satisfied and worried ($\alpha = 0.05$). The control was uniquely significant in relative frequency for the terms calm, peaceful, pleasant and warm. Calm was chosen more significantly for the biscuits and gravy, cereal and milk and fruit parfait breakfast

meals (27.5%, 35.0%, and 57.5% relative frequency, respectively). The test did show differences among videos for bored, calm, content, disgust, good, good-natured, friendly, happy, joyful or pleased. The fruit parfait, and pancakes and fruit breakfast meals were most similar in word choice to the control, as well as received the most approach term selection. The fruit parfait, pancakes and fruit breakfast meals, and control video were statistically similar in greater relative frequencies for good (75.0%, 60.0% and 55.0%) and happy (75.0%, 55.0% and 75.0%, respectively). Joyful was also chosen significantly more for the fruit parfait (25.0%) and control (52.5%) videos; the pancakes and fruit breakfast meal received a greater relative frequency for joyful (15.0%) compared to the others, but was not statistically significant. The fruit parfait, pancakes and fruit, and cereal and milk breakfast meals (and the control) were significantly higher in choice for the terms friendly and pleased compared to the sausage sandwich and biscuits and gravy meals (pancakes: 22.5%, 35.0%; cereal: 12.5%; 32.5%; parfait: 27.5%, 57.5%; control: 40.0%; 45.0%; relative frequency, respectively for friendly and pleased terms). Good-natured showed interesting selection; biscuits and gravy, pancakes and fruit, fruit parfait and the control had greater choice for the term than the others (7.5%, 17.5%, 20.0% and 35.0% relative frequency, respectively). Lastly, the biscuits and gravy meal was statistically similar in choice, for content, to the control and they received significantly greater selection compared to all other meals (50.0% and 77.5% relative frequency, respectively). Alternatively, two withdrawing terms were used frequently, bored and disgust. Disgust was highly and significantly chosen for the biscuits and gravy and sausage sandwich breakfast meals (25.0%, 45.0% relative frequency, respectively); while not as frequent, the pancakes and fruit breakfast meal also saw some usage of disgust (12.5%). Lastly, it is interesting to note that the cereal and milk breakfast meal had a high and significant relative frequency for bored (35.0%); the biscuits

and gravy and sausage sandwich breakfast meals has slightly lower usage of bored (20.0%, each).

The mean scores for the six basic emotion intensity questionnaire were calculated for all stimuli and each emotion and presented graphically (Figure 4). For consistency throughout reporting of implicit and explicit measures, the six terms were categorized based off emotion terminology related to physiological and neurobiological motivational behavior responses (as opposed to categorization based off of a semantic justification). Two graphs were created, the top graph illustrates felt approach (angry, happy and surprised) emotion intensities and the bottom graph illustrates felt withdrawal (disgust, sad and scared) emotion intensities. Statistical analysis results from the six basic emotion intensity rating questionnaire showed that approach terms, anger and surprise, and withdrawal term, sad, had no significant differences in intensity ratings across all videos. Differences were observed with the sausage sandwich breakfast meal. This stimuli received a significantly lower happy intensity ratings compared to all others, as well as significantly higher intensity ratings for fear and disgust emotion terms. Additionally, happy was significantly lower and fear was significantly higher for the biscuit and gravy breakfast meal. Similarly, the pancakes and fruit breakfast meal also had a higher intensity for fear.

a.) Approach



b.) Withdrawal

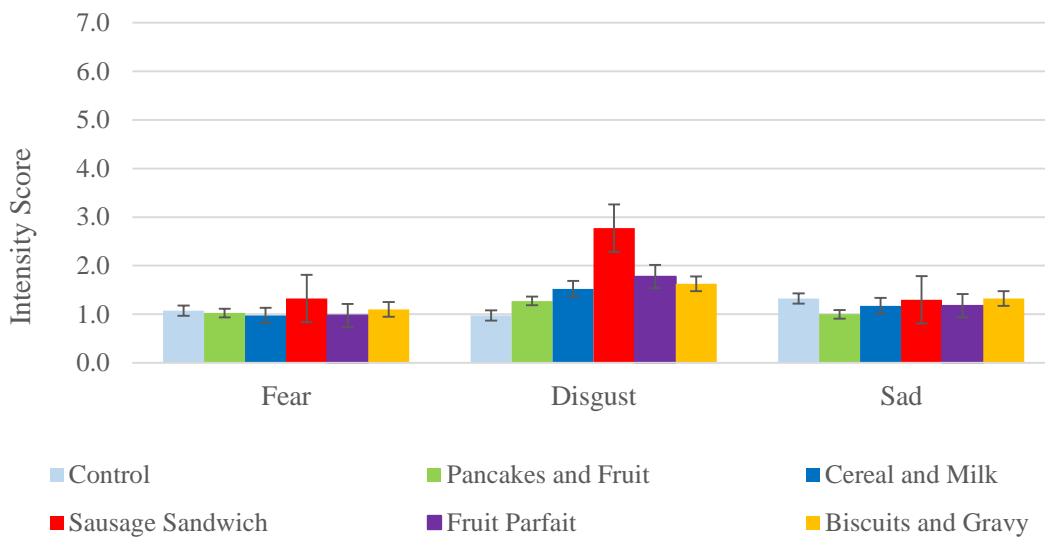


Figure 4. Intensity scores (mean \pm s.d.) for all breakfast meals and the control (n=40); a.) approach emotion term responses, b.) withdrawal emotion term responses.

3.2 Implicit Response Results.

HR (bpm) data was analyzed between each breakfast meal and the control (n=40, $p < 0.05$; Table 3). Only one stimuli, fruit parfait, elicited a significant response ($p = 0.023$) in HR comparison. We note that HR comparisons between the control and the pancakes and fruit and

the biscuits and gravy stimuli had p-values less than 0.1 but greater than 0.05. All videos showed an increase in HR for the food stimuli in comparison to the control, except the pancakes and fruit breakfast meal ($t = -1.918$).

EEG analysis of motivational behavior response was determined by finding the frontal cortex asymmetry scores for the F3/F4 electrodes. No statistical differences ($p > 0.05$; Table 4) were found between each breakfast meal. The t-statistics show direction; a negative t-statistic indicates a greater relative activation of the F4 electrode or right hemisphere of the frontal cortex. All stimuli, except the fruit parfait breakfast, received positive t-statistics, which indicate greater activation of the F3 electrode (left hemisphere). The fruit parfait breakfast meal ($t = -0.167$) showed greater right hemisphere activation although not statistically different. Additional analysis of other frontal cortex electrode pairs (F7/F8 and Fp1/Fp2), did not provide any additional information; no significant differences were seen for both additional pairs of electrodes for all stimuli (see Appendix B).

Table 4: Paired student's t-test comparison of mean heart rate (bpm) between breakfast meals and the control (n=40, p<0.05).

HR	Breakfast Meal		Control		Mean Diff.		t	p
	M	SD	M	SD	Diff.	SD		
Pancakes and Fruit vs. Control	71.28	11.082	72.63	10.660	-1.35	4.455	-1.92	0.062
Cereal and Milk vs. Control	73.68	10.906	72.63	10.660	1.05	5.633	1.18	0.247
Sausage Sandwich vs. Control	71.91	11.227	72.63	10.660	-0.72	5.868	0.22	0.443
Fruit Parfait vs. Control	74.45	10.530	72.63	10.660	1.82	4.866	2.37	0.023
Biscuits and Gravy vs. Control	74.24	10.913	72.63	10.660	1.61	5.828	1.75	0.088

Table 3: Paired student's t-test comparison of mean frontal cortex asymmetry scores (F4-F3) between breakfast meals and the control ($\alpha=0.05$).

Frontal Cortex Asymmetry Scores: F4 - F3	Breakfast Meal		Control		Mean Diff.		t	p
	M	SD	M	SD	Diff.	SD		
Pancakes and Fruit vs. Control	0.052	0.400	-0.019	0.416	0.087	0.511	40	0.868
Cereal and Milk vs. Control	0.063	0.420	-0.019	0.416	0.097	0.515	40	0.995
Sausage Sandwich vs. Control	0.014	0.347	-0.019	0.416	0.048	0.421	40	0.449
Fruit Parfait vs. Control	-0.055	0.673	-0.036	0.416	-0.021	0.730	39	-0.167
Biscuits and Gravy vs. Control	0.080	0.348	-0.036	0.416	0.115	0.480	39	1.498

Mean intensities of emotions expressed over five seconds (Table 5) and ten seconds (Table 9; Appendix B) were calculated. Within emotion and across stimuli, no significant difference in expressed emotional intensity means were found for either time duration ($p > 0.05$). Differences are seen within stimuli and across emotions for both durations, however discussion will focus on the five second analysis. Five seconds was chosen for discussion, as opposed to ten seconds (to match time series graphs), because the averages over the longer period seemed to dilute differences in the intensity of emotional response (refer to Table 9 in Appendix B). In the five second analysis, it is interesting to note that no differences in emotion expression were seen across all emotions for the control stimuli (except neutral). All stimuli received highest mean intensities for the neutral state and the expression anger as the second most intense. Aside from the neutral state, all expressed emotion intensities were statistically different from the beach scene. For three of the breakfast meals, cereal and milk, sausage sandwich and fruit parfait, the same trend occurred; anger and surprised were elicited more ($p < 0.05$) than happy, sad, surprised, scared and disgust, which saw no difference in intensity. For the pancakes and fruit breakfast meal, anger was uniquely highly expressed ($p < 0.05$). But, anger was also statistically similar to sad and surprised ($p < 0.05$), which were also considered similar in lower expression intensity to happy, scared and disgust ($p < 0.05$). The biscuits and gravy breakfast meal was similar to most other breakfast meals in that expression of anger and surprised were more intense ($p < 0.05$) than the other emotions. However, happy and scared were considered similar to expressions of anger and surprised ($p < 0.05$), but were also similar in lower intensity to scared and disgust ($p < 0.05$).

To provide further context to the mean intensities of expressed emotions, AFEA Time series graphs were completed and are represented in two panels per figure (Figure 5, a-e). The continuum of mean differences of expression intensity for each emotion is plotted between the

control and the respective breakfast meal over time (20 sec; breakfast meal - control) (Figure 5, Top Graph, Panel A). Sequential paired nonparametric Wilcoxon tests were performed between the control and the corresponding treatment to identify significant positive and negative emotional differences over time ($\alpha=0.025$ for positive and for negative differences; $n=40$). Results were summarized and plotted into time series graphs where the stimuli for each expressed emotion was of higher intensity (Figure 5, Bottom Graph, Panel B). The time series graphs illustrate where significant differences in emotion expression intensity between the control and the evented breakfast meals exist within 20 sec. In other words, these graphs (Figure 5, Bottom Graph, Panel B) are not illustrating the intensity value of the emotion expressed, but the presence (or absence) of an emotion expression intensity that is statistically significantly different in one treatment video compared to the control.

AFEA shows all breakfast meals elicited a significantly higher expression of anger (pancakes and fruit: $\sim 0 - 2, 5$ sec; cereal and milk: $\sim 0 - 10$ sec; sausage sandwich: $\sim 0 - 10$ sec; fruit parfait: $\sim 0 - 10$ sec; biscuits and gravy: $\sim 0 - 6.5; 7.5 - 10$ sec; $p < 0.05$) in comparison to the control. Sad is also identified as being significantly higher in expression for the cereal and milk (~ 2 sec), sausage sandwich ($\sim 2.5; 5.5 - 6.5; 7.8 - 8$ sec) and fruit parfait ($\sim 0 - 5.5; 6.5 - 9$ sec). Although time series graphs indicate significances of emotion expression based on an alpha of 0.05 from a statistical test, short periods may not indicate a true expression due to an insufficient duration; similarly, no difference in emotion expression can be meaningful information. In contrast, the control had significantly higher expression occurrences of the neutral state (*control comparison to*: pancakes and fruit: $\sim 1.5, 2.5, 4 - 4.5; 5 - 6$ sec; cereal and milk: $\sim 2, 4, 5.5 - 7.5$ sec; sausage sandwich: $\sim 1 - 2.5, 5.5 - 7.5$, fruit parfait: $\sim 0 - 3, 4 - 8$ sec; biscuits and gravy: $\sim 1 - 3, 5 - 7$) in comparison to all breakfast meal stimuli. Additionally, the control had unique

significant expression of happy (~1 – 2; 6.5 – 7 sec) in comparison to the cereal and milk breakfast meal.

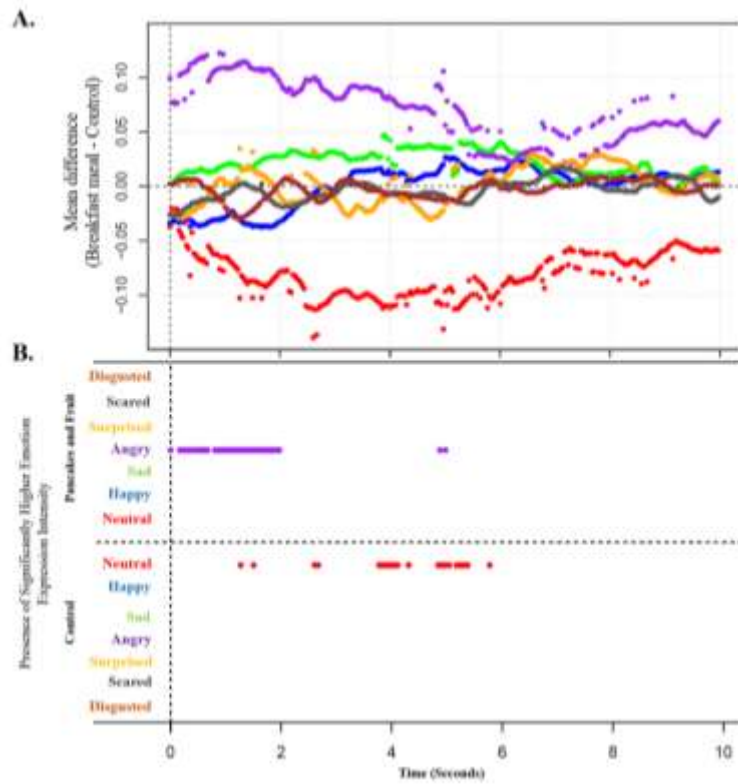
Table 5: Mean intensities (\pm s.d.) of expressed emotions identified by automated facial expression analysis and multiple comparisons within emotion and across video stimuli (five seconds; $n=40$, $p<0.05$).

Event	Neutral		Happy		Sad		Anger		Surprised		Scared		Disgusted	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Beach	0.534 ^a	0.322	0.043 ^b	0.119	0.019 ^b	0.074	0.089 ^b	0.238	0.137 ^b	0.274	0.038 ^b	0.151	0.040 ^b	0.138
Cereal and Milk	0.461 ^a	0.305	0.010 ^c	0.035	0.045 ^c	0.163	0.218 ^b	0.353	0.129 ^{bc}	0.296	0.006 ^c	0.027	0.029 ^c	0.076
Pancakes and Fruit	0.451 ^a	0.286	0.031 ^c	0.107	0.045 ^{bc}	0.165	0.180 ^b	0.317	0.126 ^{bc}	0.278	0.030 ^c	0.099	0.034 ^c	0.082
Sausage Sandwich	0.445 ^a	0.312	0.025 ^c	0.128	0.069 ^c	0.202	0.215 ^b	0.337	0.139 ^{bc}	0.292	0.009 ^c	0.048	0.033 ^c	0.105
Fruit Parfait	0.430 ^a	0.303	0.031 ^c	0.136	0.065 ^c	0.154	0.242 ^b	0.351	0.124 ^{bc}	0.290	0.015 ^c	0.067	0.024 ^c	0.073
Biscuits and Gravy	0.438 ^a	0.326	0.045 ^{bc}	0.156	0.049 ^{bc}	0.171	0.204 ^b	0.334	0.193 ^b	0.364	0.006 ^c	0.025	0.020 ^c	0.059

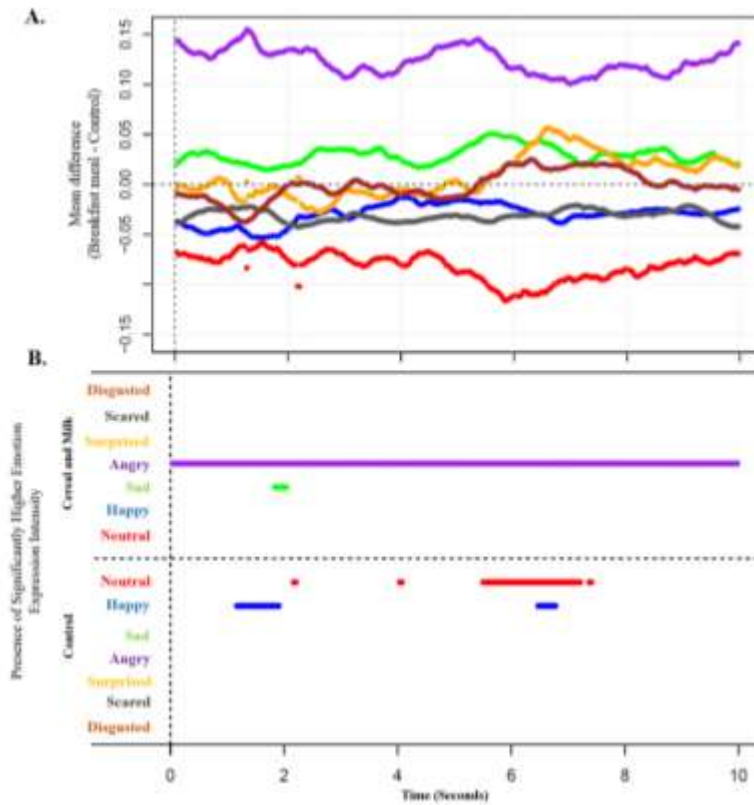
*Means within each emotion (column) had no significant differences ($p>0.05$).

^{a, b, c} Means within each event (row) with different superscripts are significantly different ($p<0.05$).

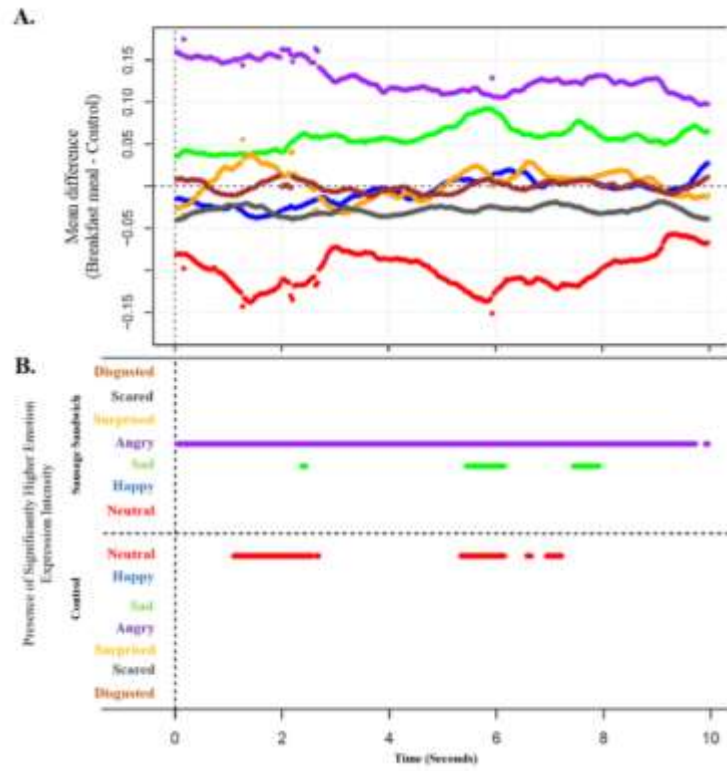
a.) Pancakes and Fruit



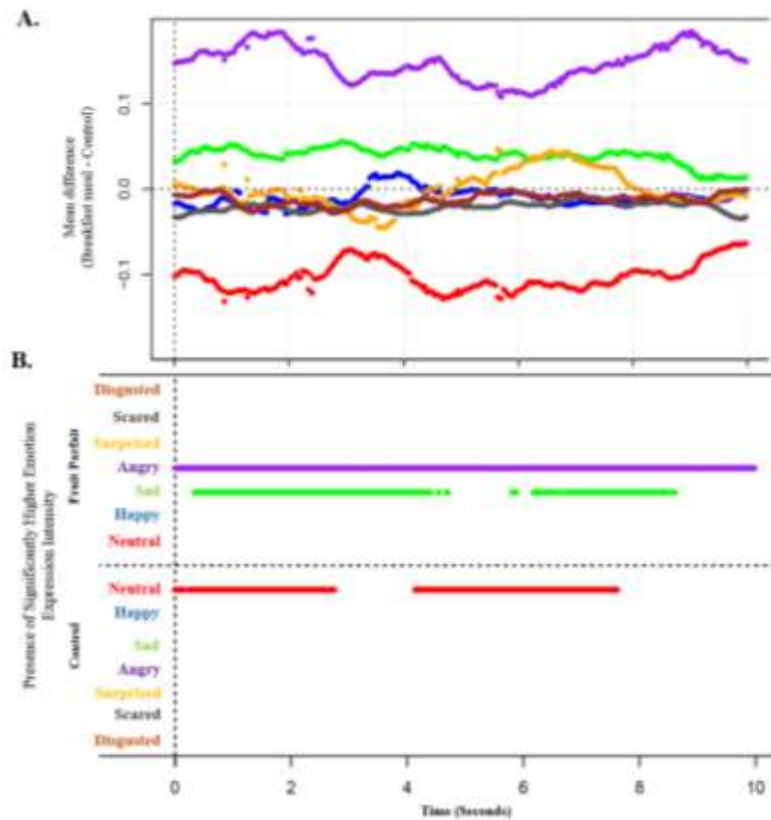
b.) Cereal and Milk



c.) Sausage Sandwich



d.) Fruit Parfait



e.) Biscuits and Gravy

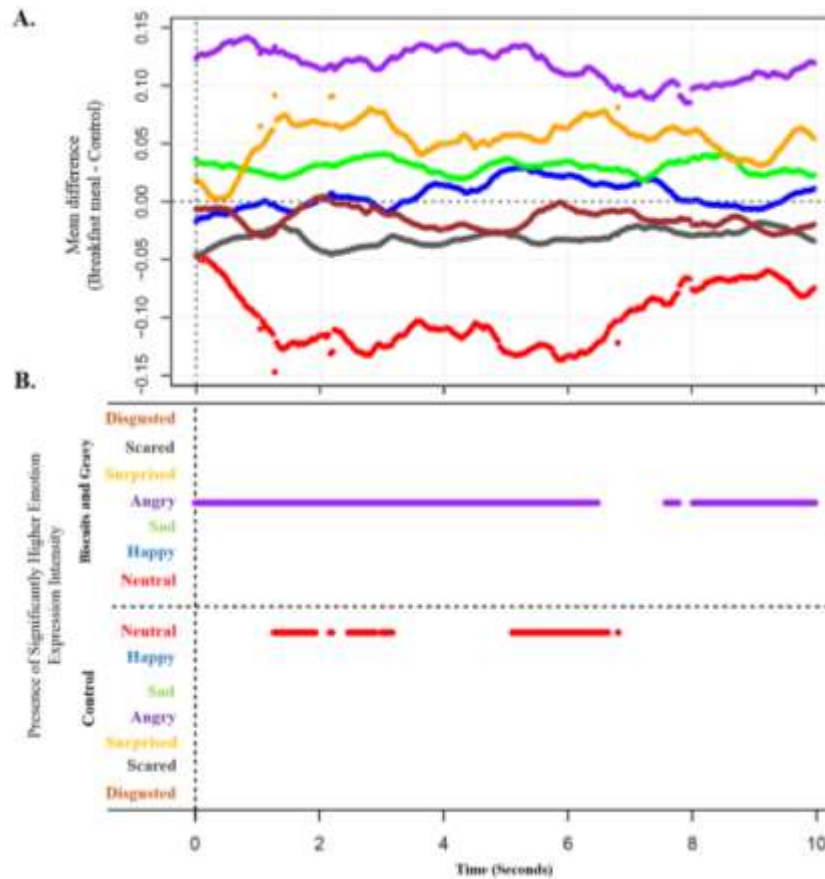


Figure 5: Time series comparison of the six basic emotions expressed and a neutral state between the five breakfast meals and the control; Top graph, Panel A: Sequential mean difference of intensities of emotion expression; Bottom graph, Panel B: Time series indicating the presence and directionality of statistically significantly greater emotion expression intensities from sequential paired nonparametric Wilcoxon tests ($\alpha=0.025$; $n=40$); a.) pancakes and fruit, b.) cereal and milk, c.) sausage sandwich, d.) fruit parfait, e.) biscuits and gravy.

4. DISCUSSION

Explicit results showed significant differences in acceptability, emotion term selection and emotion intensity ratings for the breakfast meals presented, as hypothesized. The two meals containing fruits (fruit parfait and pancakes and fruit) received significantly higher scores and more approach emotional term use (good, happy, pleased, friendly and joyful (fruit parfait only)) compared to all other meals. Interestingly, meals with lower acceptability contained meat products (sausage and bacon). With a further look into the food preference survey, this can be explained. No individuals reported disliking fruit and very few individuals disliked any specific

parts of these meals containing fruit. For example, only one participant responded with disliking everything in the pancakes and fruit meal, while only four participants liked every element in the meal except the sugar sprinkled on top. The cereal and milk stimuli received a lower acceptability score in comparison to the other non-meat containing meals; the high use of the term, bored, accompanied this response. The food survey questionnaire also presents a diverse response for the non-meat containing products. Eight participants did not like bacon and seven did not like sausage, which influenced the mean score. These preferences support the lower mean hedonic scores for the sausage sandwich and biscuits and gravy meals, as well as the differences in emotion terminology and emotion intensity scores. Disgust was used significantly for the sausage sandwich and biscuits and gravy meals (as well as the pancakes and fruit). The mean intensity score for disgust was significantly higher for the sausage sandwich breakfast meal, as well as happy was observed as significantly lower in intensity. It is interesting to note that the term content was significantly higher in selection for the biscuits and gravy breakfast meal. No other explicit measures, hedonics or emotion intensity, support this finding, bringing to question the meaning of this word to the participants. In the preference questionnaire, a greater difference in number of individuals disliking the entire sausage sandwich meal (10) in comparison to the biscuits and gravy (5) could be an indication that the meal is meeting a satisfactory standard. This would explain a higher use of the term, content; however, the positive valance to the definition of content and the option for selecting the term, satisfied, provides further question. Interestingly, the pancakes and fruit meal, received some disgust usage (12.5%, not 'frequently used'), but had a very low number of individuals disliked the entire meal (1); looking closer at specific attributes of the meal, butter was not liked by some participants (6), in addition to the four participants that did not like the powdered sugar. This illustrates the

importance of reviewing every attribute of a meal for a complete understanding of a food experience. Emotional terminology usage, intensity ratings and food preference questionnaires provided further depth and context to a simple acceptability rating.

Explicit emotional response questionnaires have been shown to add value to more traditional affective measures through their discriminating capabilities (Jiang et al., 2014; Ng et al., 2013). Although the aim of this study was for understanding approach-related positive food experiences, there are some common limitations between the types of studies that must be addressed. First, the type of stimuli and specific research question make a great difference in the words that should be included in the list. For example, unequal approach/withdrawal (or positive/negative) terms can unintentionally skew the result (Chaya, Pacoud, Ng, Fenton & Hort, 2015; Meiselman, 2015; Ng et al., 2013). Without a variety of words to describe the different intensities of possible emotions felt, a lack of suitable terms can lead to miscommunication. Specifically for this study, all meals were intended to produce a positive/neutral reaction, while negative responses would result from preference, not from revulsion. Thus, with disgust being one of the few withdrawal terms, a participant whom may dislike or simply does not care for a particular breakfast meal, is forced to respond with the strong word, disgust. Options for expressing feelings that are more neutral or have a slight negative connotation were missing. This limitation may explain why the term disgust was used for the sausage sandwich, biscuits and gravy and pancakes and fruit breakfast meals. As previously discussed, with the help of the food preference survey the disgust emotion usage was identified as being related to dislikes within the meals. More variety of emotions with negative valence would have likely made the explicit responses different. It is important to research and develop the proper term list for the

research question to prevent biased results, and for the same purpose, to thoroughly investigate the participants of interest for the study.

Past experiences, memories, frequency of consumption/exposure to food, physical or nutritional state, cultural importance and other personal characteristics/preferences can all influence one's responses to food (Desmet & Schifferstein, 2008; Jiang et al., 2014). Diligent care was taken in exclusion criteria (eyewear, facial hair, handedness and education background) so loss of motor expression, EEG, and ECG data could be minimized; however, controls for personal trait influences were not considered. More conclusive results for both explicit and implicit responses may be found when considering participant individuality of responses to food. This may be addressed by grouping more common backgrounds, acceptability ratings or consumption patterns together. However, the generality of individuals participating in the experiment was an effort to further develop the basic understanding of pleasurable food experiences when combining explicit and implicit responses in a broad population.

Implicit measures, AFEA, HR and frontal cortex asymmetry, did not show differences in emotional and motivational behavior tendencies compared to the beach scene, as hypothesized. The beach scene stimuli was incorporated into the design to relax and return participants to a common neutral state between emotional stimuli. However, when reevaluating the affect the beach scene had on the participants' experiences, it was concluded that it had an unintentionally greater positive and approachable influence, as opposed to the predicted neutral affect. As the beach scene was chosen for comparison to the food videos, some positively valenced approach reactions may be lost when analyzing the results of the meals due to the similarity in responses. The beach scene was originally chosen for comparison as opposed to the baseline measurement (eyes open) because the beach scene was a visual video stimuli and could be directly compared

to the food videos. Because of this unintentional affect, further exploration of a better control video is needed. Water pouring into a glass may be a suitable neutral video to be used as a control for beverage video comparisons. However exploration into a suitable control for food comparisons may be a greater challenge.

Time series analysis of AFEA (Figure 5, a-e) showed significantly greater occurrence of the anger expression for all breakfast meals compared to the beach scene control. However, ANOVA analysis (Table 5) determined no significant differences in anger (or any other emotion) expression intensity across all stimuli. The ANOVA results (5 sec), illustrate that even though there are differences of expression occurrence over time, as seen in the time series graphs, the time series analysis may not be an indication of a true facial expression in overall assessment of the emotional moment (also see Appendix B for the ANOVA results at 10 sec). Similarly, the cereal and milk, sausage sandwich and fruit parfait breakfast meals, all elicited significant sad expressions compared to the control. The ANOVA analysis found no significant differences for the emotion across breakfast meals. The significantly low value of expression intensity for sad may be a limitation of the statistical test chosen. Because the values are very small and there is wide variation among the participants, the significant presence of the sad expression observed in the time series graphs, may be irrelevant or unseen in the overall facial expression assessment (explicit results also did not find anger or sad to describe the breakfast meals). This is likely a limitation of the software labeling an emotion as pure when a mixture of motor expressions are presented and the emotion displayed (or felt) was not one of the six basic emotions. Although, a greater incidence of neutral for the control was observed in the time series report, ANOVA results show each videos' neutral expression intensity as similar ($p < 0.05$). Thus, as previously discussed, there are limitations in both methods. With the times series analysis, determining

greater presence of emotion expression through intensity scores may indicate a greater expression of an emotion in comparison to the other stimuli (control). However, this may not be significant in comparison to the presence of other emotions or in the overall emotional experience. At the same time, finding the mean intensity of each emotions over five seconds (or 10 sec) may convolute the results by assigning an overall expression intensity when emotion can change and evolve dramatically over a few seconds. Although inconsistencies in the statistical analysis exist, what may be more telling is the absence of significant differences in the time series. This would indicate that emotions are similarly expressed over time between the control and the breakfast meals; disgust, happy, scared, and surprise were not observed as different. This observation is supportive of other research describing the difficulty of expressing positive responses on the face (Danner et al., 2014; de Wijk et al., 2012; de Wijk et al., 2014; Wendin et al., 2014; Zeinstra et al., 2009). No difference in terms happy and surprise is an indication that the beach scene elicited similar approach motivational behaviors over time, similarly found in response to pleasurable meals. In this same manner, no difference in disgust and scared in the time series indicates these withdrawal emotions are also similarly observed overtime between the control and breakfast meal. The inconsistencies in AFEA results render further exploration on the accuracy of the tool and the methods used to analyze AFEA data collected.

HR analysis saw little significant differences, consequently, direction of HR responses is likely to provide more telling information. However, inconsistent patterning causes some uncertainty; evidence for HR responses were supported by both arousal influences, as well as by specific emotion. All breakfast meals, except the fruit parfait, saw no significant differences in HR. Additionally, all food stimuli, except the pancakes and fruit, saw an increase in HR in comparison to the control. This is concurrent with a study by de Wijk et al. (2014), who found

consumed 'liked' foods to be associated with an increase HR. When considering t-values, it can be seen that the sausage sandwich had lowest influence on HR ($t=0.222$) and was also the least liked food stimuli (3.8 hedonic score). Furthermore, the biscuits and gravy, and cereal and milk breakfast meals received similar lower acceptability scores (4.4 and 4.7, respectively) and also showed similar slightly increased effects on HR ($t= 1.748$; $t=1.176$, respectively); while the fruit parfait was most well liked and caused the greatest increase in HR ($t=2.366$). Although the pattern seems true with most stimuli, inconsistency in the findings occurs with the pancakes and fruit breakfast meal. This meal was similarly liked to the fruit parfait breakfast meal, however, the HR response was in the opposite direction ($t=-1.918$). Another study on odors (He et al., 2014) found that 'liked' samples decreased in HR. This discrepancy provides an interesting question as to if the response is elicited by a preference or liking, or if it is elicited by an emotion. The results continue to the debate of whether ANS responses are related to arousal or if they are truly emotion specific (Kreibig, 2008). Literature on emotion specificity of ANS responses describe an increase in HR is most often associated with the positively valenced terms, happy and joy, as well as surprise, but also the negatively valenced term, disgust (contamination) among others. A decrease in HR has been associated with positively valenced terms, contentment (visual) and anticipatory pleasure, as well as non-crying and acute sad (Kreibig, 2010). Thus, not only is the source of the response (arousal or emotion) a question, slight differences in the connotation of the emotion makes a large difference in directionality even if their valence is the same direction. Based on emotion as the source, and the degree of liking as an indication of the direction of response, it can be said that the decrease in HR for the fruit parfait breakfast meal is due to content and pleasure feelings, while the degrees of acceptability for the remainder of the meals is indicative of the extent of happiness, joy and possibly, surprise

the participants experience. Another possible driver of the increases in HR is disgust. Disgust was chosen for the sausage sandwich and biscuits and gravy breakfast meals (45%, 25% relative frequency, respectively), which may relate to increased HR resulting from viewing both meals. It should be noted that disgust was chosen for the pancakes and fruit breakfast meal, but at a much lower frequency (12.5%). It is likely this response was lost due to the otherwise positive responses seen in the explicit results. Although some findings can be argued, the uncertainty of how to interpret the HR responses renders the results as inclusive. Further exploration to understand the source of ANS responses in food-related studies is needed to truly understand the workings of and differences in responses between stimuli.

Implicit measures of emotional and motivational behavior tendencies using EEG did not provide the hypothesized responses. No significant differences were found between the breakfast meals and the control. Direction may reveal important information on the motivational behavior tendency. Direction of the t-statistics were all positive, except for the fruit parfait breakfast meal. A positive sign represents an activation of the left hemisphere, which is an indication of an approach response (Coan & Allen, 2004). It was hypothesized that frontal cortex asymmetry scores would reflect small differences in explicit responses. However, as all the food experiences analyzed were essentially positive (no food concerns or other withdrawing elements were present), having no reflection of the differences in acceptability, emotion terms chosen or intensity of emotions in the EEG data, produces concern for applying the technique in food research. Food videos may not be stimulating enough to see a response in brain activity or the technique is not sensitive enough to detect small differences in preference of pleasurable meals. Because food is an everyday time, in comparison to stimuli used in psychology literature, the stimuli used in this research may not be detectable using the current techniques.

Additionally, the earlier discussion about terms such as the withdrawal term, disgust, being too severe in meaning for differences in taste, is further evidence that the term list was not suitable for comparing explicit and implicit responses. The sausage sandwich breakfast meal had the smallest positive t-value ($t=0.449$); although this positive sign indicates activation of the left frontal cortex, the small value could be an indication of a decreased approach (or even a greater withdrawal) motivational behavior in comparison to the other videos. This belief is supported by the greatest disgust term choice, highest intensity of self-reported disgust, and lowest acceptability score for the sausage sandwich breakfast meal. The majority of frontal cortex asymmetry responses showed approach motivational behavior tendencies which is arguably expected. The negative sign for the t-value for the fruit parfait breakfast meal ($t= -0.167$, right frontal cortex activity) provides concern because this stimuli received the highest hedonic rating, the most approach term usage, as well as was the only stimuli to have a significant HR response. The inconsistent pattern and no significant differences in frontal cortex asymmetry leads to unsupportive findings and lends further discussion of the study's limitations.

A potential limitation of the study was the stimuli used. Although, food can be emotional (Desmet & Schifferstein, 2008), it is debatable whether the nature of the video media was able to elicit the implicit response expected or if the measures were sensitive enough to detect differences. A study by Fernandez et al. (2012) found that ANS measures (HR and skin conductance) were able to detect discrete emotional responses with video stimuli. However, a real life food experience not only stimulates the visual sense, but also the other senses, smell, taste and touch. The explicit measures reported in the current study confirm that participants had emotional experiences and differing feelings, but it is unclear if the measurements are sensitive to the small differences in pleasurable meal experiences in solely a visual medium. This

supported by a study by Danner et al. (2014), who found that although differences in acceptability were obvious, ANS (HR, pulse volume amplitude, skin conductance level and skin temperature), AFEA and acceptability results were weakly linked and they rendered the implicit measures as unable to effectively determine related valence differences. Another limitation is highlighted by Berkman and Lieberman (2009), who describe the importance of standardization of stimuli for equal perception and attention. In the current study, the setting of the video and the general actions of each stimuli were similar, but no preliminary tests for coloring, brightness, contrast, resolution and size were made (Berkman and Lieberman, 2009). Prescreening the stimuli would have helped alleviate concerns for the effectiveness of the videos. Another important point of discussion is analysis methodology. As previously noted, it is debatable if the beach scene was the best choice for comparison. It may be argued that the true baseline should be used as the control for determining the motivational behavior responses. However in an effort to create a more cohesive analysis, direct comparison between two video stimuli was determined as a more accurate evaluation for the data collected in this study. Additionally, as one of the few studies in food science literature using ANS measures and the first using EEG, this study took a traditional approach from established psychology literature to determine emotional and motivational behavior differences in positive food situations. A recent study by Valenzi, Islam, Jurica and Cichocki (2014) argues for a nontraditional method using a more individualistic approach to analyzing EEG, as opposed to looking at a large sample size. As all individuals respond to stimuli differently, one of the next steps to advancing this work would be use an analysis method that specifically controls for individual differences. Even though, limitations exist and the findings of this study were inconclusive, this was the first endeavor to integrate

methodologies of implicit and explicit measures in food science research for enriched consumer insight knowledge and provide a starting point for further research.

5. CONCLUSION

This study was intended to evaluate the use of implicit and explicit responses to different pleasurable breakfast meal experiences in order to better understand emotional and motivational behavior responses. In sensory science, combining measures of physiological and neurological (implicit) responses with cognitive (explicit) assessments is a rapidly growing research area. The results of this study suggest current implicit measures provide minimal supportive information for explicit emotional measures. Further investigative research on standard method development for food stimuli, endeavors to validate results and improvements to individualize analyses are a few obstacles that warrant attention for the advancement of this body of work. Once these challenges are overcome, an understanding of emotions and motivational behaviors to food will be a great asset for not only for food companies, but for food service and restaurant establishments, for enhancing their knowledge of how to create positively approachable and pleasurable food experiences.

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CHAPTER 6: CHARACTERIZING EMOTIONAL RESPONSE AND VISUAL ATTENTION TO FOOD SAFETY AND QUALITY CONCERNS

ABSTRACT

Food spoilage, safety, and hygienic concerns influence emotional response to well-liked foods, both packaged and prepared. In a previous study (chapter 4), a comparison of emotional responses to videos containing food-related quality and safety concerns were evaluated. The current study was designed to determine if visual attention and fixation, in combination with explicit emotion assessment, provided evidence of visual observation of the concern and related emotional withdrawal response to these same videos. A set of videos included a control (no event) and an evented video (included food concern). Nine participants (n=9; male=6) watched the matched videos with eye-tracking software recording attention and fixation measures. Participants provided self-report of acceptability (1= 'dislike extremely'; 7 = 'like extremely'), emotional response (list of Check-All-That-Apply emotion terms, n=43) and intensity of the six basic emotions (1= "not at all," 7= "very much") immediately following each video. Analysis showed that average hedonic scores decreased greatly for the evented spoilage, hygiene, and safety videos compared to their matched control videos (spoilage: 1.7, 5.0; hygiene: 3.5, 6.5; and safety: 2.2, 4.2; respectively). Emotional responses showed a greater than 20% frequency usage for the terms angry, disgusted, sad, and worried for all evented videos, while the terms calm, content, good, happy and interested were frequent for all control videos. Even though acceptability and emotion term selection were congruent with the previous study as well as indicated the observation of the concern, key performance indicators of attention showed

participants focus was dependent on the type of breakfast meal shown. This study suggests that indirect observation of food spoilage, safety or hygiene concerns can create emotional withdrawal.

KEYWORDS

Emotion, eye-tracking, meals, safety, spoilage, hygiene

1. INTRODUCTION

Maintaining food sensory and hygienic quality is important for retaining consumer motivation and commitment to food brands (Wardy, Sae-Eaw, Sriwattana, No, & Prinyawiwatkul, 2015). Perception of safe and wholesome foods is an important aspect of consumer confidence and trust in a food brand (Lassoued & Hobbs, 2015; Wardy et al., 2015). Food quality and safety attributes have primarily been evaluated based on analytical measurements of sensory criteria and chemical and microbiological standards. However, consumers rely on their food experience, memories and feelings to make these assessments (Jiang, King & Prinyawiwatkul, 2014; Olsen, Rossvoll, Langsrud & Scholderer, 2014; Piqueras-Fiszman & Jaeger, 2015). The relationship of consumer emotional response to foods with apparent visual quality, hygiene or safety concerns has not been well studied. Such problems in packaged food or prepared foods, especially in food service settings, may create emotional responses that cause loss of trust and emotional withdrawal, thus leading to declining product sales, loss of brand loyalty or product market failure.

Visual observation of the problem is the first cue consumers use to determine if a food might be consumed. Visual cues are even referred to as the “first taste,” emphasizing vision’s importance in a food experience (Jantathai, Danner, Joechl & Durrschmid, 2013). Self-reports of an observation are often used for validating the existence of a problem (Manzocco, Rumignani & Lagazio, 2013). However, there is the potential that indirect awareness, or passive information acquisition, is a result of variances in attention which may affect down-stream implicit (unstated) emotional response and subsequent self-report of liking, as well as perception of quality and safety (Olsen et al., 2014; Orquin & Mueller-Loose, 2013).

Visual attention and focus can be studied using eye-tracking technology. This approach is frequently used for research studies in neuroscience, marketing and advertising, psychology, computer science and transportation (Duchowski, 2002). Successful marketing utilizes media with “attention grabbing” or visually salient characteristics. Combinations of color, contrast, texture and location of characteristics are used to capture the attention and evoke emotion from the viewer (van der Laan, Hooge, Ridder, Viergever & Smeets, 2015). Attention, or the awareness of something, is described as bottom-up or top down attentions (Orquin & Mueller-Loose, 2013; van der Laan et al., 2015). Bottom-up attention explains the success of advertisements. This type of attention is described as a stimulus-oriented or as containing visually salient characteristics to capture the first attention and hold a greater fixation (Orquin & Mueller-Loose, 2013; van der Laan et al., 2015). In contrast, top-down attention is described as goal-oriented; previous knowledge, preferences or goals can influence one’s attention and fixation behaviors (Orquin & Mueller-Loose, 2013; van der Laan et al., 2015). Eye tracking technology may be useful for understanding consumer food choice and behaviors by observing visual attention to food and food stimuli (Doolan, Breslin, Hanna, Murphy & Gallagher, 2014). This technology may also be useful for characterizing whether visual cues inferring problems with food quality and safety attract attention and influence emotional responses.

Studies of emotions in relation to food acceptance are proving to be insightful for understanding individual responses to food (Jiang et al., 2014; King, Meiselman, & Carr 2010). With the expectation of a few studies, emotions research in food science literature is limited to written and verbal measures of emotions. However, the network of emotional response to food is complex. Emotions are influenced by a variety of factors including the environment, health status, goals, past experiences, social/cultural constructs etc., rendering traditional measurement

methodologies insufficient for the complexity of the emotional response (Jiang et. al, 2014; Fontaine, Scherer, Roesch & Ellsworth, 2007). Food scientists studying emotions have just begun to delve deeper into the psychology of emotions by incorporating more advanced physiological and neurological measurements of implicit (unstated) emotions (Danner, Sidorkina, Joechl & Duerrschmid, 2013; Danner, Haindl, Joech & Duerrschmid, 2014; de Wijk, He, Mensink, Verhoeven, & de Graaf, 2014; de Wijk, Kooijman, Verhoeven, Holthuysen, & de Graaf, 2012; He, Boesveldt, de Graaf & de Wijk, 2016; Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015; Walsh, Duncan, Potts, & Gallagher, 2015; Walsh, 2016).

Eye tracking is a rapid qualitative indication of implicit (unstated) behaviors through the monitoring of one's visual processes (Duchowski, 2002; Graham, Orquin & Visschers, 2012; Rebollar, Lidon, Martin & Puebla, 2015). Although eye movements can be cognitively controlled, attention may not be conscious (Duchowki, 2002; Mawad, Trias, Gimenez, Maiche & Ares, 2015; Mitterer-Dalton, Queiroz, Fiszman & Varela, 2014). Fixation patterns and individual differences in processes that acquire and interpret visual information can be predictive of choice. In a recent food study on yogurt labels, eye-tracking software for monitoring vision processes found individuals with different cognitive styles (field independent or dependent) spent different amounts of time fixated on different elements of the stimuli (Mawad et al., 2015). Field independent individuals focus less on peripheral information and spend more time processing salient visual information (Mawad et al., 2015). These individuals sustained their attention and thus more thoroughly evaluated the visuals (longer fixations), whereas field dependent individuals spent less time fixating on the visuals of interest, providing difference importance to nutrition information in shaping both groups' choice behavior (Mawad et al., 2015). This is an important finding for food and sensory scientists and marketing departments to

be aware of when developing and advertising products and may be important for relationships to packaging and product integrity. Application of eye-tracking technology for collecting data on attention and fixation patterns can provide important information on how consumers form preferences to their products and ultimately develop eating behaviors (Mawad et al., 2015). Potentially influential vision behaviors related to consumer choice are first fixation and fixation duration (Armel, Beaumel & Rangel, 2014; Jantathai et al., 2013; van deer Laan et al., 2015). First fixation may be motivated by visual saliency in a decision process; meaning important information to the individual is often observed first, which in turn effects the perspective of the subsequent observations. Although, first fixation may not be directly related to personal preference, a fixation is likely to influence the individual's choice by leading to the incorporation of the fixation within the pool of options; providing an additional choice that may have otherwise been excluded from the preference evaluation (Orquin & Mueller-Loose, 2013). At the same time, fixation duration, the length of time spent observing the stimuli, has also been found to influence decision making. By increasing exposure, more time is spent computing the stimuli, which then can lead to value changes that affect the decision made (Armel et al., 2014; Jantathai, et al., 2013). Evaluation of fixation and attention behaviors to food through eye-tracking may reveal additional information about consumer consumption behaviors and food choices (Doolan et al., 2014; Orquin & Mueller-Loose, 2013, van deer Laan et al., 2015).

Recently published eye-tracking studies in food science literature focuses on how visual attention, measured through eye movement, influences nutrition and health perception. The majority of published studies have objectives that assess consumer attention and understanding of nutrition labels (Antunez, Gimenez, Maiche, Ares, 2015; Antunez, Vidal, Sapolinski, Gimenez, Maiche, Ares, 2013; Graham & Jeffery, 2011; Graham & Jeffery, 2012; Graham et al.,

2012; Mawad et al., 2015; Ares, Mawad, Gimenez & Maiche, 2014; Piqueras-Fiszman, Velasco, Salgado-Montejo, & Spence, 2013; Siegrist, Leins-Hess & Keller, 2015; Vidal, Antunez, Sapoliniski, Gimenez, Maiche & Ares, 2013), overweight/obese populations (Doolan et al., 2014) and healthy versus unhealthy foods perception (Mitterer-Dalton et al., 2014 Velazquez & Pasch, 2013), with a few exceptions. One exception includes a study from van der Laan et al. (2015), who studied how manipulating fixation points prior to stimuli observation influenced consumer choice and preference. The researchers found that the length of total fixation was associated with food preferences and goal-oriented food decisions (van der Laan et al., 2015). van der Laan et al. (2015) argued that if attention is retained then a fixation duration will be longer and influence preference. In a color quality study, Jantathai et al. (2013) found that gazing behaviors, fixation count, and duration were positively associated with food choice. However, in opposition to these studies, Haindl & Dürschmid (2010), found that food with visual spoilage have stronger attention-grabbing properties than similar fresh food visuals. To further emphasize the significance and complexity of attention, a study on food packaging discusses there are two types of visual patterns to consider when assessing attention: (1) the most important elements to the viewer are seen first, followed by lesser significant elements; and (2) the western system where vision pathways follow a top left to bottom right pattern (Rebollar et al., 2015). On the other hand, another study found attention to related to the degree of attractiveness (greatly attractive or unattractive) to be most influential in attention patterning (Haindl & Dürschmid, 2010). Similar to emotional response, many elements ranging from environmental cues, personal motivations, culture and previous knowledge can affect attention behavior and should be taken into consideration when interpreting eye-tracking results.

Understanding emotional response to product integrity challenges (quality, safety) has received little attention. Understanding food attributes that may cause unwarranted emotional “side effects” to a particular product is important knowledge for food companies (Desmet & Hekkert, 2009). This information is particularly significant in marketing and product development phases, to reduce negative emotions that may impact user satisfaction and acceptance, brand loyalty, and purchasing behaviors (Desmet & Hekkert, 2009; Hobbs & Goddard, 2015; Lassoued & Hobbs, 2015; Wardy et al., 2015). Subtle problems in food quality or perception of food safety problems, that only passively capture one’s attention, may influence consumer acceptability and choice. Such challenges occurring in packaged foods or in food service settings may create an emotional withdrawal even when the problem may not be cognitively recognized. The goal of this study was to determine if visual attention and fixation, in combination with measures of explicit emotion, provided evidence of emotional withdrawal to food quality (spoilage, hygiene) and safety concerns and affected acceptability. We determined if participants directly viewed stimuli of concern and assessed visual processes might indicate influences on emotional response and acceptability.

2. MATERIALS AND METHODS

2.1 Participants and Human Subjects Approval



Approval was granted from the Virginia Tech Institutional Review Board (IRB #14-020). Informed consent was obtained prior to any tasks. A total of nine persons participated (average age 21.1 years, n=9, male= 6). Participants were prescreened and asked to refrain from participating if: (1) they were less than 18 years old; (2) they participated in a related study offered previously; (3) they studied food science, nutrition or another related field; (4) they had




excessive facial hair; or (5) wore glasses or contacts. All participants reviewed and signed an informed consent form and permission for video capture prior to beginning the study.

2.2 Video Stimuli: Food Hygiene, Safety, and Quality

Eight different color videos (averaging 40 seconds) from the previous research project (Walsh, 2016) were used as stimuli. Three food meal videos, containing emotion-eliciting events (food hygiene quality, food spoilage quality, food safety concerns), were matched with their nearly identical control (no concern) videos. Two (unmatched) videos were used as distractor videos and intended to prevent anticipation and video pattern learning. For further details on the production and descriptions of the videos see Walsh (2016), *Chapter 4; Video Stimuli: Food Hygiene, Safety and Spoilage*. Videos are described in Table 1.

Table 1: Image representation of control breakfast meal and distractor videos, and a description of the corresponding “evented” videos presented.

Stimuli Type	Control: Example Image	Evented Description
Emotional Evaluation Stimuli	a. Milk and cereal 	Food spoilage quality concern: Poor product quality from bacterial fermentation; curdled milk chunks pour out of milk package onto the cereal.
	b. Pancakes and fruit 	Food hygiene quality concern: Poor product quality from improper food handler hygiene; a hand pulls a contaminating hair out of the syrup in a stack of pancakes and fruit after the pancake bite is picked up by the fork.

	<p>c. Sausage sandwich</p> 	<p>Food safety concern: Improper preparation for food safety; the red color of raw meat is visible when the cut sandwich is turned toward the viewer.</p>
<p>Distractor Stimuli</p>	<p>d. Yogurt and fruit parfait</p> 	<p>No concerning event</p>
	<p>e. Biscuits and gravy</p> 	<p>No concerning event</p>

2.3 Explicit Measures

Data was considered as explicit when participants used thought and/or reason to make a cognitive effort to record their response. Explicit responses measured included acceptability scores, check-all-that-apply (CATA) emotional terminology selection (EsSenseTM Profile; King & Meiselman, 2010) and an emotions rating scale for each of the six basic emotions (Ekman, 1999; Ekman, Friesen, O’Sullivan, Chan, Diacoyanni-Tarlatzis, Heider, Krause, LeCompte, Pitcairn, Ricci-Bitti, Scherer, Tomita, & Tzavaras, 1987; Prinz, 2004). Acceptability was rated on a 7-point hedonic scale (1= “dislike extremely;” 4 = “neither like nor dislike;” 7= “like extremely”). The CATA emotional terminology questionnaire (EsSenseTM Profile; King &

Meiselman, 2010) was modified to a list of 42 terms as described by Arnade (2013). Each of the six basic emotions were rated on a 7-point intensity scale (1= “not at all;” 7= “very much”) for the basic emotions of happy, sad, surprised, angry, disgusted and fearful. All questionnaires were completed after watching each food video. For an overview of explicit measures see Walsh (2016), *Chapter 4: Explicit Measures*.

2.4 Eye-tracking

Eyes were tracked using the SMI iViewX Eye system Version 2.4.31 (SensoMotoric Instruments GmbH; Teltow Germany). The SMI Experiment Suite™ 360° (SensoMotoric Instruments GmbH; Teltow Germany) software program was used to mediate the video presentations. Software also allowed video recordings to be taken as a precaution for the need to review participants’ individual session.

2.5 Study Design and Testing Procedure

Individual appointments were scheduled for each participant (n=9) in the Visionarium at Torgersen Hall (Virginia Tech, Blacksburg, VA). Upon consent, participants were seated at a desk with the eye-tracking computer monitor. Each individual was calibrated to the eye-tracking monitor through a pupil tracking task and body position adjustment indicators to make certain participants were readable for the software. Each participant observed all eight videos. A moderator controlled the start of each video, allowing for each participant to have as much time as needed to fill out the emotional questionnaires between videos. Control videos were always shown before the evented video within each set of food concerns (safety, hygiene and quality). Distractor videos were always placed between video sets. This presentation scheme was an effort to reduce repulsion to control videos, reduce anticipation and expectation bias, and mimic

procedures of the previous study (Walsh, 2016) as closely as possible. Video sets were shown in random balanced order.

3. DATA ANALYSIS

3.1 Explicit Measures Analyses

CATA emotional terminology, hedonic scores and the six basic emotion intensity scores were tabulated in an electronic spreadsheet (Excel 2013, Microsoft Corporation, Inc., Redmond, WA). For each stimuli, normality of acceptability scores was determined using the Shapiro-Wilk Goodness-of-Fit test (JMP Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC). Means, confidence intervals and median hedonic scores calculated (Table 3). A comparison of mean hedonic scores using Tukey-Kramer test determined the significance ($\alpha = 0.05$) between control and evented videos. Mean hedonic responses were graphed (Figure 1). Although, statistical analysis was completed for acceptability scores due to a small sample size the significance of the analysis is limited; these results should be used as an indication of differences that may be seen in a larger population.

Initial CATA emotion terminology sorting was based on frequency of selection of emotion terms. Terms that were not selected by at least 20% of participants for at least one breakfast meal were removed from further analysis (King & Meiselman, 2010; Arnade, 2013). Spider graphs present the percent frequency of choice for frequently selected emotional terms (Figure 2). Although a Cochran's Q test might typically be applied to provide statistical evidence for differences in emotions, the small sample size ($n=9$) limited the value of statistical analysis on the CATA emotional term questionnaire.

The mean scores for the six basic emotion intensity questionnaire were calculated for all stimuli and each emotion and presented graphically (Figure 3) to illustrate felt intensities of approach (angry, happy and surprised) and withdrawal emotions (disgust, sad and scared). No further statistical analysis was completed due to the small sample size; typically a Tukey-Kramer test is completed to assess significance.

3.2 Eye Tracking Analyses

Analysis of eye movement was performed using BeGaze™ (SensoMotoric Instruments GmbH; Teltow Germany; BeGaze 3.5.74, Teltow, Germany). The Dynamic Area of Interest (Dynamic AOI) analysis used the editing function, Move & Morph™ (SensoMotoric Instruments GmbH; Teltow Germany; BeGaze 3.5.74, Teltow, Germany), to identify objects based on the content and the food concern in each video. Identified objects were manually outlined for the entirety of the video. In order to locate and adjust the markers to the movements of each object, frame by frame editing of each outlined object was completed (Figure 4). For example in the cereal and milk breakfast meal, as the spoon moved towards the camera, the outlined markings moved tightly around the object; the cereal and spoon objects were identified similarly in both the control and evented videos. Dynamic AOIs were matched similarly in each video set; for example, two areas with visible fresh milk in the control video and two areas with curdled milk in the evented video were identified. Eye tracking software calculated six Key Performance Indicators (KPIs): the sequence of viewing, entry time (ms), dwell time (ms), number of revisits, the average fixation (ms), and the first fixation duration (ms) for the Dynamic AOI analysis. Table 2 contains short descriptions of each KPI. An additional analysis called Gridded Areas of Interest (Gridded AOI) was completed. This technique set a standard grid over the video imaging and calculated the dwell time average for each AOI (each square in the grid); colder

colored squares (blue to green) indicate little time (ms) spent dwelling in the area, warmer colors (yellow to orange) indicate a greater dwell time (ms), and red indicates the greatest amount of average dwell time (ms). This Gridded AOI analysis can be used to see if there is a vision pattern over the entire visual (Figure 5).

Table 2: Description of the Six Key Performance Indicators (KPIs) from the Dynamic Area of Interest Analysis (AOI).

KPIs	Description
<i>Sequence</i>	Order of observation for a specific AOI among the other AOIs observed.
<i>Entry Time (ms)</i>	The time (in milliseconds) when the AOI is first observed.
<i>Dwell Time (ms)</i>	The total amount of time (in milliseconds) spent on an AOI.
<i>Revisits</i>	The number of times the AOI was viewed after the initial observation.
<i>Average Fixation Duration (ms)</i>	The average length of time (in milliseconds) that each observation of the AOI lasted.
<i>First Fixation Duration (ms)</i>	The length of time (in milliseconds) that the first observation of the AOI lasted.

4. RESULTS

4.1 Explicit Results

Control videos received higher acceptability scores than did evented videos ($p < 0.05$). The control pancakes and fruit video received the highest average hedonic score (6.6 ± 0.5 ; ‘like extremely’); however, the control sausage sandwich video had a lower ($p < 0.05$) acceptability rating (4.2 ± 1.7 ; ‘neither like nor dislike’) (Figure 1; Table 3). The evented cereal and milk and sausage sandwich videos received the lowest acceptability scores (1.7 ± 1.0 and 2.2 ± 1.3 , respectively; ‘dislike moderately’).

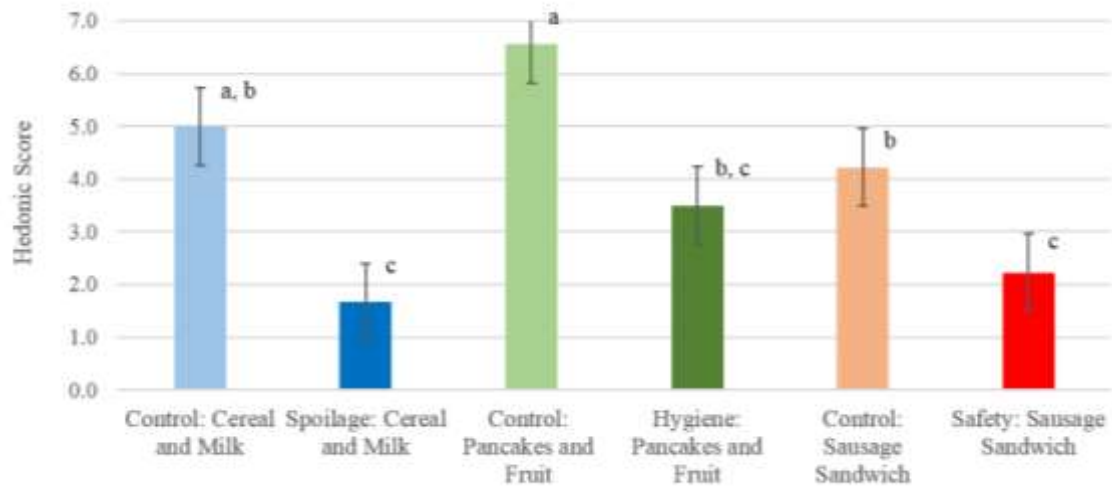


Figure 1: Acceptability scores (mean \pm s.d.) for control and evented breakfast meals ($n=40$; 1="dislike extremely"; 7="like extremely").

Table 3: Statistical summary for acceptability scores for breakfast meals (matched control and evented videos) illustrating quality and safety differences.

Video	Event Category	M	SD	95% CI		Median
				Lower	Upper	
Cereal and Milk	Control	5.0 ^{a,b}	1.1	4.14	5.86	5
	Spoilage	1.7 ^c	1.0	0.90	2.44	1
Pancake and Fruit	Control	6.6 ^a	0.5	6.15	6.96	7
	Hygiene	3.5 ^{b,c}	2.0	1.83	5.17	3
Sausage Sandwich	Control	4.2 ^b	1.7	2.90	5.54	5
	Safety	2.2 ^c	1.3	1.22	3.22	2

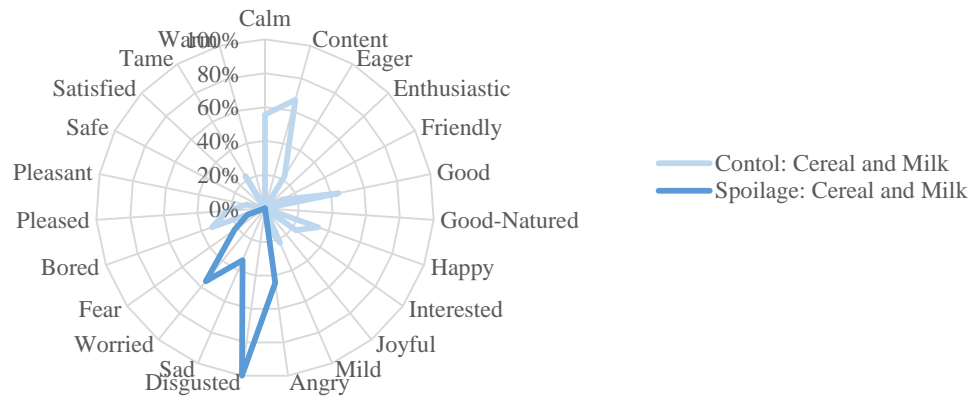
^{a, b, c, d} Means with different superscripts are significantly different ($p < 0.05$).

When examining the CATA data (Figure 2), positively valenced approach emotions were chosen more frequently for control videos compared to the matched evented video. Frequently chosen terms (greater than 20% selection frequency) for the control videos included calm, content, good, happy and interested. The terms eager, enthusiastic, friendly, good-natured, pleased, pleasant, satisfied, tame warm and joyful were also chosen frequently to describe at least one of the control videos. Negatively valenced withdrawal emotions, including angry,

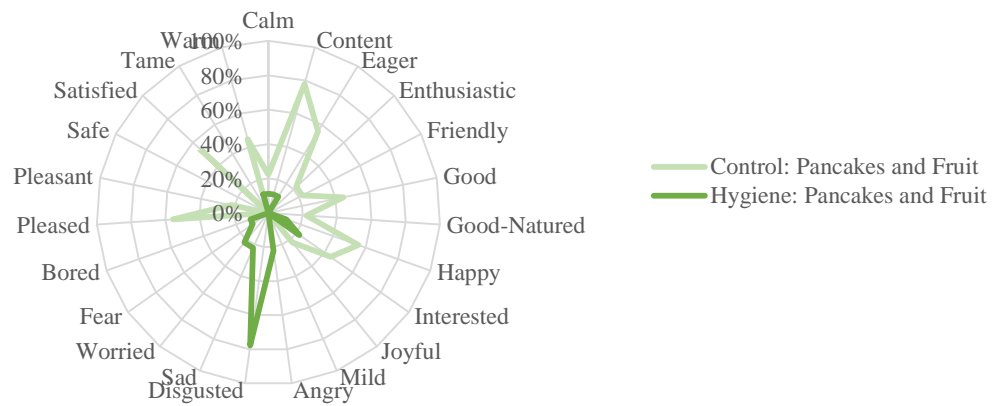
disgusted, sad, worried, and disgusted, were frequently selected for all evented videos. The control video for the sausage sandwich was the only control video to receive frequent choice of the withdrawal emotions, disgusted (33%) and worried (44%). Disgust was chosen by all participants (100% frequency) for the spoilage quality concern, while the hygiene and safety concerns received a 78% frequency for the term. Bored was expressed frequently (33%) for both the cereal and milk and sausage sandwich controls; fear was only used frequently (22%) for the spoilage quality concern.

The basic emotion intensity rating scales results were generally supportive of the hypotheses (Figure 3). The withdrawal emotion, disgust, and the negatively valenced approach emotion, anger, were both rated higher for the evented breakfast meal videos compared to the control videos. Out of the same emotions, disgust was rated most intense (6.0) for the spoilage quality video (evented cereal and milk). However, the withdrawal terms, fear and sad, had slightly higher (maybe not significant) ratings for the control compared to the evented videos. All control videos received higher scores for the positively valenced approach term, happy. The control cereal and milk received the highest happy score (5.4). Interestingly, the approach term, surprised, which can be valenced positively or negatively, was always rated higher for the evented video compared to the control.

a.) Spoilage:



b.) Hygiene:



c.) Safety:

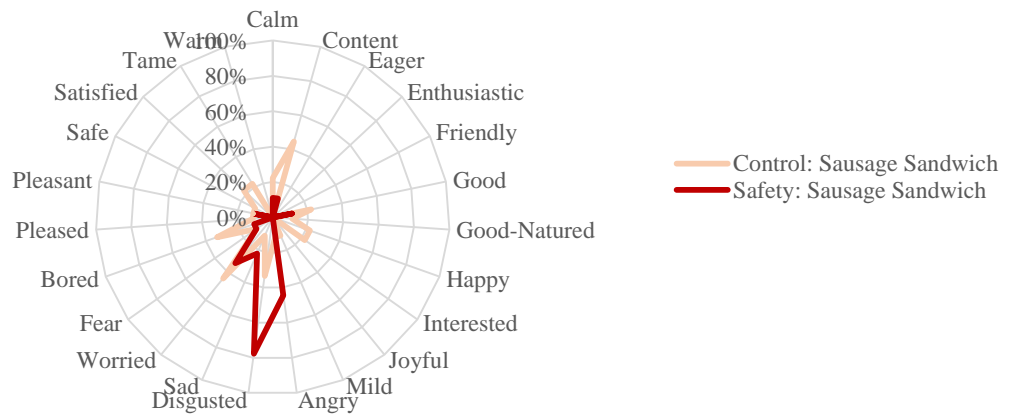
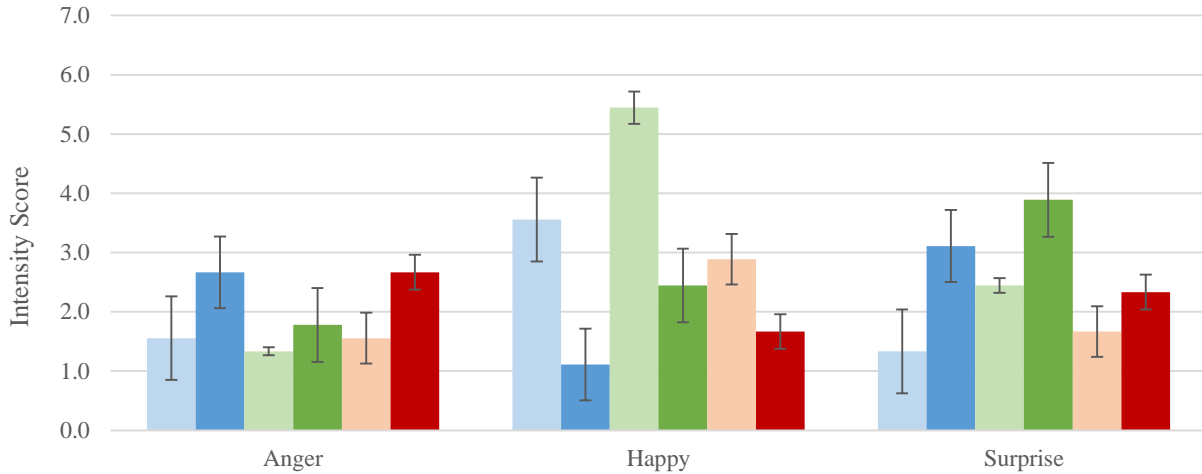


Figure 2: Emotional term selection for control and evented breakfast meals (n=9); a.) Cereal and milk, b.) Pancakes and fruit, c.) Sausage sandwich breakfast meals.

a.) Approach:



b.) Withdrawal:

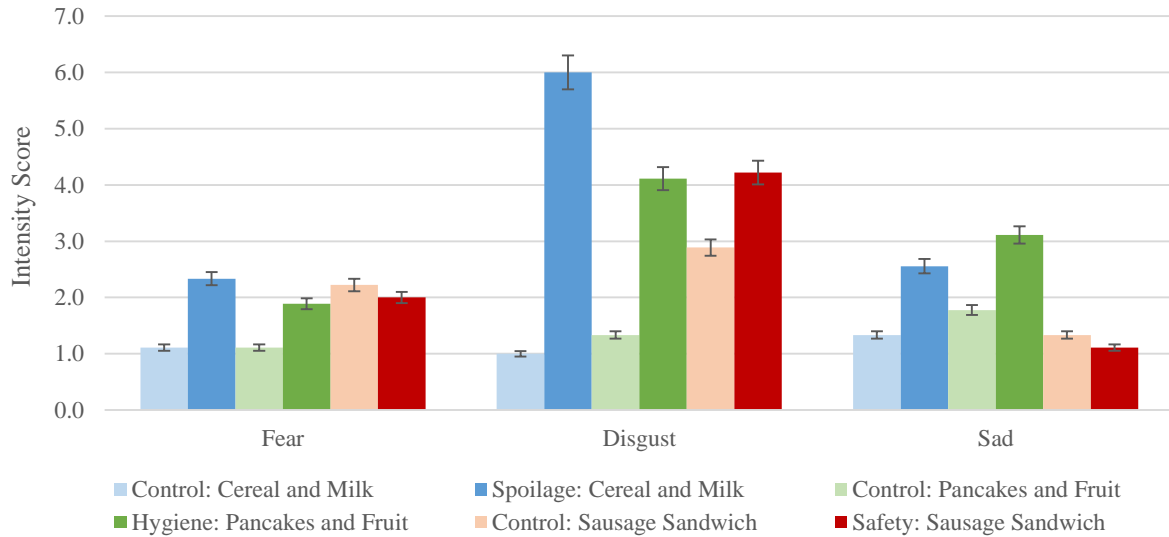


Figure 3: Intensity scores (mean \pm s.d.) for control and evented breakfast meals (n=9); a.) Approach emotion responses, b.) Withdrawal emotion responses.

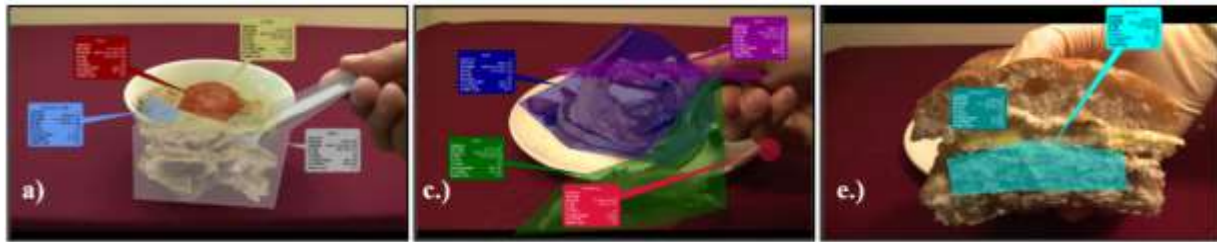
4.3 Eye-Tracking Results

4.3.1 Dynamic Areas of Interest (AOI)

Images of the Dynamic AOIs for each video (Figure 4) show high variation in eye fixation patterns. The key performance indicators (dwell times, average fixation, and first fixation durations) were longer for some of the specific Dynamic AOI areas in the evented

videos compared to the matched control videos (Table 4). The spoilage quality concern video set (cereal and milk) contained two Dynamic AOIs each for fresh milk and curdled milk. When comparing the second Dynamic AOI for fresh milk and curdled milk, the dwell times (51.9ms, 174.3ms; respectively), the average fixations (25.3ms, 74.0ms; respectively) and the first fixation durations (87.1ms, 21.3; respectively) were all longer for the spoilage quality video. The pattern for the evented Dynamic AOI object having a longer duration than the control Dynamic AOI object was not seen between the AOIs for the fresh milk 1 and curdled milk 1. In the food safety (sausage sandwich) video sets the duration pattern between evented and control Dynamic AOIs was observed for both Dynamic AOIs sets (sausage 1/uncooked sausage 1 and sausage 2/uncooked sausage 2). The dwell time, average fixation and first fixation duration were all longer for the uncooked sausage 1 AOI (8264.5ms, 289.7ms, and 424.5; respectively) compared to the control sausage 1 AOI (5682.4ms, 283.1ms, and 335.6ms; respectively), and between the uncooked sausage 2 (190.9ms, 190.0ms, and 190.9ms; respectively) compared to the control sausage 2 (111.2ms, 48.8ms, and 64.9ms; respectively). For the hygiene quality video (pancakes and fruit), no pattern was observed. Only one Dynamic AOI, the knife, received a higher duration for the evented video compared to the control, and for only one KPI measurement, dwell time (4659.2ms, 4346.9ms; respectively). The AOI containing the hair for the hygiene quality concern was never observed; sequence, entry time, dwell time, revisits, average fixation duration, and first fixation duration were all valued at zero.

Control:



Evented:

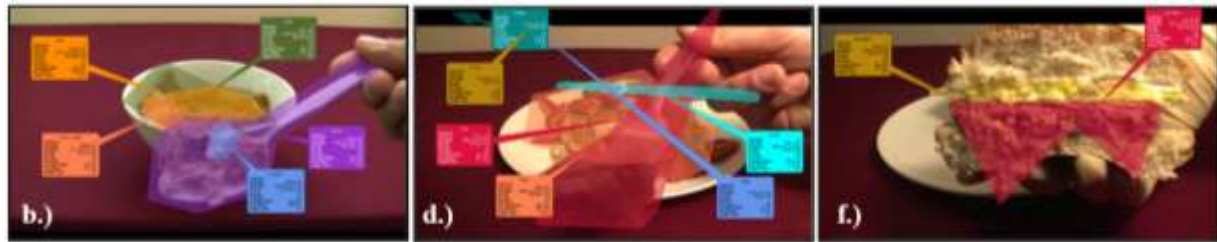


Figure 4: Dynamic Areas of Interest for breakfast meals with different concerns (refer to Table 4 for KPI values and color code): a) control: cereal and milk; b) spoilage quality: cereal and milk; c) control: pancakes and fruit; d) hygiene quality: pancakes and milk; e) control: sausage sandwich; and f) safety: sausage sandwich.

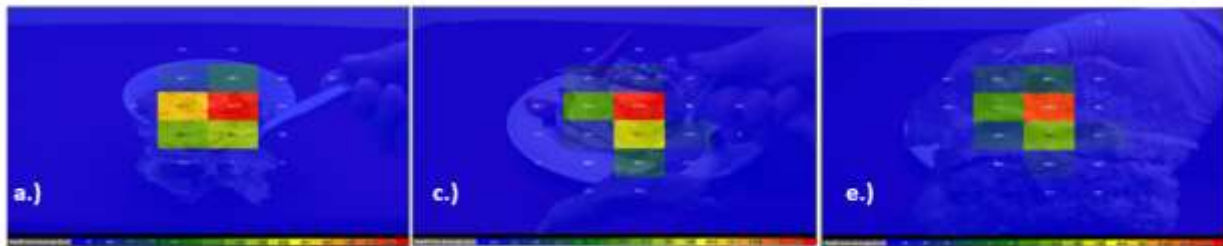
Table 4: Key Performance Indicator measures for breakfast meals with different concerns: Eye tracking Dynamic Areas of Interest.

Key Performance Indicators for the Dynamic Areas of Interest		KPI Color (Figure 4)	Sequence	Entry Time (ms)	Dwell Time (ms)	Revisits	Average Fixation (ms)	First Fixation Duration (ms)
Cereal and Milk	Cereal	yellow	1	1431.9	29724.0	11.7	414.8	475.5
	Fresh Milk 1	red	2	14118.4	12044.3	8.7	406.5	903.7
	Fresh Milk 2	blue	4	23944.6	51.9	1.0	25.3	21.3
	Spoon and Food	white	3	22587.8	12627.1	4.2	388.3	481.9
Spoilage	Cereal	green	1	1245.7	23533.9	10.0	379.1	509.7
	Milk Curdle 1	orange	2	24282.8	3196.7	4.7	415.0	309.5
	Milk Curdle 2	blue	4	28206.7	174.3	0.7	74.0	87.1
	Spoon and Food	purple	3	18338.8	7328.5	4.4	392.6	275.3
Pancakes and Fruit	Pancake Stack	blue	1	2656.2	40099.9	7.7	369.2	625.6
	Fork and Food	green	3	31174.3	4346.9	3.7	395.6	437.5
	Knife	purple	2	30693.4	734.1	0.7	527.8	558.9
	Pancake Stack	orange	1	3609.5	37668.1	7.6	286.0	239.1
Hygiene	Fork and Food	red	3	37531.0	4659.2	3.1	343.6	364.3
	Knife	turquoise	2	35525.7	624.6	3.0	118.6	93.6
	Hair	blue	0	0.0	0.0	0.0	0.0	0.0
	Sausage 1	dark turquoise	1	8484.0	5682.4	7.8	283.1	335.6
Sausage Sandwich	Sausage 2	turquoise	2	31365.6	111.2	0.0	48.8	64.9
	Uncooked Sausage 1	red	1	9613.8	8264.5	10.3	289.7	424.5
Safety	Uncooked Sausage 2	yellow	2	33666.6	190.9	0.0	190.9	190.9

4.3.2 Gridded Areas of Interest (AOIs)

When viewing the images of the Gridded AOI analysis (Figure 5) it can be seen that participants' eyes remained in the center of the screen even though some events of interest occurred in the periphery. The Gridded AOI analysis does not indicate the peripheral objects were observed by the participants' analysis of dwell time average.

Control:



Evented:

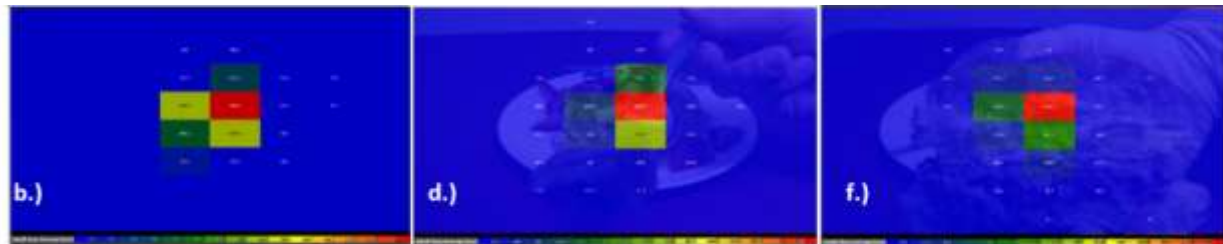


Figure 5: Gridded Areas of Interest for breakfast meals with different concerns: a) control: cereal and milk; b) spoilage quality: cereal and milk; c) control: pancakes and fruit; d) hygiene quality: pancakes and milk; e) control: sausage sandwich; and f) safety: sausage sandwich.

5. DISSCUSSION

Comparing hedonic scores across control stimuli showed differences in acceptability between breakfast meal types. The control sausage sandwich meal had a much lower score than the pancakes and fruit, and cereal and milk breakfast videos. Choice of emotional terms were also generally similar across control videos. Some differences were seen in terms of frequency of selection of withdrawal terms chosen for the control sausage sandwich; this difference is supported by the lower acceptability score received by this control stimuli. The sight differences in emotion term selection and acceptability scores indicate that the different breakfast meals

were not equally liked and produce different emotional responses within the population (Jiang et al., 2014). Difference within sets of breakfast meals (control and evented) can be used as an illustration of the effect that the concern has on the breakfast meal evaluation. Mean hedonic scores revealed lower acceptability for all evented videos in comparison to its matched control, which closely reflects what was seen in the parallel study, Walsh (2016), *Chapter 4*. More specifically, only one stimuli's acceptability score, the control pancakes and fruit breakfast meal (6.6), did not fall within the confidence interval (5.32 - 6.18) of the hedonic scores for the same meal found in Walsh (2016), *Chapter 4; Explicit Response Results*. The differences in acceptability (between the control and evented videos) indicate that each food concerning event was seen in each video as well as the expected decrease in acceptability was accomplished. In the same manner, differences in approach and withdrawal terms usage between the control and evented videos was apparent. A greater withdrawal response is evident from the use of the terms, disgust and worried, in greater frequency for the evented stimuli compared to its matched control; the control sets received mostly positively approach terms, calm, content, good, happy and interested. This difference in term usage also indicates the observation of the concern. The withdrawal terms, disgust and worried, and the approach terms, content, good and interested are shared in high usage between the current study and Walsh (2016), *Chapter 4; Explicit Response Results*. This parallel finding helps to validate the explicit responses found with the small number of participants in the current study. Differences cannot be compared across evented breakfast meals due to the great difference in content. However, further support for these findings lies in the six basic emotional intensity questionnaire; all evented breakfast meals saw an increase in basic emotion intensity of the withdrawal emotion, disgust, and approach emotions, anger and surprise, compared to its control set. While, the approach term, happy, was

always greater in intensity for the control stimuli compared to the evented stimuli. These expected findings provide further confirmation that the event was observed and that the stimuli was emotion eliciting. Dissimilarity in response intensities between video sets for the withdrawal emotions, fear and sad, exhibit the need for more participants to confirm the findings. Walsh (2016), *Chapter 4; Explicit Response Results*, do not validate the higher fear and sad emotion intensities found for the control compared to the evented stimuli, found in the current study. Together, the CATA, basic emotion intensity questionnaire, and acceptability scores illustrate that the content caused changes in cognitively determined (explicit) responses and are important emotionally.

Analysis of attention, measured using the Dynamic AOI analysis, is supportive of previous research, as evidenced by the KPI (dwell time, average fixation and first duration fixation) differences between control and evented stimuli. Previous research show individuals focus on information that is either salient to them and/or unique to the alternative choice (Armel et al., 2014; Jantathai et al., 2013; Mawad et al., 2015; Sutterlin, Brunner & Opwis, 2008). In other words, in preference judgment situations, individuals will focus their attention on the elements of the stimuli that are different or more important when comparing to an alternative. Elements of the stimuli that are the same are cancelled out of the decision process; this model is called cancellation and focus (Haindl & Dürrschmid, 2010; Sutterlin et al., 2008). Longer gaze times, fixations or dwell time durations are a reflection of greater attention to the areas of interest (Armel et al., 2014; Haindl & Dürrschmid, 2010; Jantathai et al., 2013; Mawad et al., 2015; Sutterlin et al., 2008). The KPIs provided evidence for the participants observing and attending the food spoilage quality and safety food concerns more intently than the control. Both AOIs for the safety concern (sausage sandwich) stimuli saw greater dwell time, average fixations and first

fixation durations. Although not as consistent, the spoilage quality (cereal and milk) stimuli saw some similar results; the milk curdle 2 AOI observed longer dwell times, average fixation, and first fixation, the spoon and food AOI, and the milk curdle 1 AOI had longer average fixations, and lastly the cereal AOI had a longer first fixation. The common food parts were cancelled out and the concern became the focus for the decision indicating that the concern more greatly influenced the participants' attention compared to the control video. The greater withdrawal emotion selection and lower acceptability scores are supported by the greater focus on KPIs for the food spoilage quality and safety food concerns and thus support the overall withdrawing effect of these concerns. Many, but not all, AOIs support the cancellation and focus model, another concept referred to as feature attractiveness can help explain the inconsistent findings across the stimuli (Haindl & Dürschmid, 2010; Sutterlin et al., 2008).

Feature attractiveness is an important concept in understanding consumer preference. In eye tracking research it has been demonstrated that depending on the intensity of attractiveness and the direction of attraction to the stimuli, attention is influenced. Very attractive and greatly unattractive stimuli both grab one's attention for a longer time than a more neutral or temperate stimuli (Sutterlin et al., 2008; Haindl & Dürschmid, 2010). This concept is likely effecting all attention results found in this study, but it is of particular interest for the pancakes and fruit breakfast meal. The pancakes and fruit breakfast meal was liked the most; it received the highest acceptability scores, highest intensity for the happy emotion, as well as had the greatest usage of approach terms. Thus, there is solid explicit evidence that the positive attributes of this meal were most influential over all other breakfast meal types; providing evidence for the attractiveness of this meal being the driver of attention. All dwell times (except for one AOI: the fork and food), average fixations and first fixation durations were longer in duration for the

control compared to the evented breakfast meal. This reveals that attractiveness of the meal outweighed the concern for hygiene quality as evidenced by the greater attention given to the control meal. The difference in attention processing for the hygiene quality concern could also be a result of the hair AOI not being observed; the hair AOI was not observed in any of the KPI measures. However, no observation of the concern is unlikely due to the firm evidence of the concern's identification from the explicit results. This inconsistency could be explained with two different arguments: 1) the technology for eye tracking system is currently not sensitive enough for these small observations or eye movements, or 2) peripheral information gathering can provide important information in decision making processes. A human visual field contains about 100 degrees of periphery vision out of the total 170 degrees of vision. This relatively large field of vision is an evolved protection mechanism that allows humans to detect a threat before it comes into the center of gaze (Goldstein, 2014). Thus, it is possible that even though the participants' gaze was to the center, they were still able to identify the salient information and record their emotions and acceptability as such. This concept of peripheral information processes is further evidenced by the pattern of gaze found in the Gridded AOI analysis. Average dwell times varied within the central gridded spaces of the visual, but remained constrained to the middle of the screen. The difference in attention processing for the hygiene quality compared to the spoilage quality and safety concerns is also likely effected by personal preferences and other individual characteristics of the participants.

The differences in attention behavior models (cancellation and focus, and feature attractiveness) between the videos sets is also important in understanding bottom-up and top-down processing. It seems that in this study, both stimulus-oriented (bottom-up) and goal-oriented (top-down) are significant (Orquin & Mueller-Loose, 2013; van der Laan et al., 2015).

The concerning stimuli in the spoilage quality and safety videos (curdled milk and undercooked meat) are engaging bottom-up attention as focus grabbing salient information, while the control pancakes and fruit (hygiene quality set) is engaging top-down attention influenced by personal preference for that meal. When considering these models, the importance of understanding participants' personal characteristics is emphasized. No prior screening was completed to understand if participants' responses would be affected by influencing factors such as personal food preferences, body composition, hunger level, consumption behaviors and/or past experiences. For example, there is debate on whether consumption behaviors influence attention. More recent work by Werthmann, Roefs, Nederkoorn, Mogg, Bradley & Jansen (2013) explain that food restraint behaviors have no effect on attention bias, whereas other researchers (Ventra, de Jong, Koster & Roefs, 2010) found differences of engagement and avoidance behaviors in different eaters and with different food types. Subsequent research would benefit from prescreening participants who have a distaste/extreme like for the foods presented as differences in dieting behaviors, hunger status and many other more personal characteristics that may influence a response to a food. Executing this control provision is likely to help more accurately define results as there is question of if the responses were related to the food product itself or the food concern. By controlling for food preference differences, further conclusions could be made in relation to understanding the salient information and feature attractiveness that influence attention and subsequent emotional responses. Participant controls are important to consider in food studies, additional project limitations warrant discussion for potential improvements in using eye-tracking technology and for measuring attention.

Sample size is an arguable limitation for this project. Nielson and Land Auer (2000) suggest five subjects is sufficient to draw conclusions in eye tracking studies. However, another

more recent study using eye tracking technology for studying attention to snack packages used 123 subjects (Rebollar et al., 2015). For the current study, the small sample size limits statistical interpretation to a broader audience; however we are using this information for qualitative comparisons, not statistically significant conclusions. We recognize that nine participants is not a representative population for the explicit measures, but comparisons to Walsh (2016), *Chapter 4* (n=40 participants) suggests that the participants in this study mirror those that were found in the parallel study. As previously explained, we refrained from conducting many of the usual statistical analyses for the explicit responses, and although statistical analysis was completed for the acceptability scores, we refrained from making conclusions about significances. It was a hope that imagery the statistics show is used to exemplify trends that are supportive to findings in Walsh (2016): *Chapter 4*. Some additional experimental improvements can be made to increase confidence in data by adjusting environmental features. Inadequate lighting due to desk placement within the dark room of the Visionaries, provided little light to illuminate the faces of the participants. Although the system checks and calibrations were adequate according to the software, it can be debated as to whether the monitoring system was able to reliably record eye movements. Although limitations in this experiment exist, monitoring attention and fixation patterns through eye tracking technology in combination with explicit emotional responses has great potential for better understanding the relationship between food and emotions.

6. CONCLUSION

In this study, we aimed to assess whether visual processes of attention would indicate influences on explicit responses. More specifically, the objective was to determine if measures of attention, dwell times, fixations, etc., in combination with emotional responses and acceptability would provide evidence of a withdrawal emotional response to food quality

(spoilage, hygiene) and safety concerns. Upon analysis, it was clear that the majority of attention indicators showed a greater focus on the concerning attributes as was predicted due to its intentionally salient information. However, unpredicted findings lead to the understanding of the importance of peripheral information gathering and feature attractiveness's influence on attention, emotions and acceptability. This information is useful in many areas of the food industry, such as in retail, and restaurant settings as well as in marketing and advertising, however, other consumer-focused industries will also benefit from having greater insight into how attention can influence consumer emotions and their subsequent preferences or choice behaviors to different products or services. Further research in this area should explore a deeper understanding of individuals' personal characteristics and how perception of food (or other product) attributes influence visual processing.

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CHAPTER 7: CONCLUSIONS

1. SUMMARY

This dissertation contributes to the growing body of literature related to food and emotions. Across all four projects, strong evidence was found for explicit emotional responses providing additional explanatory information for understanding consumers' relationship with food and food concerns. The culmination of this work illustrates the importance of implicit measures to advance sensory science and consumer insights research for a more complete outlook on what encompasses and affects an experience with food. The studies included in chapter 3 present the first evidence for the use of emotional responses as an effective measure for determining the influence that quality changes in milk have on consumer acceptability. Together, the research in chapters 4 and 6, illustrate the significance of studying many different modalities (explicit and implicit) of emotional responses to measure specific food attributes, particularly potentially health concerning food attributes, for a more thorough understanding of the consumer's perception of the food. However, within these research chapters, measures of implicit emotional response and motivational behaviors (automatic facial expression analysis, heart rate, and frontal cortex asymmetry), as well as attention (eye tracking), found marginal support for the theory of their use as more representative indicators of individuals' true reactions to food; participant variability and the nature of the stimuli are likely to be largely influential in the overall conclusions. We challenged the use of traditional analysis of variance statistics, based on mean emotion responses, and contend that understanding the temporal effect provides more information for understanding emotional differences to products. Our use of time series analysis for characterizing population differences in expressed emotion toward food products/meals, as characterized by AFEA, is novel and shows promise for providing insights

into consumer affective response. Lastly, chapter 5 emphasized the understanding of the positive aspects of food. Our enhanced understanding of emotional responses elicited from pleasant foods allows many areas of the food industry to be better equipped with knowledge and tools for creating positive food experiences. However, many factors influence an individual's perception and decision processes in relation to food. The comprehensive dynamic of these influences create a complex network and the findings of this research show the collective population response analysis overrides the importance of the individual response. By measuring emotions, attention and motivational behaviors to food, some important elements that influence this network will be uncovered leading to a better understanding of the consumer-food relationship.

2. FUTURE WORK

The food and emotions studies conducted in this dissertation project presented are some of the first steps in understanding this multifaceted area of study and have helped open the door to endless opportunities for future scientific exploration in fields of food science, marketing, psychology, nutrition and many others. We contend that both implicit and explicit measures of emotion offer value for providing insight to product development. One of the most challenging problems for a food company is determining what products will have the highest success rate in the market place. Most often large companies rely on their sensory departments for an indication of this success. If future sensory research focuses on understanding complex emotional and motivational behavior indicators that are uninfluenced by thought or reason, it is possible to better predict and differentiate between food/food products that generate more satisfied consumers and fewer dissatisfied ones. Additionally, research in this area would benefit from similar food video stimuli or other non-consumption studies to help establish what probable responses can be observed as to food stimuli. Studies that exclude actions such as chewing,

swallowing and food serving will help reduce noise and prevent data collection concerns, such as obstruction to facial expression observation, which is currently a limitation in AFEA. Due to relatively few published articles existing, it is difficult to compare findings across food studies, but also when relating observations to studies with similar measurement tools. Methodologies that warrant standardization and further exploration include: stimuli presentation, environment and participant controls, and statistical analyses. Furthermore, the efforts of this project were to create extreme negative and positive food situations for means of comparison and to establish observable differences in implicit responses. However, the variability of responses found across all participants necessitates a broader understanding of how an individual's characteristics and personal experiences influence emotional responses, attention and motivational behaviors to food in a normal (non-disordered) eating population.

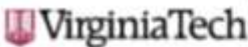
Although the efforts of this study were to observe the general population, future research would benefit from exploring how segmenting groups of people based on their preference or product usage/consumption would reduce personal biases from unfamiliarity, distaste, cultural influences, memories and many more individual influences. Because emotions are always changing and every individual is different, the possibilities of exploring the interaction between food and emotions is nearly endless. The value in such research is developing a better understanding for reducing costs associated with new product development, relating food quality characteristics to consumer choice and behavior, and providing improved communications relating to health messages and dietary controls. The outcomes of this dissertation have direct relevance to the food and food service industries, especially relating to new product development and consumer engagement with food meals. In addition, researchers in psychology, human nutrition, human-computer interfaces, statistics, marketing and related consumer-focused

sciences will find information of value within these pages. Ultimately, this work, as a part of the larger body of literature on food and emotions, will assist in informing policy and provide guidance relating to communications associated with obesity, food safety, and consumer-targeted messages.

APPENDIX FOR IRB APPLICATIONS, CONSENT FORMS, QUESTIONNAIRS AND SUPPLEMENTARY DATA

A. Appendix Supporting Documents: Chapter 3.

IRB Approval Letter: IRB #: 13-756; Characterization of Explicit and Implicit Emotions as Related to Acceptability of Light-Induced Oxidation Flavor in Milk (Study 1).

 **Office of Research Compliance**
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540231-4606 Fax 540231-0909
email irb@vt.edu
website <http://www.irs.vt.edu>

MEMORANDUM

DATE: April 7, 2014

TO: Susan E Duncan, Alexandra Margaret Walsh, Hayley Potts

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)

PROTOCOL TITLE: Consumer Response to Oxidation Flavors in Milk

IRB NUMBER: 13-756

Effective April 7, 2014, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	Expedited, under 45 CFR 46.110 category(ies) 4,6,7
Protocol Approval Date:	September 4, 2013
Protocol Expiration Date:	September 3, 2014
Continuing Review Due Date*:	August 20, 2014

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

Informed Consent: IRB #: 13-756

Virginia Polytechnic Institute and State University

**Informed Consent for Participants in Research Projects Involving Human Subjects
(Sensory Evaluation)**

Title Project: Consumer Response to Oxidation Flavors in Milk

Investigators: Susan E. Duncan, Hayley Potts, Alexandra M. Walsh

I. Purpose of this Research/Project

You are invited to participate in a study to characterize the response to light exposed white milk samples. This study will help identify the influence of light on acceptability and emotional response to milk.

II. Procedures

You will receive two samples as well as questionnaires within room 132. Evaluate the first sample by putting the whole amount (approximately 1 oz) into your mouth, and taking time to evaluate the taste as you swallow. Respond, by checking the emotional terms, working from a list of emotions that apply to your response to the product. Next fill out the demographics questionnaire. Evaluate the second sample in the same manner, using the second word list. Lastly, please fill out the beverage consumption questionnaire. Return the 4 questionnaires before heading to room 127 for the last task.

You will be asked to taste two samples. They will be presented one at a time. Using a Hedonic Scale presented on the monitor, please assess both samples.

III. Risks

There are no more than minimal risks for participating in this study. If you are aware of any allergies to milk protein or lactose sensitivity or intolerance, please inform the investigator. Risks for milk allergies and intolerances can include gastrointestinal discomforts, respiratory problems and dermatological reactions. Please refrain from participating if there is any concern that you may have a reaction. Withdrawal from the experiment is permitted at anytime.

IV. Benefits

Your participation in this study will provide valuable information about consumer response to light exposed white milk and the emotional response one has to milk using questionnaires as a sensory evaluation tool. This information will be useful to the food and related consumer industries. If you would like a summary of the research results, please contact the researcher at a later time.

V. Extent of Anonymity and Confidentiality

The results of your performance as a panelist will be kept strictly confidential except to the investigators. Individual panelists will be referred to by a code number for data analyses and for any publication of the results.

VI. Compensation

A small snack and a \$2 Kroger gift card will be provided as an expression of appreciation for your participation. In addition, two canned food items, valued at approximately \$2.00, will be offered. An option for donating the canned foods to a local food bank will be provided.

VII. Freedom to Withdraw

If you agree to participate in this study, you are free to withdraw from the study at any time without penalty. There may be reasons under which the investigator may determine you should not participate in this study. If you have allergies to dairy products, or are under the age of 18, you are asked to refrain from participating. You are eligible for the snack if you withdraw.

VII. Subject’s Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

Follow the directions on the instruction sheet as well as the monitor, which will direct me with guidelines about how to evaluate the products, and provide my responses. Complete the surveys as provided.

IX. Subject’s Permission

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent: Date

 Subject Signature _____

Subject Printed Name _____

-----For human subject to keep-----

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject. I may contact:

Susan Duncan, Faculty/ Investigator

(540) 231-8675; duncans@vt.edu

Hayley Potts

hpotts45@vt.edu

Alexandra Walsh

alexmw@vt.edu

David Moore

Chair, Virginia Tech Institutional Review
Board for the Protection of Human Subjects
Office of Research Compliance

(540) 231-4991; moored@vt.edu

Participant Instructions and Scorecards

Instructions [Note: the instructions and data collection may be presented as a paper ballot or on the touch screen monitor in the sensory laboratory]:

You are participating in a sensory test to evaluate your emotional response to milk beverages. Today, you will be evaluating two products on two occasions. After the first product is evaluated with the list of words below, you will complete a demographic questionnaire. Then you will evaluate the second product using the same list. Finally, you will be asked to complete a beverage consumption questionnaire, before completing the last task in the sensory booth down the hall.

1. Taste the product by taking the full amount into your mouth and swirling it around. Please, swallow the product.
2. Think about the emotions you are experiencing that are associated with the product experience. [Ignore any feelings associated with doing this task with others in the room].
3. Using the list below, check the terms (all that apply) that you associate with the product you just tasted. There is no correct number of responses so you may choose as many as you can identify with this experience. You may rinse your mouth/drink the water to refresh your mouth.
4. Complete the demographic questions.
5. Taste the second product, following steps 1-3.
6. Again, fill out the list below for the second beverage tasted *AND* then complete the beverage consumption questionnaire (a total of 4 sheets should be filled out).
7. Turn in your response forms and please head down the hall to room 132 to complete a second tasting of two milk beverages, while following the instructions on the monitor.
8. Once the evaluation is complete, help yourself to the gift as a token of our appreciation, or chose the option to donate the gift to a local food bank.

Product #: _____

Please select the word(s) which describe how you **FEEL RIGHT NOW**. *Select all that apply.*

<input type="checkbox"/> Active	<input type="checkbox"/> Energetic	<input type="checkbox"/> Joyful	<input type="checkbox"/> Safe
<input type="checkbox"/> Adventurous	<input type="checkbox"/> Enthusiastic	<input type="checkbox"/> Loving	<input type="checkbox"/> Satisfied
<input type="checkbox"/> Affectionate	<input type="checkbox"/> Fear	<input type="checkbox"/> Merry	<input type="checkbox"/> Secure
<input type="checkbox"/> Aggressive	<input type="checkbox"/> Free	<input type="checkbox"/> Mad	<input type="checkbox"/> Steady
<input type="checkbox"/> Angry	<input type="checkbox"/> Friendly	<input type="checkbox"/> Nostalgic	<input type="checkbox"/> Tame
<input type="checkbox"/> Bored	<input type="checkbox"/> Good	<input type="checkbox"/> Peaceful	<input type="checkbox"/> Tender
<input type="checkbox"/> Calm	<input type="checkbox"/> Good-natured	<input type="checkbox"/> Pleased	<input type="checkbox"/> Understanding
<input type="checkbox"/> Content	<input type="checkbox"/> Guilty	<input type="checkbox"/> Pleasant	<input type="checkbox"/> Warm
<input type="checkbox"/> Daring	<input type="checkbox"/> Happy	<input type="checkbox"/> Polite	<input type="checkbox"/> Whole
<input type="checkbox"/> Disgusted	<input type="checkbox"/> Interested	<input type="checkbox"/> Quiet	<input type="checkbox"/> Wild
<input type="checkbox"/> Eager		<input type="checkbox"/> Sad	<input type="checkbox"/> Worried

Hedonic Scorecard

Instructions [Instructions and Evaluation will be on the touch screen monitor]: You will be provided two samples of milk to evaluate. You are to determine how well you like each product. For each product, take the full sample into your mouth and swallow the full amount. Think about the emotions you are experiencing from the sample and evaluate accordingly. Please rinse your mouth with water before you receive the next sample.

Sample _____

Indicate how much you like this sample by checking the term that best describes your response to the product.

- Like extremely _____
- Like very much _____
- Like moderately _____
- Like slightly _____
- Neither like nor dislike _____
- Dislike slightly _____
- Dislike moderately _____
- Dislike very much _____
- Dislike extremely _____

When you are finished, hit “Next”.

Now complete the Demographics Questionnaire.

Demographic Survey

Please fill out this survey, and then follow the instructions on the computer to complete the test (circle your answer).

1. Indicate your age:
 - 18-19
 - 20-21
 - 22-23
 - 24-25
 - 26-30
 - >30

You must be at least 18 years old to participate in this study. If you are under 18, please do not continue. Come to the sensory kitchen to receive a token of appreciation for your interest in the study.

2. Indicate your gender:
 - Male
 - Female

3. Indicate your classification at the university (select the one that best fits):
 - Undergraduate student
 - Graduate student
 - Staff
 - Other (describe): _____

4. If you are a student, please indicate your Department/Major or area of study [if not a student, please continue to Q5]:

5. Do you participate in any dairy science-related or food science-related clubs/activities or research?
 - NO [please continue to Q6]
 - YES

If yes, please describe: _____

6. How important is it to you, as a consumer, that the packaging for fluid milk allows you to see the product contained within the package?.
 - Extremely important
 - Moderately important
 - Slightly important
 - Not important/neutral/don't care

Please continue with evaluating the second sample now.

Informed Consent: IRB #: 13-756; Characterization of Explicit and Implicit Emotions as Related to Acceptability of Light-Induced Oxidation Flavor in Milk (Study 2).

Virginia Polytechnic Institute and State University

**Informed Consent for Participants in Research Projects Involving Human Subjects
(Sensory Evaluation)**

Title Project: Consumer Response to Oxidation Flavors in Milk using Facial Coding Software and Emotion Term Questionnaire (part 2)

Investigators: Susan E. Duncan, Hayley Potts, Alexandra M. Walsh

I. Purpose of this Research/Project

You are invited to participate in the second part of a study to characterize the response to light exposed white milk samples. This study will help identify the influence of light on acceptability and facial responses to milk.

You will be videotaped while you are evaluating milk samples. Videos will be analyzed for results using facial recognition software (FaceReader). This software is designed to collect real time emotional response by videotaping facial features as a reaction to information or stimuli and is a novel method for evaluating sensory responses to foods. This activity is designed to collect data on facial recognition software to assess its use as a tool in sensory evaluation of foods.

II. Procedures

First, please fill out the beverage consumption questionnaire. You will then receive a sample as well as an index card to hold up close to your face before tasting the sample. Evaluate the first sample by putting the whole amount (approximately 1 oz) into your mouth while being conscious of facing forward; take time to evaluate the taste as you swallow. Then respond, by checking all of the emotional terms that apply from a list of emotions, and marking on the Hedonic scale how much you like the sample. Next fill out the demographics questionnaire. Evaluate the second sample in the same manner as the first, using the same scale and list of terms. Return the sheet before exiting.

III. Risks

There are no more than minimal risks for participating in this study. If you are aware of any allergies to milk protein or lactose sensitivity or intolerance, please inform the investigator. Risks for milk allergies and intolerances can include gastrointestinal discomforts, respiratory problems and dermatological reactions. Please refrain from participating if there is any concern that you may have a reaction. Some individuals may be uncomfortable about being videotaped or recorded. Withdrawal from the experiment is permitted at anytime.

IV. Benefits

Your participation in this study will provide valuable information about consumer response to light exposed white milk and the emotional response one has to milk using questionnaires and facial coding software as a sensory evaluation tool. This information will be useful to the food and related consumer industries. If you would like a summary of the research results, please contact the researcher at a later time.

V. Extent of Anonymity and Confidentiality

The results of your performance as a panelist will be kept strictly confidential except to the investigators. Individual panelists will be referred to by a code number for data analyses and for any publication of the results.

Collected videos may be used for educational, research (research publications, research presentations, research videos) and demonstration purposes including promotion or marketing videos about this sensory application.

VI. Compensation

A small snack and a \$2 Kroger gift card will be provided as an expression of appreciation for your participation.

VII. Freedom to Withdraw

If you agree to participate in this study, you are free to withdraw from the study at any time without penalty. There may be reasons under which the investigator may determine you should not participate in this study. If you have allergies to dairy products, or are under the age of 18, you are asked to refrain from participating. You are eligible for the snack if you withdraw.

VII. Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

Follow the directions on the instruction sheet (or monitor), which will direct me with guidelines about how to evaluate the products, and provide my responses. Complete the surveys as provided.

IX. Subject's Permission and Video Release

I have read the consent form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent to participate in this study.

Additionally, by signing this consent form, I am giving permission for the investigators on this project to capture and use video footage associated with my participation for educational, research, and/or demonstration purposes. I waive any video rights of compensation or ownership thereto. There is no time limit on the validity of this video release nor is there any geographic specification of where these materials may be distributed. This release applies to video footage collected as part of the sensory sessions associated with the identified IRB study #13-756 listed on this document:

Date _____

Subject Signature _____

Subject Printed Name _____

-----For human subject to keep-----

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject. I may contact:

Susan Duncan, Faculty/ Investigator

(540) 231-8675; duncans@vt.edu

Hayley Potts

hpotts45@vt.edu

Alexandra Walsh

alexmw@vt.edu

David Moore

Chair, Virginia Tech Institutional Review
Board for the Protection of Human Subjects
Office of Research Compliance

(540) 231-4991; moored@vt.edu

Participant Instructions and Scorecards

Scorecard

Instructions [Instructions and Evaluation will be on the touch screen monitor (if available at the time) or as a paper ballot]: You have just been provided a milk sample to taste. Think about the emotions you are were experiencing from the sample and evaluate accordingly. Please rinse your mouth with water and/or have a cracker before you receive the next sample.

Sample #: _____

Please select the word(s) which describe how you **FEEL RIGHT NOW**. *Select all that apply.*

<input type="checkbox"/> Active	<input type="checkbox"/> Energetic	<input type="checkbox"/> Joyful	<input type="checkbox"/> Safe
<input type="checkbox"/> Adventurous	<input type="checkbox"/> Enthusiastic	<input type="checkbox"/> Loving	<input type="checkbox"/> Satisfied
<input type="checkbox"/> Affectionate	<input type="checkbox"/> Fear	<input type="checkbox"/> Merry	<input type="checkbox"/> Secure
<input type="checkbox"/> Aggressive	<input type="checkbox"/> Free	<input type="checkbox"/> Mad	<input type="checkbox"/> Steady
<input type="checkbox"/> Angry	<input type="checkbox"/> Friendly	<input type="checkbox"/> Nostalgic	<input type="checkbox"/> Tame
<input type="checkbox"/> Bored	<input type="checkbox"/> Good	<input type="checkbox"/> Peaceful	<input type="checkbox"/> Tender
<input type="checkbox"/> Calm	<input type="checkbox"/> Good-natured	<input type="checkbox"/> Pleased	<input type="checkbox"/> Understanding
<input type="checkbox"/> Content	<input type="checkbox"/> Guilty	<input type="checkbox"/> Pleasant	<input type="checkbox"/> Warm
<input type="checkbox"/> Daring	<input type="checkbox"/> Happy	<input type="checkbox"/> Polite	<input type="checkbox"/> Whole
<input type="checkbox"/> Disgusted	<input type="checkbox"/> Interested	<input type="checkbox"/> Quiet	<input type="checkbox"/> Wild
<input type="checkbox"/> Eager		<input type="checkbox"/> Sad	<input type="checkbox"/> Worried

Indicate how much you like this sample by checking the term that best describes your response to the product.

- Like extremely _____
- Like very much _____
- Like moderately _____
- Like slightly _____
- Neither like nor dislike _____
- Dislike slightly _____
- Dislike moderately _____
- Dislike very much _____
- Dislike extremely _____

When you are finished, hit “Next” (or pass the paper back through the hatch).

Sample #: _____

Please select the word(s) which describe how you **FEEL RIGHT NOW**. *Select all that apply.*

<input type="checkbox"/> Active	<input type="checkbox"/> Energetic	<input type="checkbox"/> Joyful	<input type="checkbox"/> Safe
<input type="checkbox"/> Adventurous	<input type="checkbox"/> Enthusiastic	<input type="checkbox"/> Loving	<input type="checkbox"/> Satisfied
<input type="checkbox"/> Affectionate	<input type="checkbox"/> Fear	<input type="checkbox"/> Merry	<input type="checkbox"/> Secure
<input type="checkbox"/> Aggressive	<input type="checkbox"/> Free	<input type="checkbox"/> Mad	<input type="checkbox"/> Steady
<input type="checkbox"/> Angry	<input type="checkbox"/> Friendly	<input type="checkbox"/> Nostalgic	<input type="checkbox"/> Tame
<input type="checkbox"/> Bored	<input type="checkbox"/> Good	<input type="checkbox"/> Peaceful	<input type="checkbox"/> Tender
<input type="checkbox"/> Calm	<input type="checkbox"/> Good-natured	<input type="checkbox"/> Pleased	<input type="checkbox"/> Understanding
<input type="checkbox"/> Content	<input type="checkbox"/> Guilty	<input type="checkbox"/> Pleasant	<input type="checkbox"/> Warm
<input type="checkbox"/> Daring	<input type="checkbox"/> Happy	<input type="checkbox"/> Polite	<input type="checkbox"/> Whole
<input type="checkbox"/> Disgusted	<input type="checkbox"/> Interested	<input type="checkbox"/> Quiet	<input type="checkbox"/> Wild
<input type="checkbox"/> Eager		<input type="checkbox"/> Sad	<input type="checkbox"/> Worried

Indicate how much you like this sample by checking the term that best describes your response to the product.

- Like extremely _____
- Like very much _____
- Like moderately _____
- Like slightly _____
- Neither like nor dislike _____
- Dislike slightly _____
- Dislike moderately _____
- Dislike very much _____
- Dislike extremely _____

Thank you for completing the test. You may conclude the test (touch “finished”) (or pass the paper back through the hatch). Then please exit opposite from where you came in to receive your gift.

Demographic Survey

Please fill out this survey, before continuing to the next sample (circle your answer).

7. Indicate your age:
- 18-19
 - 20-21
 - 22-23
 - 24-25
 - 26-30
 - >30

You must be at least 18 years old to participate in this study. If you are under 18, please do not continue.

8. Indicate your gender:
- Male
 - Female

9. Indicate your classification at the university (select the one that best fits):
- Undergraduate student
 - Graduate student
 - Staff
 - Other (describe): _____

10. If you are a student, please indicate your Department/Major or area of study [if not a student, please continue to Q5]:
- _____

11. Do you participate in any dairy science-related or food science-related clubs/activities or research?
- NO [please continue to Q6]
 - YES

If yes, please describe: _____

12. How important is it to you, as a consumer that the packaging for fluid milk allows you to see the product contained within the package?
- Extremely important
 - Moderately important
 - Slightly important
 - Not important/neutral/don't care

Please pass the sheet through the hatch. You will receive second sample now.

Administrative Instruction Worksheet

FaceReader Analysis on Light Induced Oxidized Milk

Participants will activate the green light indicating they are present and ready.

1. Slide consent form through first.
2. Upon retrieval, pass beverage intake questionnaire (BevQ-15) through next.
3. Once they are finished filling out the BevQ-15, turn on camera and make sure it is recording properly and is focused center on their face.
4. Slide a sample along with the appropriate index card (contains sample number, instructs them to hold card to their face and reminds them to face camera when sampling).
*** Refer to table below for sample order.

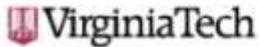
*** Cross off panelist number for that booth.

5. Once they are done tasting and slide the cup back through, pass the sheet containing the CATA list of terms and the hedonic score card through next.
6. Pass water, crackers, and demographics questionnaire.
7. Once returned, repeat steps 4 and 5 for the second sample.
8. Stop recording after they pass the hedonic score sheet back. Inform them they have completed the study and can now exit to receive their gift.

Booth #_____		1 st Sample	2 nd Sample
Odd Panelist #	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39	570	384
Even Panelist #	2, 4, 6, 8, 10, 12, 14,16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40	384	570

B. Appendix Supporting Documents: Chapters 4, 5 and 6.

IRB Approval Letter: IRB #: 14-020; Integrating Data for Emotional Assessment of Food Safety, Hygiene and Quality Concerns AND Integrating Data for Emotional Assessment between Types of Breakfast Meals AND Characterizing Emotional Response and Visual Attention to food Safety and Quality Concerns



Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0909
email irb@vt.edu
website <http://www.irb.vt.edu>

MEMORANDUM

DATE: December 14, 2015
TO: Susan E Duncan, Alexandra Margaret Walsh, Leslie Ann Patton, Martha Ann Bell, Angelica Shemari Melvin, Hayley Potts
FROM: Virginia Tech Institutional Review Board (FWA00000572, expires July 29, 2020)
PROTOCOL TITLE: Emotional Response to Food Video Images
IRB NUMBER: 14-020

Effective December 14, 2015, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 4,6,7**
Protocol Approval Date: **January 13, 2015**
Protocol Expiration Date: **January 12, 2016**
Continuing Review Due Date*: **December 29, 2015**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

Informed Consent: IRB #: 14-020.

Virginia Polytechnic Institute and State University

**Informed Consent for Participants in Research Projects Involving Human Subjects
(Sensory Evaluation)**

Title Project: Emotional Response to Food Video Images

Investigators: Susan E. Duncan, Alexandra Walsh, Martha Ann Bell, Leslie Patton, Angelica Melvin

I. Purpose of this Research/Project

You are invited to participate in a study to characterize the emotional response to food and non-food video images. This study will help identify similarities and/or differences in emotional response to these video images using several measurements (emotional ballot, facial expressions, EEG, and physiological responses) as well as a traditional measurement (liking scale) used in the food industry and in psychological research.

You will be videotaped while you are evaluating video clips. Videos will be analyzed for results using facial recognition software (FaceReader). This software is designed to collect real time emotional response by videotaping facial features as a reaction to information or stimuli and is a novel method for evaluating sensory responses to foods. This activity is designed to collect data on facial recognition software to assess its use as a tool in sensory evaluation of foods.

You will also be using an EEG cap, chest electrodes, as well as a fingertip sensor to measure brain activity as well as physiological measurements (e.g. heart-rate, galvanic skin response, temperature) as you view the food and other video clips.

The results from all the technological measurements as well as the emotion ballot and liking scale will be compared.

II. Procedures

The experimenter and trained assistants will aid you in placing the EEG cap on your head and preparing the device. We will ask you to attach the chest electrodes yourself. You will then be assisted in attaching the fingertip sensor to your hand. Also, during this setup time we will ask for you to fill out a short demographic questionnaire.

You will view an initial non-food, 8 food and 8 non-food video images presented one at a time. Following the guidance by the experimenter, you will watch each video and then will be asked to immediately fill out a rating on basic emotions and respond to a question asking you how well you liked the food in the video you just watched. You will also fill out an emotion ballot, which asks you to select all the terms from a list to describe how you feel about the food in the video you just viewed. For the non-food videos, you will be asked to fill out a rating on basic emotions.

Once you have viewed all the video images you will be asked to complete a few questions about your food preferences.

It is important that you maintain eye contact with the television screen as changes in head position/eye contact affects the video information available for the research. As such, please

keep your face positioned towards the television screen as you view the images. Please try to refrain from looking to the sides or down to the floor. Please do not touch your face.

At the completion of the study, the researchers will remove the sensors and respond to any additional questions you may have.

III. Risks

There are no more than minimal risks for participating in this study. Some individuals may be uncomfortable about being videotaped or recorded. Some individuals may be uncomfortable with using the EEG cap, chest electrodes, and/or fingertip sensor.

IV. Benefits

Your participation in this study will provide valuable information about consumer emotional response to foods and the application of technological measurements as sensory evaluation application tools, which will be useful to the food and related consumer industries.

V. Extent of Anonymity and Confidentiality

The results of your performance as a panelist will be kept strictly confidential except to the investigators. Individual panelists will be referred to by a code number for data analyses and for any publication of the results.

Collected videos may be used for educational, research (research publications, research presentations, research videos) and demonstration purposes including promotion or marketing videos about this sensory application.

VI. Compensation

Research participants will be compensated with 2 extra credit class points.

VII. Freedom to Withdraw

If you agree to participate in this study, you are free to withdraw from the study at any time without penalty. There may be reasons under which the investigator may determine you should not participate in this study. If you are under the age of 18, you are asked to refrain from participating.

VII. Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:

Follow the directions provided by the experimenter, who will direct me with guidelines about how to evaluate the video images, and provide my responses.

IX. Subject's Permission and Video Release

I have read the consent form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent to participate in this study.

Additionally, by signing this consent form, I am giving permission for the investigators on this project to capture and use video footage associated with my participation for educational, research, and/or demonstration purposes. I waive any video rights of compensation or ownership thereto. There is no time limit on the validity of this video release nor is there any geographic specification of where these materials may be distributed. This release applies to video footage collected as part of the sensory sessions associated with the identified IRB study # listed on this document:

Date _____

Subject Signature _____

Subject Printed Name _____

-----For human subject to keep-----

Should I have any pertinent questions about this research or its conduct, and research subjects' rights, and whom to contact in the event of a research-related injury to the subject. I may contact:

Susan Duncan, Faculty/ Investigator (540) 231-8675; duncans@vt.edu

Alexandra Walsh alexmw@vt.edu

Martha Ann Bell, Faculty/Investigator (540) 231-2546;
mabell@vt.edu

Leslie Patton lapatton@vt.edu

Angelica Melvin angelm6@vt.edu

David Moore
Chair, Virginia Tech Institutional Review Board for the Protection of Human Subjects
Office of Research Compliance (540) 231-4991; moored@vt.edu

Participant Instructions and Scorecards

Video Images_Instructions_ 6 Emotion Ratings_Hedonic Score and Emotional Ballot Scorecards for task 1 - (14-020)

Instructions [Instructions will be verbally provided by moderator]: For task one, you will be shown a total of 9 videos. Eight of which are food video clips to which you will evaluate.

Take a minute to familiarize yourself with the score sheets. First, you will be rating your feeling of angry, disgust, happy, sad, scared, and surprised.

Next, for each video clip, you are to evaluate how well you like the food shown in that clip as if you were to eat it

Then you will check all emotions (from on the emotions list scorecard) that you felt while watching each video clip.

**Make certain you are facing the television screen while you are asked to view the videos.
Refrain from looking to your side or looking down. Refrain from touching your face.**

[Before Task 1 Begins.]

What is your age? _____

Please indicate your gender.

- Female
- Male

What is your academic year? _____

- Freshman
- Sophomore
- Junior
- Senior
- Other _____

What Major/s and Minors are you studying? _____

Are you or have you pursued a degree in Food Science, Human Nutrition or other food related majors or minors?

- Yes
- No

If yes, which one? _____

Do you wear glasses or contact lens?

- Yes
- No

If yes, which one are you wearing now? _____

Do you have a full beard or mustache?

- Yes
- No

Are you left-handed?

- Yes
- No

When was the last time you ate food? _____

Would you be willing to participate in a food sensory study wherein you are asked to watch 8 short (30-second) video clips of food?

- Yes
- No

Videos 1-8

[After viewing each video image participants will rate the level to which they feel each of the 6 emotions given. They will also fill out an emotional ballot selecting terms they associate with each food they have just seen.]

Emotion Video Rating Scale

How did you feel while watching the videos?

Video 1	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 2	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 3	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 4	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 5	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 6	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 7	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 8	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Video 9	Not at all			Somewhat		Very much	
Angry	1	2	3	4	5	6	7
Fearful	1	2	3	4	5	6	7
Disgusted	1	2	3	4	5	6	7
Happy	1	2	3	4	5	6	7
Sad	1	2	3	4	5	6	7
Surprise	1	2	3	4	5	6	7

Consider the food in the video clip as if you were to eat that food. Indicate how much you like the food you just saw by checking the term that best describes your response to the food shown.

- 7-Like extremely _____
- 6-Like moderately _____
- 5-Like slightly _____
- 4-Neither like nor dislike _____
- 3-Dislike slightly _____
- 2-Dislike moderately _____
- 1-Dislike extremely _____

[Emotional Term Ballot]

Consider the food in the video clip. Select all the word(s) from the list below that describe how you feel right now about the product you have just seen. Check *ALL* that apply.

Select all that apply.

<input type="checkbox"/> Active	<input type="checkbox"/> Energetic	<input type="checkbox"/> Joyful	<input type="checkbox"/> Safe
<input type="checkbox"/> Adventurous	<input type="checkbox"/> Enthusiastic	<input type="checkbox"/> Loving	<input type="checkbox"/> Satisfied
<input type="checkbox"/> Affectionate	<input type="checkbox"/> Fear	<input type="checkbox"/> Merry	<input type="checkbox"/> Secure
<input type="checkbox"/> Aggressive	<input type="checkbox"/> Free	<input type="checkbox"/> Mild	<input type="checkbox"/> Steady
<input type="checkbox"/> Angry	<input type="checkbox"/> Friendly	<input type="checkbox"/> Nostalgic	<input type="checkbox"/> Tame
<input type="checkbox"/> Bored	<input type="checkbox"/> Good	<input type="checkbox"/> Peaceful	<input type="checkbox"/> Tender
<input type="checkbox"/> Calm	<input type="checkbox"/> Good-natured	<input type="checkbox"/> Pleased	<input type="checkbox"/> Understanding
<input type="checkbox"/> Content	<input type="checkbox"/> Guilty	<input type="checkbox"/> Pleasant	<input type="checkbox"/> Warm
<input type="checkbox"/> Daring	<input type="checkbox"/> Happy	<input type="checkbox"/> Polite	<input type="checkbox"/> Whole
<input type="checkbox"/> Disgusted	<input type="checkbox"/> Interested	<input type="checkbox"/> Quiet	<input type="checkbox"/> Wild
<input type="checkbox"/> Eager		<input type="checkbox"/> Sad	<input type="checkbox"/> Worried

[After video image 9 and completion of emotion rating scale and emotional term ballot]

Do you like cereal with milk?

- I like both cereal and milk.
- I like cereal without milk.
- I like milk, but not cereal.
- I do not like cereal or milk.

Do you like fried eggs, bacon, biscuits and gravy?

- Yes, I like it all.
- I do not like my eggs fried.
- I do not eat bacon.
- I like biscuits but not gravy.
- I do not like this breakfast at all.

Do you like pancakes with butter, fruit, syrup, and powdered sugar?

- I like all of the above.
- I like my pancakes with only syrup.
- Everything, but the powdered sugar.
- Everything, except the fruit.
- Everything, except the butter.
- I do not like pancakes.

Do you like fruit, granola and yogurt parfaits?

- Yes, I like it all.
- I only like the fruit.
- I like yogurt and fruit, but not granola.
- I like granola, but not fruit or yogurt.
- I do not like fruit, but I do like granola and yogurt.
- I do not like any of it.

Do you like egg, sausage, cheese sandwiches?

- I like all of the above.
- I do not like cheese on my sandwich.
- I do not like sausage.
- I do not like this sandwich at all.

When choosing a breakfast food, what is important to you?

- The taste of the food.
- Health aspects of food.
- Convenience of food.
- Other Dietary concerns (e.g. allergies, vegetarianism, ect.)

I ... (mark multiple answers if applicable)

- Am a vegetarian or vegan. If yes, which one? _____
- Do not eat red meat. I only eat white meat (e.g. chicken or fish)
- Am lactose intolerant.
- Am allergic to some foods. If so, which ones? _____

Are you on a restricted diet?

- Yes, for weight management.
- Yes, for other health reasons.
- No

Thank you for completing this study. You will be assisted in the removal of the cap and fingertip device.

Chapter 4: Additional Results

Table 7: Student's t-test comparison of mean frontal cortex asymmetry scores (F8-F7) between control and evented videos for pre- and post-event ($\alpha=0.05$).

Frontal Cortex Asymmetry Scores: F8 - F7	Food Concern	Event	Control		Evented		Mean Diff.	SD	n	t	p
			M	SD	M	SD					
Five sec pre-event	Cereal and Milk		0.024	0.425	-0.037	0.414	-0.081	0.556	39	-0.683	0.499
	Pancakes and Fruit		-0.145	0.356	-0.237	0.393	-0.033	0.463	39	-0.448	0.657
	Sausage Sandwich		-0.042	0.494	-0.112	0.465	-0.049	0.620	38	-0.317	0.753
Five sec post-event	Cereal and Milk		-0.047	0.381	-0.143	0.367	-0.096	0.388	40	-1.230	0.226
	Pancakes and Fruit		-0.177	0.452	-0.124	0.391	0.098	0.535	40	1.336	0.189
	Sausage Sandwich		-0.074	0.408	-0.042	0.390	0.070	0.462	40	0.957	0.345

Table 8: Student's t-test comparison of mean frontal cortex asymmetry scores (Fp2-Fp1) between control and evented videos for pre- and post-event ($\alpha=0.05$).

Frontal Cortex Asymmetry Scores: Fp2 - Fp1	Food Concern	Event	Control		Evented		Mean Diff.	SD	n	t	p
			M	SD	M	SD					
Five sec pre-event	Cereal and Milk		0.049	0.432	0.062	0.245	0.013	0.469	39	0.176	0.861
	Pancakes and Fruit		0.029	0.217	-0.011	0.247	-0.040	0.309	39	-0.815	0.420
	Sausage Sandwich		-0.029	0.339	-0.001	0.207	0.018	0.365	38	0.487	0.629
Five sec post-event	Cereal and Milk		0.023	0.250	0.047	0.283	0.027	0.316	40	0.458	0.650
	Pancakes and Fruit		-0.026	0.209	0.014	0.224	0.026	0.307	40	0.794	0.432
	Sausage Sandwich		-0.011	0.287	-0.069	0.228	-0.049	0.285	40	-1.309	0.198

Chapter 5: Additional Results

Table 6: Nutrition facts for food stimuli shown.

Event	Total Calories	Carbs (g)	Fat (g)	Protein (g)
Cereal and Milk	220	34	6	10
Pancakes and Fruit	561	115	6	6
Sausage Sandwich	615	31	41	32
Fruit Parfait	440	67	9	21
Biscuits and Gravy	480	34	33	24

Table 7: Student's *t*-test comparison of mean frontal cortex asymmetry scores (F8-F7) between breakfast meals and the control ($\alpha=0.05$).

Frontal Cortex Asymmetry Scores: F8 - F7	Breakfast Meal			Beach			Mean Diff.			n	t	p
	M	SD	M	M	SD	SD	Diff.	SD	SD			
Cereal and Milk vs. Control: Beach	-0.047	0.381	-0.116	0.509	0.075	0.580	0.075	0.580	39	0.768	0.447	
Pancakes and Fruit vs. Control: Beach	-0.237	0.452	-0.116	0.509	-0.101	0.585	-0.101	0.585	39	-1.294	0.203	
Sausage Sandwich vs. Control: Beach	-0.112	0.408	-0.116	0.509	0.017	0.688	0.017	0.688	39	0.038	0.970	
Fruit and Yogurt Parfait vs. Control: Beach	-0.068	0.559	-0.131	0.509	0.103	0.743	0.103	0.743	38	1.171	0.249	
Biscuits and Gravy vs. Control: Beach	0.012	0.542	-0.131	0.509	0.064	0.675	0.064	0.675	39	0.589	0.559	

Table 8: Student's *t*-test comparison of mean frontal cortex asymmetry scores (Fp2-Fp1) between breakfast meals and the control ($\alpha=0.05$).

Frontal Cortex Asymmetry Scores: Fp2 - Fp1	Breakfast Meal			Beach			Mean Diff.			n	t	p
	M	SD	M	M	SD	SD	Diff.	SD	SD			
Cereal and Milk vs. Control: Beach	0.023	0.250	0.036	0.372	0.007	0.323	0.007	0.323	39	-1.010	0.319	
Pancakes and Fruit vs. Control: Beach	-0.026	0.209	0.036	0.372	-0.033	0.349	-0.033	0.349	39	-1.010	0.319	
Sausage Sandwich vs. Control: Beach	-0.011	0.287	0.036	0.372	-0.017	0.359	-0.017	0.359	39	-0.745	0.460	
Fruit and Yogurt Parfait vs. Control: Beach	0.020	0.217	0.017	0.372	0.009	0.418	0.009	0.418	39	0.038	0.970	
Biscuits and Gravy vs. Control: Beach	0.050	0.206	0.017	0.372	0.032	0.333	0.032	0.333	39	0.604	0.550	

Table 9: Mean intensities (\pm s.d.) of expressed emotions identified by automated facial expression analysis and multiple comparisons within emotion and across video stimuli (ten seconds; $n=40$, $p<0.05$).

Event	Neutral		Happy		Sad		Anger		Surprised		Scared		Disgusted	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Beach	0.532 ^a	0.322	0.037 ^b	0.111	0.019 ^b	0.068	0.097 ^b	0.251	0.127 ^b	0.274	0.036 ^b	0.141	0.035 ^b	0.128
Cereal and Milk	0.451 ^a	0.310	0.008 ^c	0.029	0.049 ^c	0.167	0.221 ^b	0.353	0.135 ^{bc}	0.303	0.005 ^c	0.023	0.034 ^c	0.094
Pancakes and Fruit	0.455 ^a	0.285	0.038 ^b	0.121	0.040 ^b	0.150	0.163 ^b	0.300	0.127 ^b	0.280	0.033 ^b	0.107	0.032 ^b	0.090
Sausage Sandwich	0.444 ^a	0.316	0.032 ^b	0.134	0.077 ^{bc}	0.216	0.208 ^b	0.333	0.133 ^{bc}	0.288	0.009 ^c	0.045	0.032 ^c	0.099
Fruit Parfait	0.429 ^a	0.308	0.027 ^c	0.129	0.058 ^c	0.144	0.246 ^b	0.354	0.127 ^{bc}	0.293	0.016 ^c	0.068	0.023 ^c	0.069
Biscuits and Gravy	0.443 ^a	0.315	0.044 ^{cd}	0.147	0.049 ^{cd}	0.171	0.198 ^b	0.333	0.184 ^{bc}	0.355	0.006 ^d	0.029	0.017 ^d	0.054

*Means within each emotion (column) had no significant differences ($p>0.05$).

^{a, b, c} Means within each event (row) with different superscripts are significantly different ($p<0.05$).

Dunnett's Analysis:

Table 10: Mean heart rate (BPM) for five seconds for all breakfast meals and the control ($\alpha=0.05$)

HR	M (BPM)	SE
Control: Beach	72.633	1.685
Cereal and Milk	73.680	1.724
Pancakes and Fruit	71.282	1.752
Sausage Sandwich	71.914	1.775
Biscuits and Gravy	74.244	1.725
Fruit and Yogurt Parfait	74.453	1.665

Table 11: Dunnett's test comparison of mean heart rate (BPM) for five seconds for all breakfast meals compared to the control beach scene ($\alpha=0.05$)

Category	Diff.	Std. Diff.	Critical Value	Critical Diff.	p
Control: Beach vs. Cereal and Milk	-1.047	-0.572	3.615	6.619	0.961
Control: Beach vs. Pancakes and Fruit	1.351	0.738	3.615	6.619	0.906
Control: Beach vs. Sausage Sandwich	0.719	0.392	3.615	6.619	0.991
Control: Beach vs. Fruit and Yogurt Parfait	-1.820	-0.994	3.615	6.619	0.779
Control: Beach vs. Biscuits and Gravy	-1.611	-0.880	3.615	6.619	0.840

Table 12: Mean frontal cortex asymmetry score (F4-F3) for five seconds for all breakfast meals and the control ($\alpha=0.05$)

Frontal Cortex Asymmetry Scores: F4 - F3	M	SE	n
Control: Beach Scene	-0.019	0.066	40
Cereal and Milk	0.063	0.066	39
Pancakes and Fruit	0.052	0.063	40
Sausage Sandwich	0.014	0.055	40
Biscuits and Gravy	0.080	0.056	39
Fruit and Yogurt Parfait	-0.055	0.108	39

Table 13: Dunnett's test comparison of mean frontal cortex asymmetry score (F4-F3) for 5 seconds for all breakfast meals compared to the control beach scene ($\alpha=0.05$)

Category	Diff.	Std. Diff.	Critical Value	Critical Diff.	p
Control: Beach vs. Cereal and Milk	-0.082	-1.117	3.617	0.264	0.710
Control: Beach vs. Pancakes and Fruit	-0.071	-0.972	3.617	0.264	0.792
Control: Beach vs. Sausage Sandwich	-0.033	-0.449	3.617	0.264	0.985
Control: Beach vs. Fruit and Yogurt Parfait	0.036	0.492	3.617	0.266	0.978
Control: Beach vs. Biscuits and Gravy	-0.099	-1.341	3.617	0.266	0.583