

Measuring Consumer Emotional Response to Tastes and Foods through  
Facial Expression Analysis

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## ABSTRACT

Emotions are thought to play a crucial role in food behavior. Non-rational emotional decision making may be credited as the reason why consumers select what, how, and when they choose to interact with a food product. In this research, three experiments were completed for the overall goal of understanding the usefulness and validity of selected emotional measurement tools, specifically emotion questionnaire ballots and facial expression analysis, as compared to conventional sensory methods in developing a holistic view of product interest and engagement. Emotional response to 1% low-fat unflavored and chocolate-flavored milk was evaluated by using an emotion-based questionnaire as well as facial expression analysis software, to measure post-experience cognitive and in-the-moment intrinsic (implicit) emotional response, respectively. The software correlated facial movements of participants to associated basic emotions to estimate with what degree consumers were expressing these measured emotions upon presentation of each sample. Finally, the adapted facial expression method was compared to expected measurements from previous studies by measuring emotional facial response to four (sweet, salt, sour, and bitter) basic tastes. The cognitive emotion ballot and implicit facial analysis were able to differentiate between milk samples and offer a greater understanding of the consumer experience. Validity of the facial expression method was lacking for reasons including high individual taste variability, social context, intensities of stimuli, quality of video data capture, calibration settings, sample size number, analysis duration, and software sensitivity limitations. To better validate automatic facial expression methodology, further study is needed to investigate and minimize method limitations.

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## **Chapter 1: Introduction**

Consumer emotions play a key role in an individual's overall experience with a product. This experience may involve, but is not limited to, a decision to initially purchase a product as well as to repurchase. For instance, by creating a unique emotional connection in one product versus another, consumer emotions can control which brand is favored in the market and ultimately lead to the success of that particular brand (Hill, 2008). Simply put, a person's feelings can be attributed as a driving force to their behavior. A consumer can choose something because they feel a positive response or conversely not choose something because they feel a negative response; while consumers may attempt to rationalize their choices, they do not necessarily understand them fully (Lindström, 2008). This preference or judgment from a consumer is neither right nor wrong but may be influenced by an emotional response.

One particular area where consumers form emotional responses is in the selection and interaction with food. Consumers have the ability to connect with foods on many sensory levels including taste, touch, sight, and at times sound. Functionally, foods provide the ability for satiation, energy, and generally sustaining life. While a consumer may see the advantage of a food product in such basic terms, it does not wholly represent their motivations for when, how and why they interact with a particular food product (Lundahl, 2012).

Conventional sensory methods to collect consumer feedback are often limited in identifying consumers' emotional responses as well as relating consumer response to market success. A current limitation is that consumers are generally asked to verbalize responses through oral or written selection methods. For example, a hedonic scale generating a liking rating

is often used to capture how much a consumer states they like or dislike a product. This liking rating is very general and non-descript. It lacks information on how a product influences an experience (Lundahl, 2012). Other common methods such as focus groups and one-on-one interviews can cause a consumer difficulty in selecting the exact language in which to express their emotions. It may cause a consumer to inflate a positive response or deflate a negative response in order to seem pleasing and cooperative. It also allows for a consumer to post-rationalize an answer over a period of time instead of responding in real time. Such delay may cause a disconnection from what is actually being felt versus what is verbally being said, therefore, widening what has been coined as the say/feel gap (Hill, 2008). Additionally, a consumer's emotional response may not be consciously obvious to the consumer themselves (Lindström, 2008). As such, measuring a consumer's emotional response has thus far been a difficult task.

More recently, however, new methodologies have been developed to gather non-verbal cues to a consumer's emotional response to a product. One method, facial expression analysis (a.k.a. facial coding, herein used interchangeably), has been developed to measure muscular facial movements to stimuli in order to indirectly assess a consumer's emotional response. Facial coding requires gathering images and/or video of consumers' facial expressions immediately after or during exposure to particular stimuli and analyzing the presence and/or change of specific muscular facial movements. This analysis may be done manually or by using automated software platforms. For example, consumers' facial expressions have been previously analyzed by utilizing software such as Observer<sup>TM</sup> XT and FaceReader<sup>TM</sup> (Noldus Information Technology, The Netherlands) (Danner et al., 2013; De Wijk et al., 2012; Wendin et al., 2011; Zeinstra et al., 2009). The Observer<sup>TM</sup> XT software allows for an individual to create a self-

guided coding scheme in which to interpret facial expressions. FaceReader™ (Noldus Information Technology, The Netherlands) on the other hand is pre-coded and trained to mathematically analyze the direction and extent to which certain facial features move. These movements are used to determine which basic emotions (happy, sad, angry, surprised, scared, and disgusted) and with what intensity those emotions are being expressed by a consumer in real time.

Facial coding has thus far produced results suggesting that the investigation of facial emotion can provide additional knowledge into understanding consumer response and behavior. More frequently, facial coding has been used to understand human psychology and psychopathology (Ekman & Rosenberg, 2005). It has been used in industry to evaluate response and engagement to product commercials, political campaign ads, and new product designs. The facial coding results have been helpful by demonstrating differences in consumers' verbal responses vs. facial responses, thus leading to decisions such as moving forward with a specific product design and selecting one ad campaign over another (Hill, 2008).

As for tastes and foods, specifically, a very limited amount of testing has been completed using facial coding to measure emotional response, particularly with the aid of automated software. Furthermore, no consistent methodology has been used. Further testing must be carried out to better understand the feasibility and implications of utilizing facial coding to measure consumers' emotional responses to tastes and foods. This is the overall motivation for our study.

Automated facial coding methodology may be studied by focusing on acquiring a foundational understanding of consumer emotional facial response to taste by evaluating the known basic tastes. Knowledge may be added by focusing on a generally accepted positive taste,

i.e. sweet (Ekman, 2007), or other specific stimuli. Also, analyzing a more complex beverage that incorporates a sweet taste and has a potential measurable emotional response, such as fluid milk, may add further insight in assessment between conventional consumer response collection methods vs. facial coding.

## **Goal**

The goal of this research was to create a knowledge base for validating the use of automated facial expression analysis software as a sensory method for value added understanding of consumer emotional response in the food and beverage industry. The results from our study could allow for a more in depth understanding of the complex motivations behind consumer food behavior. It can better define what internal responses consumers have but cannot always verbally describe. Our study can provide an outlet for gathering quantitative information on intrinsic emotional response to tastes and food. Ultimately, outcomes from our research may be used to create new sensory methodologies, beyond current conventional practices, that can be used to innovate or improve upon a food product to provide a better overall consumer experience.

## **Objectives**

- 1) Evaluate emotional response to unflavored and flavored milk using the recently created emotion based questionnaire, the EsSence Profile<sup>TM</sup> Ballot (Cardello et al., 2012; King & Meiselman, 2010; King et al., 2010), and compare the findings to reported behavior, knowledge and attitudes and acceptability ratings for a young college population.
- 2) Develop a method to measure intrinsic emotional response to fluid milk by evaluating and comparing two different samples (chocolate-flavored and unflavored milk), using



automated facial expression analysis software (FaceReader™, Noldus Information Technology, The Netherlands).

- 3) Create a baseline understanding of consumer emotional facial response to four (sweet, salt, sour, and bitter; not including umami) basic tastes using automated facial expression analysis software (FaceReader™, Noldus Information Technology, The Netherlands) to:
  - a) validate that an emotional response does occur; b) characterize similarities and/or differences in emotional response to the basic tastes based on objective facial coding interpretation of 6 basic emotions (happy, surprised, sad, angry, scared, disgusted) and a neutral state; and c) compare the results in relation to historical research learning of emotional response, specifically facial response, to the basic tastes, to substantiate the potential reliability of the selected analysis method.

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## **Chapter 2: Literature Review**

### **Influence of Emotions in the Consumer Experience**

Emotions are believed to be an integral but subconscious part of a consumer's decision-making process (Hill, 2008). However, even when consumers are consciously aware of their emotions, they generally lack focus on these emotions. This has been summarized as being consciously aware but in a mindless manner (Langer, 1989) or not attentively considering one's emotional feelings (Ekman, 2007). Thus, when consumers are asked to assess why they made their selection, they may post-rationalize their thoughts to support their choice even though the decision-making process was emotional rather than rational. Consumers often make a selection or point of preference just because it "feels right". This response is a precognitive affective reaction in which consumers feel before they rationally think (Zajonc, 1980). Such emotional verdicts are not easily refutable as they are not based in rational fact.

One current view associated with product success is that a driving force is created through the formation of an emotional connection to a particular product, which may ultimately lead to the success of that particular product over another (Hill, 2008; Lundahl, 2012). Lindstrom (2008) describes emotions as "the way in which our brains encode things of value, and a brand that engages us emotionally...will win every single time". Lindstrom (2008) argues that emotions can form strong associations to a product or product brand, which allow for ultimate commercial success (or failure) of a product. Support for this position is based on brain scans using functional magnetic resonance imaging (fMRI), during product usage. For example, when consumers were given two popular cola products, without cues (blinded), preference was equally split in the absence of branding; when branding was introduced, Coke was preferred over Pepsi.

This difference in selection was associated with differences in brain activity, as measured by fMRI, in areas related to emotion, the hippocampus and dorsolateral prefrontal cortex. Significant differences were found in brain scans when branded vs. unbranded Coke product were consumed, whereas no significant differences were seen in the fMRI brain scans for branded vs. unbranded Pepsi product (McClure et al., 2004). Furthermore, once these emotional associations (biases) are reinforced and accepted, they can be very difficult to modify (Hill, 2008).

### **The Ambiguity of ‘Emotion’**

There is not a singular well agreed upon definition of emotion. Ekman et al. (1982) relay this message by stating that there are various definitions and positions on the matter. Ekman et al. (1982) also point out that there is further disagreement on what stimuli elicits emotional behavior. This leaves the field of ‘emotion’ with lack of agreement not only on what is considered to be an ‘emotion’ but also on what stimuli should be used to elicit emotions along with research settings to study such phenomenon.

For our research study, an overarching perspective was taken as to what was considered emotional response. Emotional response was broadly defined as an affective response which included the more agreed upon definitions of limited, quick duration and implicit ‘basic emotions’ as well as more subjective extended duration ‘feeling/attitude/mood’ response states and descriptive terms related to those states, e.g. excited, energetic, merry, worried, friendly. Affective response was defined as a response to a stimulus that can be linked to having positive or negative connotations that relate to acceptance/rejection or liking/disliking of that stimulus. The terms ‘basic emotions’ in this study refers to emotion definitions as studied through facial

interpretation of emotion, i.e. sad, angry, happy, sacred, disgusted, fear, and surprised (Collier, 1985; Danner et al., 2014; Ekman, 1982, 2007). Within the term ‘basic emotion’ and/or ‘primary emotion’ there is still debate as to exactly which ‘emotions’ should be included; other ‘emotions’ beyond what has been defined for our study have been included and described in this context of ‘basic emotions’ or ‘primary emotions’ such as anxiety (Croy et al., 2011), contempt (Ekman, 1982, 2007; Russell & Fernandez-Dols, 1977), and shame, distress, interest, and enjoyment (Collier, 1985). The ‘feeling/attitude/mood’ emotional response states and descriptive terms related to those states are believed to be the product of open-endedness and variability in interpretation of and delivery in verbal communication of ‘emotion’ (Collier, 1985; Fussell, 2002). These descriptive terms (e.g. bored, calm, active, secure, wild, nostalgic) diverge from what are considered ‘basic emotions’. The difficulty in finding language to describe or evoke emotional response verbally beyond such ‘basic emotion’ terms leads to more figurative or metaphorical language (Davitz & Beldoch, 1976; Fussell, 2002) to verbally communicate emotion. As such, methods to investigate verbally communicated ‘emotion’ often incorporate language that includes both ‘basic emotions’ as well as other ‘emotion-based/emotional’ terms that relate to ‘feeling/attitude/mood’ emotional response states. The term ‘emotion’ is therefore used interchangeable in this literature review and study to refer to ‘basic emotions’ and/or ‘emotion-based/emotional states’ unless explicitly described.

### **Interrelation between Foods, Tastes and Emotions**

Prevailing ideas have suggested a link between an individual’s anticipated or thought induced emotional response by a particular food and the rationale for the selection and consumption of that food; anticipation is associated with the expected sensory properties, including textural and structural characteristics of the food (Galef Jr, 1996; Martins & Pliner,

2005). Long-term, established pleasurable emotional and memory connections with a food product may be linked to an individual's preference to seek out such foods, with a high likelihood being that those products exhibit sweet and fatty characteristics. Conversely negative emotions and memories can influence distancing to particular food sources (Rozin & Gohar, 2011).

Associations have been made for the intrinsic emotional response to foods. A sweet taste is considered inherently pleasant while other tastes, such as sour and bitter, are considered inherently aversive (Barker, 1982; Gibson, 2006; Steiner, 1979). As such, a sweet taste is generally accepted as providing a positive, enjoyable experience for a consumer. Other tastes such as sour and bitter may be enjoyed as well but this enjoyment is considered to be the result of an ability acquired by a consumer over time (Ekman, 2007; Green, 1990). Sweet and high-energy dense foods have been associated with improving mood and reducing levels of stress. For example, chocolate, which is high in both fat and sugar, is often chosen more frequently during times of stress (Gibson, 2006). Another sweet and high fat product, milk, has been shown to ease stress and reduce crying in infants (Blass et al., 1989).

Barr et al. (1999) investigated whether different sources of sweet, sucrose or aspartame, had the same calming in infants. Solutions with the same sweetness equivalence (sucrose concentration: 24%; aspartame concentration: 0.12%), as determined by adults, reduced crying in infants with the same magnitude and time results when relatively compared to a water baseline. This study suggested that sweetness was the reason for the reduction in crying as opposed to the sweetness source (sucrose vs. aspartame) (Barr et al., 1999).

## Methods of Measuring Emotions

Different methods are used in an attempt to better understand when, how and why consumer emotions are formed. Methods that focus on implicit responses include the measurement of physiological autonomic and facial response. Physiological response can be measured through tools such as functional magnetic resonance imaging (fMRI; brain scans), electroencephalography (EEG; brain electrical activity), electrocardiography (ECG; heart rate), body temperature, and perspiration. Methods that focus on explicit response rely on cognitive thinking from a participant to self-report their own emotions. Questionnaire-type ballots are often used for intensity ratings or binary check all that apply (CATA) of pre-selected basic emotions and/or emotion-based terms. Other ballots may be open-ended questions relating to recall of associated emotions towards a stimulus with no pre-conceived terms for restriction. The latter method often times is used to create and narrow down the list of pre-selected emotions to be used in a second/future round of experiments.

Which method is more useful is debatable; both methods have pros and cons. Explicit extraction of emotions relies on conscious post-rationalization to think about one's own emotions after the fact. This method can be seen as subjectively variable since emotional language can be defined and interpreted in different manners from one participant to the next. Implicit extraction is based on subconscious spontaneous response that is hard to suppress or falsify yet gathering clear readings can be challenging. For example with EEG, data portions must be removed (a.k.a. artifact data) when the data stream is too noisy or interrupted by body/eye movements, e.g. blinking (Reddy & Narava, 2013). This produces an end data stream that is known as artifact-free data. Differing approaches may be used to artifact (Ahmed et al., 2012; Delorme et al., 2007; Joyce et al., 2004). The robustness and amount of remaining artifact-free data can thus be

diminished if proper protocols or experimental instructions are not properly put in place. Additionally with EEG, left-handed participants and infants of a left-handed parent are often removed from study due to differences in brain activity between left and right-handedness (Fox & Davidson, 1986; Galin et al., 1982; Herron, 1980; Zhavoronkova, 2000). Furthermore, baseline controls for autonomic responses may need to be adequately measured per participant, to correct and compare to test results due to individual variability.

### ***Measuring Emotions through Facial Expression Analysis***

One method to measure emotions involves the use of facial coding. While the application of other implicit methods, e.g. fMRI, may be useful as well, facial coding provides a less invasive, less costly, and more feasible method of characterizing emotional response.

Facial coding is a method of measuring the muscular movements of the face in response to stimuli and correlating these movements to specific emotions and/or positive and negative facial behavior, which are known to facilitate such movements (Ekman, 1982; Ekman & Friesen, 1978). Particular areas of the face that often involve expression of emotion include the eyes, cheeks, lips, nose and eyebrows. For example, in a showing of disgust, the nose is wrinkled, the eyebrows are lowered and the cheeks are raised; in showing happiness, the edges of the lips are curled up, and both the muscles of the inner and outer part of the eyes are used; in a showing of fear, brows are raised and drawn together, eyes are wide, and lips are stretched (Ekman, 2007). Facial expressions are not learned but are inherent, as determined by comparing individuals born congenitally blind versus sighted individuals (Galati et al., 2001, 1997). Blind individuals were able to produce similar expressions to those of sighted individuals.

Facial coding relies on the principle that the overwhelming majority of individuals across cultures and ethnicities react to an emotion by moving their facial muscles in a similar and



recognizable manner, suggesting that facial expressions are universal (Ekman et al., 1987; Ekman et al., 1969; Izard, 1971). In a study assessing the impact of culture on emotions, photographs were shown to individuals from five different cultures (New Guinea, Borneo, Brazil, Japan, U.S.) and were judged on what emotion was shown for each facial expression presented. The majority of individuals agreed on the emotions depicted in the photographs (Ekman et al., 1969). In a similar study, individuals across cultures agreed on emotions depicted through facial expression (Izard, 1971). Individuals across cultures agreed on what emotion was being shown in a presented photograph but did not always agree on the intensity of the presented emotion (Ekman et al., 1987). Additionally, it has been suggested that in some cultures there may be a tendency to try to mitigate or suppress negative emotions in public as opposed to in private (Ekman, 1972).

### **Manual Facial Coding**

Facial coding generally requires gathering images and/or video of consumers during or immediately after interaction with particular stimuli, followed by characterizing the changes in facial muscular motion. Several facial coding methodologies or ‘tools’ have been developed. Ekman and Friesen (1978) developed the well-known Facial Action Coding System (FACS). This method discriminates 44 potential facial movements that are anatomically separate and visually distinguishable; each movement is characterized as an action unit (AU). The method includes an intensity rating on a 5-point scale of each AU (Ekman & Friesen, 1978). Facial Expression Coding System (FACES), focuses on negative and positive facial response (Kring & Sloan, 2007). Maximally Discriminative Facial Coding System (MAX) differentiates across 3 facial regions (forehead and brows, mid-face, and mouth) and categorizes between type of movements in each region (Izard 1979; Matias, 1989). Monadic Phases Coding System (MP) is an additional coding method developed for infant affective response that combines information

about gaze, facial and vocal expression, posture, and activity type (Cohn & Tronick, 1987; Matias, 1989; Tronick et al., 1980). Manual data coding for these methods is a lengthy and time consuming process.

### **Automatic Facial Coding**

Computer aided integration provides more efficient translation of facial coding data analysis methods. Several perspectives on development, commercial and non-commercial, have been created for use in a variety of areas. Pantic and Rothkrantz (2000) discuss the limitations and attempts at automated FACS analysis for detecting AUs. Some methods rely on the use of images (Lyons et al., 1999; Pantic & Rothkrantz, 2000; Wiskott et al., 1997) while others are video based (Cohen et al., 2003; Littlewort et al., 2006; Yacoob & Davis, 1996). Automatic analysis, not based on FACS, which specifically focuses on video analysis instead of 2-D static images was developed for capturing facial expression changes and linking them to facial classifications (neutral, happiness, sadness, anger and fear) for understanding neuropsychiatric disorders, e.g. schizophrenia (Wang et al., 2008); the method was adapted from initial development using elicited photographic images of these emotions with differing ranges of intensity (mild, moderate, and peak) (Alvino et al., 2007; Verma et al., 2005). Other automated analysis based on FACS, similarly developed for neuropsychiatric disorders and for use with videos, allows for frequency outputs in AU units displayed singularly or in combination (Hamm et al., 2011).

One commercially available software platform, known as Affdex (Affectiva, Inc., Waltham, MA), focuses on automatic facial coding through video webcam analysis. Two other commercially available software platforms, Observer<sup>TM</sup> XT and FaceReader<sup>TM</sup> (Noldus Information Technology, The Netherlands) allow for indirect and direct automation of facial coding, respectively. Observer<sup>TM</sup> XT is a video software platform that allows an individual to

create their own selected coding scheme; thus, the researcher can dictate what facial movements to look for and how these movements relate to a specific emotion and/or positive or negative response. They may integrate, but are not limited to using, the FACS methodology along with a potential secondary methodology to further interpret the AUs. Essentially, the usefulness of Observer<sup>TM</sup> XT (Noldus Information Technology, The Netherlands) is its ability to review video in real time frame-by-frame and go back and review/reassess moments. It also allows different individuals to review a video image using the exact same coding scheme to thus reinforce not only the coding scheme but also the results by replication. FaceReader<sup>TM</sup> (Noldus Information Technology, The Netherlands) on the other hand already has a specific coding scheme integrated into the software. FaceReader<sup>TM</sup> is essentially pre-coded and trained to mathematically analyze the direction and extent to which certain facial features move. These movements are used to predictively define which 6 basic emotions- happy, surprised, sad, angry, scared, disgusted as well as a neutral state- a consumer is expressing in real time and with what intensity these emotions are being expressed. The intensity measurements are judged on a continuous scale from 0 to 1, with 0 being that the emotion is not expressed and 1 being that the emotion is fully expressed. This software is limited in emotional characterization. Happy is considered the only positive emotion while sad, angry, scared and disgusted are considered negative emotions. Surprised can be considered either positive or negative. Results can also be delivered as a mixture of emotions, which is often the case, and therefore the sum of intensity across emotions will not generally equal one.

FaceReader<sup>TM</sup> works on three main principles. First, the software must detect that a face exists, which is done by using two face detection algorithms; the Viola-Jones algorithm (Viola & Jones, 2001) specifically recognizes the presence of a face while a deformable template method

(Sung & Poggio, 1998) creates a framing of the face. The second step is to create a 3-D model of the face using the Active Appearance method (Cootes & Taylor, 2000). This allows for 491 key points on the face to be detected, which include but are not limited to areas of the lips, eyebrows, nose and eyes. The final step involves interpretation of facial movements/expressions into emotions by utilizing a trained artificial neural network (Bishop, 1995) that incorporates approximately 2000 interpreted images. The automation of FaceReader™ allows for the results to be analyzed and delivered in real time and substantially reduces the time required for data translation into emotional characterization.

### **Facial Coding Limitations**

There are several limitations within the scope of facial coding. Partial occlusion of the face can cause failed data capture and/or misrepresentation in analysis of the facial expression and corresponding emotion being expressed for both human observers and automated software (Kotsi et al., 2008). Training for manual coding can be very time intensive and generally requires, for validation purposes, the use of several trained coders. Automated facial coding can still be time intensive when compared to traditional methods of data gathering, e.g. asking consumers to fill out questionnaire data, since the method involves collection and analysis of video or photographic footage. Then, depending on how the raw emotional data from a singular video footage is extracted, a short (e.g. 1-20 second) video sequence could be analyzed for emotional response in several minutes; however, the full analysis time would be increased and vary with the type of software used while the manipulation and interpretation of the compiled raw results would add lengthy analysis time. The facial coding method also requires training on how to use related software and methods of interpreting collected data. Additionally, there is currently no standardized procedure for evaluating such data.

## *Measuring Emotions through Questionnaires*

Alternative methods of gathering consumer emotional response to stimuli have been developed beyond facial coding and autonomic responses in the form of more typically used questionnaires. Emotion-based questionnaires have been used for many different research areas including but not limited to emotion response/regulation for athletes (Uphill et al., 2012; Vast et al., 2010), children, adolescents and adults (Beedie et al., 2011; Gullone & Taffe, 2012; Phillips & Power, 2007; Sohn et al., 2002), and students in varying academic settings (Lichtenfeld et al., 2012; Pekrun et al., 2011).

Several studies have specifically focused on emotional response towards foods and odors. Consumers have been asked to verbalize their emotional response through creation and rating of term lists (Chrea et al., 2009; Desmet & Schifferstein, 2008; Porcherot et al., 2012; Thomson et al., 2010). Specifically for odors, the Geneva Emotion and Odor Scale (GEOS) (Chrea et al., 2009) or modified versions have been used to gather insight on odor-elicited emotions (Porcherot et al., 2010). GEOS was developed through two studies that narrowed 480 terms (taken from literature on emotions and odor) down to 73 emotion-based (e.g. relaxed, serene, soothed) and basic emotion (e.g. disgusted, surprise, angry) terms by using participants rating responses to the relevance of each term to past odor experiences. The 73 terms were then narrowed down to 36 terms by asking participants to determine the relevance of each term in correspondence to 56 presented odors (Chrea et al., 2009).

One particular food and beverage questionnaire-based method, known as the EsSense Profile™ ballot (Cardello et al., 2012; King & Meiselman, 2010), gathers preference data on a 9-point hedonic scale as well as incorporates a 39-term word list that includes words which describe basic emotions (e.g. disgust, happy) and attitudes/moods /feelings (e.g. nostalgic,

loving, polite). For the ballot, panelists are asked to use the hedonic scale to select how much they liked or disliked a product, either following tasting or by recollection, and then to check all the words that apply (CATA) in the list that reflect how they feel in association with the product. Alternatively, the EsSence Profile™ ballot has been developed such that instead of using CATA in the list, consumers may rate each term for how much they feel or don't feel the given mood and feeling terms on a scale from 1 to 5 (King & Meiselman, 2010). Differences in test design methods for presenting the ballot (hedonic acceptability before vs. after emotional term selection, order of term selection, stimulus type, test sample number, time of day) were investigated to understand impact towards results (King et al., 2013).

## **Measuring Emotions towards Tastes and Foods**

### ***Facial Coding Emotional Assessment to Application in Food and Beverage***

Facial coding has been used in a variety of research areas including mental illness (Healey et al., 2010; Kohler et al., 2008a,b; Lotzin et al., 2013; Wang et al., 2008), substance abuse (Sayette et al., 1992; Sayette et al., 2003), child behavior (Larochette et al., 2006; Matias, 1989), gender differences (Fujita et al., 1980; Kring & Gordon, 1998), and general marketing and advertising campaigns (Hill, 2008). Its application in the food and beverage area is just emerging. The assessment of emotional response to the basic tastes was an early research entry into this application. FACS approach was applied to study the facial expressions of newborns to four basic tastes (sweet, sour, salty and bitter) to understand whether or not newborns were able to discriminate among the tastes. Newborns were able to not only discriminate sweet from the other tastes, but could also discriminate among non-sweet tastes (Rosenstein & Oster, 1988). MAX approach was used to determine durations of affective (interest, disgust) facial expression in newborns to three taste conditions, two taste stimuli (sweet, sour) and a water control. The

sucrose stimulus elicited shorter duration in the disgust emotion than the water and citric acid stimulus although significance could not be determined due to small sample size (Fox & Davidson, 1986). Facial coding utilizing FACS and the Observer<sup>TM</sup> software has been used to gather understanding of facial reactions to the basic tastes, including umami, in adults; facial reactions, inclusive of intensity, were compared to hedonic pleasantness ratings at different concentrations of basic taste solutions (Wendin et al., 2011). The tastes, concentration of tastes, and perceived pleasantness could be differentiated and correlated to specific facial reactions. Greimel et al. (2006), using FACS, suggested that inducing emotions of sadness and joy did not change the facial expressions of adults to differing tastes (sweet, bitter and bitter-sweet), although the induced emotions did modulate perceived pleasantness and intensity ratings of the tastes.

Facial coding has also been used to measure children's facial responses to beverages and tastes. In one study children's facial responses were concurrently compared to their preferences, which were assessed via a traditional rank order method (Zeinstra et al., 2009). The results demonstrated that a significant correlation existed between the frequency of negative facial response (AUs) and a given stimulus' rank order preference, i.e. the more the stimuli was disliked, the greater the sum of negative AUs expressed. No correlation was found between rank order and the frequency of positive or neutral AUs expressed; thus, it was concluded that facial expression was a good indicator of a lesser preferred, disliked stimulus but not of a greater preferred, liked stimulus (Zeinstra et al., 2009).

Facial coding has also been used to measure emotional response towards food and beverage with adults. In one study, adults' facial expressions were automatically analyzed (Facereader<sup>TM</sup>, Noldus Information Technology, The Netherlands) for intensity of emotional

response towards liked and disliked foods (De Wijk et al., 2012). Researchers measured changes in emotion of participants from before and after the sight of foods as well as before and after tasting foods. Results suggested that facial expressions changed more for the viewing of liked foods than disliked foods (De Wijk et al., 2012). In another study also using automatic facial expression software (Facereader<sup>TM</sup>, Noldus Information Technology, The Netherlands), researchers studied the facial expressions of participants in response to the consumption of different orange juice products (Danner et al., 2013). Participants delivered both intrinsic (implicit) as well as explicit responses post stimulus consumption wherein significant differences were seen in the mean intensity of select emotions (angry, disgusted, happy and neutral state) between juice samples.

Even though there have been emotional insights provided from the use of facial coding in this category, certain limitations can be identified. Obscuring portions of the face, particularly the mouth, can reasonably happen with testing of foods and beverages, as consumers would likely be bringing food or a beverage carrier to their mouth directly prior to consumption. As such, a time delay would be presented as video analysis may not be accurately performed until the item or hand is removed from the face. Additionally, such muscle movements as swallowing or chewing may further diminish the ability to accurately identify continuous facial expression. If this is the case, study significance can be diminished due to failure to collect and analyze sufficient video footage. There has been no prior determination of how many observations are needed and for what length of time they should be assessed in order to capture accurate results and sufficient statistical power.



### ***Questionnaire Emotional Assessment to Application in Food and Beverage***

Emotion-based questionnaires have been used in a variety of research areas as described above. Results from specific food and odor related studies have allowed for a more in depth understanding of the emotional connection an individual may experience to such stimuli and its relation to affect. It has also provided for more optimized consumer friendly ballots that can be easily administered to participants. Porcherot et al. (2010) found that emotion term results towards differently fragranced products of a modified shortened questionnaire ballot (ScentMove™; 18 terms) were comparable to the original GEOS questionnaire (Chrea et al., 2009) consisting of 36 terms. Furthermore, results were discriminating between products exhibiting similar acceptability scores thus allowing for a broader understanding of consumer product experience (Porcherot et al., 2010). Other ScentMove™ questionnaire studies involving food odorant names found both matches and discrepancies between emotions elicited via memory linked to odorant names and actual presented odorants (Porcherot et al., 2012).

King and Meiselman (2010) found that when developing an emotion-based questionnaire to study foods that emotional terms consumers associated with foods were generally positive. They found that a term list of emotion/mood based terms added value in distinguishing between foods and food categories. Comparisons between favorite vs. least favorite foods showed that higher acceptability (favorite) related to more positive term usage whereas lower acceptability (least favorite) related to more negative term usage. By relating hedonic values to term selection among participants, differences in emotion selection weren't found to always correlate to differences in acceptability scores. Results also suggested that emotion selection profiles change with product usage; non users had different, more negative emotional profiles than frequent users who held stronger positive emotions (King & Meiselman, 2010).

Studies using the EsSense Profile™ ballot have shown a correlation between overall food and beverage stimuli acceptability and selected emotion-based terms although these correlations differed among product, product category, and demographics such as gender. For example, two emotions (satisfied and disgusted) within males and twenty-five positive emotions (e.g. joyful, good, happy, pleasant) and one negative emotion (disgusted) were correlated to acceptability; the remaining terms were not correlated to acceptability (King et al., 2010). Further studies using the ballot showed that emotional responses varied by stimulus type, e.g. food names and foods tasted. It was also shown that emotion response to stimuli was highly reliable in replication when re-tested at a later date (one week later) (Cardello et al., 2012).

### **Emotions, Food Behavior, Obesity and Health**

Emotions are an underlying issue with food related behaviors that are associated with health and obesity issues. Emotions have been shown to influence types of foods eaten as well as amount, while eating has been shown to influence and regulate emotions (Macht, 2008). Previously highlighted above, energy-dense foods with sugar and fat induce positive affective response promoting consumption while other tastes, i.e. bitter, induce negative affective response and encourage rejection (Rosenstein & Oster, 1988; Steiner, 1979; Steiner et al., 2001). As further discussed by Macht (2008), emotions can increase food intake in certain individuals while reducing the amount in others. For example, restrained eaters eat more food as a consequence of fear and negative moods than non-restrained eaters (Greeno & Wing, 1994; Heatherton et al., 1998; Rotenberg & Flood, 1999; Ward & Mann, 2000); restrained eaters are identified as persons who have a continuous eating behavior pattern and food-thoughts focused on a goal to reduce or maintain body weight (Herman & Mack, 1975). Other studies where individuals were self-identified through the Dutch Eating Behavior Questionnaire (DEBQ) (Van

Strien et al., 1986) as emotional or non-emotional eaters, showed higher consumption of high-fat, sweet foods in response to stress in emotional eaters than non-emotional eaters (Oliver et al., 2000; Wallis & Hetherington, 2009). Another study, which assessed high emotional eaters identified through self-report survey, found gender differences wherein females identified stress and males identified boredom or anxiety as reasons for emotional eating; both genders stated that emotional eating resulted in poor, unhealthy food choices (Bennett et al., 2013). It has also been shown that meals consumed in a positive or negative mood influenced selection of larger size meals as compared to neutral state (Patel & Schlundt, 2001). The results of the compilation of these studies and others suggest that emotions in the food experience may be tied to increased weight and obesity.

The incidence and continuing rise of obesity in the U.S. has been of great concern, particularly among children and adolescence. The National Center for Health Statistics 2009-2010 data indicated that approximately 17% of children and adolescents were obese (Ogden, 2012). Additionally the American College Health Association recently indicated that 22% of college students were categorized as overweight with 10% being considered obese (American College Health Association, 2009). Rationale for concern among a young population can be associated with data that suggests being overweight or obese in childhood and adolescence can lead to elevated risks of health problems, including cardiovascular disease and diabetes, during periods of growth and into adulthood (Hannon et al., 2005; Juonala et al., 2011; Rocchini, 2002, 2011).

### ***Sugar Sweetened Beverages, HFCS, and Obesity***

The onset of obesity has led to questions of why there is such progression. There is some belief that there is a link between obesity and the consumption of sugar-sweetened beverages

(Berkey et al., 2004; Ludwig et al., 2001; Schulze et al., 2004). This is further influenced by believed associations between positive induced emotions and sweetness (Rosenstein & Oster, 1988; Steiner, 1979). Research has suggested that consumption of sugar-sweetened beverages among children and adolescents may contribute to weight gain, which is likely caused by the increase in overall calorie intake (Berkey et al., 2004; Ludwig et al., 2001). Conversely, the removal of SSB from diet has been shown to decrease weight in adolescents, with increasing weight loss benefits for increasing initial body weight (Ebbeling et al., 2006).

The incorporation of high fructose corn syrup (HFCS) as a sweetening agent in these beverages has been of concern. There is both arguable support (Bocarsly et al., 2010; Bocarsly et al., 2010; Bray et al., 2004) and discredit (Forshee et al., 2007; Klurfeld et al., 2013) for the connection between HFCS and obesity. Nevertheless, HFCS is used in many beverages, which are often marketed for consumption by young adults and children (Wiehe et al., 2004).

### ***The Emotional Conflict of Healthy and Indulgent Choices***

Knowledge of positive emotional and questionably addictive (Drewnowski & Bellisle, 2007) associations of sweetness as well as SSB consumption and their possible link to obesity, particularly in children, has caused conflict. Furthermore, SSB availability and consumption has quickly increased over the years coinciding with the obesity epidemic (French et al., 2003; Nielsen & Popkin, 2004). Health advocacy of better eating habits for children and adolescents has pushed for improved food choices and removal of SSB at school settings (Fried & Nestle, 2002). The way to implement such changes is debatable. One could argue that removing all SSB and HFCS products would be a solution, particularly since it's been shown that removal of SSB can help decrease weight in adolescents (Ebbeling et al., 2006). At the same time it's debatable whether all SSB are really 'villainous'. For example, one particular product within recent debate

on whether it should be a school beverage option is sweetened (chocolate) flavored milk. Flavored milk, often sweetened with HFCS, has been reported as a top source of SSB for Americans over age two alongside soda, fruit drinks, tea, coffee, and energy/sports drinks (Miller et al., 2013). Flavored milk is also a nutrient dense beverage. Removing it from school settings may further reduce the consumption of fluid milk overall, as indicated by recent studies (Patterson & Saidel, 2009; Quann & Adams, 2013); milk consumption has already been steadily decreasing over the years (Sebastian et al., 2010; Stewart et al., 2013).

### **Milk Consumption and Health**

Milk is a healthy product providing 9 essential nutrients, vitamins and minerals including proteins and valuable lipids. Milk consumption has been declining throughout the years, particularly among children and adolescents (Sebastian et al., 2010; Stewart et al., 2013). Generational differences have shown that for each coming generation, milk consumption has decreased further compared to the generation before; this decrease has been attributed to the frequency of consumption occasions and not necessarily the portion size per occasion. Potential sources for the generationally associated decrease have been connected to the increasing amount of alternative beverage options available to each new generation, e.g. sports and soft drinks (Stewart et al., 2013).

Significant decreases in the number of children and adolescent populations consuming fluid milk has been found through comparisons of US consumption based survey data across the years. From 1977-1978 to 2005-2006, there was a decrease of approximately 10% and 28% in the number of individuals aged 2-11 and 12-19 consuming fluid milk, respectively; additionally, there was a significant decrease by almost half in mean milk intake between the same time frames for the adolescent aged individuals. Approximately 50% of milk consumption overall

(2005-2006) was from unflavored fluid milk consumption with 28% and 17% coming from flavored (sweetened) fluid milk for individuals aged 2-11 and 12-19, respectively (Sebastian et al., 2010).

Studies have suggested that milk consumption, directly and indirectly, in children and adolescents, can lead to beneficial health benefits. Data have suggested that women with a higher consumption of dairy products during adolescence and into adulthood had a lower associated risk of acquiring type two diabetes than women who had a lower consumption of dairy products during adolescence (Malik et al., 2011). A study investigating increased milk intake in adolescent girls found that increased milk consumption significantly enhanced bone mineral density and content which could positively enhance future peak bone mass (Cadogan et al., 1997). Additionally, nutrients associated with milk consumption, such as calcium, have been associated with reduced blood pressure in children (Gillman et al., 1995). As such, there is a conflicting balance between the health benefits of encouraging individuals, particularly children and adolescents, to drink low-fat milk options (inclusive of flavored milk), while discouraging SSB intake overall.

This supports the need for insight into ways to encourage healthy levels of consumption of ‘good for you’ low-fat fluid milk options for adults and particularly children and adolescents. Emotional response is one avenue to help identify sources of disparity that may be occurring. There is some literature on the subject of emotional response to fluid milk and its influence on preference ratings (Seo et al., 2009) but the literature overall is very limited as studies are just starting to be performed with this emotional objective in mind.

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### **Chapter 3: Characterizing Consumer Emotional Response to Flavored and Unflavored Milk through an Emotion Based Questionnaire**

#### **Abstract**

Flavored milk in school food service settings has received significant media attention because of higher caloric content, mostly from high fructose corn syrup, and questions about contributions to childhood obesity. The goal of the experiment was to characterize emotional response to unflavored (white) vs. flavored (chocolate) milk as compared to reported behavior and hedonic preference for a young adult population to better understand the current sentiment and potential disconnect between milk intake and acceptability. Participants (n=48) consumed chocolate and white milk (1% fat) and selected, in a check all that apply (CATA) method, emotional terms (n=43) from a list describing the way they felt immediately post-consumption of each milk sample. Participants completed demographic, knowledge and attitudes, and beverage consumption questionnaires, and rated each sample using a 9-point hedonic scale. Frequency in emotional terms selection across samples were compared for similarities (shared terms) and differences (unique terms). Chocolate milk received a statistically higher ( $p=.0017$ ) overall mean acceptability score than white milk,  $7.0 \pm 1.5$  and  $5.7 \pm 2.4$ , respectively (n=52). Gender segmentation showed a statistically higher ( $p=.0047$ ) mean acceptability score for chocolate milk than white milk within females (n=34); no statistical difference in acceptability scores were shown within males (n=18). Emotional term analysis identified 14 frequently used terms as well as shared terms (calm, good) across samples. Unique terms were identified between the chocolate (satisfied, happy, warm, nostalgic, and joyful) vs. white (disgusted) milk. Gender segmentation showed that females (n=31) differentiated between the samples with many more unique terms than males (n=17), while males had a greater number of shared terms among the samples than females, suggesting that female and male emotional response may differ.

Emotional response may provide an added value understanding for the acceptability of flavored and unflavored fluid milk, suggesting an opportunity to foster the current positive response to flavored milk by providing rationale for promotion and continued access to low-fat flavored milk options.

## **Introduction**

The potential link of sugar-sweetened beverage (SSB) consumption to the rise of obesity in the U.S. has been highly debated. The main concern has been the use of high fructose corn syrup (HFCS) as a sweetening agent in beverages. While some studies suggest that HFCS is directly linked to weight gain and increased factors associated with cardiovascular disease (Bocarsly et al., 2010a,b; Swarbrick et al., 2008; Teff et al., 2004; Teff et al., 2009), a critical review of the current published scientific literature on HFCS determined that much of the available data is unreliable and that HFCS was not necessarily shown to contribute to weight gain and obesity any differently than other energy sources (Forshee et al., 2007). The public health issue of obesity, particularly among children and young adults, has increased awareness of consumer behavior, choices and emotional response to foods.

HFCS is used in many beverages, including flavored milk products generally targeted for consumption by young adults and children. These two populations, where obesity concerns have gained great importance, are also important target populations for milk consumption. The National Center for Health Statistics 2009-2010 data indicated that approximately 17% of children and adolescents were obese (Ogden, 2012). Additionally the American College Health Association recently indicated that 22% of college students were categorized as overweight with 10% being considered obese (The American College Health Association, 2009).

Consumption of sugar-sweetened beverages among adolescents may contribute to weight gain, which is likely caused by the increase in overall calorie intake (Berkey et al., 2004). As such, beverages such as flavored milk are now of concern relating to increased dietary HFCS and calorie intake in these young populations. This train of thought has led to suggestions that flavored milk should be removed as an option for school lunch programs. However, milk provides a highly bioavailable source of protein, calcium, vitamins and minerals, which are particularly important for the growth and development of bones and tissues in children, teens and young adults. Dietary calcium has been associated with reduced blood pressure in children (Gillman et al., 1995). Additionally, research has indicated that the consumption of nonfat and low-fat milk can help control weight gain, reduce body fat, and increase lean muscle mass (Barba et al., 2005; Faghih et al., 2011; Gilbert et al., 2011; Hartman et al., 2007; Lorenzen et al., 2012).

It is well recognized that milk is a valuable nutritional beverage during these critical years of growth and development but consumption of fluid milk is decreasing for all age groups and even more so with each continuing generation (Stewart et al., 2013). From 1977-1978 to 2005-2006, there was a decrease of approximately 10% and 28% in the number of individuals aged 2-11 and 12-19 consuming fluid milk, respectively; additionally, there was a significant decrease by almost half in mean milk intake between the same time frames for adolescents (Sebastian et al., 2010). There have been several attempts at nutritional and health campaigns to motivate increased consumption of milk, e.g. “Got Milk?” and “Fuel up to Play 60” campaigns, yet these have not been particularly successful in the long-term as fluid milk consumption continues to decrease (Stewart et al., 2013). Encouragement to consume milk is often attributed to parents as they strive to help their children learn good nutrition patterns and incorporate milk

as part of a healthy diet; the rationale being that parents are recognized as having a direct influence on child and adolescent eating behaviors (Anzman et al., 2010; Johannsen et al., 2006; Kinard & Webster, 2012). There is still a need to understand the important connections for advocating and positively influencing individuals to drink milk.

The affinity to certain foods experienced recurrently in childhood or those that are considered comfort foods may be explained through psychological aspirations. Long term established pleasurable emotional and memory connections with food products may be linked to an individual's preference and interest in seeking out such foods; likely examples being those that exhibit sweet and fatty characteristics (Rozin & Gohar, 2011). Additionally, the link between an individual's anticipated or induced emotional response by a particular food may provide rationale for the selection and consumption of that food (Galef, 1996; Martins & Pliner, 2005; Stricker, 1990).

Little is known about the characteristics and potential link of emotional response to flavored and unflavored milk and the motivations for consumption or lack thereof. Thus, the objective of the study was to evaluate emotional response to unflavored and flavored milk using a modified version of the recently created emotion based questionnaire, the EsSence Profile<sup>TM</sup> Ballot (Cardello et al., 2012; King & Meiselman, 2010; King et al., 2010), and compare the findings to reported behavior, knowledge and attitudes and acceptability ratings for a young college population. The compilation of such information would provide for a better understanding of young adult/college consumer views and rationale for consumption and/or avoidance of fluid milk choices.

## **Materials and Methods**

Prior to study execution, Virginia Tech Institutional Review Board (IRB) approval was requested and received (IRB 12-122) (Appendix E) for the use of human subjects in this research.

### ***Sample Preparation***

Two products, unflavored and flavored (chocolate) low-fat (1%) milk, were purchased at a local retailer (Kroger, Cincinnati, OH). Samples (approximately 1oz) were portioned into 2-ounce plastic sample cups (Monogram, Columbia, MA) and capped. Samples were labeled with a randomly selected three-digit code assigned to each sample type (flavored, unflavored). Samples were refrigerated (4°C) to maintain temperature.

### ***Participant Recruitment***

Students enrolled in the Food Science and Technology undergraduate and graduate (spring semester 2012) sensory science courses at VT were recruited. Students were recruited on the basis that they were at least 18 years of age and did not present known allergies or sensitivities to milk products. They were recruited to participate in two separate but linked sensory experiments. This first experiment (Chapter 3) collected demographic, knowledge, attitudes, consumption and emotional terminology data. The second experiment, described in detail in Chapter 4, collected hedonic and video data.

Forty-eight individuals, the majority aged 18-25 (92%), 31 females (65%) and 17 males (35%), who met recruitment criteria, participated in the study in a designated classroom on the VT campus. Participants provided signed consent prior to consumption of any samples through

the use of an informed consent form (Appendix F) detailing the procedures, objectives and potential risks of the study.

### ***Data Collection***

Milk samples were presented to participants in a balanced order (50% of participants evaluated flavored milk first; 50% evaluated unflavored milk first). Participants were asked to separately taste each sample (flavored, unflavored). Immediately after consumption of each sample, participants used a “check all that apply” approach (CATA) to select from a list of 43 emotional terms that described how they felt about the sample. A modified version of the EsSense<sup>TM</sup> ballot (King & Meiselman, 2010) (Appendix A, Figure A-1) included 38 of the original 39 EsSense<sup>TM</sup> ballot terms plus an additional 5 terms (Appendix A, Figure A-2). One original term (glad) was removed and 5 new terms (angry, content, fearful, sad, and safe) were added. The term glad was considered too close and therefore redundant to the original term happy. Additional terms were placed in for comparison to facial expression data collected in a subsequent experiment, as described in Chapter 4. After selecting emotional terms, participants answered demographic questions including age range, gender and academic class standing. Participants then completed a knowledge and attitudes questionnaire (Appendix D, Figure D-1, D-2, D-3) about beliefs about potential health benefits of milk. Participants also completed a beverage intake questionnaire, which captured consumption data on a variety of beverages (Appendix A, Figure A-4). The beverage questionnaire was slightly modified from (Appendix B, Figure B-1) a previously beverage intake questionnaire (BevQ-15) that assesses amount and frequency (daily, weekly) intake of many beverage categories and types (Hedrick et al., 2010; Hedrick et al., 2012); the modification added flavored milk with sweeteners (fat free, low fat, reduced fat) added as an additional beverage type.

## ***Hedonic***

Hedonic data for both products was collected in a subsequent study (Chapter 4), with participation from most (77%) of the participants in the current experiment. Each participant, seated in a sensory booth in the Food Science and Technology Sensory Evaluation Laboratory, was presented with a tray of two milk samples. Participants followed instructions presented on a touch screen monitor, which utilized sensory information management (SIMS) data collection software (SIMS2000, version 6, Sensory Computer Systems, Berkeley Heights, NJ). Samples were presented in a balanced order across panelists (50% received chocolate-flavored milk sample first; 50% received unflavored milk sample first). Participants consumed the first sample in full and wait approximately 30 seconds before they moved forward with the experiment. An on screen timer, embedded on monitor, was used to prevent the participants from moving forward with the experiment until the time period had elapsed. Participants rated each sample for acceptability on a 9-point hedonic scale (9 = extremely like; 5 = neither like nor dislike; 1 = extremely dislike). Participants were instructed to sip room temperature drinking water (Kroger Brand, Cincinnati, OH) between samples.

Mean hedonic values and standard deviation for overall population (n=52) as well as per gender were calculated. Distribution normality was tested using a Shapiro-Wilk goodness-of-fit test. A two-tailed paired t-test was used to statistically compare means and determine significant differences ( $p < 0.05$ ) in acceptability between samples for overall population as well as per gender. A percent frequency response for each hedonic rating value (1-9) was calculated for both samples to visualize acceptability distribution (normal vs. right tailed vs. left tailed).



### ***Emotional Term Selection and Trend Analyses***

Count frequency and percent frequency in selection of each emotional term were calculated per sample (flavored, unflavored). A classification system was developed and defined to further partition term selection data to investigate trends in term usage and potential association with milk type. Terms were classified as “frequently used” or “infrequently used” term. If a term was considered to be frequently used it could also be defined as a “shared” or a “unique” term. A frequently used term was classified as a term exhibiting greater than 20% selection frequency for at least one milk sample. A shared term exhibited greater than 20% selection frequency for both samples and less than 8% difference in selection frequencies between samples. A unique term exhibited greater than 20% selection frequency for one sample and greater than 15% difference in selection frequency from the other sample (Table 3-1). The classified terms were then tabulated and graphed for overall comparison of the similarities and differences between flavored and unflavored milk. Gender differences in term selection per product were evaluated in the same manner.

**Table 3-1. Definition of Emotional Term Selection Classification for Participant Response to Modified EsSense Profile Ballot for Flavored and Unflavored Milk**

<b>Term Selection Classification</b>	<b>Definition</b>
‘Frequently’ Selected Term	>20% selection frequency for at least one milk sample
‘Shared’ Term	>20% selection frequency for both samples and < 8% difference between sample frequencies
‘Unique’ Term	>20% selection frequency for one sample and > 15% difference in frequency from the other sample

Additionally, term selection was partitioned based on hedonic scores for each milk sample. Participant-selected CATA terms for each milk product were segmented into three categories: terms associated with product rated in the ‘disliked’ hedonic range of 1 to 4, neutral response (hedonic score of 5), and ‘liked’ hedonic range of 6 to 9. The percent frequency in response for each term was calculated for each hedonic category. Modified classifications, similar to those described above (Table 3-1), were used for comparison between the ‘liked’ and ‘disliked’ sample groups. A frequently used term was classified as a term exhibiting greater than 20% selection frequency for either the ‘liked’ or ‘disliked’ group. A shared term exhibited greater than 20% selection frequency for both groups (liked, disliked) and less than 8% difference in selection frequencies between groups (liked, disliked). A unique term exhibited greater than 20% selection frequency for one group and greater than 15% difference in selection frequency from the other group.

A penalty-lift analysis (Meyners et al., 2013) was used to estimate the average change in liking score based on whether a term was checked or not checked across both samples. This was done by segmenting the population per term between observations for participants who checked the term and who did not check the term. The hedonic mean value of observations of participants in the ‘not checked term’ group was subtracted from the hedonic mean value of observations of participants in the ‘checked term’ group. This delta mean was graphically compared across terms to relatively compare the increase or decrease in liking associated with selection of each term analyzed. This analysis was completed for 16 terms of interest. These terms were considered frequently used across the two milks sample and/or frequently used across ‘liked’ and ‘disliked’ milk samples as determined by the classifications discussed above. The results of the penalty-left analysis were compared to the results of the term classification analysis across the ‘liked’ and

‘disliked milk samples to validate reliability of term selection classification using the defined parameters.

### ***Knowledge and Attitudes Survey***

Data from the knowledge and attitude survey was tabulated per participant. Percentage response for the overall population was calculated in terms of degree of agreement or disagreement on a 1-5 rating scale with three categories of statements associated with milk and dairy beverages- a) “I believe” statements (strongly believe; moderately believe; weakly believe; do not believe; don’t know); b) Attitudes (strongly agree; moderately agree; weakly agree; do not agree; don’t know); and c) General Beliefs (strongly agree; moderately agree; neither agree nor disagree; moderately disagree; strongly disagree).

Percent frequency in response to particular category statements from the survey was cross-referenced with hedonic data for trend analysis. Investigation was done to understand the potential correlation between agreement/disagreement with a negative/positive attribute and the influence or lack thereof to hedonic liking ratings. Category statements of interest included:

- 1) I believe that milk, specifically flavored milks, do not provide health benefits
- 2) I believe that milk, specifically flavored milks, provide excess calories from sugar
- 3) Flavored milks should not be included in primary or secondary lunch programs
- 4) Flavored milks should not contain high fructose corn syrup
- 5) Milk is a healthy nutritional component of my normal diet

### ***Beverage Intake Survey***

Data collected from the modified beverage intake questionnaire (BevQ-15) were analyzed as described by Hedrick et al. (2010, 2012). The frequency (“How often”) which

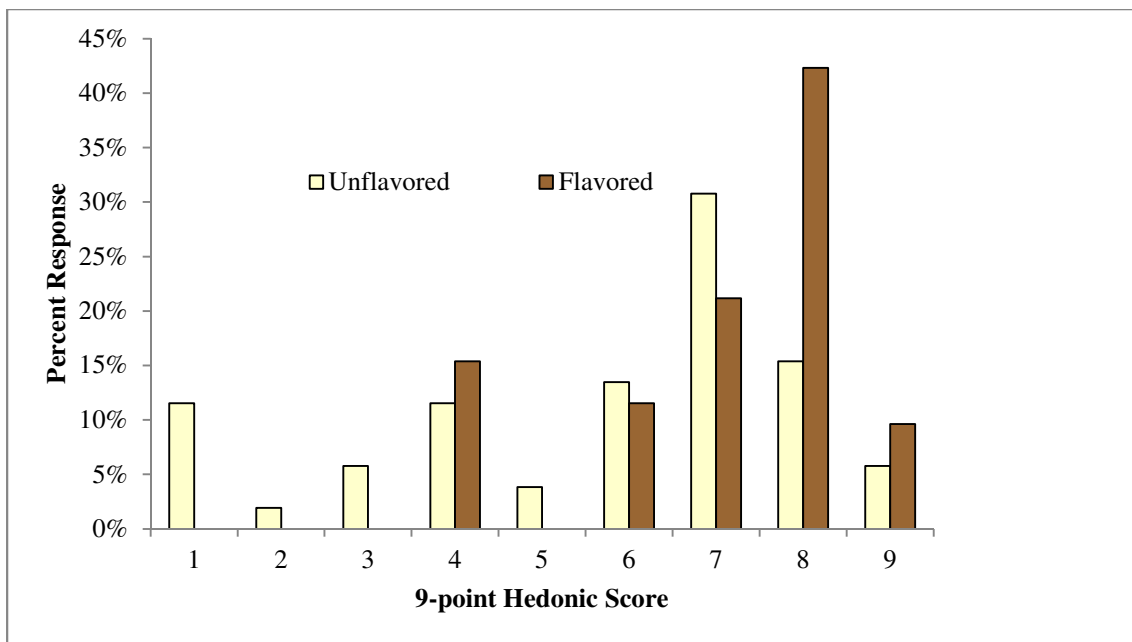
participants consumed a beverage was converted to a daily unit and was multiplied by the amount consumed (“How much each time”) to calculate an average daily beverage consumption in fluid ounces. This was then converted to energy and grams using average kilocalories and grams per fluid ounce determinations for each beverage type. For SSB calculations, aggregation of data from all beverages containing added sugars was summed (Hedrick et al., 2010). For the flavored milk category calculations, 19.75 and 31.25 was used as the average kilocalories and average grams per fluid ounce, respectively.

The total overall average beverage daily intake, in fluid ounces (fl. oz.), and associated average daily kilocalories (kcal) were calculated per participant and a population mean was subsequently calculated. In the same manner, the total average SSB daily intake (fl. oz.) and associated average daily kcal from SSB were calculated per participant and a population mean was subsequently calculated. The degree of milk intake, average daily milk consumption (fl. oz.), and associated average daily kcal from milk were calculated per participant per milk type (flavored, unflavored) including whole milk, 2% milk, 1% milk and skim milk. A population mean of daily milk fluid ounces and daily milk kilocalories was calculated and compared between flavored and unflavored milk. The unflavored milk intake data per participant was compiled from intake data separately calculated for each unflavored milk option (whole milk, 2% milk, 1% milk and skim milk) wherein the average daily milk fluid ounces and associated average daily milk kilocalories was calculated per participant per unflavored milk option; 2% milk being considered reduced fat milk and 1% milk and skim milk being lumped together in a single group as low fat/fat-free milk. A population mean of daily milk fluid ounces and daily milk kilocalories was calculated and compared between each unflavored milk option (whole, reduced, and lowfat/skim).

## Results

### *Milk Acceptability*

Hedonic scores for each milk sample did not follow a normal distribution as determined by a Shapiro-Wilk goodness-of-fit test ( $p < 0.0001$ ). Left-skews were shown for both milk samples reflecting a presence of outliers in the lower tail (Figure 3-1). The chocolate-flavored milk did not receive any ratings below 4. The average hedonic score ( $n=52$ ) for chocolate-flavored milk ( $7.0 \pm 1.5$ ) was equivalent to a “liked moderately” rating. Acceptability was higher ( $p=.0017$ ) than for unflavored milk ( $5.7 \pm 2.4$ ), which fell between “neither liked nor disliked” and “liked slightly”. Gender segmentation showed a statistically higher mean acceptability score ( $p=.0047$ ) within females ( $n=34$ ) for flavored ( $7.0 \pm 1.5$ ) than unflavored milk ( $5.4 \pm 2.6$ ); there was no difference ( $p>0.05$ ) in acceptability within males ( $n=18$ ) for the flavored ( $7.2 \pm 1.7$ ) and unflavored ( $6.2 \pm 2.0$ ) milk.

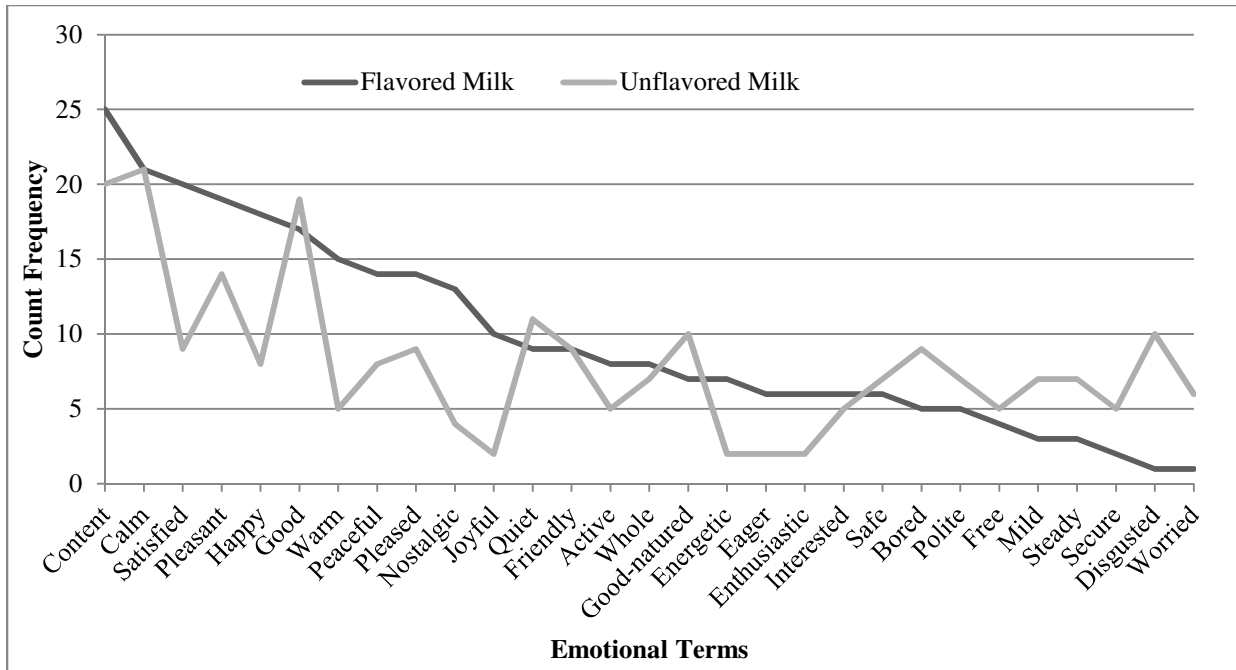


**Figure 3-1. Overall Hedonic Rating Percent Response for Chocolate Flavored and Unflavored Milk** ( $n=52$ ); 1= dislike extremely, 5= neither like nor dislike, and 9= like extremely

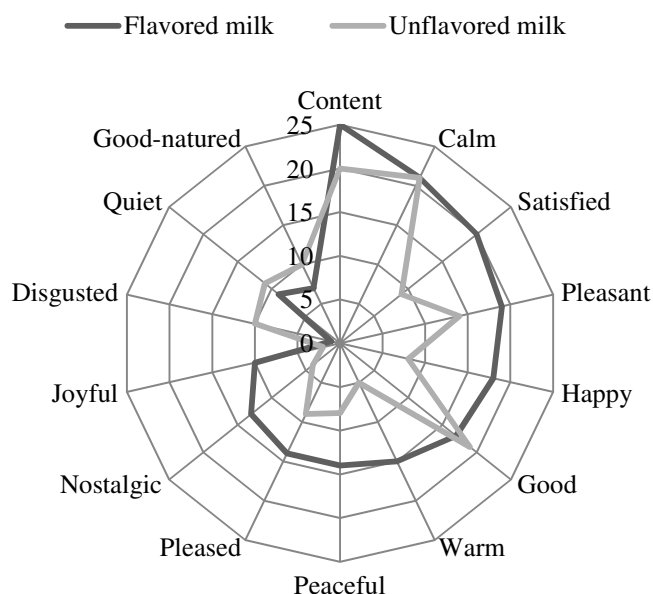
### ***Emotional Term Selection and Trend Analyses***

A large proportion of the emotional terms (67%; 29 of 43 terms) was selected by at least 10% (5 or more participants) for either flavored or unflavored milk (Figure 3-2). The fourteen remaining terms selected less than 10% of the time for both samples (count frequency < 5 for each sample) included adventurous, affectionate, aggressive, angry, daring, fearful, guilty, loving, merry, sad, tame, tender, understanding, and wild. The count frequency results for all terms are tabulated in the Appendix (Appendix C, Table C-1).

Fourteen terms were frequently selected (count frequency  $\geq 10$ ), including content, calm, satisfied, pleasant, happy, good, warm, peaceful, pleased, nostalgic, joyful, disgusted, quiet, and good-natured (Table 3-2). The frequency in selection of these terms illustrated similarities and differences in emotional language associated with chocolate and unflavored milk (Figure 3-3). Two shared terms were identified (calm, good); five unique terms were associated with chocolate milk (satisfied, happy, warm, nostalgic, and joyful) and one unique term was identified for unflavored milk (disgusted) (Table 3-3). The terms pleasant and content were borderline shared terms; they each exhibited greater than 20% frequency for both samples and had a difference in frequency of selection between samples that was approximately 11% (count difference of 5).



**Figure 3-2. Count Frequency of Emotional Terms Selected for 1% Low-fat Chocolate Flavored and Unflavored Milk** (n=48); 29 terms depicted in figure exhibited greater than 10% frequency selection (count frequency  $\geq 5$ ) across participants for at least one milk sample; order of terms in figure is based on frequency of response for flavored milk ranging from high to low; 43 total terms were presented to participants in a ‘check all that apply’ method using a modified emotion based questionnaire created from the EsSense Profile™ Ballot (King & Meiselman, 2010)



**Figure 3-3. Differences in Count Frequency of ‘Frequently’ Selected Terms for 1% Low-fat Chocolate Flavored and Unflavored Milk (n=48);** 14 terms depicted in figure classified as ‘frequently’ selected terms exhibiting greater than 20% selection frequency for at least one milk sample (count frequency  $\geq 10$ ); 43 total terms were presented to participants in a ‘check all that apply’ method using a modified emotion based questionnaire created from the EsSense Profile™ Ballot (King & Meiselman, 2010).

Count frequency by gender identified 13 and 15 frequently used terms for females and males, respectively (Table 3-2). There were 10 terms which were classified as frequently selected across genders, with 5 additional terms for males (bored, good-natured, mild, polite, quiet) and 3 for females (disgusted, joyful, whole) thus suggesting gender influences. Males on average selected approximately 6 terms per sample per participant while females on average selected approximately 7 and 5 terms per flavored and unflavored milk sample, respectively, per participant. Further analysis of this subset of terms identified two shared terms for females and ten shared terms for males (Table 3-3). For females, unique terms were identified between the chocolate-flavored (content, happy, warm, peaceful, pleased, pleasant, satisfied, joyful) vs.



unflavored (disgusted) milk. For males, unique terms were identified solely with the chocolate-flavored (satisfied, warm, nostalgic) milk (Table 3-3). These differences in shared and unique terms between genders further suggested gender specific distinctions. Since the overall population was majority females (65%), overall population term classifications were heavily female gender influenced.

**Table 3-2. Overall and Gender Based ‘Frequently’ Selected Terms for 1% Low-fat (Chocolate) Flavored and Unflavored Milk**

<b>Participant</b>	<b>Frequently Selected Terms</b>
Overall	content, calm, satisfied, pleasant, happy, good, warm, peaceful, pleased, nostalgic, joyful, disgusted, quiet, and good-natured
Female	calm, content, disgusted, good, happy, joyful, nostalgic, peaceful, pleased, pleasant, satisfied, warm, whole
Male	bored, calm, content, good, good-natured, happy, mild, nostalgic, peaceful, pleased, pleasant, polite, quiet, satisfied, warm

n=48 overall; n=31 females, n= 17 males; ‘Frequently’ selected term exhibited greater than 20% selection frequency for at least one milk sample; 43 total terms were presented to participants in a ‘check all that apply’ method using a modified emotion based questionnaire created from the EsSence Profile Ballot (King & Meiselman, 2010). Note: Classifications were considered separately within each participant type- overall population, male, female.

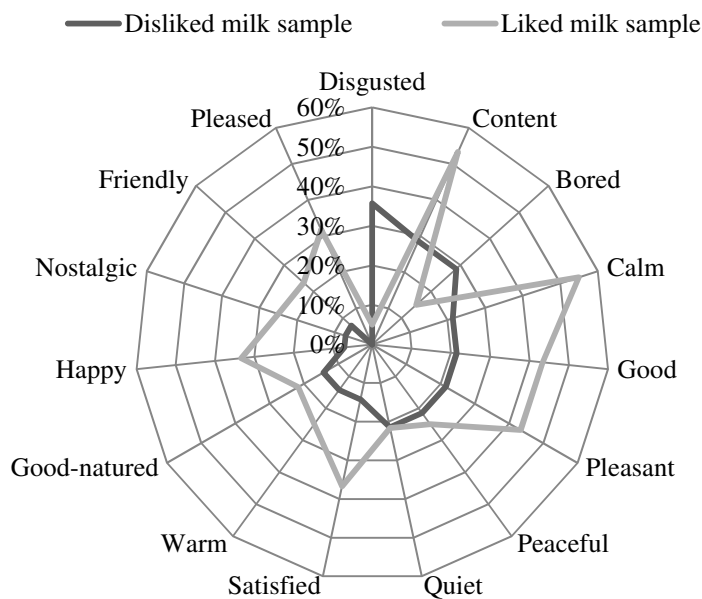
**Table 3-3. Overall and Gender Based ‘Shared’ and ‘Unique’ Terms Selected for 1% Low-fat (Chocolate) Flavored and Unflavored Milk**

<b>Participant</b>	<b>Shared Term</b>	<b>Unique Term (Flavored)</b>	<b>Unique Term (Unflavored)</b>
Overall Population	Calm, good	Satisfied, happy, warm, nostalgic, joyful	disgusted
Female	Calm, good	Content, happy, warm, peaceful, pleased, pleasant, satisfied, joyful	disgusted
Male	Calm, content, good, good-natured, happy, mild, peaceful, pleased, pleasant, quiet	Satisfied, warm, nostalgic	(none identified)

n=48 overall; n=31 females, n= 17 males; 43 total terms were presented to participants in a ‘check all that apply’ method using a modified emotion based questionnaire created from the EsSense Profile™ Ballot (King & Meiselman, 2010); Shared term exhibited greater than 20% selection frequency for both samples and less than 8% difference in selection frequencies between samples; Unique term exhibited greater than 20% selection frequency for one sample and greater than 15% difference in selection frequency from the other sample.

\*Note: Classifications were considered separately within each participant type- overall population, male, female.

Emotional terminology selection, based on hedonic score segmentation distinguished term indicative of positive (hedonic rating of “liked slightly” or higher) and negative (rating of “disliked slightly” or lower) affective response to milk products, regardless of flavored or unflavored. Fifteen frequently selected terms for either the ‘liked’ or ‘disliked’ milk sample were identified (Figure 3-4). Three shared terms (good-natured, peaceful, quiet) while unique terms were identified between the ‘liked’ (calm, content, friendly, good, happy, nostalgic, pleased, pleasant, satisfied) vs. ‘disliked’ (disgusted) milk sample (Table 3-4). The terms warm and bored were borderline unique terms for the liked and disliked milk sample, respectively; warm and bored had differences in frequency of selection between samples that were approximately 11% and 14%, respectively.



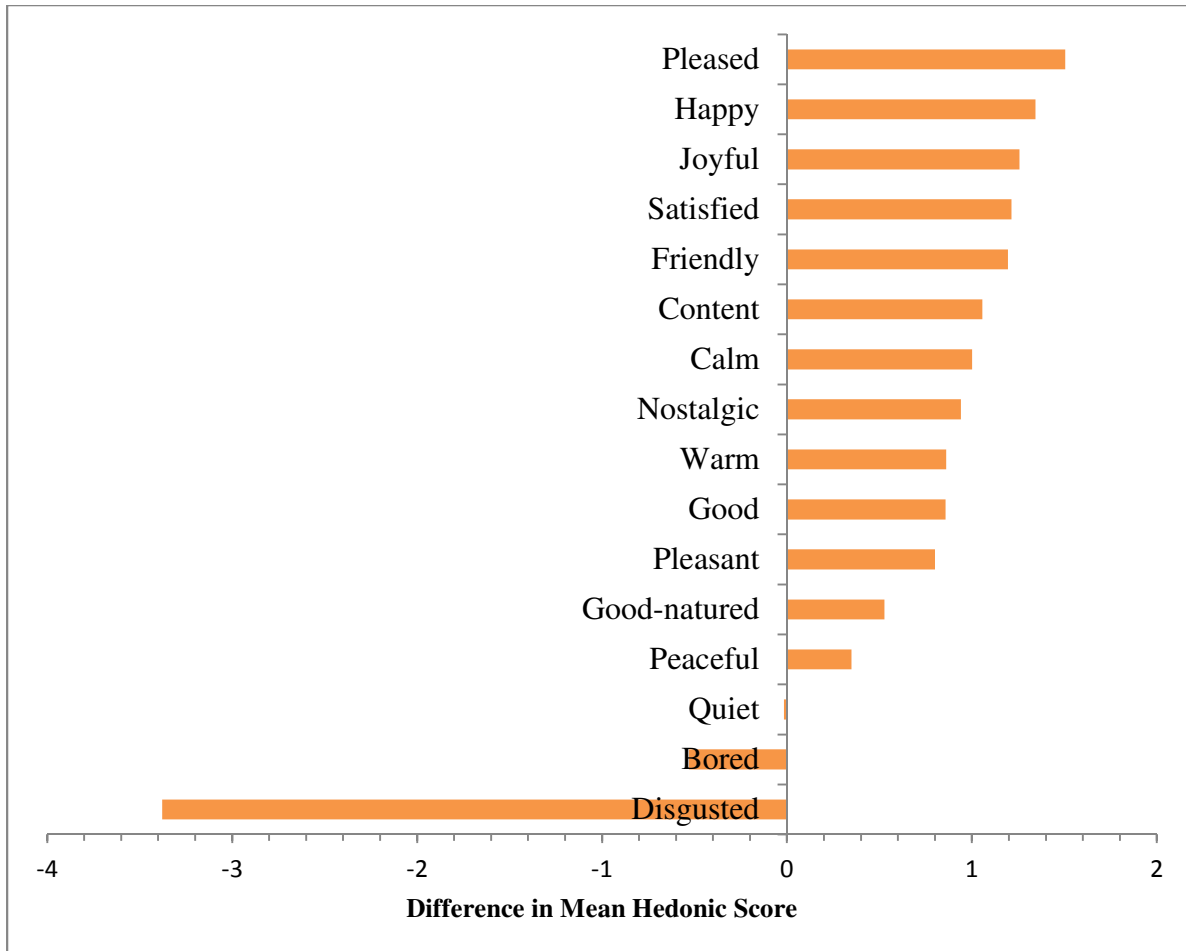
**Figure 3-4. Differences in Percent Frequency of ‘Frequently’ Selected Terms for ‘Liked’ and ‘Disliked’ Milk Samples;** Participants rated two milk samples, 1% low-fat chocolate-flavored and unflavored milk on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike); milk sample categorized as ‘liked’ or ‘disliked’ if a participant rated the sample 6-9 or 1-4, respectively; n=37 participants; n= 74 hedonic total responses (n= 60 liked samples, n= 14 disliked samples); ‘Frequently’ selected term exhibited greater than 20% selection frequency for at least one milk sample; 43 total terms were presented to participants in a ‘check all that apply’ method using a modified emotion based questionnaire created from the EsSense Profile Ballot (King & Meiselman, 2010)

**Table 3-4. Shared and Unique Terms for ‘Liked’ and ‘Disliked’ Milk Samples**

Shared Terms- ‘Liked’ and ‘Disliked’	Unique Term-‘Liked’ Sample	Unique Term- ‘Disliked’ Sample
good-natured, peaceful, quiet	calm, content, friendly, good, happy, nostalgic, pleased, pleasant, satisfied	disgusted

Participants rated two milk samples, 1% low-fat chocolate-flavored and unflavored milk on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike); milk sample categorized as ‘liked’ or ‘disliked’ if a participant rated the sample 6-9 or 1-4, respectively; n=37 participants; n= 74 hedonic total responses (n= 60 liked samples, n= 14 disliked samples); Shared term exhibited greater than 20% selection frequency for both samples and less than 8% difference in selection frequencies between samples; Unique term exhibited greater than 20% selection frequency for one sample and greater than 15% difference in selection frequency from the other sample.; 43 total terms were presented to participants in a ‘check all that apply’ method using a modified emotion based questionnaire created from the EsSense Profile™ Ballot (King & Meiselman, 2010).

Penalty-lift analysis showed that two terms, disgusted (-3.38) and bored (-0.53), had negative penalty towards hedonic data upon selection. The term quiet (-0.02) also had a negative mean difference but this difference was very minimal and close to zero. The two smallest positive values were for the terms peaceful and good-natured at 0.35 and 0.53, respectively. The remaining terms analyzed had positive mean differences, close to or greater than one, between observations of participants who selected the term vs. observations of participants who did not select the term for either milk sample. The highest positive differences were seen in the terms pleased, happy and joyful at 1.50, 1.34, and 1.26 respectively.



**Figure 3-5. Penalty-lift Analysis for 1% Low-fat Chocolate Flavored and Unflavored Milk**

(n=74 total observations; n=37 flavored milk, n=37 unflavored milk); The values indicate the difference in mean hedonic value of observations for which an emotional term was checked, compared to observations for which that emotional term was not checked. In one session, 43 total terms were presented to participants in a ‘check all that apply’ method using a modified emotion based questionnaire created from the EsSence Profile™ Ballot (King & Meiselman, 2010) to capture emotional term selection data towards 1% low-fat flavored and unflavored milk post-consumption. In a second session, participants rated the two milk samples, 1% low-fat chocolate-flavored and unflavored milk, on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike).

***Knowledge and Attitudes toward Milk***

Tabulated results for percent frequency in agreement and disagreement towards all statements are shown in the Appendix (Appendix D, Tables D-1, D-2, D-3). For the “I believe” statements, the majority of participants strongly believed that milk delivers calcium for strong bones (77%) and vitamin D and for enhancing bone health (66%). The majority moderately believed that milk contains 9 essential nutrients to maintain life (56%) and delivers high value

proteins for strong muscles (52%). The majority did not believe that milk contributes to obesity in the U.S. population (60%) and that flavored milks do not provide health benefits (56%). A combined majority strongly believed (33%) and moderately believed (46%) that milk delivers high value proteins for strong muscles. A combined majority strongly believed (38%) and moderately believed (40%) that flavored milks provide excess calories from sugar. Responses to the remaining four “I believe” statements showed varying levels of agreement and disagreement without any majority distinction.

For the attitude statements, the majority strongly agreed that flavored milk should not contain high fructose corn syrup (63%) and that there should be a variety of dairy-based beverage options in primary and secondary school lunch programs (58%). A majority (60%) did not agree that flavored milks should not be included in primary or secondary school lunch programs. A combined majority strongly agreed (33%) and moderately agreed (33%) that there is a need for more dairy-based beverages in vending machines (not limited to school settings).

For all the general belief statements, a majority strongly agreed or a combined majority strongly and moderately agreed with them. One particular belief wherein a combined majority of participants strongly agreed (33%) and moderately agreed (27%) was in direct conflict with intake results; this belief being that milk is a healthy nutritional component of my (the participant's) normal diet. Although participants inferred from the agreement of this belief that they incorporated milk into their diets, intake results showed that participants consumed very little milk on an average daily basis (Table 3-5).

**Table 3-5. Average and Range of Daily Fluid Ounces for Dairy Fluid Milk Intake in a Young Adult College Population**

<b>Milk Type</b>	<b>Average <math>\pm</math> SD Daily Fl. Oz.</b>	<b>Average Daily Fl. Oz. Range</b>
Unflavored (overall)	5.01 $\pm$ 7.06	0-32.6
Unflavored (whole fat)	0.56 $\pm$ 2.01	0-12.0
Unflavored (reduced fat)	2.01 $\pm$ 5.46	0-32.0
Unflavored (lowfat/fat free)	2.45 $\pm$ 2.45	0-16.0
Flavored (fat free, low fat, reduced fat)	0.21 $\pm$ 0.61	0-2.86

n= 48; aged 18+, majority (92%) aged 18-25 31; females (65%) and 17 males (35%); Based on response and scoring instructions from modified Beverage Intake Questionnaire (BevQ-15) (Hedrick et al., 2010; Hedrick et al., 2012) with inclusion of flavored milk (fat free, low fat, reduced fat) with sweeteners; whole fat (full fat), reduced fat (2%), lowfat/fat free (1% and skim).

Cross referencing of hedonic data (n=37) with agreement and disagreement concerning beliefs about milk showed both congruent and discordant trends between response type and mean hedonic scores. An inverse trend was shown for the negatively phrased statement that flavored milk does not provide health benefits. Mean hedonic score tended to decrease from participants who did not believe (7.30) to those who weakly believed (7.13) to those who strongly or moderately believed (6.50) (Table 3-6). In other words, overall, the more strongly a participant believed that flavored milks do not provide health benefits, the lower the milk acceptability score was for flavored milk; this suggests that agreeing with this (negative) belief did provide an expected discouragement towards flavored milk acceptability. Participants who strongly or moderately believed that milk, specifically flavored milks, provides excess calories from sugar, had a higher overall mean hedonic score, 7.09 and 7.44, respectively, than participants who weakly believed the statement, 6.44 (Table 3-7); suggesting that agreeing with this (negative) belief did not necessarily provide an expected discouragement towards flavored milk acceptability, but rather, conversely, may have increased acceptability ratings.

**Table 3-6. Mean Hedonic Scores for Varying Groups of Agreement and Disagreement for the Statement “I Believe that Milk, Specifically Flavored Milks, Do Not Provide Health Benefits”**

<b>Response Group</b>	<b>Percent response</b>	<b>Flavored Milk Mean Hedonic</b>
Strongly or Moderately Believe	22%	6.50
Weakly Believe	22%	7.13
Do Not Believe	54%	7.30

n=37; In one session, participants rated from 1-5 how much they agreed or disagreed with a set of statements concerning knowledge, attitudes and general beliefs towards milk and milk products. In a second session, participants rated two milk samples, 1% low-fat chocolate-flavored and unflavored milk on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike) post consumption.

**Table 3-7. Mean Hedonic Scores for Varying Groups of Agreement and Disagreement for the Statement “I Believe that Milk, Specifically Flavored Milks, Provide Excess Calories from Sugar”**

<b>Response Group</b>	<b>Percent response</b>	<b>Flavored Milk Mean Hedonic</b>
Strongly Believe	30%	7.09
Moderately Believe	43%	7.44
Weakly Believe	24%	6.44

n=37; In one session, participants rated from 1-5 how much they agreed or disagreed with a set of statements concerning knowledge, attitudes and general beliefs towards milk and milk products. In a second session, participants rated two milk samples, 1% low-fat chocolate-flavored and unflavored milk on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike) post consumption.

No directional trend was seen between mean acceptability of flavored milk and varying levels of agreement of disagreement towards the attitude that flavored milks should not be included in primary or secondary school lunch programs. Mean hedonic score of flavored milk for participants who strongly or moderately agreed (7.13) showed little difference from those that weakly agreed (7.20) or from those that did not agree (7.08) (Table 3-8). Similarly, no directional trend was seen between acceptability of flavored milk and varying levels of agreement of disagreement towards the attitude that flavored milks should not contain high fructose corn syrup. Mean hedonic score of flavored milk for participants who strongly agreed (7.17) showed minimal difference from those that moderately agreed (6.67) or from those that weakly agreed or did not agree (7.29) (Table 3-9).



A directional trend was seen between mean acceptability of unflavored milk and varying levels of agreement or disagreement towards the statement that milk is a healthy nutritional component of my (the participant's) normal diet. Mean hedonic score tended to decrease from participants who strongly agreed (6.82) to those who moderately agreed (6.73) to those who neither agreed nor disagreed (4.80) and further to those that moderately or strongly disagreed (4.60) (Table 3-10). In other words, overall, the more strongly a participant suggested that they identified milk as healthful part of their diet, the higher the milk acceptability score was for unflavored milk, suggesting that the healthy contributions of provided encouragement towards unflavored milk acceptability. No directional trend was seen for flavored milk as mean hedonic score decreased then increased from participants who strongly agreed (7.91) to those that moderately agreed (6.36) to those that neither agreed nor disagreed (6.80) to those that moderately or strongly disagreed (7.20) (Table 3-10).

**Table 3-8. Mean Hedonic Scores for Varying Groups of Agreement and Disagreement for the Statement “Flavored Milks Should not be Included in Primary or Secondary School Lunch Programs”**

<b>Response Group</b>	<b>Percent response</b>	<b>Flavored Milk Mean Hedonic</b>
Strongly or Moderately Agree	22%	7.13
Weakly Agree	14%	7.20
Do Not Agree	65%	7.08

n=37; In one session, participants rated from 1-5 how much they agreed or disagreed with a set of statements concerning knowledge, attitudes and general beliefs towards milk and milk products. In a second session, participants rated two milk samples, 1% low-fat chocolate-flavored and unflavored milk on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike) post consumption.

**Table 3-9. Mean Hedonic Scores for Varying Groups of Agreement and Disagreement for the Statement “Flavored Milks Should Not Contain High Fructose Corn Syrup”**

<b>Response Group</b>	<b>Percent response</b>	<b>Flavored Milk Mean Hedonic</b>
Strongly Agree	65%	7.17
Moderately Agree	16%	6.67
Weakly Agree or Do Not Agree	19%	7.29

n=37; In one session, participants rated from 1-5 how much they agreed or disagreed with a set of statements concerning knowledge, attitudes and general beliefs towards milk and milk products. In a second session, participants rated two milk samples, 1% low-fat chocolate-flavored and unflavored milk on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike) post consumption.

**Table 3-10. Mean Hedonic Scores for Varying Groups of Agreement and Disagreement for the Statement “Milk is a Healthy Nutritional Component of My Normal Diet”**

<b>Response Group</b>	<b>Percent response</b>	<b>Unflavored Milk Mean Hedonic</b>	<b>Flavored Milk Mean Hedonic</b>
Strongly Agree	30%	6.82	7.91
Moderately Agree	30%	6.73	6.36
Neither Agree nor Disagree	14%	4.80	6.80
Moderately or Strongly Disagree	27%	4.60	7.20

n=37; In one session, participants rated from 1-5 how much they agreed or disagreed with a set of statements concerning knowledge, attitudes and general beliefs towards milk and milk products. In a second session, participants rated two milk samples, 1% low-fat chocolate-flavored and unflavored milk on a 9-point liking scale (9- extremely like; 5- neither like nor dislike; 1- extremely dislike) post consumption.

### ***Beverage Intake Survey***

On average, participants consumed approximately seven and a half cups (60.7 fl. oz.) of fluids daily, translating to a daily average of approximately 368 kilocalories (Appendix C, Table C-2). Approximately 15% of the average daily beverage intake and 27% of the average daily beverage kilocalories were attributed to the consumption of SSB (sweetened juice beverage/drink, soft drinks, sweetened tea, coffee with cream and/or sugar, flavored milk with sweeteners).

The average daily consumption of milk, both flavored and unflavored, across participants was approximately 2/3 cup (5.22 fl. oz.) which is lower than the recommended intake of 3 cups of dairy for males and females aged 9 and over (USDA, 2013). Overall milk consumption accounted for approximately 8.6% of the average daily beverage intake and 22% (82.45 kilocalories; 78.24 unflavored, 4.21 flavored) of the average daily beverage kilocalories. Most of this volume was unflavored milk and most was reduced fat (2%), lowfat (1%) or fat free (skim) with an average daily intake of a little less than 2/3 cup (5.01 fl. oz.) (Table 3-5). There was large variability for intake with the average daily range for the combined intake of all milk types per participant falling between 0-32.6 fluid ounces.

## **Discussion**

### ***Emotional Term Selection***

The term selection classification definitions were not selected based on previous methodology but based on initially assessing the data and approximately gauging where levels of parity and levels of difference fell overall. The level of 20% was used as a boundary parameter since this was the original criteria used to develop the original EsSense Ballot questionnaire by narrowing down a larger list of terms by frequency of use, i.e. at least 20% selection checklist frequency (King & Meiselman, 2010). The 15% (unique) and 8% (shared) parameters were selected based on the desire for percentages to elicit divergence and similarity among selection, respectively. These definitions are by no means a one-size fits all approach, but a starting point to begin to qualitatively judge differences and similarities in the given CATA data. Changes to percentages within the definitions may be deemed appropriate for different stimuli.

The emotion based questionnaire results suggested points of parity and differentiation in emotional response between the samples for the overall population as well as within gender. Due to the majority of our population being represented by females, it is likely that the population response was heavily female influenced. Nevertheless, clear distinctions were seen between samples suggesting that participants had divergent emotional connections towards flavored and unflavored milk, with males showing less divergence. In the present study, both males and females on average had about the same selection of terms per participant across samples (12 terms selected/ participant) but females were overall more expressive about differences in samples while males were more expressive about similarities. Gender differences may be partly explained by the theory that males and females use different signals in defining their own emotional state (Pennebaker & Roberts, 1992). Several studies about gender differences have suggested that females have a tendency to be more emotionally expressive than males when viewed through a variety of measures (e.g. electromyography, rating of non-verbal facial expression, self-report ratings) as referenced and discussed in Kring and Gordon (1998); the results of their own two studies showing significant gender differences in intensity of facial expressions to visual stimuli but self-reports of experienced emotion did not show significant gender differences (Kring & Gordon, 1998). Further studies described in Kring and Gordon (1998) investigating emotion differences within gender found that females are more expressive of specific emotions including that of disgust (Fujita et al., 1980; Rotter & Rotter, 1988; Tucker & Riggio, 1988; Wagner et al., 1993, 1986; Zuckerman et al., 1975); although these studies measured facial expressions and not reported emotion, the results may partially translate to reported emotions and explain why females may have reported greater disgust towards the unflavored milk. Related studies using the EsSence Profile™ methodology and an intensity

rating scale for emotional terms, in lieu of CATA, have shown that females, on average, rated emotion intensities stronger than males, but that this pattern is product specific and is the opposite case for some products (King et al., 2010). In the present study, it is not conclusive whether women were more expressive than men as rating scales were not used and gender numbers were not approximately equivalent for a balanced comparison.

Emotional term selection, quality and quantity, was considerably predictive of hedonic response. Uniquely positive terms (5 overall, 8 for females, and 3 for males) were associated with what was considered to be the statistically better liked sample, flavored milk. A uniquely negative term (disgusted) was associated with what was considered to be the statistically less liked sample, unflavored milk. For males, the terms satisfied and disgusted (-) have been previously associated with acceptability while for females the terms joyful, good, happy and pleasant and disgusted (-) have been previously associated positively and negatively (-) with acceptability (King et al., 2010). In the present study, these same terms were uniquely identified by males, including satisfied (flavored milk), and females, including satisfied, joyful, happy, pleasant (flavored milk) and disgusted (unflavored milk), suggesting that these terms may have also been associated with acceptability. Furthermore, the greater use of (similar) shared terms between samples within males was predictive of the lack of statistical differences in acceptability. In other words, the flat acceptability response may be explained by the numerous shared positive emotional connections males had for both samples (10 shared terms) and/or the lack of uniquely distinguishing terms for the unflavored milk sample. The minimal use of shared terms between samples within females combined with the more abundant choice of unique positive terms (8 terms) for the flavored milk sample and choice of unique negative term

(disgust) for the unflavored milk sample were predictive of the statistically significant preference towards flavored milk.

Terms not used frequently could be categorized as terms that suggest negative affect (aggressive, angry, fearful, sad, guilty) or excitable (adventurous, daring, wild) states which may not have been well associated with either of the samples. Other terms minimally used related to positive affect of deep emotional intensity (loving, tender, understanding, affectionate). The samples may not have provided a deep enough emotional connection to evoke such a degree of emotion. Alternatively, it is likely that since food is generally considered to be a stimulus producing a pleasant experience linked more often to positive emotions (Desmet & Schifferstein, 2008), highly negative terms may not be well-suited as emotional descriptors. Furthermore, milk, specifically, is a quintessential substance having naturally sweet and fatty characteristics which are considered to be preferential innate biases (Rozin & Gohar, 2011).

The remaining infrequently used terms, merry and tame, may have been expected to be used more frequently with merry being associated with the flavored milk and tame being associated with either sample. The rationale being that other highly positive terms were associated with the flavored milk sample, particularly happy, and the term merry would be a closely related but slightly more positive term; the term merry being defined as very happy and cheerful (Merriam-Webster.com). It was thought that the term tame could have been associated with one of the milk samples, particularly the unflavored milk, based on intrinsic physiological and/or early development connections. Milk nurtures from birth and is known to reduce crying, alleviate stress and improve mood in newborns and test animals (Blass, 1997; Blass & Fitzgerald, 1988; Blass et al., 1989). Furthermore, sweetness itself has been suggested to have a calming effect in crying newborns (Barr et al., 1999). As such, the term tame, when viewed as a

greater extension of the term calm, may have been used more often if the participants had been in a highly uncomfortable or irritable state before the study to have transitioned to a calmer state and thus been ‘tamed’ by the sample. Since participants were not asked to describe their emotional state prior to the experiment, the predisposed state of mind of participants was unknown; but the lack of the use of the term tame may suggest that they were in a more neutral state.

The amount of terms distinguished as unique terms, specifically for the greater accepted sample, when separating products within hedonic ranges of ‘liked’ and ‘disliked’ suggested that certain terms might have been more specifically associated with acceptability versus others (i.e. unique terms identified between samples for the overall population). The terms good, happy, pleasant and satisfied, which were uniquely identified with the ‘liked’ sample, and disgust, which was uniquely identified with the ‘disliked’ sample, have been specifically associated with acceptability in a previous study (King et al., 2010), suggesting congruency between the present and former study. It is unclear why the term friendly was not identified in the overall population or within gender segmentation, but was identified as a unique term towards the ‘liked’ sample suggesting it may have additionally (perhaps slightly less so than the other unique terms) been associated with acceptability. The shared terms identified across samples (good-natured, peaceful, and quiet) fall into a very neutral category of emotional response, neither being considered highly positive nor negative descriptors, and may not have been associated with acceptability. However, there were insufficient observations, specifically within the ‘disliked’ samples, to be conclusive about those segments (liked/disliked).

The penalty-lift analysis data was predicted based on the term selection data. The results mimicked the classification of terms for ‘liked’ and ‘disliked’ milk groups. Terms which had

negative penalty, bored and disgusted, could be cross-referenced to uniquely classified terms associated with the disliked sample. Terms that were below one and close to zero (quiet, peaceful, good-natured), could be cross-referenced to shared classified terms associated with both samples. The remaining terms, with the exception of joyful (which went undefined for the 'liked' and 'disliked' groups), that exhibited positive promotion in hedonic mean value for being selected, could be cross-referenced to uniquely classified terms associated with the liked sample. The carry-over between the two types of analyses, term selection and penalty-lift, suggest that both methods complement the other. Furthermore, the results of penalty-left analysis suggest some validation in reliability for the term selection definitions.

### ***Knowledge, Attitudes and Consumption of Milk***

A disconnect between beliefs and behavior was shown in that the majority of participants strongly or moderately believed in the nutritional and functional health benefits of milk yet the average daily intake values were very low, particularly when compared to the recommended 3 cups per day of fluid milk or equivalent milk products (USDA, 2013). A disconnect was also seen between emotional response and acceptability as compared to milk intake type. Term selection and acceptability showed that flavored milk was more liked and had many more positive emotional connections as compared to unflavored milk, yet the average consumption of flavored milk was very minimal overall and comparatively to unflavored milk. If consumption were directly based on acceptability scores and/or emotional term response, this would not be expected. Even though participants may have statistically liked the flavored milk sample more than unflavored milk, environmental factors may be the cause for lack of consumption. For example, chocolate milk is not showcased readily in the supermarket dairy aisle and is not as convenient to purchase oftentimes at places of meal consumption, i.e. restaurants. The overall



minimal milk intake (flavored or unflavored) may further be explained by the general US trend in the steady decline of fluid milk consumption through the number of individuals consuming milk as well as the amount of milk being consumed over the years; this trend is readily apparent in adolescents aged 12-19 (the age at which the participants would have been at the time of the survey data analysis) (Sebastian et al., 2010). Additional analyses have shown that adults over 18 have also been consuming less fluid milk over time (Enns et al., 1997; Popkin, 2010). A generational influence may also be at play as has been suggested by the greater decrease in milk consumption from one generation to the next (Stewart et al., 2013). Since this population was a young college population, a millennial generation, they may have been even more likely to not consume milk.

A compounded theory presented by Stewart et al. (2013) for the decrease in milk consumption is that with each new generation there is a greater availability of alternative beverages including energy drinks, soft drinks, and bottled (flavored) water that compete with fluid milk as a beverage. If this were the case, it would have been expected that the average daily amount of SSB would have been greater than amount reported, that being a little more than one cup on average per day. Previous studies using the BevQ-15 intake questionnaire found 135 kilocalories to be the average daily amount of SSB for an adult population aged  $37 \pm 2$  years which wasn't that far off from what was found in the present study for a younger adult population (Hedrick et al., 2012).

It's possible that the consumption of SSB is partly responsible for the minimal milk consumption and participants under-reported the amount of SSB that they actually consume. Another explanation for low flavored milk consumption could be found in the directional trend between negative beliefs about flavored milk and overall acceptability. It was not surprising that

as participants more strongly believed that flavored milks do not provide health benefits that their overall acceptability for flavored milk would decrease. Agreeing with this (negative) belief may have provided an expected discouragement towards flavored milk acceptability. Although it was somewhat surprising that a possible similar discouragement was not found for participants as their (negative) belief increased in agreement towards believing that flavor milks provided excess calories from sugar. It is possible that although participants agreed with this negative belief, it is not a great concern or deterrent to consumers since many beverages provide excess calories yet are well liked. Similarly this may have been the reason why agreement or disagreement with HFCS addition into milk showed no directional trends in acceptability; many well-liked beverage products on the market incorporate HFCS and although individuals may say they don't like the use of HFCS, these beverage products are readily consumed in the U.S. on a daily basis.

The directional trend seen between acceptability of unflavored milk and varying levels of agreement or disagreement towards the statement that milk is a healthy nutritional component of the participant's normal diet was fairly expected. The more supposedly familiar the participant was with the unflavored milk product, the more acceptable the product was to them. This may be explained by the idea that memory plays a very essential role in our present food choices because those choices are based on memories of relevant past experiences with the same or related foods and not the actual experience with the food (Rozin & Gohar, 2011). The lack of directional trend with the same statement towards the flavored milk is also fairly expected. It is likely that participants answered the statement with the bias of unflavored milk being incorporated into their diet and not flavored milk. Additionally, it is very likely that flavored milk acceptability was driven by the taste of sweet which is considered an inherently pleasant taste (Barker, 1982;

Gibson, 2006; Steiner, 1979). This would have likely played a role not only in the greater acceptability but also in the lack of association with the disgust terminology of the flavored milk vs. unflavored milk.

## **Conclusions**

Emotions are believed to play an important role in the acceptability and deterrence of a product yet widely accepted methodology practices to capture emotional response is still in development. The present study has demonstrated that a robust picture of potential emotional motivations and limitations can be captured by using simple ballot methodology. Even though ballot completion requires the act of post-rationalization and self-reporting emotion, which is arguably not a purely intrinsic response, it provides value-added understanding to a product experience beyond conventional Likert scales. This emotional terminology provides additional insight that may help segment and characterize emotional response to different products within the same class. Ultimately, it could be used for products such as flavored and unflavored milk, which are declining in consumption, to foster positive response through ‘emotion’ based promotion and test new improvements against negative response as a baseline for change and potential market success.

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## **Chapter 4: Measuring Consumer Emotional Response to Flavored and Unflavored Milk through Facial Expression Analysis**

### **Abstract**

Consumer emotions play a key role in an individual's overall experience with a food product. Current sensory methodology is limited in its ability to measure and understand emotions involved with food selection and interaction. The goal of the experiment was to assess the use of automatic facial coding software as a sensory method for understanding consumer emotional response to a dairy stimulus, flavored and unflavored milk, compared to traditional hedonic values. Participants (n=52) consumed 1% low-fat chocolate-flavored and unflavored milk, and rated each sample using a 9-point hedonic scale (1=dislike extremely; 9=like extremely) while being video-recorded. Facial recognition software was used to continuously analyze the emotional response from videos by correlating muscular facial movements to six emotions (happy, surprised, angry, sad, scared, and disgusted) along with a neutral response for 3 different video analysis time durations (5, 10, 20s) post-consumption of each sample. Video data (n=10 participants) with extreme differences (scores  $\geq 4$  intervals on the 9-point scale) in acceptability of the two products were further evaluated to identify trends associated with high and low affective scores. Chocolate milk received higher mean acceptability scores than white milk, 7.0 and 5.7, respectively (overall; n=52), and 7.0 and 3.3, respectively, for the 10 video-recorded participants. Software analysis of emotions illustrated high individual variability in identified emotions. Overall mean intensities for all participants across all time durations analysis showed that happy trended higher while sad trended lower for the flavored milk sample; disgusted was statistically lower in flavored milk sample for 5, 10, and 20s (p=0.019, 0.011, 0.041, respectively). Mean intensities for participants exhibiting extreme differences in



acceptability showed that emotional intensities in surprised and happy tended to be higher and scared tended to be lower with the positively perceived product for all video analysis time durations. A statistically higher mean intensity ( $p=0.049$ ; 20s) in the surprised emotion was identified. Specific trends in facial response, particularly negative emotional facial response at early onset, may potentially be used to predict hedonic rating spread as well as a more intrinsic response.

## **Introduction**

Societal concern about obesity has increased interest in better understanding motivations behind consumer behavior and selection toward food products. Fostering better eating habits at an earlier age, particularly among children and young adults, is important in addressing incidence of obesity. Recent data reinforces that being overweight or obese in childhood and adolescence can lead to elevated risks of health problems, including cardiovascular disease and diabetes, during periods of growth and into adulthood (Hannon et al., 2005; Juonala et al., 2011; Rocchini, 2002, 2011).

To alter consumer behavior, it is advantageous to more fully understand current preferences and barriers for the consumption of healthier, more nutrient dense products. As individuals, we may acknowledge and openly state that we have an interest in a product, yet our internal feelings and actions do not always reflect what is said. The disconnect that often occurs between what a person says and what they actually feel has been coined as the “say/feel” gap (Hill, 2008). Additionally, self-awareness of the health benefits or lack thereof for a food product does not completely represent the logic for our food choices.

Traditional methods of understanding consumer response often use affective tests, both qualitative and quantitative, to assess preference or acceptance to a product, product idea, or

specific product characteristics (Meilgaard et al., 2007). Affect can be linked to having positive or negative connotations that relate to acceptance/rejection or liking/disliking. Theories for the development of affect (preferences) to foods and tastes include genetic predispositions, environmental, childhood eating patterns and learned preferences/aversions through post-positive rewards or negative consequences of eating (Birch, 1999). One commonly used quantitative affective acceptance test is the 9-point hedonic 'Likert' scale, which categorizes affective response from dislike extremely to like extremely and was originally developed as a scale to measure food acceptance by US Army soldiers (Jones et al, 1955; Meiselman & Schutz, 2003). Limitations of the 9-point scale and hedonic scales in general have been discussed in view of differing presentations as well as word usage and numerical compatibility (Lim, 2011; Nicolas et al., 2010).

Emotional responses to foods, tastes, and aromas are beyond what is captured through traditional affective (acceptability or preference) sensory methods, including the Likert-type scales. Research into food and emotions has enforced the idea that positive and negative emotional affect can influence our memory for adaptive promotion or distancing to particular food sources (Rozin & Gohar, 2011). Similarly related associations have been made for the intrinsic emotional response to foods. A sweet taste is considered inherently pleasant providing a positive, enjoyable experience while other tastes, such as sour and bitter, are considered inherently aversive (Barker, 1982; Gibson, 2006; Steiner, 1979). Although tastes of sour and bitter may be enjoyed as well, this enjoyment is viewed as an acquired ability developed over time (Ekman, 2007; Green, 1990). Additionally, sweet taste as well as high-energy dense foods have been associated with improving mood and reducing levels of stress (Blass et al., 1989; Gibson, 2006). Overall, these emotional responses may play a key role in an individual's overall

experience with a product as well as provide insight into possible motivations to purchase and consume a product.

Capturing emotional responses to food may occur through several different approaches. In several studies, consumers have been asked to verbalize their emotional response towards foods and odors through creation and rating of term lists (Chrea et al., 2009; Desmet & Schifferstein, 2008; Thomson et al., 2010). A formalized emotional word list and scale, the EsSence Profile™ Ballot provides terminology associated with emotions (Cardello et al., 2012; King & Meiselman, 2010; King et al., 2010). In these techniques, the respondent has time to reflect and consider their ballot selections, which may reflect a justification or reasoning process. A novel sensory technique utilizing automated facial recognition software has been tested as a method of collecting consumer emotional response to foods and tastes through facial expression analysis (Danner et al., 2013; De Wijk et al., 2012; Wendin et al., 2011). Such software has the capability of analyzing the direction and extent to which certain facial features move and as a result predictively defines what emotion a consumer is expressing in real time. This method of measuring implicit consumer emotional response overcomes the need to ask consumers to identify language to express their emotions, which may be difficult and not consciously obvious to the consumer. Furthermore, verbal recall allows time to rationalize a response wherein such lag time may cause disconnect between what is actually felt versus what is verbally said, reinforcing the say/feel gap (Hill, 2008).

Although a few studies have been completed using automated facial expression analysis, the methodology, results and potential applications are in their infancy. Additional studies are needed to understand analysis methods as well as accuracy, validity and usefulness of such data. One area of potential application investigated in the present study is the understanding of the

implicit emotional motivations behind consumer behavior towards healthier food product options, specifically fluid milk. Low-fat milk is generally regarded as a healthier option compared to sugar sweetened beverages, yet consumption of milk has declined in lieu of alternative less nutrient dense options, such as sports and soft drinks, particularly among adolescents and young adults (Stewart et al., 2013). In comparing consumption survey data among the US population, it was found that there was a significant decrease, approximately 28%, in the number of individuals aged 12-19 consuming fluid milk from 1977-1978 to 2005-2006; additionally, there was a significant decrease, by almost half, in mean milk intake between the same time frames for the adolescent aged individuals (Sebastian et al., 2010). The objective of the present study was to develop a method to measure implicit emotional response to fluid milk, by evaluating and comparing two different samples (1% low-fat, chocolate flavored and unflavored milk), utilizing objective facial coding software (FaceReader<sup>TM</sup>, Noldus Technologies, The Netherlands).

## **Materials and Methods**

Prior to study execution, Virginia Tech Institutional Review Board (IRB) approval was requested and received (IRB 12-122) (Appendix E) for the testing of human subjects.

### ***Sample preparation***

Two products, unflavored and (chocolate) flavored low-fat (1%) milk, were purchased and prepared for testing as described in Chapter 3. Two colors of cards numbered with the 3-digit codes that matched the codes given to the milk samples, were used to provide visual identification of sample on video.

### ***Participant Recruitment and Description***

Participant recruitment and population demographics were as described in Chapter 3. Fifty-two individuals, 34 females (65%) and 18 males (35%), who met recruitment criteria, participated in the study.

### ***Hedonic Data Collection***

Collection of hedonic data was as described in Chapter 3. The same hedonic data was used for this study as it was collected while video capture for facial response was recorded. Participants were verbally told to maintain eye contact with the computer screen and affixed video web camera, as changes in head position and eye contact would affect the video information available for the research analysis portion of the experiment. Additionally participants were asked to raise the appropriate colored 3-digit marked notecard, which had been placed below the appropriate sample cup, to provide a video record of the sample being evaluated.

### ***Facial Expression Analysis***

#### **Video Recording Conditions and Data Capture**

A video web camera (2.0 megapixel Microsoft LifeCam NX-6000) was attached to the lower portion of the monitor screen in each sensory booth. For each participant, the camera view was adjusted to center on the face, e.g. camera angle (up/down) and distance from the camera (forward/ back). Video recording of the participant's face and experimental activity began immediately after written participant consent (Appendix G) was provided and camera adjustments were made; video was captured throughout the experimental session. To optimize video capture results and minimize facial occlusion, participants were asked to maintain eye contact after the consumption of samples. Lighting conditions were adjusted, with overhead and

booth lights off and incidental lighting provided via the monitor screens. Such lighting conditions were chosen based on preliminary trials that indicated that too much illumination of the face and/or glare would hinder video analysis. Conditions were selected to minimize facial glare, facial occlusion, and facial rotation, as well as maximize facial frontal view in the video so that the facial recognition software (FaceReader4, Noldus Information Technology, The Netherlands) could locate facial positions and properly analyze facial movements on the recorded video. FaceReader4 software version was particularly sensitive to rotational movements, shadows, and glare, resulting in potential for videos to provide limited or no data (video failure).

Video recording resolution was 640 x 480 and recorded by the webcam (2.0 megapixel LifeCam NX-6000, Microsoft, Redmond, WA) using Microsoft Movie Maker (version 2011) platform. Recordings were saved as Windows Media™ video files (.wmv). Videos were analyzed at every third frame, and used the general face calibration setting in the software. Post-consumption video of each milk product for each participant was analyzed. Time zero was established as the point of post-consumption when the sample cup was below the lip but above or at the chin. Each video was analyzed for 5s, 10s, and 20s durations past time zero.

Video state and emotional intensity data were estimated through the software. Intensity of six emotions (angry, happy, disgusted, sad, scared and surprised) as well as a neutral state was estimated via fitted model algorithms inherent in the software. Intensity values ranged between 0 (not expressed/present) to 1 (fully expressed/maximum intensity); outputs were saved in the form of text files.

### **Overall Emotional State**

Expression summaries of overall emotional state were calculated from the estimations of individual emotional states (angry, happy, disgusted, sad, scared, surprised, neutral or other/unknown) based on amplitude, duration and continuity shown in individual emotional responses (FaceReader4 Methodology, Noldus Information Technology). The software assigned “other/unknown” when no specific emotional state could be estimated. The percent of time spent in each estimated emotional state over the time duration was relatively calculated; the expression summary was represented by the software in a pie graph; these overall emotional state outputs were saved as image files. The emotional state data per panelist per milk sample over one specific time frame (20s) was estimated by recording the percent of each emotional state depicted in the pie graph into tabular form into a data spreadsheet (Microsoft Excel 2010, Redmond, WA).

### **Emotional Intensity Data**

Detailed intensity data for each emotion (each panelist for each milk sample) were imported into a data spreadsheet (Microsoft Excel 2010, Redmond, WA) using the saved text files. All data points for the intensity of each emotion measured for the approximate 20 second time frame for each milk sample were included.

### **Statistical and Trend Analyses**

Compilation, aggregation, and transposing of the raw data were completed using Microsoft Excel while the statistical analyses were completed through the use of JMP software (SAS Institute Inc., Cary, NC). For all statistical analyses,  $\alpha$  was pre-set at 0.05;  $\alpha$  between 0.10 to 0.05 was considered for important trends. Hedonic data was statistically analyzed as described in Chapter 3.

### **Overall Emotional State Data Analysis**

The overall mean for the relative percent of time spent in each estimated emotional state (angry, happy, disgusted, sad, scared, surprised, neutral and other/unknown) per milk sample (flavored, unflavored) was found by averaging the state data across panelists (n=36; 16 of the 52 recorded videos had failed analyses) over the 20s duration. A two-tailed paired t-test was used to compare percent means across milk samples and identify significant differences in overall emotional state response between samples. A two-tailed paired t-test was used to compare means and identify significant differences in overall emotional state response between samples within each gender sample population (n = 20 females; n= 16 males).

To investigate potential added value of state estimate data and possible best practices in analysis methods within this data output set, state data per sample type was partitioned based on associated hedonic score (Chapter 3) assigned by participant. Participants who rated samples (flavored and unflavored) with a high hedonic score [8 (like very much) or 9 (like extremely)] or a lower hedonic score [1 (dislike extremely) to 4 (dislike slightly)] were separated into positive and negative affect groups, respectively. The mean of the state estimate data for these two affect groups was calculated (low affect group, n= 17; high affect group, n=24). The results were compared graphically to relatively assess possible trends in emotional state that may be associated and/or correlated to hedonic score. A student's t-test was completed to investigate differences.

### **Emotional Intensity Data Analysis**

Intensity values per emotion and neutral state were averaged over each time duration (5s, 10s, 20s). This created a single average intensity data point per emotion per sample per participant for each designated time period. The three time periods were selected to investigate



the influence of time duration on analysis. An overall population mean was calculated per emotion, including the neutral state, for both flavored and unflavored milk, by averaging the individual means over all participants. The overall population means across emotions within each milk sample were compared for statistical differences using a one-way ANOVA and means test using Tukey's Honestly Significant Difference test (HSD). This was done independently for each time duration (5s, 10s, 20s).

A two-tailed paired t-test was completed between the two milk samples to identify significant differences between overall population means per emotion. This was done for each separate time frame of analysis completed (5s, 10s, 20s).

To investigate time duration effects on emotional results, repeated one-way ANOVA and HSD tests were separately completed for each milk sample to identify significant differences between overall population means across the three time durations (5s, 10s, 20s) per emotion. This was done per emotion by using emotion intensities as measurements and time duration as factors.

#### *Positive vs. Negative Affect Difference Analysis: 'Liked' vs. 'Disliked' Samples*

Participants exhibiting extreme differences in hedonic score between milk samples were identified as a subset population (n=10). Extreme differences were defined by a hedonic score difference of  $\geq 4$  points between samples wherein the 'liked' sample was  $> 5$  and the 'disliked' sample was rated  $< 5$ . Statistical analysis of emotional state and emotional intensity data was completed as previously described for the subset population. With the emotional state data, a two-tailed paired t-test was used to compare subset population means and identify any significant differences in overall emotional state response between 'liked' and 'disliked' samples. With the emotional intensity data, a two-tailed paired t-test was used to identify significant differences

between overall subset population means per emotion between the 'liked' and 'disliked' samples. These analyses were done for each separate time frame of analysis completed (5s, 10s, 20s).

Area under the curve (AUC) of emotional time intensity data was calculated and compared for emotional trends as well as statistical differences. Average intensity data point per emotion per milk sample was transposed into an AUC value for each subset participant. Transposing of the data for each emotion by participant was completed by using an approximation for calculation of area under the curve via the trapezoidal rule (Atkinson, 1989). The trapezoidal area between each intensity data point was calculated and the resulting trapezoidal segmented areas were summed across each of the three time durations (5s, 10s, 20s); the elapsed time between each intensity data point was the height value while base one and base two values were sequential emotion intensities for each trapezoidal segment (area =  $\frac{1}{2}$  height x (base1 +base2)) (See Chapter 5, Figure 5-1).

Statistical differences in overall AUC means per emotion between 'liked' and 'disliked' samples were analyzed by a two-tailed paired t-test. This was done for each of the three time durations (5s, 10s, 20s).

Trends in AUC were also investigated by converting AUC values in both the 'liked' and 'disliked' samples to binomial counts. The sample with the higher AUC was binomially counted as 1 and the other sample as 0 until comparisons were made for all subset participants per emotion. The count number was totaled to provide the count frequency across the population within each sample for each time duration (5s, 10s, 20s). Results were tabulated and graphed for visual comparison of emotional trends and potential correlations between hedonic liking score and emotional response. A chi-squared test for goodness of fit (Gacula & Singh, 1984) was completed for totaled binomial counts per emotion to distinguish statistical differences in

observed results of the sample subset vs. expected population results. Expected results of a hypothesized population were calculated as half of the observed sample size for both the ‘liked’ and ‘disliked’ sample groups ( $e_{\text{liked}}=n/2$ ;  $e_{\text{disliked}}=n/2$ ).

## **Results**

### ***Milk Acceptability***

Results from hedonic data are as described in Chapter 3.

### ***Facial Expression Data Analyses***

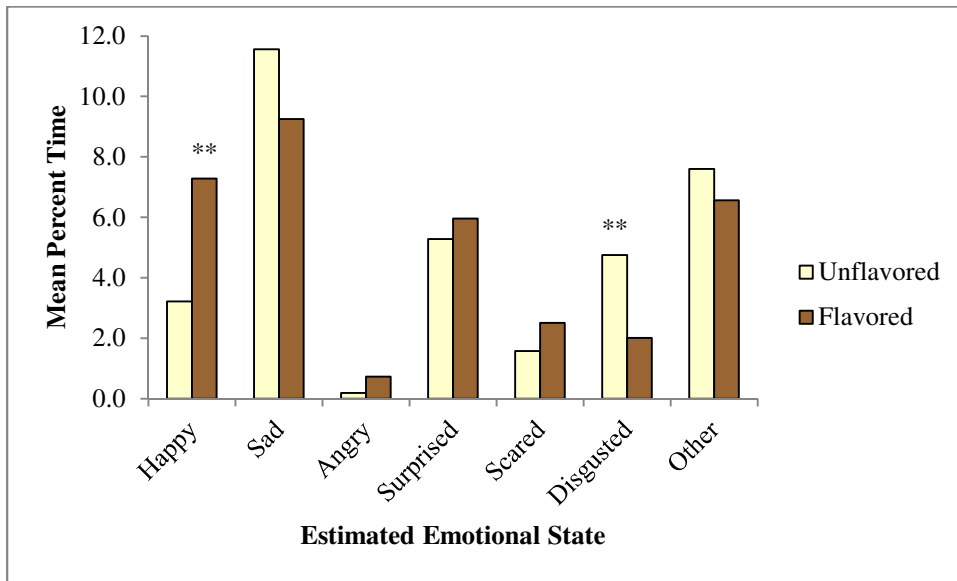
#### **Video Analysis Failures**

Approximately one-third of participant videos, 16 of the 52, were unable to be analyzed by the facial recognition software. Lighting issues and facial occlusions were primary challenges. Seven video failures were due to lighting issues that resulted in a face that could not be detected by software. Five videos failed due to facial occlusion because panelists looked away and/or down from the camera (3 videos) or due to the use of glasses (2 videos). The remaining four video failures were caused by difficulty on the part of the participant to properly follow experimental instructions or operator error. While some video failures resulted in no part of the video suitable for analysis (full failure,  $n=11$ ), others had only partial failure ( $n=5$ ). A partial failure had segments of video that could be analyzed but the majority of the targeted time duration could not, thus leading to large gaps in the data at the desired point of interest. All types of failure lead to the inability to include videos into overall analysis, reducing the usable data set to 36.

#### **Overall Emotional State**

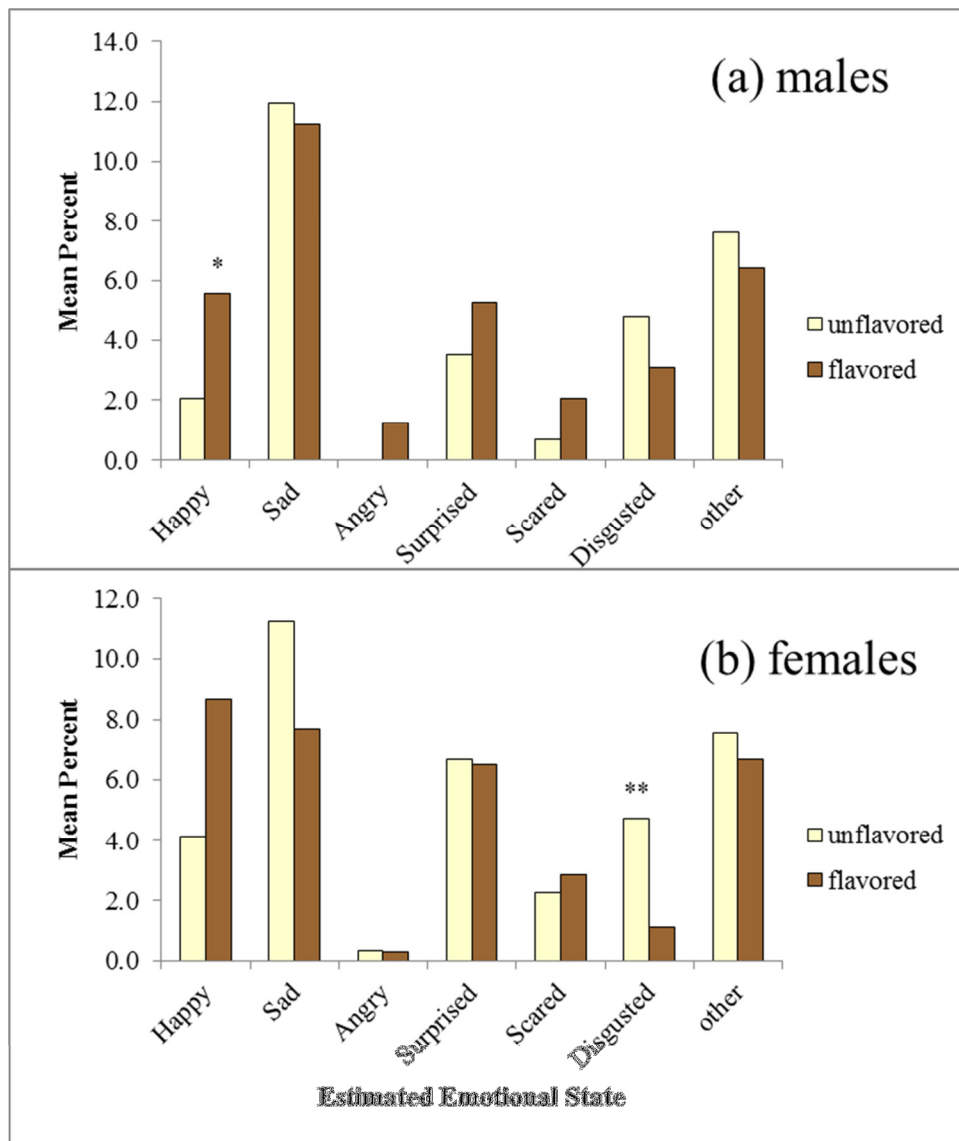
While more time tended to be spent in the happy state (flavored mean=7.3%; unflavored mean=3.2%;  $p=0.0851$ ) and less time tended to be spent in either the sad (flavored mean=9.3%;

unflavored mean=11.6%;  $p=0.1693$ ) or disgusted (flavored mean=2.0%; unflavored mean=4.8%;  $p=0.0787$ ) state for the flavored milk compared to the unflavored milk sample (Figure 4-1), there were no statistical differences when comparing estimated emotional states between samples ( $p>0.05$ ). Significant differences were approached ( $p<0.10$ ) for happy and disgusted states.



**Figure 4-1. Mean Percent of Time Spent in Estimated Emotional State for Low-fat 1% Chocolate Flavored and Unflavored Milk** (n=36); Based on 20 sec video analysis time frame of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample; neutral state has been omitted. \*\*Significant differences approached ( $p<0.10$ ) for happy ( $p=0.0851$ ) and disgusted ( $p=0.0787$ ).

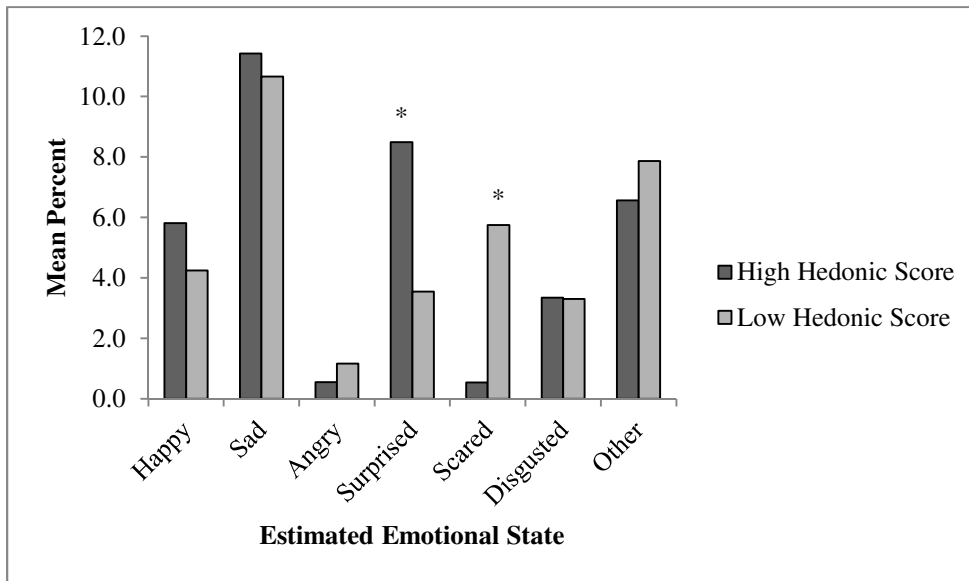
Males spent more time in the happy state (unflavored mean=2.1%; flavored mean=5.6%;  $p = 0.0191$ ) for flavored milk than for unflavored milk (Figure 4-2a). Although there were no other statistical differences in emotional states between products within gender, it is valuable to note the additional emotional state trends. The percent time in disgusted state approached significant difference in females ( $p<0.10$ ); females tended to stay in a disgust state longer for unflavored milk compared to chocolate milk (unflavored mean=4.7%; flavored mean=1.1%;  $p=0.0659$ ) (Figure 4-2b).



**Figure 4-2. Mean Percent of Time Spent in Estimated Emotional State in a) Males (n=16) and b) Females (n=20) for 1% Low-fat Chocolate Flavored and Unflavored Milk;** Based on 20 sec video analysis time frame of facial response (FaceReader4, Noldus Information Technology) post-consumption of milk sample; neutral state has been omitted. \*Percent time in happy state ( $p = 0.0191$ ) was statistically longer ( $p < 0.05$ ) for chocolate milk than unflavored milk for males (a). \*\*Percent time in disgusted state ( $p = 0.0659$ ) approached significant difference ( $p < 0.10$ ) in females (b).

Statistical differences ( $p < 0.05$ ) in mean values were found in the surprised ( $p = 0.0437$ ) and scared ( $p = 0.0443$ ) mean values within estimated emotional state between positive (high hedonic scores) and negative (low hedonic scores) affective subpopulations across flavored and unflavored milk (Figure 4-3). Participants who rated a milk sample with a high hedonic score

tended to spend more time in a surprised state than participants who rated a sample with a low hedonic score. Participants who rated a sample with a low hedonic score tended to spend more time in the scared state than participants who rated a sample with a high hedonic score.



**Figure 4-3. Mean Percent of Time Spent in Estimated Emotional State between Samples Exhibiting Positive and Negative Affect Ratings for 1% Low-fat Chocolate Flavored and Unflavored Milk;** Based on 20 sec video analysis time frame of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample; neutral state has been omitted. Participants rated two milk samples, 1% low-fat chocolate flavored and unflavored milk, on a 9-point hedonic scale (1=dislike extremely; 5=neither like nor dislike; 9= like extremely) after consumption. Participant facial response to samples segregated based on high (8-9) and low (1-4) hedonic sample score; (n=24 high), (n=17 low). \*Statistical differences ( $p < 0.05$ ) found in the surprised ( $p = 0.0437$ ) and scared ( $p = 0.0443$ ) state.

### Emotional Intensity Data Analysis

#### *Influence of Time Duration on Emotional Intensity Profile within Sample*

For each time duration of analysis (5s, 10s, 20s), population means of emotion intensity were compared within each milk sample. For all time durations of analysis and both products, neutral facial expression had the greatest intensity, ranging from 0.52 to 0.61 (0 = not expressed; 1 =

fully expressed). Sad was expressed at the second highest intensity. For all time durations, with the exception of 20 seconds for the flavored milk, the mean for the sad emotion was significantly higher ( $p < 0.05$ ) than the mean for the angry emotion. For all time durations, disgusted was not different from sad for both unflavored and flavored milk but the expression of disgust intensity for flavored milk was about half as intense as compared to unflavored milk (Tables 4-1 and 4-2).

**Table 4-1. Comparisons of Mean Intensity of Facial Emotions for 1% Low-fat Unflavored Milk for Varying Analysis Durations to Determine Influence of Time Duration on Emotional Intensity Profile within Sample**

Emotion	5-sec time duration			10-sec time duration			20-sec time duration		
	Mean	±	SD	Mean	±	SD	Mean	±	SD
Neutral	0.520 <sup>a</sup>	±	0.227	0.540 <sup>a</sup>	±	0.215	0.605 <sup>a</sup>	±	0.191
Happy	0.049 <sup>c</sup>	±	0.047	0.049 <sup>c</sup>	±	0.054	0.044 <sup>c</sup>	±	0.038
Sad	0.158 <sup>b</sup>	±	0.173	0.127 <sup>b</sup>	±	0.113	0.110 <sup>b</sup>	±	0.087
Angry	0.013 <sup>c</sup>	±	0.013	0.014 <sup>c</sup>	±	0.015	0.011 <sup>c</sup>	±	0.012
Surprised	0.035 <sup>c</sup>	±	0.058	0.051 <sup>c</sup>	±	0.059	0.063 <sup>bc</sup>	±	0.071
Scared	0.025 <sup>c</sup>	±	0.053	0.032 <sup>c</sup>	±	0.058	0.024 <sup>c</sup>	±	0.040
Disgusted	0.085 <sup>bc</sup>	±	0.110	0.062 <sup>bc</sup>	±	0.074	0.054 <sup>bc</sup>	±	0.070

(n=36 per duration); Based on 5, 10 and 20 sec video analysis of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample; SD = standard deviation

<sup>a,b,c</sup> Means within a column with different letters are significantly different at  $p < 0.05$ .

**Table 4-2. Comparisons of Mean Intensity of Facial Emotions for 1% Low-fat Flavored Milk for Varying Analysis Durations to Determine Influence of Time Duration on Emotional Intensity Profile within Sample**

Emotion	5-sec time duration			10-sec time duration			20-sec time duration		
	Mean	±	SD	Mean	±	SD	Mean	±	SD
Neutral	0.562 <sup>a</sup>	±	0.263	0.570 <sup>a</sup>	±	0.249	0.609 <sup>a</sup>	±	0.235
Happy	0.069 <sup>bc</sup>	±	0.081	0.073 <sup>bc</sup>	±	0.083	0.071 <sup>b</sup>	±	0.098
Sad	0.113 <sup>b</sup>	±	0.104	0.100 <sup>b</sup>	±	0.099	0.088 <sup>b</sup>	±	0.088
Angry	0.022 <sup>c</sup>	±	0.051	0.019 <sup>c</sup>	±	0.031	0.013 <sup>b</sup>	±	0.019
Surprised	0.058 <sup>bc</sup>	±	0.081	0.053 <sup>bc</sup>	±	0.060	0.063 <sup>b</sup>	±	0.062
Scared	0.029 <sup>bc</sup>	±	0.052	0.037 <sup>bc</sup>	±	0.083	0.029 <sup>b</sup>	±	0.069
Disgusted	0.036 <sup>bc</sup>	±	0.056	0.030 <sup>bc</sup>	±	0.035	0.028 <sup>b</sup>	±	0.043

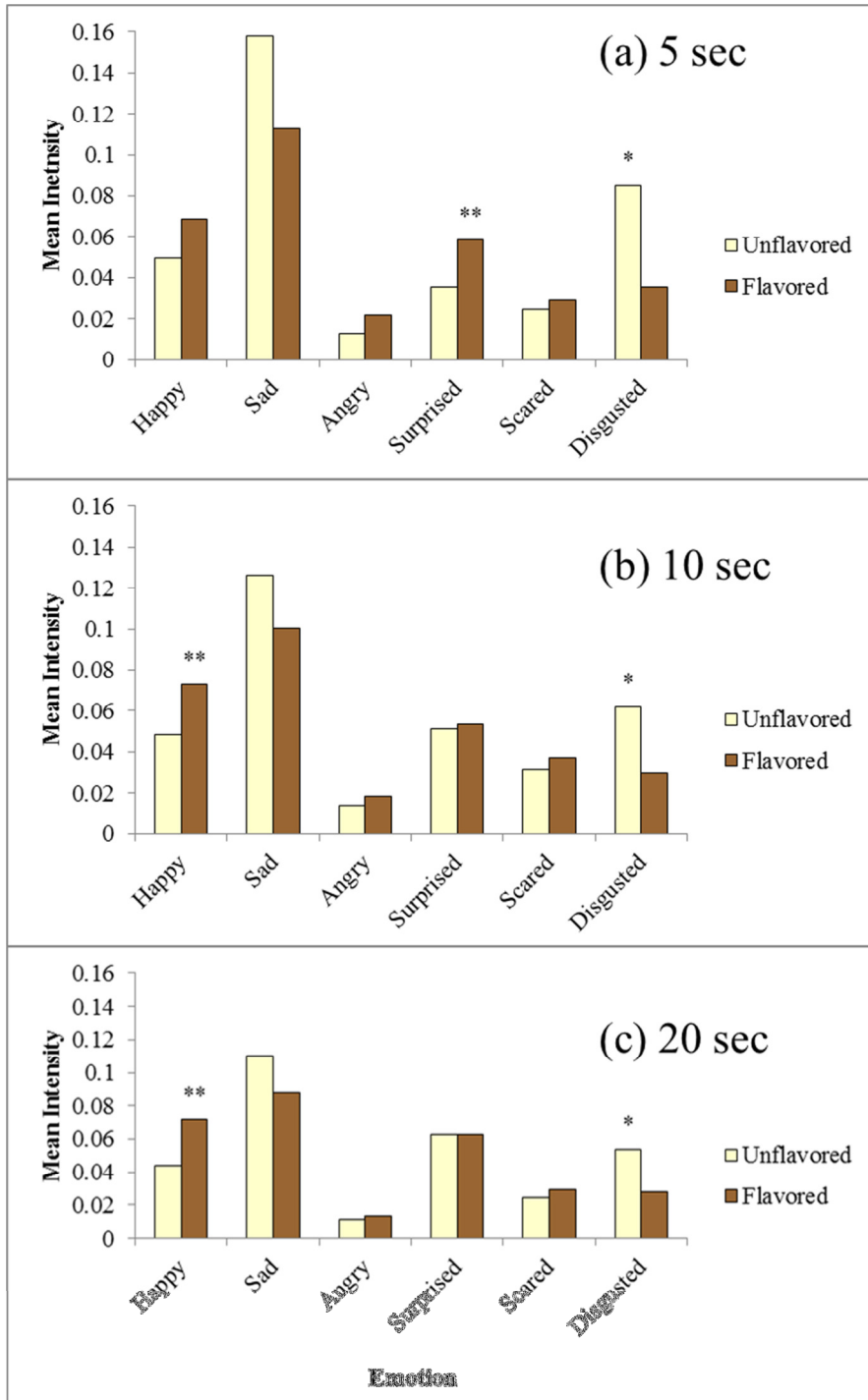
(n=36 per duration); Based on 5, 10, and 20 sec video analysis of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample; SD = standard deviation

<sup>a,b,c</sup> Means within a column with different letters are significantly different at  $p < 0.05$ .

### *Influence of Time Duration on Between Sample Comparisons of Emotional Intensity*

Only the disgust emotion was significantly different between the flavored and unflavored milk over the 5s, 10s, and 20s time durations ( $p=0.0193, 0.0110, 0.0409$ , respectively); disgust was higher for the unflavored milk than for the flavored milk. No other emotions were identified as significantly different between the milk samples. Consistent trends were found when comparing means between samples for all time durations. Mean values indicated that, on average, emotion intensity was greater in the happy state and lesser in the sad state for the flavored vs. unflavored milk sample. Significant difference was approached ( $p<0.10$ ) in the happy emotion for 10 and 20 seconds ( $p=0.0630, 0.0734$ , respectively) as well as in the surprised emotion for 5 seconds ( $p=0.0850$ ) (Figure 4-4a,b,c; Appendix F, Table F-1).





**Figure 4-4a,b,c. Mean Intensities of Facial Emotions for 1% Low-fat Chocolate Flavored and Unflavored Milk for a) 5 second; b) 10 second; and c) 20 second Analysis Duration**

(n=36 per duration); Based on 5, 10, and 20 sec video analysis time frame of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample; neutral state has been omitted.

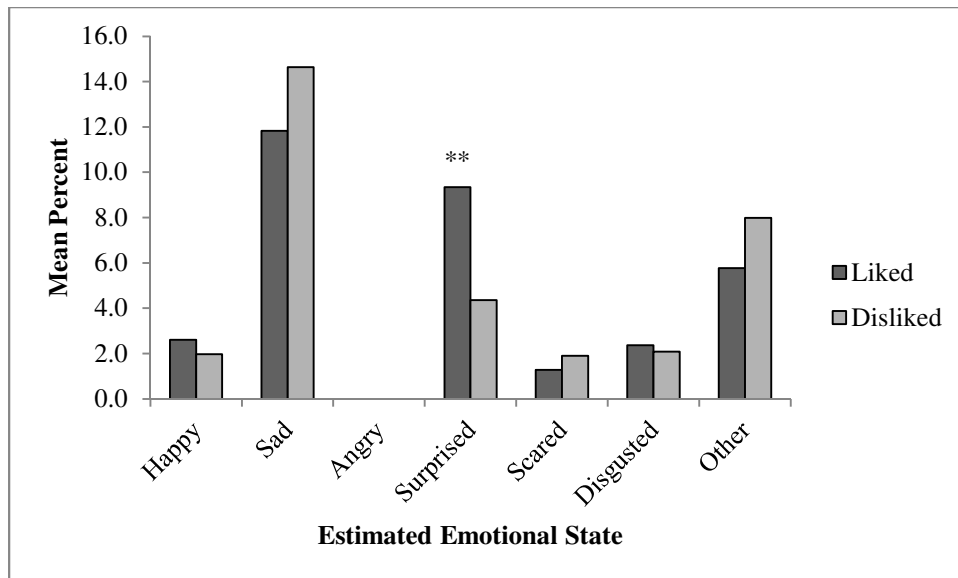
\*Significant difference found in disgust emotion for 5, 10, and 20s ( $p=0.0193, 0.0110, 0.0409$ , respectively). \*\* Significant differences approached ( $p<0.10$ ) in happy state for 10 and 20s ( $p=0.0630, 0.0734$ , respectively) and surprised state for 5s ( $p=0.0850$ ).

### *Time Duration Effects within Emotion*

Increasing analysis time did not necessarily add value. Results from repeated one-way ANOVA tests comparing overall population means per emotion (neutral, happy, sad, angry, surprised, scared, and disgusted) across the three time frames (5s, 10s, 20s), within each milk sample, showed no significant differences ( $p > 0.05$ ) (Appendix F, Table F-2, F-3). It is worthwhile to note that consistent directional patterns were seen in specific emotions from increasing time duration. The mean values in the neutral and surprised state increased within each milk sample as duration increased. The mean values in the disgusted, angry and sad state sequentially decreased within each milk sample as duration increased (Appendix F, Table F-2, F-3).

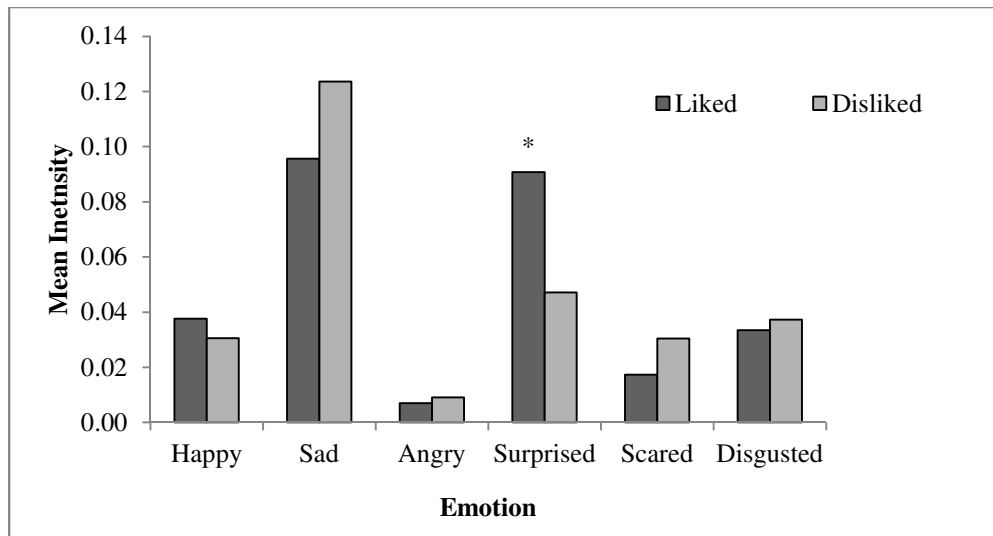
### **Positive Affect and Negative Affect: 'Liked' vs. 'Disliked' samples**

Fourteen participants exhibiting extreme differences in hedonic score between milk samples were identified but only 10 had useable video and emotional output data that could be further analyzed. Eight of the ten chose the chocolate-flavored milk as their 'liked' sample and the unflavored milk as their 'disliked' sample. There were no significant differences in overall percent time spent in each estimated emotional state (Figure 4-5) within this subpopulation. Significant difference was approached ( $p < 0.10$ ) in the surprised state ( $p = 0.0568$ ).



**Figure 4-5. Mean Percent of Time Spent in Estimated Emotional State for ‘Liked’ and ‘Dislike’ Milk in Participants Reporting Extreme Differences in Acceptability between 1% Chocolate Flavored and Unflavored Milk (n=10);** Based on 20 sec video analysis time frame of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample; neutral state has been omitted. Participants rated two milk samples, 1% low-fat chocolate flavored and unflavored milk, on a 9-point hedonic scale (1=dislike extremely; 5=neither like nor dislike; 9= like extremely) after consumption. Extreme differences were defined by a hedonic score difference of  $\geq 4$  points between samples wherein the ‘liked’ sample must have been rated  $> 5$  and the ‘disliked’ sample must have been rated  $< 5$ . No significant differences found ( $p>0.05$ ). \*\*Significant difference approached ( $p<0.10$ ) in surprised state ( $p=0.0568$ ).

Results from t-tests comparing subset population intensity means per emotion between the ‘liked’ and ‘disliked’ samples showed no significant differences for the 5 and 10 second analysis durations. Significant differences were identified between ‘liked’ and ‘disliked’ samples for the 20 second analysis duration in the surprise emotion ( $p=0.0491$ ) (Figure 4-6; Appendix F, Table F-4.) Tendencies were noted in mean intensities for participants exhibiting extreme differences in acceptability showed that emotional intensities in surprised and happy tended to be higher and scared tended to be lower with the positively perceived product for all video analysis time durations (Appendix F, Table F-4).

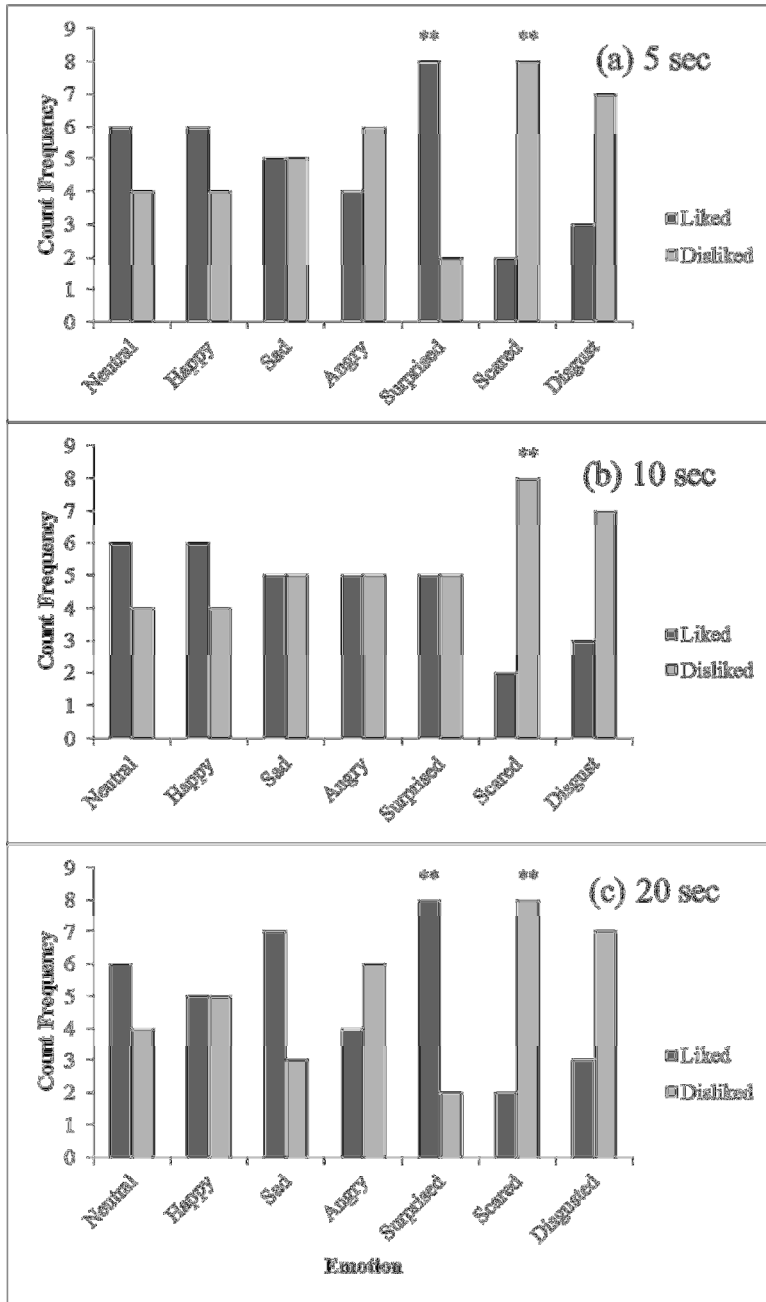


**Figure 4-6. Mean Intensity of Emotion for ‘Liked’ and ‘Dislike’ Milk in Participants Reporting Extreme Differences in Acceptability between 1% Chocolate Flavored and Unflavored Milk** (n=10); Based on 20 sec video analysis time frame of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample; neutral state has been omitted. Participants rated two milk samples, 1% low-fat chocolate flavored and unflavored milk, on a 9-point hedonic scale (1=dislike extremely; 5=neither like nor dislike; 9= like extremely) after consumption. Extreme differences were defined by a hedonic score difference of  $\geq 4$  points between samples wherein the ‘liked’ sample must have been rated  $> 5$  and the ‘disliked’ sample must have been rated  $< 5$ . \*Statistical difference ( $p < 0.05$ ) in the surprise emotion ( $p = 0.0491$ ).

Results from t-tests comparing subset population AUC means per emotion between the ‘liked’ and ‘disliked’ samples showed no significant differences for the 5 and 10 second analysis durations. Significant differences were identified between ‘liked’ and ‘disliked’ samples for the 20 second analysis duration in the surprise emotion ( $p = 0.0411$ ) (Appendix F, Table F-5).

Trends in count frequency were identified in AUC from comparing AUC in both the ‘liked’ and ‘disliked’ milk sample using a binomial count method. Consistent trends in count frequency, across all time durations, suggested that the scared and disgust emotion were more frequently associated with the ‘disliked’ milk and the neutral response was more frequently associated with the ‘liked’ milk. For the 5 and 10 second durations, the happy emotion was more frequently associated with the ‘liked’ milk. For the 5 and 20 second durations, the surprise emotion was more frequently associated with the ‘liked’ milk. Results of count frequency, for

the three time durations, representing potential correlations between hedonic liking score and emotional response are summarized in Figure 4-7a,b,c. Results from chi-squared tests for goodness of fit determined that scared approached significant difference ( $p < 0.10$ ) for all time durations (5,10,20s, respectively) (Figure 4-7a,b,c). Surprised approached significant difference ( $p < 0.10$ ) for the 5 second and 20 seconds time durations (Figure 4-7a,c).



**Figure 4-7a,b,c. Frequency for Higher AUC Between 'Liked' and 'Disliked' Milk in Panelists Reporting Extreme Differences in Acceptability between 1% Chocolate Flavored and Unflavored Milk for a) 5 second; b) 10 second; and c) 20 second Analysis Duration** (n = 10 per duration); Based on 5, 10, and 20 sec video analysis time frame of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample. Participants rated two milk samples, 1% low-fat chocolate flavored and unflavored milk, on a 9-point hedonic scale (1=dislike extremely; 5=neither like nor dislike; 9= like extremely) after consumption.

AUC was determined for both 'liked' and 'disliked' samples wherein the sample with the higher AUC was binomially counted as 1 and the other sample as 0 until comparisons were made for all participants per emotion. The number of counts was totaled to provide the count frequency. Chi-squared tests for goodness of fit per emotion determined that scared approached significant difference ( $p < 0.10$ ) for all time durations (5, 10, 20s, respectively). Surprised approached significant difference ( $p < 0.10$ ) for the 5 second and 20 seconds time durations.

## **Discussion**

### ***Video Analysis Failures***

The proportion of participant video data that could not be incorporated into facial analysis was slightly unexpected. Some expectation of video failure did exist based on a previous study that used the same facial coding software as well as the same version (FaceReader4, Noldus Information Technology, The Netherlands) that experienced 18% and 27% failure rates; reasons for errors stemming from hairstyles occluding face, facial hair, participants not facing the camera, and participants placing their hand on chin (Danner et al., 2013). There was also further expectation based on descriptions of the software from Noldus Information Technology's FaceReader4 Methodology White Paper; descriptions specifically state that: 1) pose, movement and rotation of the participant is limited in that ideal conditions are towards camera with less than a 40 degree angle; 2) strict lighting requirements exist (although further detail is not described); 3) facial occlusion from facial hair and hand (via eating motions) should be avoided; and 4) glasses, particularly thick or dark frames, can impede analysis.

While operator error could be easily remedied, other errors including participant misunderstanding of directions, lighting conditions, and occlusion of the face would need to be further investigated to improve overall video capture quality. To facilitate better understanding of participant instruction, a mock trial could be run previous to the experimental test runs. This had been previously done in another study using both young adults and children wherein after

being given verbal instructions by an experiment leader, the young adults and children practiced the experimental procedures by completing one and three practice trials, respectively, using a neutral stimulus (cracker) (De Wijk et al., 2012). The possible consequence with running practice trails may be that participants become overly familiar with the experimental procedure and camera position/presence, that they may become camera shy or are focused on carrying out the experiment ‘successfully’ so that they are no longer in a natural state. De Wijk et al. (2012) also discusses how each test trial started with an “attention” instruction directing participants to look straight into the direction of the camera. De Wijk et al. (2012) fails to mention, with the exception of one participant who failed to understand instructions, whether there were any particular videos removed from study analysis for instances of partial facial occlusion, looking away movements, or lighting conditions. In the present study, participants were directed to maintain eye contact towards the instruction screen/camera post-consumption of sample although the directions may not have been explicit enough. Additionally, participants may have felt slightly shy or self-conscious being video recorded and looked away without realization. This may have been the reason that another study, using an orange juice beverage as a stimulus, may have experienced lower failure rates (Danner et al., 2013). In that study, Danner et al. (2013) states that participants were unaware that they were being filmed; the test purpose was hidden from participants until after testing and participants provided consent to use their video data after it was collected. Camera shyness could be tempered by having less obvious or more compact cameras that do not overtly notify the participant that they are being videotaped. Otherwise it is possible that in the present study participants became bored or anxious during the study and shifted their body in a way that their face wasn’t towards the camera. For this instance, shorter



study durations and better instructions to maintain eye contact may alleviate some but not all of these types of occurrences.

Lighting conditions would need to be optimized to further reduce video failures. Improved camera quality may significantly improve clarity of video in view of sub-perfect lighting environments. Although it should be noted that both the similarly executed referenced study (Danner et al., 2013) that presented less video failures and the present study that presented more failures both used webcams with video resolution of 640 x 480. The difference in video failure may be due to environmental conditions that were not fully optimized as different directional light sources caused heavy illumination for some participants. This may have been based on seating booth arrangement and/or camera angle based on participant position (e.g. height and seat position). The need for lighting optimization is supported by Danner et al. (2013) wherein it is discussed that certain attention was taken to ensure good illumination of participant face although no further details are mentioned.

### ***Overall Estimated Emotion State***

It is not clear whether information regarding percent time spent in estimated emotional states is a useful analysis as compared to detailed emotional intensity data analysis. Estimated emotional state data offers a 'big picture' view of a participant or sample population response. In this instance, estimated responses were predictive of detailed intensity data. The estimated emotional state data was predictive of the significant difference in disgust emotion between the milk samples found in the intensity data analysis for all video time durations (5, 10, 20s). It was predictive for the happy state; based on the estimated emotional state, it would have been expected that happy would have showed significant ( $p < 0.05$ ) or near significant ( $p < 0.10$ )

differences between milk samples, with intensity being greater for the flavored milk sample and this was the case (near significant) for 10 and 20 sec video analysis durations. It was also predictive for 'liked' and 'dislike' milk in participants reporting extreme differences in acceptability between samples. Based on estimated emotional state data it would have been expected that the surprise emotion would have been significantly different or near significantly different, greater for the liked sample, as was shown ( $p < 0.05$ ) in same subset population intensity results for 20 second video analysis.

The state data within females was also expected based on hedonic differences between gender. It was not surprising that females had close to significant differences with close to greater time spent in the disgusted state for the unflavored milk. This was expected based on the hedonic data wherein it was shown that females significantly preferred the flavored milk. This was also expected based on the terminology data selected by female participants in the related study described in Chapter 3 where it was found that females associated disgust with much greater frequency for unflavored milk. It was slightly surprising that although males showed not significant differences in hedonic scores between the milk samples that estimated emotional state data showed significant differences in the happy state with greater time spent in this state towards the flavored milk sample. This could suggest that males had implicit happy emotions towards the flavored milk sample that were not fully registered through hedonic scoring. This may be supported by the results from Chapter 3 where it was found that males did not report with great frequency any negative terms associated with the unflavored milk sample as was the case for females. Males reported with great frequency several positive terms (satisfied, warm, nostalgic) associated with the flavored milk sample (Chapter 3). This may be a representation of the "say/feel gap" wherein there lies a separation between what individuals say and how they

actually (implicitly) feel (Hill, 2008). It may also be a representation towards the suggested view based on previous studies using manual detection of children's facial movements through the Facial Action Coding System (FACS) to liked and disliked foods, that implicit facial expressions are better measures for negative affective (dislike) vs. positive affect (like) (Zeinstra et al., 2009). Otherwise, it is possible that estimated state data was not robust due to sample size number (n=16) and individual variability.

Inherent in analysis of estimated emotional state data is that certain emotions may be completely disregarded from result output. In other words, an emotion may be present throughout the analysis but not recognized as the dominant emotion and therefore not registered as the singular estimated state from one instance to the next. This may have been the cause of many outputs in the estimated data showing a 0% time output. Such high variability within range of output could influence the accuracy of mean comparison tests.

Overall the researchers do not consider estimated emotional state as effective a measure, as compared to intensity data, if the objective is to find more sensitive differences in emotion between stimuli. It may be useful as a quick tool to understand large-scale changes. For example, if the goal is to have a participant happier during a certain time point in analysis (e.g. ad campaign, product feature introduction) or overall for one stimulus over another, this could be quickly viewed by capturing estimated state results.

### ***Emotional Intensity***

The three time periods (5, 10, 20s) were selected to investigate the influence of time duration on analysis. There is currently no specific standard in automatic analysis as to what duration is optimally appropriate, particularly for food and beverage stimuli. Differing

approaches have been used. Automatic facial expression studies by De Wijk et al. (2012) analyzed a one second post and pre- consumption time frame using a 1 second lag/gap time for stimulus introduction. Studies by Danner et al. (2013) used an open-ended time duration for explicit measurements wherein participants were told to explicitly deliver facial expressions relating to their liking of the sample after 20 seconds of reflection post-consumption; a rough 20 second analysis (not timed exactly) was used for implicit automatic measurements wherein analysis of facial expression post-consumption was completed from the time the participant removed the carrier cup from their lips and the cup or hand were not occluding the participant's face (Danner et al., 2013).

Further rationale for investigating differing time durations is that emotion is known to be expressed very rapidly post stimulus but at the same time may have a potential lingering and/or fade effect (Ekman, 1982; Ekman, 1992; Hill, 2008). Ekman (1982) discusses that durations of emotion response (slow and relaxed vs. quick and sharp) can be contrasting depending on whether the emotion was stimulated by a positive (e.g. enjoyment) or negative (e.g. anger) influencer. Ekman (1992) describes facial expression correlated to emotions as having a quick onset that can start in milliseconds and sustain for just a matter of seconds. When discussing brain-to-face connections, Hill (2008) points out that facial expressions have an onset, a peak and a fade wherein the duration of expression will generally range from half a second to four seconds. This rapid time sequence as well as the results found in the present study may suggest that the time durations investigated could have been too long to obtain truthful descriptive depictions. Although investigations in time suggested no statistical differences across durations, the overall directional decrease or relative sameness in absolute values of mean response, with

the exception of neutral response and surprise which increased, suggest that response may be diluted as time duration increase.

The analysis investigating statistical differences across emotions, within each time duration, further suggested that increases in time duration may dilute accuracy in response. The rationale for investigating statistical differences across emotions was to understand whether or not results were flat between emotions. If results were flat, this would suggest that there was not differentiation between the emotions, regardless of time, and that it was possible that no emotional response was present and therefore measurable. This was not shown to be the case overall although for the 20 second time duration for the flavored milk samples, the mean values across emotions were flat apart from the neutral state. This suggests that 20 seconds may have been too long of a duration in that the basic emotions presented (the neutral state being considered a control state rather than basic emotional state) showed no distinction between one another. Furthermore it suggests that a longer time duration wouldn't necessarily provide valuable information and may continue to increase neutral response and dilute actual basic emotion response. As such, it is suggested that further research should incorporate a shortened time duration unless specific carry over or lingering effects were of investigative interest.

It was expected that between samples comparisons would show significant differences in disgust, with greater mean intensity for the unflavored milk as compared to the flavored milk. This was anticipated based on results from emotional terminology data (Chapter 3) wherein the majority of the same participants from the present study differentiated the same milk samples (flavored, unflavored) through the use of the word disgust; the term being assigned to the unflavored sample rather than the flavored sample. Results were also anticipated based on the hedonic results, which distinguished unflavored milk as less liked than flavored milk.

Furthermore, a little over half (56%) of participants whose videos were analyzed were females. This is a potential influencer of the facial expression results for several reasons. Firstly, for the hedonic data, females showed statistical differences in liking between samples as opposed to males. Secondly, several studies with the goal of understanding influencers and more so barriers to consumption of milk in females (Brewer et al., 1999; Gulliver & Horwath, 2001; Horwath et al., 1995) have suggested that dislike of (unflavored) milk is an important barrier to consumption (Horwath et al., 1995) and that consumption is not necessarily motivated by sensory preference (Brewer et al., 1999). Horwath et al. (1995) further discusses that participants believed that incorporating flavored milk into their diets would be a useful way to encourage them to consume more milk. Thirdly, several studies about gender differences have suggested that females have a tendency to be more emotionally expressive than males when viewed through a variety of measures (e.g. electromyography, rating of non-verbal facial expression, self-report ratings) as referenced and discussed in Kring and Gordon (1998); the results of their own two studies showing significant gender differences in intensity of facial expressions to visual stimuli (Kring & Gordon, 1998). Further studies described in Kring and Gordon (1998) investigating emotion differences within gender found that females are more expressive of specific emotions including that of disgust (Fujita et al., 1980; Rotter & Rotter, 1988; Tucker & Riggio, 1988; Wagner et al., 1993, 1986; Zuckerman et al., 1975). Therefore, if the females in the study were dislikers of (unflavored) milk, it is reasonable to believe that they may have been more expressive of their dislike through a showing of the negative disgust emotion than male dislikers. Since the study was not balanced for gender this could have influenced the overall population results.

### *Positive Affect and Negative Affect: 'Liked' vs. 'Disliked' samples*

The lack of significant difference found, with the exception of the surprise emotion, between 'liked' and 'disliked' samples through both the percent time spent in estimated emotional state and mean intensity analysis was somewhat unexpected. It would have been expected that the positive emotion, happy, and/or negative emotions, disgust, scared, angry, sad would have been associated with the liked and disliked milk sample, respectively. The reason may be that the subset population number was too low for results to be sensitive. This could be supported through the binomial analysis data, which did show near significant differences for all time durations between the 'liked' and 'disliked' sample for the scared emotion; this negative emotion being expectedly associated with the disliked sample. This may mean that with low sample size number, further types of probing analysis, e.g. binomial count and chi squared analysis, may provide alter ways to investigate differences in response.

Overall, it is inconclusive as to the sensitivity capability of the facial coding software and therefore the power needed to be able to identify micro-emotions displayed. Larger subject numbers may be needed to investigate differences in facial emotional response between stimuli as well as correlations and disconnect between explicit verbal (hedonic) response and implicit facial response. Further studies would need to be carried out to better understand these limitations.

### **Conclusion**

This study suggests that emotional response may provide an added value understanding for the acceptability of flavored and unflavored fluid milk beyond hedonic rating. Research into the application of automatic facial expression in the food and beverage category is novel and developing. There are still many unknowns for data collection and data analyses. Sensitivity and

limitations in software capability can cause failures in facial expression analysis for videos collected making quality of video capture crucial. It may also be the case that the application may not be sensitive enough for all types of stimuli. Best practices in methodology and statistical analysis of results may require adaption based on sample size. A direct relationship is not necessarily exhibited between individual emotional response versus mean emotional response for all participants due to the potential for high variation in emotional response per individual. Furthermore, adaptations and/or corrections for a participant's emotional pre-disposition may need to be accounted for with baseline readings and/or a control stimulus. Additional studies in the area of automatic facial expression in the food and beverage category are thus needed to answer these methodology questions.

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## **Chapter 5: Measuring Consumer Emotional Response to the Basic Tastes through Facial Expression Analysis**

### **Abstract**

Interest in novel approaches for understanding human emotional response had led to the development of automatic facial coding software. This tool measures facial movement in response to stimuli and correlates these measures to intensities for certain basic emotions presented. Standard methodology has not been developed for this automatic response. The objective of the study was to create a baseline understanding of emotional facial response to four basic tastes (sweet, salt, sour, bitter) using automated facial coding software to: a) validate occurrence of an emotional response; b) characterize similarities and/or differences in response to the tastes based on objective facial coding interpretation of 6 emotions (happy, surprised, sad, angry, scared, disgusted) and a neutral state; and c) compare results to historical learning of emotional facial response to basic tastes to substantiate the reliability of the selected analysis method. In the first session, participants (n=39) were presented with a water control and 4 basic tastes solutions while facial response was video-recorded. Participants (n=37) completed a second session with the same procedures repeated but with a higher level concentration of all taste solutions. Participants rated the liking and taste intensity of each sample upon consumption on 9-point scales. Videos from both sessions were analyzed per participant per sample for 5 seconds post-consumption through facial coding software to undergo facial expression analysis. Emotion intensity readings (0=not expressed at all to 1= fully expressed) were collected. Sweet was statistically preferred for both sessions compared to the other tastes ( $p < 0.05$ ;  $6.62 \pm 1.52$ , low;  $6.76 \pm 1.92$ , high). Liking for the higher concentration bitter solution ( $2.97 \pm 1.12$ ) was

statistically lower ( $p < 0.05$ ) than liking for the lower concentration bitter solution ( $3.92 \pm 1.19$ ). Results were inconclusive as to whether a unique distinguishable emotional response was seen for each basic taste. No statistical differences in emotion intensity were found across tastes per emotion ( $p > 0.05$ ) with exception of the disgusted emotion. No statistical differences were found from paired t-tests of emotion intensity based on increasing concentration of solution. No correlations were suggested between liking scores and emotional intensity based on multiple linear regression analysis. Possible reasons for lack of significance and correlative response include high individual taste variability, social context, intensity of stimuli, quality of video data capture, calibration settings in software emotional interpretation, sample size number, analysis time duration, and software sensitivity limitations. To better validate automatic facial coding methodology, further study would need to investigate and minimize these sources of influences.

## **Introduction**

Conventional consumer sensory methodologies have historically focused on evaluating product success by capturing consumer liking through the use of a hedonic scale. Such data reflects consumer self-reported response of how much they like or dislike a product and/or product experience. This type of feedback does not capture the consumer's deeper internal response to a product inclusive of their emotional response. More so, it is generally thought that there is limited predictive correlation between hedonic response and market success (Hill, 2008; Lundahl, 2012; Wichchukit & O'Mahony, 2011).

It has been suggested that market success from initial product selection to repurchase can be linked to an emotional response that goes beyond product functionality. Having an emotional connection to a particular product can be seen as a driving force for consumer behavior and choice and ultimately lend to the success of that particular product over another (Hill, 2008;

Lundahl, 2012). A positive emotional response can motivate a consumer to choose something for purchase while conversely a negative emotional response can influence lack of selection. If consumers are asked why they made their choices, many attempt to post-rationalize their choices because they do not necessarily understand them fully, not recognizing the irrational and subconscious nature of their decision-making process (Ekman, 2007; Hill, 2008; Langer, 1989; Lindström, 2008). Typically, consumers experience affect (feeling/emotion) before rationally thinking, suggesting that their actions may be reactions to these susceptible feelings (Zajonc, 1980).

To better understand this emotional connection, updated methodologies and advances are needed; current sensory methodology is limited in its ability to measure and understand emotions. One area that has been investigated as a potential sensory tool is facial expression analysis, also known as facial coding. Facial coding is a method of measuring the muscular movements of the face in response to stimuli and correlating these movements to specific emotions and/or positive and negative facial behavior, which are known to facilitate such movements (Ekman, 1982; Ekman & Friesen, 1978).

Facial coding has been used to a limited extent for gathering data in the food and beverage area, particularly on the assessment of emotional response to the basic tastes. A majority of the research has been done using a manual assessment wherein assessors have made use of the facial action coding system (FACS) (Ekman & Friesen, 1978). The FACS method has been applied to study the facial expressions of newborns to basic tastes (excluding umami) to understand whether or not they were able to discriminate among tastes (Rosenstein & Oster, 1988). In adults, the FACS has been used to gather understanding of facial reactions to basic tastes. Facial reactions and the intensity of those reactions were compared to hedonic

pleasantness ratings at different concentrations of basic taste solutions (Wendin et al., 2011). The authors suggested that the tastes, concentration of the tastes, and perceived pleasantness could be differentiated and correlated to specific facial reactions (Wendin et al., 2011). Other studies utilizing the FACS have fostered a baseline of understanding of emotions towards the basic tastes in adults and children focusing on both the possible correlations or lack thereof between facial response and verbal preference rankings (Greimel et al., 2006; Zeinstra et al., 2009).

Although useful, manual facial coding operations are very time consuming and involve substantial training in the method. It also involves validation of results through the use of multiple assessors. An automated version would be advantageous and although such automated software presently exists, no standard methodology has been developed to assess consumer emotions to a food stimulus using such software. Thus, the objective of the study was to create a baseline understanding of consumer emotional facial response to four (not including umami) basic tastes- sweet, salt, sour, and bitter - using automated facial expression analysis software (FaceReader<sup>TM</sup>, Noldus Information Technology, The Netherlands) to: a) validate that an emotional response does occur; b) characterize similarities and/or differences in emotional response to the basic tastes based on objective facial coding interpretation of 6 emotions (happy, surprised, sad, angry, scared, disgusted) and a neutral state; and c) compare the results in relation to historical research learning of emotional response, specifically facial response, to the basic tastes, to substantiate the potential reliability of the selected analysis method.

## **Materials and Methods**

### ***Experiment 1- Participant Screening: Potential Bitter Blindness and Participant Compliance***

#### ***Screening***

Prior to study execution, IRB approval was requested and received (IRB 13-037) (Appendix H) for the use of testing on human subjects from the VT IRB.

#### **Sample Preparation**

Concentrations for three bitter taste solutions were determined using Spectrum™ intensity scales for descriptive analysis (Meilgaard et al., 2007). Low, med, and high intensity values, representing, 2, 5, and 10 on the 15-point scale, corresponded to solutions of 0.05%, 0.08%, and 0.15% anhydrous caffeine (C7731-Sigma Aldrich) in room temperature dH2O (Kroger Brand, Cincinnati, OH; wt/vol), respectively, in 500 mL volumetric flasks. After swirling, solutions were allowed to sit for 10-15 minutes before being transferred into clean, dry glass bottles containing an insertable pouring spout. Room temperature dH2O (Kroger Brand, Cincinnati, OH) was used as the control. Each bottle was labeled using unique colored labels for each concentration and control. Sample solutions were prepared within 8 hours of sensory testing. Unused solutions were discarded.

Approximately 0.5 to 0.75 fl. oz. were poured into appropriate color-coded plastic serving cups (1 oz.) (Monogram, Columbia, MA) and capped. All samples were presented simultaneously on a tray at room temperature, with color codes and increasing bitter intensities arranged left to right. Color-coded identifier notecards, which matched solution color codes, were placed on top of the samples.



### **Participant Recruitment**

An announcement (Appendix I) for the recruitment of study participants was sent to Virginia Tech faculty, staff, students and affiliates through email listservs. Participants interested in completing the study filled out an online survey (Appendix J) in which they stated their interest, availability and knowledge of allergies to study ingredients involved in both experiments 1 and 2 as well as potential future related studies. Participants also made note of their personal physical characteristics for consideration with video recording capture and evaluation. Characteristics included the presence of facial hair and glasses as such physical characteristics were considered important considerations to potential software analysis failure due to visual occlusion of a participant's face in the latter part of the experiment.

### **Data Collection**

Sixty-five individuals, 47 females and 18 males, who met recruitment criteria, participated in the screening study. Participants provided signed consent prior to consumption of any samples or video recording through the use of an informed consent form (Appendix K), as approved through the VT IRB, detailing the procedures, objectives and potential risks of the study.

Participants individually completed the experiment in the sensory lab in the Food Science and Technology building at VT. Participants were seated in an individual sensory booth and presented with a tray of four coded samples, ordered from left to right beginning with the control, low medium and high concentration bitter taste solutions, respectively. Participants were instructed to follow instructions on the touch screen monitor in the sensory booth. Prior to sample evaluation, specific protocols (Table 5-1) were verbally provided as well as initially displayed on the monitor. Participants were asked to consume each sample in full and wait approximately 30 seconds before they could move forward with the experiment. An on screen

timer embedded on the monitor was used to prevent the participants from moving forward with the experiment until the timer period had elapsed. During this wait period, participants were meant to be facing in a forward direction. Participants were then instructed to indicate using a 9-point hedonic scale (extremely like; neither like nor dislike; extremely dislike) how much they liked or disliked the sample they had just tasted. They then rated the intensity of the bitter taste on a 9-point intensity scale (extremely strong bitter taste; neither strong nor weak; extremely weak bitter taste/no bitter taste). Participants were instructed to sip room temperature drinking water (Kroger Brand, Cincinnati, OH) before the first sample and in between each sample. Additionally participants were asked to raise the colored notecard assigned to each sample cup before the consumption of the solution within the sample cup to identify the consumed sample on the video recording.

Touchscreen monitor instructions were programmed and data collection was transferred from the touch response to a central computer using Sensory Information Management System (Berkeley Heights, NJ). Data responses (hedonic, intensity) were transformed from verbal response to numeric values (9= extremely like or extremely strong bitter taste; 5= neither like nor dislike or neither strong nor weak; 1= extremely dislike or extremely weak bitter taste/no bitter taste) and were exported to data spreadsheet (Microsoft Excel 2010, Redmond, WA) for comparative analysis.

### **Video Recording and Facial Expression Analysis**

A video web camera (Microsoft 2.0 megapixel LifeCam NX-6000) was attached to the lower portion of the monitor screen and positioned such that the camera's viewing capability, camera angle (up/down) and participant's distance from the camera (forward/ back), adjusted to center participant's face. The camera began recording the participant's experimental activity and

face, from approximately the time after written participant consent was given and camera adjustments were made, until the time the experiment session was completed in full. To optimize video capture and minimize facial occlusion participants were asked to follow certain protocols (Table 5-1) before the consumption of any samples. It was important to minimize facial occlusion and facial rotation and to maximize the face looking towards the camera so that the facial recognition software could locate participants' facial positions and properly analyze facial movements throughout the experiment.

**Table 5-1. Participant Protocols Delivered Prior to Sample Consumption**

1	Fasten/sweep hair away from face
2	Focus your attention on the monitor in front of you
3	Refrain from looking to your left/right or looking up/down
4	Do not lean your head; keep your posture comfortable but alert
5	Immediately after taking in the sample from the cup, drop your hand/cup below your chin as quickly as possible
6	Refrain from touching your face after sample consumption
7	Face the monitor while you are evaluating the sample

Lighting conditions in the booth offered illumination of the face for video-recording through fluorescent ceiling panel lights. Minimal lighting from the monitor screen offered further illumination. The door of the sensory booth lab was closed to prevent any additional outside lighting source to cause undesired reflection of the participant face.

The full session of each participant's video was analyzed using facial recognition software (FaceReader5, Noldus Information Technology, The Netherlands). Recordings were in a resolution of 640 x 480 and recorded by the Microsoft webcam (Microsoft 2.0 megapixel

LifeCam NX-6000, Redmond, WA) using Microsoft Movie Maker (version 2011) as a platform. Recordings were saved as Windows media video (.wmv) files. Videos were analyzed frame by frame and used the default general face calibration setting through FaceReader5 (Noldus Information Technology, The Netherlands).

### **Facial Recognition Software Compatibility, Bitter Blindness Risk and Compliance Analysis Screening**

For the purposes of excluding preliminary study participants from secondary facial recognition experiments (Experiment 2), exclusion criteria were established. Emotional output data was assessed for participant-software compatibility as well as participant compliance issues. The software presents limitations in that for a minor proportion of the population, it is difficult to capture and analyze the participant's facial response. Participants that showed output data with limited to no data readings were deemed to be potentially non-compatible with the software analysis. Other potential sources of complications that could result in a low to minimum data output reading, such as participant lack of instructional compliance, was monitored. For example, if a participant repeatedly looked down after consumption of the sample or had a tendency to move forward or backward or side-to-side during the experiment session, they were considered to be noncompliant.

Data collected from the 9-point intensity scale were reviewed and compared for all four samples for each participant. A potential risk of bitter blindness was assigned to each participant based on their comparative intensity scores. Participants who rated the sample intensities in the appropriate order of increasing bitter concentration (control, low, medium, high), even if ratings were not in the known magnitude of concentration, were identified as having minimal risks of

being bitter blind. Participants who did not were deemed to have a potential higher risk of being bitter blind.

Selection criteria for subsequent experiment testing included in order of relevance: 1) facial recognition software analysis compatibility 2) low bitter blindness risk and 3) instructional compliance.

### ***Experiment 2- Basic Taste Screening***

Prior to study execution, IRB approval was requested and received (IRB 12-1100) (Appendix L) for the use of testing on human subjects from VT IRB.

#### **Sample preparation**

Four basic taste solutions (salt, bitter, sweet, and sour) were created along with a room temperature distilled water (Kroger Brand, Cincinnati, OH) control sample. Each basic taste was represented with two concentrations (low, high). Low and high concentrations for each basic taste were determined using the Spectrum™ intensity scales for descriptive analysis (Meilgaard et al., 2007). Low values representing 2.5, 2, 5, and 2 on the 15-point scale corresponded to solutions of 0.2%, 0.05%, 5.0%, and 0.05% sodium chloride (table salt, Kroger Brand, Cincinnati, OH), anhydrous caffeine (C7731-Sigma Aldrich), sucrose (table sugar, Kroger Brand, Cincinnati, OH) and citric acid (251275-Sigma Aldrich) in room temperature dH2O (Kroger Brand, Cincinnati, OH; wt/vol), respectively in 500 mL volumetric flasks. High values representing 8.5, 5, 15, and 10 on the 15-point scale corresponded to solutions of 0.5%, 0.08%, 16.0%, and 0.15% sodium chloride (table salt, Kroger Brand, Cincinnati, OH), anhydrous caffeine (C7731-Sigma Aldrich), sucrose (table sugar, Kroger Brand, Cincinnati, OH) and citric acid (251275-Sigma Aldrich) in room temperature dH2O (Kroger Brand, Cincinnati, OH;

wt/vol), respectively in 500 mL volumetric flasks (Table 5-2). Preparation including dispensed amounts for each basic taste was as described in Experiment 1 (see above).

**Table 5-2. Basic Taste Solution Samples**

<b>Taste</b>	<b>Low Conc. % (wt/vol)</b>	<b>High Conc. % (wt/vol)</b>	<b>Low/High *Spectrum™ value</b>
Salt	0.20	0.50	2.5/8.5
Bitter	0.05	0.08	2/5
Sweet	5.0	16.0	5/15
Sour	0.05	0.15	2/10

\*15-point intensity scale (Meilgaard et al., 2007)

Each of the five bottles containing sample solutions of 500ml and distilled water control were prepared each morning before participants' arrival and consumption of the samples. Any remaining solution unused at the end of each test day was discarded.

All samples were presented at room temperature on a tray from left to right with the control sample being presented first and the basic taste solutions in a randomized and balanced order. Matching color-coded identifier notecards that matched solution (bottle) color codes were placed on top of the samples with the exception of the control sample.

**Participant Selection, Instruction, and Testing Conditions**

Participants for the study were recruited from the set of participants who completed the preliminary study and who met selection criteria. Participants provided signed consent prior to consumption of any samples or video recording through the use of an informed consent form (Appendix M), as approved through the VT IRB, detailing the procedures, objectives and potential risks of the study. Two separate sessions were completed for each participant (low concentration samples; high concentration samples) and were scheduled 3-7 days apart. Each

participant was assessed individually to provide maximum potential for optimizing video capture. Participants could only complete each session, low and high, one time. Thirty-nine individuals, 31 females and 8 males, participated in the evaluation of low concentrations of the basic taste solutions. Thirty-seven, 29 females and 8 males, of the thirty-nine previous participants from the low concentration session, completed the high concentration screening session. This secondary session took place after participants had completed the first low concentration session.

### **Data Collection**

#### *Session 1: Low concentration basic taste screening session*

Participants individually completed the experiment in the sensory lab in the Food Science and Technology building at VT with the same procedures as previously described for the preliminary screening. For the 9-point hedonic and 9-point intensity scale, visual numerical values were attached to the verbal phrases to facilitate better understanding of the scale. Verbal phrases for the intensity ratings were adapted for each taste, e.g. “extremely strong bitter (sweet, sour, salty) taste”. Participants did not provide acceptability or intensity ratings for water control. Additionally, participants were one again asked to raise the colored notecard assigned to each basic taste sample cup (with the exclusion of the control sample) before their consumption.

#### *Session 2: Higher concentration basic taste screening session*

Participants followed the same procedures as in the lower concentration session with the exception that the solution samples provided had higher concentrations of the four basic taste solutions being tested. Once again, the order of the test samples was balanced and randomized, but did not necessarily match the order in which the test samples were tasted in the previous low

concentration session. Color coding and note card color placement was altered in that the color coding matched to each basic taste in the high concentration session was not the same in the first low concentration session. Participants could not necessarily have a memory or predict what basic taste solution they were going to taste until they ultimately reached the final and last sample; the last sample being potentially predictable by means of process of elimination.

### **Video Recording and Facial Expression Analysis**

Video recordings and associated protocols were carried out as previously described for the preliminary screening experiment. The full session of each participant's video was analyzed using facial recognition software (FaceReader5, Noldus Information Technology, The Netherlands). Recordings were in a resolution of 640 x 480 and recorded by the Microsoft webcam (Microsoft 2.0 megapixel LifeCam NX-6000, Redmond, WA) using Microsoft Movie Maker (version 2011) as a platform. Recordings were saved as Windows Media™ video files (.wmv). Videos were analyzed in full, frame by frame, i.e. every frame setting, and used the general face calibration setting through FaceReader 5 (Noldus Information Technology, The Netherlands). Outputs for the intensity of six emotions (angry, happy, disgusted, sad, scared and surprised) as well as a neutral state were determined by the software via fitted model algorithms inherent in the software and were given a value from 0 (not expressed/present) to 1 (fully expressed/maximum intensity).

To capture information about a participant's emotional response associated with each sample post-consumption over a specific time frame, event markers, as facilitated by software analysis capabilities, were placed into the analysis output stream for each sample. A total of five event markers (control, salt, sweet, bitter, and sour) per participant video per session were created. A time zero was determined to be at the point in which participants had just consumed



the sample and the hand that held the sample cup was just below chin level. This point zero was color coded and identified through an event marker. An end point was given at five seconds after time zero such that the event marker duration was a total of five seconds.

The raw data results for each participant for each session was saved through FaceReader5 as a text file and uploaded into data spreadsheet (Microsoft Excel, version 2010) wherein the full range of data points for the intensity of each emotion measured could be seen over the whole video recording. Additionally the color coding of the event markers could be visualized and directly associated with the data points such that further analysis of the outputs during this post-consumption duration could be completed.

### **Taste Acceptability and Intensity Rating Evaluation**

Mean hedonic and taste intensity ratings were achieved by averaging over all participant ratings per taste solution per concentration session (low, high). A one-way ANOVA was completed with each session to compare means, hedonic and intensity, between tastes. For data of participants who completed both sessions, two-tailed paired t-tests were completed between sessions (low, high) to determine significant differences in ratings within each taste from increasing taste concentration for both hedonic and intensity response.

### **Emotional Data Transformation and Statistical Evaluation**

Intensity values per emotion and neutral state, as obtained from software, were averaged over a time period of five seconds immediately post-consumption per sample. This created a single average intensity data point per emotion per sample per participant session, for the low and high concentrations. This was completed for all basic taste solution samples as well as the control sample. An overall population mean was calculated per emotion, including the neutral

state, for each sample (salt, sweet, sour, bitter, control) at each concentration, by averaging the individual means over all participants for each session. The overall population emotion means were evaluated by session, low (n=39) and high (n=37), using repeated one-way ANOVAs and means test using Tukey's Honestly Significant Difference test (HSD) to identify significant differences across overall population emotion means (angry, happy, disgusted, sad, scared and surprised as well as a neutral state) per basic taste. This was done per basic taste (per session) by using emotion intensities as measurements and emotion type as factors. Repeated one-way ANOVAs and means test, Tukey's HSD, were also completed per session to identify significant differences in overall population means across sample types (salt, sweet, sour, bitter and control sample) per emotion. This was done per emotion (per session) by using emotion intensities as measurements and basic taste type as factors. For data of participants who completed both sessions, two-tailed paired t-tests were completed across sessions, high and low, to investigate increases or decreases within each emotion per basic taste (including control sample). For all statistical analyses,  $\alpha$  was pre-set at 0.05;  $\alpha$  between 0.10 to 0.05 was considered for important trends.

The same statistical analyses mentioned above were further repeated with the average intensity data point per emotion per sample per participant session being transposed into an area under the curve value; including further transposing of the overall mean population value into an overall area under the curve population mean value. Transposing of the data was completed by using an approximation for calculation of area under the curve via the trapezoidal rule (Atkinson, 1989) wherein the area under the curve between each intensity data point was approximated and the resulting trapezoidal segmented area values were summed over the five seconds emotional response time duration post consumption of each sample type (Figure 5-1). Approximately 100

intensity data points were used wherein the duration between each emotional response intensity data point, i.e. height of the trapezoidal segmented area, was approximately one twentieth of a second. Participant responses for taste and control samples for either session that did not include at least 75% of the expected intensity data points, i.e. approximately 75, were removed from analysis. This was selected as criteria to preserve the correctness in approximating AUC transformation data as large gaps in emotional intensity data would present gaps in curve leading to lesser AUC approximations.

1) Partition curve from  $t=0$  (start point) to  $t=i$  (end point) into  $n$  subintervals from  $a$  to  $b$

2) Calculate the area for each subinterval from time  $a$  to time  $b$  using the approximation wherein  $f(a)$ = intensity of emotion at time  $a$ ;  $f(b)$ = intensity of emotion at time  $b$ :

$$\int_a^b f(x) dx \approx 1/2(b - a)[f(a) + f(b)]$$

3) Calculate the summation of all subintervals over desired time period, e.g. 5 seconds post-consumption of sample

$$\sum_{t=0}^{t=i} \int_a^b f(x) dx \approx 1/2(b - a)[f(a) + f(b)]$$

**Figure 5-1. Method for Approximating AUC with the Trapezoidal Rule**

Potential correlations between facial expressions, i.e. overall population means for intensity of emotional response, and hedonic liking were investigated via multiple linear regression analysis. This was done by completing a liner regression analysis for each emotion type including the neutral state by comparing overall population mean values per sample type against hedonic liking response; emotional response per basic taste sample type being separated

per session, e.g. bitter (salt, sour, sweet) low concentration emotional responses vs. associated bitter (salt, sour, sweet) hedonic scores and bitter (salt, sour, sweet) high concentration emotional responses vs. associated bitter (salt, sour, sweet) hedonic scores. Similar multiple linear regression analysis was completed but with a collapsed view of all emotional response data per session being compared to hedonic values regardless of associated sample type, e.g. all low concentration emotional responses vs. all associated hedonic scores and all high concentration emotional responses vs. all associated hedonic scores. Additional multiple linear regression analysis was further completed but with a combined view of emotional response regardless of session for the sweet solution sample type, e.g. both sweet high concentration and sweet low concentration emotion response for neutral (happy, sad, angry, surprised, scared, disgusted) vs. associated sweet hedonic scores. This was done to allow for a greater sample set and distribution of hedonic data. The sweet basic taste was specifically used since this taste had a potential expected correlation due to the accepted idea that a sweet taste is associated with an intrinsically positive response; the researcher's hypothesis being that as sweetness concentration increased, so would hedonic score and emotional positive facial response. Potential correlations between intensity of emotional response and hedonic liking were assessed by reviewing the R-squared values of each linear fit analysis completed.

Compilation, compression, and transposing of the raw data was completed using Microsoft Excel (version 2010) while statistical analysis was completed through the use of JMP software, version Pro10 (SAS Institute Inc., Cary, NC).

## Results

### *Taste Acceptability*

Comparisons of mean hedonic scores within lower concentration level (n=39) showed that overall participant acceptability for salt was significantly lower ( $p < 0.05$ ;  $3.00 \pm 1.26$ ) than the other tastes. Bitter and sour were statistically not different ( $3.92 \pm 1.19$  and  $3.90 \pm 1.87$ , respectively). Sweet was significantly higher ( $p < 0.05$ ;  $6.62 \pm 1.52$ ) than the other tastes (Table 5-3). Comparisons of mean hedonic scores within higher concentration level (n=37) showed that sweet was significantly higher ( $p < 0.05$ ;  $6.76 \pm 1.92$ ) than the other tastes. The tastes bitter, salt, and sour were not significantly different from one another ( $2.97 \pm 1.12$ ,  $2.86 \pm 1.57$ ,  $3.89 \pm 2.07$ , respectively) (Table 5-3).

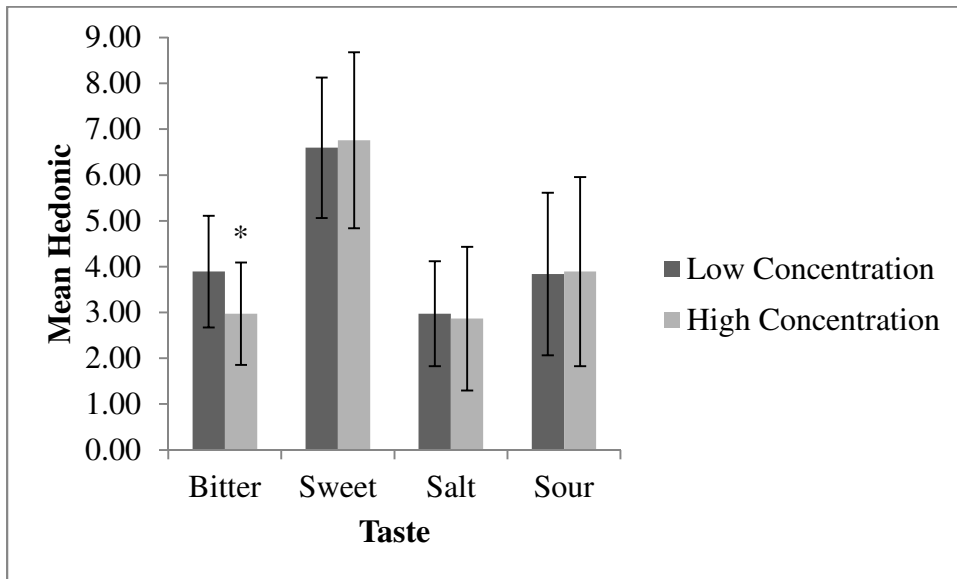
Paired t-test comparisons of data from participants who completed both sessions (low, high) (n=37) showed significant differences ( $p < 0.05$ ) in mean hedonic scores between lower and higher concentration levels for the bitter taste ( $p = 0.001$ ) (Figure 5-2).

**Table 5-3. Comparisons of Mean Hedonic Ratings of Basic Taste (Bitter, Sweet, Salt, Sour) Solutions within Lower and Higher Concentration Levels**

Taste	Low Concentration			High Concentration		
	Mean	±	SD	Mean	±	SD
<b>Bitter</b>	3.92 <sup>a</sup>	±	1.19	2.97 <sup>a</sup>	±	1.12
<b>Sweet</b>	6.62 <sup>b</sup>	±	1.52	6.76 <sup>b</sup>	±	1.92
<b>Salt</b>	3.00 <sup>c</sup>	±	1.26	2.86 <sup>a</sup>	±	1.57
<b>Sour</b>	3.90 <sup>a</sup>	±	1.87	3.89 <sup>a</sup>	±	2.07

(n=39 low; n=39 high); Participants tasted solutions of each basic taste in a balanced randomized order in two separate sessions based on solution concentrations (low, high). Participants rated each taste solution on a 9-point hedonic scale (9= extremely like; 5= neither like nor dislike; 1= extremely dislike). Low concentrations (bitter= 2; sweet=5; salt= 2.5, sour=2; bitter= 5); High concentrations (sweet=15; salt= 8.5, sour=10); Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007)

<sup>a,b,c</sup> Means within a column with different letters are significantly different at  $p < 0.05$ .



**Figure 5-2. Comparisons of Mean Hedonic Ratings of Basic Taste (Bitter, Sweet, Salt, Sour) Solutions between Lower and Higher Concentration Levels**

(n=37); Participants tasted solutions of each basic taste in a balanced randomized order in two separate sessions based on solution concentrations (low, high). Participants rated each taste solution on a 9-point hedonic scale (9= extremely like; 5= neither like nor dislike; 1= extremely dislike). Low concentrations (bitter= 2; sweet=5; salt= 2.5, sour=2; bitter= 5); High concentrations (sweet=15; salt= 8.5, sour=10); Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007).

\*Paired t-tests showed significant differences ( $p < 0.05$ ) for the bitter taste ( $p=0.001$ ).

### ***Taste Intensity Ratings***

Comparisons of mean intensity scores within lower concentration level (n=39) showed that overall participant intensity ratings were significantly lower for bitter ( $4.31 \pm 2.15$ ) than the other tastes. Sweet, salt, and sour mean intensity ratings were not significantly different ( $6.46 \pm 0.90$ ,  $5.59 \pm 1.60$ ,  $5.56 \pm 1.81$ , respectively). Comparisons of mean intensity scores within higher concentration level (n=37) showed that bitter ( $5.62 \pm 2.14$ ) was significantly lower the other tastes. Sweet, salt, and sour mean intensity ratings were not significantly different ( $7.49 \pm 0.92$ ,  $7.03 \pm 1.37$ ,  $6.86 \pm 1.28$ ) (Table 5-4).

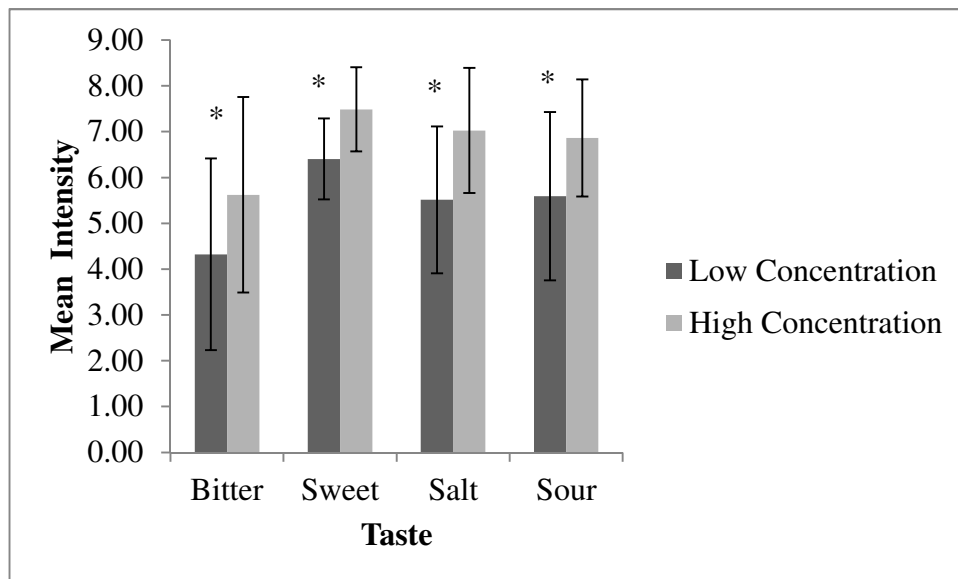
Paired t-test comparisons of data from participants who completed both sessions (low, high) (n=37) showed significant differences ( $p < 0.05$ ) in mean intensity scores between lower and higher concentration levels for all tastes (Figure 5-2).

**Table 5-4. Comparisons of Mean Taste Intensity Ratings of Basic Taste (Bitter, Sweet, Salt, Sour) Solutions within Lower and Higher Concentration Levels**

Taste	Low Concentration			High Concentration		
	Mean	±	SD	Mean	±	SD
<b>Bitter</b>	4.31 <sup>a</sup>	±	2.15	5.62 <sup>a</sup>	±	2.14
<b>Sweet</b>	6.46 <sup>b</sup>	±	0.90	7.49 <sup>b</sup>	±	0.92
<b>Salt</b>	5.59 <sup>b</sup>	±	1.60	7.03 <sup>b</sup>	±	1.37
<b>Sour</b>	5.56 <sup>b</sup>	±	1.81	6.86 <sup>b</sup>	±	1.28

(n=39 low; n=39 high); Participants tasted solutions of each basic taste in a balanced randomized order in two separate sessions based on solution concentrations (low, high). Participants rated each taste solution on a 9-point intensity scale (9= extremely strong bitter/sweet/salty/sour taste; 5= neither strong nor weak; 1= extremely weak bitter taste/no bitter taste). Low concentrations (bitter= 2; sweet=5; salt= 2.5, sour=2; bitter= 5); High concentrations (sweet=15; salt= 8.5, sour=10); Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007)

<sup>a,b,c</sup> Means within a column with different letters are significantly different at  $p < 0.05$ .



**Figure 5-3. Comparisons of Mean Taste Intensity Ratings of Basic Taste (Bitter, Sweet, Salt, Sour) Solutions between Lower and Higher Concentration Levels**

(n=37); Participants tasted solutions of each basic taste in a balanced randomized order in two separate sessions based on solution concentrations (low, high). Participants rated each taste solution on a 9-point intensity scale (9= extremely strong bitter/sweet/salty/sour taste; 5= neither strong nor weak; 1= extremely weak bitter taste/no bitter taste). Low concentrations (bitter= 2; sweet=5; salt= 2.5, sour=2; bitter= 5); High concentrations (sweet=15; salt= 8.5, sour=10); Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007).

\*Paired t-tests showed significant differences for all tastes ( $p < 0.05$ ).

### *Facial Emotional Analysis*

#### *Validation of a Distinct Emotional Response Per Taste Using Emotional Mean Intensity and Area Under the Curve Analysis*

Comparisons within taste solutions showed non-flat results for both mean intensity and area under the curve analyses, yet these results were not very robust. For mean intensity analysis, no differences were seen, apart from the neutral and sad emotion, for the sour, salt and bitter lower concentration and sweet, salt, and bitter higher concentration solutions (Table 5-5 and 5-6). For mean AUC analysis, no differences were seen, apart from the neutral and sad emotion, for all tastes for both lower and higher concentration solutions (Table 5-7 and 5-8). As such,



mean intensity analysis presented only slightly more distinguishing patterns across both sessions for all tastes solutions as compared to area under the curve analysis (Tables 5-5, 5-6, 5-7, 5-8).

*Emotional Mean Intensity Analysis*

Comparisons of mean intensities of emotions within each taste solution did show some significant differences across emotions for both lower and higher concentrations. For all taste solutions (including control sample) for both sessions (low, high) neutral facial expression had the greatest intensity, ranging from 0.42 to 0.52 (0 = not expressed; 1 = fully expressed). Sad and surprised were expressed at the second and third highest intensity, respectively. For all taste solutions for both sessions (low, high), with the exception of higher concentration sour solution, the mean for the sad emotion was significantly higher ( $p < 0.05$ ) than the mean for the angry, scared, disgusted, and happy emotion. For both sessions, disgusted was statistically different from sad and neutral for all tastes but the expression of disgust intensity for bitter was more than 3 times as intense as compared to sweet; disgust intensity for sour was more than 2 times as intense as compared to bitter (Tables 5-5 and 5-6).

**Table 5-5. Comparisons of Mean Intensity of Facial Emotions within Lower Concentration Basic Taste Solutions and Control**

Emotion	Control			Bitter			Sweet			Salt			Sour		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Neutral	0.499 <sup>a</sup>	±	0.232	0.499 <sup>a</sup>	±	0.217	0.507 <sup>a</sup>	±	0.230	0.486 <sup>a</sup>	±	0.215	0.473 <sup>a</sup>	±	0.206
Happy	0.027 <sup>cd</sup>	±	0.048	0.044 <sup>c</sup>	±	0.088	0.029 <sup>cd</sup>	±	0.039	0.052 <sup>c</sup>	±	0.078	0.061 <sup>c</sup>	±	0.095
Sad	0.142 <sup>b</sup>	±	0.152	0.136 <sup>b</sup>	±	0.160	0.155 <sup>b</sup>	±	0.157	0.170 <sup>b</sup>	±	0.195	0.155 <sup>b</sup>	±	0.158
Angry	0.007 <sup>cd</sup>	±	0.023	0.034 <sup>c</sup>	±	0.106	0.014 <sup>cd</sup>	±	0.050	0.013 <sup>c</sup>	±	0.044	0.018 <sup>c</sup>	±	0.075
Surprised	0.083 <sup>bc</sup>	±	0.082	0.076 <sup>bc</sup>	±	0.088	0.085 <sup>bc</sup>	±	0.100	0.074 <sup>c</sup>	±	0.113	0.067 <sup>c</sup>	±	0.101
Scared	0.032 <sup>cd</sup>	±	0.084	0.032 <sup>c</sup>	±	0.104	0.022 <sup>cd</sup>	±	0.070	0.011 <sup>c</sup>	±	0.026	0.011 <sup>c</sup>	±	0.032
Disgusted	0.002 <sup>d</sup>	±	0.004	0.004 <sup>c</sup>	±	0.009	0.001 <sup>d</sup>	±	0.002	0.011 <sup>c</sup>	±	0.036	0.010 <sup>c</sup>	±	0.028

(n=39); Based on 5 sec video analysis of facial response (FaceReader5, Noldus Information Technology, The Netherlands) post-consumption of each sample; SD = standard deviation; Control= dH20; bitter= 2; sweet=5; salt= 2.5, sour=2; Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007)

<sup>a,b,c</sup> Means within a column with different letters are significantly different at  $p < 0.05$ .

**Table 5-6. Mean Intensity Comparisons of Facial Emotions within Higher Concentration Basic Taste Solutions and Control**

Emotion	Control			Bitter			Sweet			Salt			Sour		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Neutral	0.446 <sup>a</sup>	±	0.233	0.494 <sup>a</sup>	±	0.218	0.518 <sup>a</sup>	±	0.207	0.419 <sup>a</sup>	±	0.2088	0.475 <sup>a</sup>	±	0.239
Happy	0.022 <sup>c</sup>	±	0.032	0.025 <sup>c</sup>	±	0.036	0.036 <sup>c</sup>	±	0.052	0.041 <sup>c</sup>	±	0.0714	0.053 <sup>bcd</sup>	±	0.114
Sad	0.204 <sup>b</sup>	±	0.200	0.166 <sup>b</sup>	±	0.207	0.167 <sup>b</sup>	±	0.194	0.185 <sup>b</sup>	±	0.1895	0.148 <sup>b</sup>	±	0.199
Angry	0.006 <sup>a</sup>	±	0.020	0.007 <sup>c</sup>	±	0.015	0.008 <sup>c</sup>	±	0.018	0.008 <sup>c</sup>	±	0.0140	0.004 <sup>d</sup>	±	0.005
Surprised	0.073 <sup>c</sup>	±	0.079	0.092 <sup>bc</sup>	±	0.083	0.082 <sup>c</sup>	±	0.082	0.086 <sup>c</sup>	±	0.1102	0.111 <sup>bc</sup>	±	0.142
Scared	0.033 <sup>c</sup>	±	0.096	0.030 <sup>c</sup>	±	0.087	0.021 <sup>c</sup>	±	0.058	0.024 <sup>c</sup>	±	0.0781	0.022 <sup>cd</sup>	±	0.070
Disgusted	0.002 <sup>c</sup>	±	0.004	0.010 <sup>c</sup>	±	0.034	0.003 <sup>c</sup>	±	0.007	0.015 <sup>c</sup>	±	0.0267	0.021 <sup>cd</sup>	±	0.073

(n=37); Based on 5 sec video analysis of facial response (FaceReader5, Noldus Information Technology, The Netherlands) post-consumption of each sample; SD = standard deviation; Control= dH2O; bitter= 5; sweet=15; salt= 8.5, sour=10; Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007)

<sup>a,b,c</sup> Means within a column with different letters are significantly different at  $p < 0.05$ .

#### *Area Under the Curve Analysis*

For the lower and higher concentration sessions, 9 and 12 participants, respectively, had certain taste responses removed from further analysis. For the lower concentration session, a combined total of 14 responses were removed as they did not meet the selected criteria of at least 75% of the expected emotional intensity data points being presented over the 5 second time frame (salt=1; bitter=4; sour=4; sweet=3; control= 2) thus resulting in curvature gaps. For the higher concentration session, a combined total of 16 responses were removed, as they did not meet the 75% criteria (salt=5; bitter=3; sour=5; sweet=2; control= 1). This was due to a few reasons including participant not looking forward toward camera from looking away or moving in chair that may have been influenced by a startle and/or intense reaction from the taste solution. Other few but notable occurrences that caused participants to move out of camera view post-consumption of sample were from spitting out the sample into an expectorant cup. This occurred for the higher concentration session only. Other clear failures that resulted in gaps in the data stream were from participants having their eyes closed for slightly extended micro-period of time

(e.g. more than half a second) in a wincing fashion after consuming sample. This occurred more for the higher than lower concentration session. In instances where the eyes were closed, the facial recognition software experienced trouble in recognizing emotion expressed and could not assign emotion intensities. Instead a ‘failure to fit’ response was produced for these micro time periods. Due to these removals, a smaller sample size number was used for AUC comparison analysis as compared to mean intensity analysis as described above.

Comparisons of mean AUC of emotions within each taste solution did show some significant differences across emotions for both lower and higher concentration sessions; although, for both concentration sessions (low, high), comparisons showed very little statistical distinction across emotions, with the exception of neutral and sad, for all taste solutions. For all taste solutions (including control sample) for both sessions (low, high) neutral facial expression had the greatest intensity, ranging from 2.1 to 2.6 (0 = not expressed; 5 = fully expressed). Sad and surprised were expressed at the second and third highest intensity, respectively. For all taste solutions for both sessions (low, high) the mean for the sad emotion was significantly higher ( $p < 0.05$ ) than the mean for the angry, scared, disgusted, and happy emotion. For both sessions, disgusted was significantly different from sad and neutral for all tastes and the expressions of disgust intensity for sweet and salt were the lower and higher end of the range (Tables 5-7 and 5-8).

**Table 5-7. Mean AUC Comparisons of Facial Emotional Intensity over 5 seconds within Lower Concentration Basic Taste Solutions and Control**

Emotion	Control			Bitter			Sweet			Salt			Sour		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Neutral	2.25 <sup>a</sup>	±	1.11	2.55 <sup>a</sup>	±	0.96	2.46 <sup>a</sup>	±	1.06	2.36 <sup>a</sup>	±	1.03	2.21 <sup>a</sup>	±	1.03
Happy	0.13 <sup>c</sup>	±	0.23	0.17 <sup>c</sup>	±	0.29	0.14 <sup>c</sup>	±	0.18	0.24 <sup>c</sup>	±	0.37	0.25 <sup>c</sup>	±	0.44
Sad	0.64 <sup>b</sup>	±	0.69	0.62 <sup>b</sup>	±	0.74	0.69 <sup>b</sup>	±	0.72	0.79 <sup>b</sup>	±	0.91	0.70 <sup>b</sup>	±	0.70
Angry	0.03 <sup>c</sup>	±	0.09	0.10 <sup>c</sup>	±	0.28	0.07 <sup>c</sup>	±	0.25	0.06 <sup>c</sup>	±	0.22	0.10 <sup>c</sup>	±	0.39
Surprised	0.35 <sup>bc</sup>	±	0.33	0.31 <sup>bc</sup>	±	0.38	0.39 <sup>bc</sup>	±	0.49	0.36 <sup>c</sup>	±	0.55	0.32 <sup>bc</sup>	±	0.49
Scared	0.15 <sup>c</sup>	±	0.43	0.11 <sup>c</sup>	±	0.46	0.12 <sup>c</sup>	±	0.36	0.06 <sup>c</sup>	±	0.13	0.06 <sup>c</sup>	±	0.17
Disgusted	0.01 <sup>c</sup>	±	0.02	0.02 <sup>c</sup>	±	0.04	0.01 <sup>c</sup>	±	0.01	0.06 <sup>c</sup>	±	0.18	0.04 <sup>c</sup>	±	0.15

(n=37 control; n=35 bitter; n= 36 sweet; n=38 salt; n=35 sour); Based on 5 sec video analysis of facial response (FaceReader5, Noldus Information Technology, The Netherlands) post-consumption of each sample; SD = standard deviation; Control= dH20; bitter= 2; sweet=5; salt= 2.5, sour=2; Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007)

<sup>a,b,c</sup> Means within a column with different letters are significantly different at p < 0.05.

**Table 5-8. Mean AUC Comparisons of Facial Emotional Intensity over 5 seconds within Higher Concentration Basic Taste Solutions and Control**

Emotion	Control			Bitter			Sweet			Salt			Sour		
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Neutral	2.18 <sup>a</sup>	±	1.18	2.34 <sup>a</sup>	±	1.11	2.45 <sup>a</sup>	±	1.04	2.06 <sup>a</sup>	±	1.02	2.40 <sup>a</sup>	±	1.04
Happy	0.11 <sup>c</sup>	±	0.16	0.12 <sup>c</sup>	±	0.18	0.17 <sup>c</sup>	±	0.23	0.17 <sup>c</sup>	±	0.27	0.24 <sup>bc</sup>	±	0.55
Sad	0.91 <sup>b</sup>	±	0.90	0.82 <sup>b</sup>	±	1.02	0.80 <sup>b</sup>	±	0.94	0.83 <sup>b</sup>	±	0.86	0.67 <sup>b</sup>	±	0.94
Angry	0.03 <sup>c</sup>	±	0.10	0.04 <sup>c</sup>	±	0.07	0.04 <sup>c</sup>	±	0.08	0.04 <sup>c</sup>	±	0.07	0.02 <sup>c</sup>	±	0.02
Surprised	0.34 <sup>c</sup>	±	0.37	0.47 <sup>bc</sup>	±	0.41	0.35 <sup>c</sup>	±	0.33	0.36 <sup>c</sup>	±	0.49	0.40 <sup>bc</sup>	±	0.43
Scared	0.16 <sup>c</sup>	±	0.48	0.16 <sup>c</sup>	±	0.44	0.10 <sup>c</sup>	±	0.29	0.13 <sup>c</sup>	±	0.41	0.10 <sup>c</sup>	±	0.35
Disgusted	0.01 <sup>c</sup>	±	0.02	0.05 <sup>c</sup>	±	0.14	0.01 <sup>c</sup>	±	0.03	0.08 <sup>c</sup>	±	0.13	0.03 <sup>c</sup>	±	0.06

(n=36 control; n=34 bitter; n= 36 sweet; n=33 salt; n=33 sour); Based on 5 sec video analysis of facial response (FaceReader5, Noldus Information Technology, The Netherlands) post-consumption of each sample; SD = standard deviation; Control= dH20; bitter= 5; sweet=15; salt= 8.5, sour=10; Sample solution concentrations based on 15-point intensity scale (Meilgaard et al., 2007)

<sup>a,b,c</sup> Means within a column with different letters are significantly different at p < 0.05.

## **Investigation of the Influence of Basic Tastes Within Emotion Using Emotional Mean Intensity and Area Under the Curve Analysis**

### *Emotional Mean Intensity Analysis*

For the lower concentration session (n=39) and higher concentration session (n=37), repeated one-way ANOVAs comparing emotional mean intensities across tastes (salt, sweet, sour, bitter) and control sample within each emotion, showed no statistical ( $p>0.05$ ) or near statistical ( $p<0.10$  to  $0.05$ ) differences within any of the 6 emotions (happy, sad, angry, scared, disgusted, surprised) and neutral state (See Table 5-5 and 5-6 for raw mean values).

### *Area Under the Curve Analysis*

For the lower concentration session, repeated one-way ANOVAs comparing mean AUC values across tastes (salt, sweet, sour, bitter and control sample) within each emotion, showed no statistical ( $p>0.05$ ) or near statistical ( $p<0.10$  to  $0.05$ ) differences within any of the 6 emotions (happy, sad, angry, scared, disgusted, surprised) and neutral state (See Table 5-7 for raw mean values). For the higher concentration session, repeated one-way ANOVAs comparing mean AUC values across tastes (salt, sweet, sour, bitter) and control sample within each emotion, showed no statistical ( $p>0.05$ ) or near statistical ( $p<0.10$  to  $0.05$ ) differences in any of the emotions and neutral state with the exception of disgusted ( $p=0.016$ ) (See Table 5-8 for raw mean values). Emotional mean AUC value of disgusted for the sweet taste was statistically the same as control. Disgusted for salt was significantly greater than control and sweet. Disgusted for bitter and sour were not significantly different from the other tastes (sweet and salt).

## **Investigation of the Emotional Influence of Basic Taste Concentration Level Using Emotional Mean Intensity and Area Under the Curve Analysis**

### *Emotional Mean Intensity Analysis*

Paired t-tests (n=37) of mean intensity data completed across differing concentration level sessions, low and high, to investigate increases or decreases within each emotion per basic taste (including control sample) showed minimal significant differences. Within the control sample, the mean intensity of sad was significantly higher (p=0.014) for the high concentration session. Near significant differences (p<0.10) were found for salt, bitter and sour solution. For the salt solution, neutral was close to significantly higher (p=0.066) for the low concentration session. For the bitter solution, sad was close to significantly higher (p=0.099) for the high concentration session. For the sour solution, scared was close to significantly higher (p=0.093) for the high concentration session. No significant differences or near significant differences (p>0.10) were found for the sweet solution.

### *Area Under the Curve Analysis*

Paired t-tests of AUC data completed across differing concentration level sessions, low and high, to investigate increases or decreases within each emotion per basic taste (including control sample) showed minimal significant differences. Within the control sample, the mean AUC value of sad was significantly higher (p=0.017) for the high concentration session. Near significant differences (p<0.10) were found for the bitter solution; sad (p=0.067) and surprised (p=0.077) were close to significantly higher for the high concentration session. No significant differences or near significant differences (p>0.10) were found for the salt (n=33), sweet (n=33), or sour (n=29) solution.

## **Investigation of Potential Correlations between Hedonic and Emotional Mean Intensity Using Linear Regression Analysis**

Linear regression analysis was unfruitful in finding potential correlations between verbalized hedonic liking/disliking and facial emotional response. Coefficients of determination,  $R^2$  values, were very small and suggested no correlations for any of the linear regressions completed per taste for both the low and high concentration sessions. The two highest low concentration session  $R^2$  values were within the salt and sour solution for the sad emotion at 0.13 and 0.09, respectively. The two high concentration session highest  $R^2$  values were within the sour and sweet solution for the surprised and disgusted emotion, respectively, at 0.08 and 0.07, respectively. Collapsed views of all taste data per session did not offer suggested correlations with  $R^2$  values all falling below 0.02. A combined view of emotional response regardless of session for the sweet solution sample, e.g. both sweet high and low concentration data collapsed together, found very low  $R^2$  values with the highest value at 0.05 for the disgusted emotion.

### **Discussion**

#### ***Taste Acceptability and Intensity Ratings***

It was expected that the sweet solution would be perceived with a significantly higher acceptability than the other tastes overall for either concentration session. Sweet is considered a preferred and inherently positive stimulus with an associated pleasant experience that has been found to be more distinct in children as to adults, whereas bitterness is considered inherently aversive (Rosenstein & Oster, 1988; Steiner, 1979; Steiner et al., 2001).

The lack of significant difference, with the exception of bitter, in acceptability between increasing concentrations was unexpected. It would have been expected that as concentration increased, pleasantness and verbal acceptability ratings for salt, sour, and bitter would have

decreased as has been shown in a recent study (Wendin et al., 2011). In studies described by Wendin et al. (2011), participants tasted low, medium, and high intensity solutions of the basic tastes (sweet, salt, sour, bitter, umami) and provided acceptability ratings on a 9-point hedonic scale. It was shown that for all tastes, with the exception of umami, as concentrations increased acceptability ratings significantly decreased.

It was expected that ratings for sweet would have increased or remained the same with increasing solution concentrations. The rationale being that the levels chosen in the present study were lower than what has been previously perceived as producing lowered acceptability ratings (Wendin et al., 2011). Wendin et al. (2011) describes that increasing sweetness concentration significantly decreased acceptability but solution concentrations used for their designated low, medium and high concentrations (12%, 24% and 48%, respectively) were relatively higher than in the present study (low, 5%; high, 16%) . Additionally, degree of preference for sweetness may have been different in the present study as compared to participants in the studies by Wendin et al. (2011) for numerous reasons including potential genetic variability (Reed et al., 2006) as well as cultural adaptation differences since testing was completed in Europe.

The difference in perception of relative taste intensity in bitterness to the other tastes per concentration session was not completely unexpected. Although the researchers intended for taste concentration intensities to be relatively similar to one another within session to minimize potential influences on concentration intensity on facial expression results within session, i.e. facial results within session could be a direct product of large differences in intensity as opposed to differences in actual taste, recognition of high variability in bitter response was anticipated. Research in genetic differences to bitter taste have suggested that human bitter perception is very diverse with as many as 30-50 genes influencing bitter receptors (Reed et al., 2006). This is



possible rationale for the standard deviations in the bitter intensity ratings being the highest among all the tastes for either concentration session.

### *Facial Emotional Analysis*

#### **Lack of Clear Validation of a Distinct Emotional Response Per Taste**

The rationale for investigating statistical differences across emotions within each taste was to understand whether or not results were flat between emotions. If results were flat, this would suggest that there was no differentiation between the emotions and that it was possible that no emotional response was present and therefore measurable. Although the neutral state and sad emotion were statistically different, this pattern was perpetually repeated from taste to taste, regardless of concentration. Furthermore, this pattern was the same for the control sample responses across both types of analysis and sessions, with the exception of the control response as determined by mean intensity analysis for the low concentration session. The lack of robustness in the pattern of differences found from taste to taste and comparatively to control, suggests that a distinct emotional response may not have been present or accurately measurable with either form of analysis, mean intensity or AUC.

The possibility that AUC analysis was not successful may have been inherent to the analysis method itself as well as the limitations in the software. Specifically AUC analysis requires time intensity data with a presented curvature. For the data, curvature gaps were caused by failure of the facial coding software to determine an intensity response. This was due to several reasons as described above including eye closures and faces being removed momentarily from direct camera viewing angle, greater prevalence of these occurrences happening in the higher concentration session. The hierarchy of failures across sessions differed from sour (most, n=9), bitter (n=7), salt (n=6), sweet (n=5) and finally control (least, n=3). It is likely that gaps for

analysis failure in the control sample were from participants becoming acclimated to the testing procedures. In other words, there may have been a slight startle response or shyness with the initial presence of the camera. This is further supported by the fact that there were two control responses removed from AUC analysis due to limited results for the low concentration and only one for the high concentration, suggesting that participants may have become less camera shy and more compliant in the second session. The failures in data collection from the taste solutions were likely from both the concentration and facial movement influenced by the concentration which caused more eye closures, i.e. wincing. In other words, the concentration level may have created highly morphed responses for some participants and even more so with increasing concentration. This is suggested since more failures within tastes (not including control) were noticed at higher (n=15) vs. lower concentrations (n=12). Furthermore for the salt solution, facial reactions may not have been distinct enough to provide for an emotional interpretation by the software. This may be explained by previous studies, which have stated that facial reactions to salty solutions, i.e. sodium chloride, do not provide for distinctive expressions (Rosenstein & Oster, 1988, 1997; Rozin et al., 1994). Conversely, Wendin et al. (2011) states that in measuring facial movements to basic tastes, facial reactions to salty solution were clear and distinguishable and even more pronounced with increasing concentration.

Lack of significant differences across emotions were expected from the control sample. It was expected that the neutral response would be the highest on control as compared to the other emotions as water was used for control. Previous studies have suggested that no distinct emotional facial reactions to a water control are evoked and that the overall response is considered neutral (Steiner, 1979; Steiner et al., 2001). Apart from sad being higher than the other emotions, this was found to be the case. There was one exception of the control response

for the low concentration session using mean intensity emotional analysis where it was found that disgusted was significantly different than sad and surprised. The reason for this exception is unknown but may have been the result of participant anticipation of a negative taste on the first experimental session only to be presented with a first sample of innocuous water. Another reason for the differences may be that distinguishable facial movements truly are present in response to a water sample as has been suggested in another study (Wendin et al., 2011) and those movements may have elicited interpretation by the facial coding software as emotional response.

### **Lack of Differentiation of Basic Tastes Within Emotion**

It was unexpected that there would essentially be no significant differences found across tastes within each emotion. It was expected that discriminating differences in intensity of emotion would be apparent across tastes and more so in the happy and disgusted emotion. It was expected that within the happy positive valence emotion that the intensity of happy emotion elicited from sweet would be significantly higher than the other tastes. It was expected that within the disgusted negative valence emotion that the intensity of disgust emotion elicited from sweet would be significantly lower than the other tastes, particularly bitter. The rationale for these expectations is supported by the literature. Facial reactions to bitter, salty, and sour stimuli having been previously classified as negative while facial reactions to sweet taste have been classified as positive (Greimel et al., 2006; Rosenstein & Oster, 1988, 1997; Rozin et al., 1994; Steiner, 1979; Steiner et al., 2001). Sour and bitter have more specifically been associated with facial expressions associated with emotional elicitation of disgust (Fox & Davidson, 1986; Rozin & Fallon, 1987; Rozin et al., 1994). Numerous studies of facial expression to basic tastes in both humans and animals have suggested that facial responses to basic taste stimuli produce specific facial expressions which are uniquely discriminating between tastes (Greimel et al., 2006; Rosenstein & Oster, 1988, 1997; Steiner, 1979; Ueno, Ueno et al., 2004; Wendin et al., 2011).

There is some suggestive studies that indicate that salty solutions provide less defined or definitive facial profiles although limited associated movements have still be defined as negative (Rosenstein & Oster, 1988, 1997; Rozin et al., 1994). This specific distinction and discrimination in response to basic tastes has been further supported by studies that monitored facial skin blood flow and facial electromyography (EMG) to basic taste stimuli (Armstrong et al., 2007; Kashima & Hayashi, 2011).

### **Lack of Influence of Increasing Basic Taste Concentration Level**

The lack of significant differences in emotional response between low and high concentration variations of each taste solution was unexpected. It would have been expected that as concentration of the solution increased, so would the intensity in emotional response as demonstrated in previous study (Wendin et al., 2011). One explanation for no significant differences could have been explained if it had been found that participants did not notice a difference in intensity of the higher concentration solution in comparison to the lower concentration. Based on verbal taste intensity rating comparisons, this was not the case, as t-tests did indicate significantly higher taste intensity ratings overall for all high concentration basic tastes. Furthermore, it would have at least been expected that positive emotions would have increased for the sweet taste, it being an inherently positive evoking stimulus, as concentration increased and/or that negative emotions would have increased for the other increasing taste solutions. Disgust was particularly expected to have increased for the bitter taste solution with increasing concentration since this taste stimulus is considered inherently aversive and associated with disgust (Rozin et al., 1994). Based on verbal hedonic ratings, participants stated that they significantly disliked the high concentration bitter solution as compared to the low concentration solution. Sour and bitter also had a high expectation for increases in intensity of negatively associated emotion based on previous study which found the most pronounced increases in facial

movements for all basic tastes (salt, sour, sweet, bitter, umami) to increasing concentrations of specifically sour and bitter solutions (Wendin et al., 2011).

### **Lack of Correlations between Hedonic and Emotional Mean Intensity**

Correlations between mean liking ratings and emotional mean intensity were neither highly expected nor unexpected. It was somewhat expected that a higher hedonic ratings, greater liking, would be associated with higher intensity positive response, i.e. happy, and lower intensity negative response, i.e. disgusted, sad, scared or angry. In a previous study which measured facial emotional intensity responses to different types of a sweet beverage, orange juice, it was shown that correlations existed between hedonic response; there was a high positive correlation,  $R^2$  values greater than 0.8, for the disgusted and angry emotion when intensity of facial emotion response was captured through facial coding software (FaceReader, Noldus Information Technology, The Netherlands) and compared to 9-point scale hedonic liking scores (1= like extremely, 9=dislike extremely) (Danner et al., 2013). Danner et al. (2013) graphically depicts that as liking decreased (hedonic score increasing with their scale), the intensity in emotion of angry and disgusted also increased. In another study it was shown that intensities of facial reactions perceived through manual operator evaluation increased with increasing concentration of basic taste stimuli while at the same time, pleasant ratings (9-point hedonic scale) decreased with increasing concentrations; although, no statistically significant correlations could be shown for these tendencies (Wendin et al., 2011).

### **Rationale for Overall Lack of Significance and Correlations**

There are several possibilities for the overall lack of significance and correlations within the data set. There is potential that a distinct emotional response may not have been present or accurately measurable with either form of analysis, mean intensity or AUC. This could have happened for several reasons. It is possible that the basic taste stimuli were not strong enough to

produce prototypical results that the facial coding software is calibrated against. In other words, participant emotional response may have fallen outside the 'average' general face settings inherent to the facial coding algorithms that are used to translate muscular movements into emotion intensity. Such cases of unobservable facial actions and associated emotion response have been discussed by Tassinari and Cacioppo (1992). They suggest that in laboratory type settings, stimuli used to elicit response may not have the intensity or valence to provide measurable responses (Tassinari & Cacioppo, 1992).

Concurrently, the stimuli may not have been strong enough for the context of the setting, a laboratory booth. Since facial emotion is a communicative way for humans to provide information to one another, facial reactions may have been subdued without a social context (Chovil, 1997 ; Fernández-Dols & Carroll, 1997). In other words, participants may have physiologically and thus emotionally responded to the basic taste stimuli in an expected fashion but without enough measurable intensity since no one else was present to communicate these positive or negative emotions toward. It may be advantageous to have a moderator present during experimentation or several participants completing the experiment in the same room to provide an element of social context.

Lack of prototypical response could have been due to high variability in a participant's ability to taste. This is supported by the large standard deviations in population response across all tastes. Such large standard deviations could have also diluted the sensitivity to find differences through analysis. With such high variability, statistical analysis methods may need to be altered to account for lack of equality in population variances, i.e. heteroscedasticity. Some participants may have been more sensitive to one taste than another. The rationale for having a pre-screening session was to minimize this possible occurrence for the instance of individuals

who may be bitter insensitive. That may have helped but did not take into account the possibility of super tasters. Additionally certain participants may have been more adapted to tastes such as sour or bitter based on their current eating habits, which could have dulled the taste effect. Since data was not collected to gather eating or beverage habit information, it is inconclusive if this may have been a contributing factor. If this is the overall case, high variability, non-parametric forms of analysis would need to be used to account for such differences in variability for sub-sets of the population.

It is also possible that the sample size number was not large enough to detect differences. If the differences between tastes were minimal due to high standard deviations in individual variability, there may need to be a larger test population to find differences. The sample size numbers for the present study were minimal and even more so for the AUC analysis due to gaps in the data capture for certain tastes as discussed above. A much larger sample size may produce more representative results and account for outliers, e.g. super-tasters, non-tasters, etc., which may produce large swings in the data for a small sample population.

Changes in calibration settings of the facial software analysis method may help to improve sensitivity to non-prototypical or highly variable response from person to person. Variability may have stemmed not just from ability to taste but also a participant's natural state, i.e. predisposition. This could be account for by updating the facial coding analysis setting to "continuous calibrating" or "individual calibration". These advanced settings are meant to take into account a participant's pre-disposition, to adjust the general algorithm inherent in the software which is used to correlate facial movements to emotional response (Noldus Information Technology, The Netherlands). Applying these advanced settings may alter the raw data output and provide a more accurate response.

It is possible that a different form of baseline be used instead of the water control introduced as the first sample. This may not be properly accurate for this automatic method as there may have been carry over from one taste to another. Also it is not fully conclusive based on the literature whether a water sample does not in and of itself produce non neutral facial responses. An alternative to correct for pre-disposition of pre-emotion state before stimulus is to take into account the emotional intensity response before a stimulus is introduced and compare it to after stimulus, i.e. examine delta response. This has been done in a previous experiment using automatic facial coding software (FaceReader, Noldus Information Technology, The Netherlands) that compared one sec post-stimulus responses to one sec durations of emotion pre-stimulus by using a one sec lag time to account for the time it takes to introduce the stimulus (De Wijk et al., 2012).

Time durations may need to be further examined for particular stimuli. There is no standard time duration currently used in automatic facial expression capture as discussed in Chapter 4. This is also the case with facial expression studies that use manual decoders to observe and detect facial movements and associated emotion responses; time durations of analysis vary from study to study (Ekman, 1982). It is possible that with basic taste stimuli, an automatic interpretation may require very short time frames, less than the 5 seconds captured in the present study. The emotional response from basic taste stimuli may happen in such short instances that the automatic software may not be able to detect these ‘blips’ of response. If this is the case, other accepted positive and negative stimuli may be better suited for validating methodology and analysis of automatic facial expression.

Lastly, video quality and protocols for data collection could continuously be improved as discussed in Chapter 4. The updated version of the facial coding software used presented less



sensitivity to environmental conditions such as lighting, quality of data capture is still critical for analysis. Occlusion of the face still presents obstacles for emotion interpretation and allows for gaps in the stream of data output. As such, until ‘cleaner’ readings can be captured, it is not recommended to use AUC analysis for data comparisons. The rationale is that too many gaps in the data present loss of curvature and thus inaccurate approximation for AUC values. Removing participant response for instances of noisy or gap data for AUC analysis thus reduces sample size number. Other comparative statistics may be sought such as delta response, min and max levels, and slope.

## **Conclusion**

The overall reliability of the method and analysis used to capture and compare facial emotional response to basic taste stimuli was inconclusive. Results were not anticipated based on the literature. It is not clear whether a distinct emotional response was present or accurately measurable for each basic taste with varying forms of statistical analysis used including mean intensity output of presence or lack of presence for 6 basic emotions as well as AUC approximation based on time intensity curves of mean intensity outputs. Possible reasons for lack of significance and correlative response are numerous and include high individual taste variability, social context, intensity of stimuli, quality of video data capture, calibration settings in software emotional interpretation, sample size number, analysis time duration, and software sensitivity limitations. To better validate automatic facial coding methodology, further study would need to be completed to investigate these potential reasons and minimize sources of influences. Lastly, other stimuli may be sought for purposes of validation beyond basic tastes.

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## Chapter 6: Summary

Understanding consumer preference and the motivations that drive consumers to select what, when, and how they interact with food and beverage products have been at the forefront of food sensory research. Conventional methods often use Likert scales that collect a verbal preference rating from consumers. These ratings are created based on the post-rationalization of thoughts and are not automatic or intrinsic. They do not explain the unconscious emotions that are believed to drive human behavior. This has spurred the development of new methods to measure consumer emotional response. Emotion type questionnaire ballots have begun to offer new insight into emotional understanding of products by allowing consumers to select or rate how well they associate certain emotion and feeling terms with their consumer product experiences. This method has allowed for differentiation between products across categories and within the same category; the latter being shown in the present study. What emotion ballots lack in communicating is the intrinsic non-verbalized emotion that consumers do not often realize exists. Facial coding software offers an opportunity to fill in this knowledge gap when further insight is deemed useful. Automatic measurements using inherent algorithms embedded into facial recognition software to link muscular movements to specific emotions are still under refinement. Current applications as shown in the study have offered glimpses of insight for understanding similarities and differences of automatic facial emotional response to a dairy beverage stimulus. Validating the data collection and analysis methods used may be rather challenging as current limitations in the software must be overcome. Overall, all three methods, conventional liking scales, emotion ballots, and facial expression can be used to offer a holistic perspective for the preferences and motivations behind consumer choices. As methodology

develops, value-added propositions can be created with better insight tied into both the explicit and implicit consumer product experience to provide for improved products.

## Appendices

### Appendix A: Original and Modified EsSense Profile™ Ballot

**Please taste (product name) #xxx now.**

How much do you LIKE or DISLIKE (product)?

Dislike Extremely	Dislike Very Much	Dislike Moderately	Dislike Slightly	Neither Like Nor Dislike	Like Slightly	Like Moderately	Like Very Much	Like Extremely
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Please select the words which describe how you FEEL RIGHT NOW. Select all that apply.

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

**Figure A-1. Original Version of EsSense Ballot™** (King & Meiselman, 2010)

Panelist # \_\_\_\_\_

First (Second) Product  
 Product # \_\_\_\_\_  
 Please taste the product in front of you now.  
 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"/> 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

**Figure A-2. Modified Version of the EsSense Ballot Presented to Participants** Hedonic liking scale removed. Included 38 of the original 39 EsSense™ ballot (King & Meiselman, 2010) terms plus an additional 5 terms. Original term (glad) removed and 5 new terms (angry, content, fearful, sad, and safe) added.



## Appendix B: Modified Beverage Questionnaire

**Instructions:**

In the past month, please indicate your response for each beverage type by marking an “X” in the bubble for “how often” and “how much each time.”

Participant ID \_\_\_\_\_

1. Indicate how often you drank the following beverages, for example, if you drank 5 glasses of water per week, mark 4-6 times per week.

Date \_\_\_\_\_

2. Indicate the approximate amount of beverage you drank each time, for example, if you drank 1 cup of water each time, mark 1 cup under “how much each time.”

3. Do not count beverages used in cooking or other preparations, such as milk in cereal.

4. Count milk added to tea and coffee in the *tea/coffee with cream beverage* category **NOT** in the milk categories.

Type of Beverage	How Often (Mark One)							How Much Each Time (Mark One)				
	Never or less than 1 time per week	1 time per week	2-3 times per week	4-6 times per week	1 time per day	2+ times per day	3+ times per day	Less than 6 fl oz (3/4 cup)	8 fl oz (1 cup)	12 fl oz (1 ½ cups)	16 fl oz (2 cups)	More than 20 fl oz (2 ½ cups)
Water	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
100% Fruit Juice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Sweetened Juice Beverage/Drink (fruit, lemonade, punch,)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Whole Milk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reduced Fat Milk (2%)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Low Fat/Fat Free Milk (Skim, 1%, Buttermilk, Soymilk)	0	0	0	0	0	0	0	0	0	0	0	0
Flavored Milk (Fat free, Low-fat, Reduced Fat) with sweeteners	0	0	0	0	0	0	0	0	0	0	0	0
Soft Drinks, Regular	0	0	0	0	0	0	0	0	0	0	0	0
Diet Soft Drinks/Artificially Sweetened Drinks	0	0	0	0	0	0	0	0	0	0	0	0
Sweetened Tea (iced)	0	0	0	0	0	0	0	0	0	0	0	0
Hot/Cold Tea or Coffee, with cream and/or sugar (includes non-dairy creamer)	0	0	0	0	0	0	0	0	0	0	0	0
Hot/Cold Tea or Coffee, black, with/without artificial sweetener (no cream or sugar)	0	0	0	0	0	0	0	0	0	0	0	0
Beer, Ales, Wine Coolers, Non-alcoholic or Light Beer	0	0	0	0	0	0	0	0	0	0	0	0
Hard Liquor (shots, rum, tequila, etc.)	0	0	0	0	0	0	0	0	0	0	0	0
Wine (red or white)	0	0	0	0	0	0	0	0	0	0	0	0
Energy/Sports Drinks (Red Bull, Rockstar, Gatorade, Powerade, etc.)	0	0	0	0	0	0	0	0	0	0	0	0

**Figure B-1. Modified Beverage Intake Questionnaire Presented to Participants** Based on BevQ-15 (Hedrick et al., 2012) with row addition of flavored milk (fat free, low-fat, reduced fat) with sweeteners.

**Appendix C: Modified EsSense Ballot and Beverage Intake Questionnaire Raw Results**

**Table C-1. Contingency Table for Count Frequency of Emotional Term Selection for 1% Low-fat (Chocolate) Flavored and Unflavored Milk**

<b>Emotional Terms</b>	<b>Flavored milk</b>	<b>Unflavored milk</b>
Active	8	5
Adventurous	2	2
Affectionate	3	2
Aggressive	0	0
Angry	0	1
Bored	5	9
Calm	21	21
Content	25	20
Daring	1	1
Disgusted	1	10
Eager	6	2
Energetic	7	2
Enthusiastic	6	2
Fear	0	2
Free	4	5
Friendly	9	9
Good	17	19
Good-natured	7	10
Guilty	4	3
Happy	18	8
Interested	6	5
Joyful	10	2
Loving	3	2
Merry	3	2
Mild	3	7
Nostalgic	13	4
Peaceful	14	8
Pleasant	19	14
Pleased	14	9
Polite	5	7
Quiet	9	11
Sad	1	2
Safe	6	7
Satisfied	20	9
Secure	2	5
Steady	3	7
Tame	2	4
Tender	3	2
Understanding	4	4

Warm	15	5
Whole	8	7
Wild	0	0
Worried	1	6

Terms ordered alphabetically

**Table C-2. Average Daily Fluid Ounce Intake and Associated Calories for Beverages**

<b>Total Beverage Avg. Daily Fl. Oz.</b>	<b>Total Beverage Avg. Daily kcal</b>	<b>Total SSB Avg. Daily Fl. Oz.</b>	<b>Total SSB Avg. Daily kcal</b>
60.65	368.44	9.10	100.02

n=48 (n= 31 females, n= 17 males); aged 18+, majority (92%) aged 18-25. Based on response and scoring instructions from modified Beverage Intake Questionnaire (BevQ-15) (Hedrick et al., 2010; Hedrick et al., 2012) with inclusion of flavored milk (fat free, low fat, reduced fat) with sweeteners; SSB= sugar sweetened beverages (sweetened juice beverage/drink, soft drinks, sweetened tea, coffee with cream and/or sugar, flavored milk with sweeteners)

## Appendix D: Knowledge and Attitudes Questionnaire Raw Results

**Table D-1. Percent Frequency Response to Belief Statements Relating to Nutritional and Functional Health Value of Milk**

Belief Statement	Percent Frequency				
	1= Strongly Believe	2= Moderately Believe	3= Weakly Believe	4= Do Not Believe	5= Don't Know
Contains 9 essential nutrients to maintain life	35%	56%	6%	0%	2%
Delivers calcium for strong bones	77%	23%	0%	0%	0%
Delivers vitamin D for enhancing bone health	66%	34%	0%	0%	0%
Is a primary dietary source of unhealthy fat that contribute to chronic disease	6%	4%	28%	62%	0%
Delivers healthy fats for reducing heart disease	8%	48%	27%	10%	6%
Delivers healthy fats for improving brain health	10%	50%	23%	8%	8%
Delivers healthy fats for reducing risk of cancer	4%	27%	29%	21%	19%
Delivers live and active cultures and probiotic bacteria for GI health	15%	31%	21%	29%	4%
Delivers high value proteins for improving the immune system	25%	52%	15%	2%	6%
Delivers high value proteins for strong muscles	33%	46%	19%	0%	2%
Delivers high value proteins for reducing the risk of high blood pressure	6%	35%	29%	15%	15%
Delivers important components that help control weight	15%	31%	29%	19%	6%
Contributes to obesity in the US population	0%	19%	19%	60%	2%
Specifically flavored milks, do not provide health benefits	4%	21%	17%	56%	2%
Specifically flavored milks, provide excess calories from sugar	38%	40%	21%	2%	0%

n=48 (n= 31 females, n= 17 males); aged 18+, majority (92%) aged 18-25

**Table D-2. Percent Frequency Response to Attitude Statements Relating to Sweetening Additive Incorporation and Distribution of Flavored Milk and Dairy-based Beverages**

Attitude Statement	Percent Frequency				
	1= Strongly Agree	2= Moderately Agree	3= Weakly Agree	4= Do Not Agree	5= Don't Know
Flavored milks should not be included in primary or secondary school lunch programs	4%	21%	15%	60%	0%
Flavored milks should not contain high fructose corn syrup	63%	19%	8%	10%	0%
There should be a variety of dairy-based beverage options in primary and secondary school lunch programs	58%	38%	4%	0%	0%
There is a need for more dairy-based beverages in vending machines (not limited to school settings)	33%	33%	25%	6%	2%

n=48 (n= 31 females, n= 17 males); aged 18+, majority (92%) aged 18-25

**Table D-3. Percent Frequency Response to General Belief Statements Relating to Milk Purchase Influencers, Diet Based Health Associations/Interests, Milk Consumption Habits, and General Food Marketing Influencers**

General Beliefs	Percent Frequency				
	1= Strongly Agree	2= Moderately Agree	3= Neither Agree Nor Disagree	4= Moderately Disagree	5= Strongly Disagree
Health claims on a package label that link functional components with health benefits positively influence my decision about milk purchases	28%	34%	23%	13%	2%
I am able to improve my health and decrease risk of chronic disease by making wise food choices	83%	15%	2%	0%	0%
I am interested in learning about foods that can improve my health and reduce the risk of chronic disease	81%	15%	4%	0%	0%
The addition of ingredients intended for health is a marketing gimmick to sell more products	13%	43%	23%	19%	2%
Sensory quality (taste, odor, appearance, texture) is one of my main considerations when purchasing/consuming milk	58%	33%	9%	0%	0%
Milk is a healthy nutritional component of my normal diet	33%	27%	18%	9%	13%
It is important to include sources of omega-3 fatty acids in my diet	64%	30%	6%	0%	0%
It is difficult to consume enough omega-3 fatty acids (equivalent to 2 fatty fish meals per week) to gain the associated health benefits	28%	38%	6%	15%	13%
Consuming milk made with omega-3 fatty acids would be a good way to increase my intake of omega-3 fatty acids	32%	38%	21%	6%	2%

n=48 (n= 31 females, n= 17 males); aged 18+, majority (92%) aged 18-25

## Appendix E: IRB approval letter 12-122



Office of Research Compliance  
Institutional Review Board  
2000 Kraft Drive, Suite 2000 (0497)  
Blacksburg, VA 24060  
540/231-4606 Fax 540/231-0959  
email [irb@vt.edu](mailto:irb@vt.edu)  
website <http://www.irb.vt.edu>

### MEMORANDUM

**DATE:** January 16, 2013  
**TO:** Susan E Duncan, Virginia C Fernandez-Plotka, Jeri Kostal, Elizabeth Amalia Arnade, Jennifer Louise Helms, Kristen Leitch  
**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)  
**PROTOCOL TITLE:** Liking and emotional response to milk as a function of sweetness  
**IRB NUMBER:** 12-122

Effective January 16, 2013, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the Continuing Review 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) 6,7**  
Protocol Approval Date: **February 10, 2013**  
Protocol Expiration Date: **February 9, 2014**  
Continuing Review Due Date\*: **January 26, 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.

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## **Appendix F: Consent Form 12-122 (Part I)**

### **Virginia Polytechnic Institute and State University**

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

**Title Project:** Emotional response and consumer attitudes to chocolate and white milk (Part I)

**Investigators:** Susan E. Duncan, Virginia Fernandez-Plotka, Elizabeth Arnade, Kristen Leitch, Jennifer Helms

#### **I. Purpose of this Research/Project**

You are invited to participate in a study to characterize the emotional response to white milk and chocolate flavored milk. This study will also assist in understanding how milk beverages are consumed compared to other beverages as well as attitudes and beliefs associated with milk consumption and health. This study will help identify the influence of flavoring the sweetness on degree of liking and the emotional response to these products.

#### **II. Procedures**

You will receive two milk samples, presented one at a time. You will taste the first sample, swirl it in your mouth, and you can expectorate (spit out) or swallow the sample. Using a checklist of emotions, you will check all that apply to your experience with the product. Then you will complete a brief demographic questionnaire and taste the second sample in the same manner, responding to the checklist of emotions again. You will complete the session by completing a beverage intake questionnaire and a Beliefs and Attitudes questionnaire. The entire session may take about 25-30 minutes.

#### **III. Risks**

There are no more than minimal risks for participating in this study. Some individuals may be uncomfortable identifying their emotions associated with food. If you are aware of any allergies to milk protein or lactose sensitivity or intolerance, please inform the investigator.

#### **IV. Benefits**

Your participation in this study will provide valuable information about consumer response to chocolate and white milk, the emotional response to milk, and the attitudes and beliefs associated with flavored and unflavored milk beverages and health benefits and risks, which 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**

No direct compensation is provided for this activity. A snack will be available as you exit the sensory laboratory.

#### **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.

#### **VII. Subject's Responsibilities**

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

Follow the directions on the monitor, which will direct me with guidelines about how to evaluate the products, and provide my responses.

#### **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](mailto:duncans@vt.edu)

Virginia Fernandez-Plotka tplotka@vt.edu

Elizabeth Arnade Elizabeth.arnade@gmail.com

Kristen Lietch kaleitch@gmail.com

Jennifer Helms jh7788@exchange.vt.edu

David Moore

Chair, Virginia Tech Institutional Review (540) 231-4991; moored@vt.edu

Board for the Protection of Human Subjects

Office of Research Compliance

## Appendix F

**Table F-1. Comparisons of Mean Intensity of Facial Emotions between 1% Flavored and Unflavored Milk for 5, 10 and 20 second Analysis Durations**

Sample	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
5 sec	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Unflavored	0.520 ± 0.227	0.049 ± 0.047	0.158 ± 0.173	0.013 ± 0.013	0.036 ± 0.058	0.025 ± 0.053	0.085 <sup>a</sup> ± 0.110
Flavored	0.562 ± 0.263	0.069 ± 0.081	0.113 ± 0.104	0.022 ± 0.051	0.058 ± 0.081	0.029 ± 0.052	0.036 <sup>b</sup> ± 0.056
10 sec							
Unflavored	0.540 ± 0.215	0.049 ± 0.054	0.127 ± 0.113	0.014 ± 0.015	0.051 ± 0.059	0.032 ± 0.058	0.062 <sup>a</sup> ± 0.074
Flavored	0.570 ± 0.249	0.073 ± 0.083	0.100 ± 0.099	0.019 ± 0.031	0.053 ± 0.060	0.037 ± 0.083	0.030 <sup>b</sup> ± 0.035
20 sec							
Unflavored	0.605 ± 0.191	0.044 ± 0.038	0.110 ± 0.087	0.011 ± 0.012	0.063 ± 0.071	0.024 ± 0.040	0.054 <sup>a</sup> ± 0.070
Flavored	0.609 ± 0.235	0.071 ± 0.098	0.088 ± 0.088	0.013 ± 0.019	0.063 ± 0.062	0.029 ± 0.069	0.028 <sup>b</sup> ± 0.043

(n=36 per duration); Paired t-test results showed significant differences ( $p < 0.05$ ) in the disgust emotion for 5, 10 and 20 seconds ( $p = 0.0193, 0.0110, \text{ and } 0.0409$ , respectively). Based on 5, 10, and 20 sec video analysis of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample. Significant differences approached ( $p < 0.10$ ) in happy state for 10 and 20s ( $p = 0.0630, 0.0734$ , respectively) and surprised state for 5s ( $p = 0.0850$ ). SD = standard deviation.

**Table F-2. Mean Intensity of Facial Emotions for 1% Low-fat Unflavored Milk for 5, 10 and 20 second Analysis Durations**

Sample	Neutral		Happy		Sad		Angry		Surprised		Scared		Disgusted	
	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
5	0.520	± 0.227	0.049	± 0.047	0.158	± 0.173	0.013	± 0.013	0.036	± 0.058	0.025	± 0.053	0.085	± 0.110
10	0.540	± 0.215	0.049	± 0.054	0.127	± 0.113	0.014	± 0.015	0.051	± 0.059	0.032	± 0.058	0.062	± 0.074
20	0.605	± 0.191	0.044	± 0.038	0.110	± 0.087	0.011	± 0.012	0.063	± 0.071	0.024	± 0.040	0.054	± 0.070

(n=36 per duration); One-way ANOVA results showed no significant differences within each emotion for varying video analysis durations (5, 10 and 20 seconds) based on facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of unflavored milk sample. SD = standard deviation.

**Table F-3. Mean Intensity of Facial Emotions for 1% Low-fat Chocolate Flavored Milk for 5, 10 and 20 second Analysis Durations**

Sample	Neutral		Happy		Sad		Angry		Surprised		Scared		Disgusted	
	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD	Mean	± SD
5	0.562	± 0.263	0.069	± 0.081	0.113	± 0.104	0.022	± 0.051	0.058	± 0.081	0.029	± 0.052	0.036	± 0.056
10	0.570	± 0.249	0.073	± 0.083	0.100	± 0.099	0.019	± 0.031	0.053	± 0.060	0.037	± 0.083	0.030	± 0.035
20	0.609	± 0.235	0.071	± 0.098	0.088	± 0.088	0.013	± 0.019	0.063	± 0.062	0.029	± 0.069	0.028	± 0.043

(n=36 per duration); One-way ANOVA results showed no significant differences within each emotion for varying video analysis durations (5, 10 and 20 seconds) based on facial response (FaceReader4, Noldus Information Technology, The Netherlands) post consumption of chocolate-flavored milk sample. SD = standard deviation.

**Table F-4. Mean Intensity of Facial Emotions for Varying Analysis Durations for ‘Liked’ and ‘Disliked’ Milk in Participants Reporting Extreme Differences in Acceptability**

Sample	Neutral		Happy		Sad		Angry		Surprised		Scared		Disgusted		
5 sec	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD
Liked	0.509	±	0.295	0.060	±	0.077	0.141	±	0.144	0.011	±	0.013	0.056	±	0.076
Disliked	0.447	±	0.255	0.039	±	0.039	0.136	±	0.133	0.012	±	0.015	0.051	±	0.084
10 sec															
Liked	0.620	±	0.279	0.042	±	0.044	0.111	±	0.130	0.008	±	0.010	0.069	±	0.067
Disliked	0.490	±	0.251	0.031	±	0.034	0.116	±	0.115	0.008	±	0.009	0.050	±	0.048
20 sec															
Liked	0.645	±	0.282	0.038	±	0.038	0.096	±	0.102	0.007	±	0.006	0.091 <sup>a</sup>	±	0.071
Disliked	0.600	±	0.210	0.031	±	0.023	0.124	±	0.111	0.009	±	0.010	0.047 <sup>b</sup>	±	0.043

(n=10 per duration); Based on 5, 10 and 20 sec video analysis of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample. Participants rated two milk samples, 1% low-fat chocolate flavored and unflavored milk, on a 9-point hedonic scale (1=dislike extremely; 5=neither like nor dislike; 9= like extremely) after consumption. Extreme differences were defined by a hedonic score difference of  $\geq 4$  points between samples wherein the ‘liked’ sample must have been rated  $> 5$  and the ‘disliked’ sample must have been rated  $< 5$ . \*Significant differences found in the surprise emotion for the 20 sec time duration (p=0.0491). SD = standard deviation.

**Table F-5. Area Under Curve Mean Intensity of Facial Emotions for Varying Analysis Durations for ‘Liked’ and ‘Disliked’ Milk in Participants Reporting Extreme Differences in Acceptability between 1% Low-fat Chocolate Flavored and Unflavored Milk**

Sample	Neutral			Happy			Sad			Angry			Surprised			Scared			Disgust			
	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	Mean	±	SD	
5 sec																						
Liked	2.041	±	1.315	0.238	±	0.302	0.513	±	0.476	0.039	±	0.045	0.227	±	0.289	0.097	±	0.151	0.307	±	0.613	
Disliked	1.683	±	0.854	0.169	±	0.148	0.775	±	0.865	0.059	±	0.069	0.189	±	0.306	0.182	±	0.178	0.354	±	0.316	
10 sec																						
Liked	4.889	±	2.455	0.348	±	0.357	0.747	±	0.728	0.058	±	0.054	0.534	±	0.488	0.172	±	0.226	0.363	±	0.651	
Disliked	3.708	±	1.687	0.267	±	0.257	1.222	±	1.291	0.076	±	0.078	0.370	±	0.361	0.321	±	0.270	0.500	±	0.520	
20 sec																						
Liked	10.134	±	5.027	0.598	±	0.560	1.287	±	1.105	0.103	±	0.079	1.354 <sup>a</sup>	±	0.975	0.217	±	0.251	0.458	±	0.815	
Disliked	9.134	±	3.239	0.476	±	0.351	1.832	±	1.582	0.146	±	0.158	0.713 <sup>b</sup>	±	0.636	0.455	±	0.353	0.593	±	0.635	

(n=10 per duration); Based on 5, 10 and 20 sec video analysis of facial response (FaceReader4, Noldus Information Technology, The Netherlands) post-consumption of milk sample. Participants rated two milk samples, 1% low-fat chocolate flavored and unflavored milk, on a 9-point hedonic scale (1=dislike extremely; 5=neither like nor dislike; 9= like extremely) after consumption. Extreme differences were defined by a hedonic score difference of  $\geq 4$  points between samples wherein the ‘liked’ sample must have been rated  $> 5$  and the ‘disliked’ sample must have been rated  $< 5$ . \*Significant differences found in the surprise emotion for the 20 sec time duration (p=0.0411). SD = standard deviation.

## **Appendix G-Consent Form 12-122 (Part II)**

### **Virginia Polytechnic Institute and State University**

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

**Title Project:** Emotional response and consumer liking of chocolate and white milk (Part II)

**Investigators:** Susan E. Duncan, Virginia Fernandez-Plotka, Elizabeth Arnade, Kristen Leitch, Jennifer Helms

#### **I. Purpose of this Research/Project**

You are invited to participate in a study to characterize the emotional response to white milk and chocolate flavored milk. This study will help identify the influence of flavoring the sweetness on degree of liking and the emotional response to these products. You will be videotaped while you are evaluating the milk samples.

Facial recognition software (FaceReader and Observer), designed to collect real time emotional response by videotaping facial features in response to information or stimuli, is a novel method for evaluating sensory response to foods. This activity is designed to collect data on facial recognition software for use as a tool in sensory evaluation of foods. Therefore it is important that you keep your face positioned towards the touch screen monitor as you taste the sample and provide your response about how well you like the sample on the touch screen monitor.

#### **II. Procedures**

You will receive two samples, presented one at a time. Following the guidance on the monitor, you will hold the index card with the sample code in front of you long enough for the camera to capture the image. Then you will evaluate the first sample by putting the whole amount (approximately 1 oz) into your mouth, swirling it around, and expectorating (spit out) into the cup or swallowing the sample. Respond, by touching the monitor, with the appropriate response to how well you like the sample. Slide the sample tray back through the hatch and wait for the second sample, taking a drink of water while you wait. Evaluate the second sample in the same manner. It is important that you maintain eye contact with the computer screen/video camera as changes in head position/eye contact affects the video information available for the research.



### **III. Risks**

There are no more than minimal risks for participating in this study. Some individuals may be uncomfortable about being videotaped or recorded. If you are aware of any allergies to milk protein or lactose sensitivity or intolerance, please inform the investigator.

### **IV. Benefits**

Your participation in this study will provide valuable information about consumer response to chocolate and white milk, the emotional response to milk, and the application of facial recognition software as a sensory evaluation application tool, which 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.

If you are willing to permit the video data associated with your responses to foods to be used for visual illustration of emotional response in research publications and reports, or demonstration purposes about this sensory application, please indicate so by checking the box below:

“By marking the box below, I am giving permission for the researchers on this project to use video data associated with my responses during this project to be used for images in research publications, demonstration purposes and/or production of a research or marketing video about this sensory application. ”

### **VI. Compensation**

No direct compensation is provided for this activity. A snack will be available as you exit the sensory laboratory.

### **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.

**VII. Subject's Responsibilities**

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

Follow the directions on the monitor, which will direct me with guidelines about how to evaluate the products, and provide my responses.

**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 \_\_\_\_\_

## Appendix H- IRB Approval Letter 13-037



Office of Research Compliance  
Institutional Review Board  
2000 Kraft Drive, Suite 2000 (0497)  
Blacksburg, VA 24060  
540/231-4606 Fax 540/231-0959  
email [irb@vt.edu](mailto:irb@vt.edu)  
website <http://www.irb.vt.edu>

### MEMORANDUM

**DATE:** March 19, 2013  
**TO:** Susan E Duncan, Elizabeth Amalia Arnade, Virginia C Fernandez-Plotka, Kristen Leitch, Courtney Alissa Crist  
**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)  
**PROTOCOL TITLE:** Facial Expression Analysis Recruitment  
**IRB NUMBER:** 13-037

Effective March 19, 2013, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the New Application 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) 6,7**  
Protocol Approval Date: **March 19, 2013**  
Protocol Expiration Date: **March 18, 2014**  
Continuing Review Due Date\*: **March 4, 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*

## **Appendix I- Preliminary Study 13-037 Recruitment Announcement**

Faculty, students and staff will be contacted via list serv emails through the Food Science and Technology dept, CALS faculty, staff, undergraduate and graduate weekly information emails, and through a VT online survey. The recruitment email/advertisement through the university calendar and VT Daily News announcement will read:

"Participants are sought for a pre-screening survey and sensory study on facial expression analysis to foods and tastes. There is one session lasting approximately 15-20 minutes. Participants will be asked to consume 4 samples of a water solution that may or may not impart a bitter taste. Participants must be willing to be videotaped while participating in the sessions. Testing will occur March/April [dates] by arrangement with the researchers. Sessions will occur in the Sensory Evaluation Laboratory (Rm 127) in the Department of Food Science and Technology (FST). Panelists will be rewarded for participation with a \$2 gift card (Kroger, Panera, or other local store), snacks, as well as canned foods (total value about \$5). Panelists can keep the gift card and snacks and may keep or choose to donate the canned food, through the FST Lab, to the Montgomery County Emergency Assistance Program. If interested please fill out the following survey: [vt survey link]."

## **Appendix J- Preliminary Study 13-037 Interest Online Survey**

### Effect of Food Stimuli on Facial Expression Analysis: Recruitment Survey

Your participation in this survey infers informed consent in future use of this data for research information related to a research study, IRB NUMBER: 13-037.

Participation in this study is limited to individuals at least 18 years of age or older. If you are 18 years of age or older, you may continue with the survey.

This survey is intended for recruiting panelists for a preliminary pre-screening research study in the Food Science and Technology (FST) Sensory Laboratory. This study is to assess potential candidates for invitation to future studies on tastes of water and beverages to be completed during the spring semester. The questions in this survey are grouped based on identifying

- interest in and availability for participating in the preliminary study
- use of products that relate to the research question
- personal characteristics that may affect successful video capture
- demographics

Panelists will be rewarded for their participation with a \$2 gift card (Kroger, Panera, or other local store), snacks, as well as canned foods (total value about \$5). Panelists can keep the gift card and snacks and may keep or choose to donate the canned food, through the FST Lab, to the Montgomery County Emergency Assistance Program (MCEAP). MCEAP provides assistance to families and individuals in immediate, temporary, and emergency situations.

The sensory study will be completed in the Food Science and Technology Building located on campus at the corner of Duckpond Dr. and Washington St.

### **Interest In and Availability for Participating in Preliminary Study**

Availability: During the spring semester, are you routinely available for at least 20 minutes, in addition to getting to the Food Science and Technology Building and returning, during any of the following blocks of time? Check all that apply.

- Monday, 9:00 am-11:00 am
- Monday, 11:00 am-1:00 pm
- Monday, 1:00 pm-3:00 pm
- Monday, 3:00 pm-5:00 pm
- Tuesday, 9:00 am-11:00 am
- Tuesday, 11:00 am-1:00 pm
- Tuesday, 1:00 pm-3:00 pm
- Tuesday, 3:00 pm-5:00 pm
- Wednesday, 9:00 am-11:00 am

- Wednesday, 11:00 am-1:00 pm
- Wednesday, 1:00 pm-3:00 pm
- Wednesday, 3:00 pm-5:00 pm
- Thursday, 9:00 am-11:00 am
- Thursday 11:00 am-1:00 pm
- Thursday, 1:00 pm-3:00 pm
- Thursday, 3:00 pm-5:00 pm
- Friday, 9:00 am-11:00 am
- Friday, 11:00 am-1:00 pm
- Friday, 1:00 pm-3:00 pm
- Friday, 3:00 pm-5:00 pm

Study information: This is a preliminary study requiring approximately 15-20 minutes of time. Participants will taste water samples and respond about the intensity of selected basic taste stimuli. During the preliminary study, panelists will be videotaped. Collected videos may be used for educational, research (research publications, research presentations, research videos) and/or demonstration purposes. The personal information and performance related to videos will be kept strictly confidential (except to the investigators)

- I am interested in participating.
  - **Please provide your contact information and then continue with the rest of the survey:**
    - **Name (First and Last):**
    - **E-mail address:**
- I am not interested in participating.  
Thank you for your time. You may leave the survey now.

### Product Use

Do you have allergies to any of the following food ingredients? Check all that apply. If you do not have any known allergies, check the final bullet on the list.

- sodium chloride (table salt)
- citric acid
- caffeine
- sucrose (table sugar)
- aspartame (i.e., Equal)
- acesulfame potassium
- saccharin
- sucralose
- honey
- monk fruit extract
- high fructose corn syrup (HFCS)
- coconut palm sugar
- I have no known allergies to these food ingredients

Do you consume sweetened iced tea beverages at least once per week?

Yes

No

**Personal Physical Characteristics for Consideration with Video Capture and Evaluation**

Do you wear glasses?

- Yes,
  - If yes, would you be willing and able to wear contacts during the time of the study OR be willing to remove your glasses and be able to read print on a computer monitor at approximately 24” from your face without squinting?
    - Yes
    - No
- No

Do you have a full beard and/or mustache?

- Yes, I have a full beard and/or mustache
- No

Thank you for your participation!

## Appendix K- IRB Consent Form 13-037

### Virginia Polytechnic Institute and State University

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

**Title Project:** Facial Expression Analysis Recruitment

**Investigators:** Susan E. Duncan, Elizabeth Arnade, Virginia Fernandez-Plotka, Kristen Leitch, Courtney Crist

#### **I. Purpose of this Research/Project**

You are invited to participate in a pre-screening study intended to identify potential candidates for future studies concerning measuring emotional response to foods and tastes through facial expression analysis. Potential candidates will be contacted at a later date for the voluntary participation in such future studies.

You will be videotaped while you are evaluating the samples. Videos will be analyzed for results using facial recognition software (FaceReader). This software, designed to collect real time emotional response by videotaping facial features as a reaction to information or stimuli, is a novel method for evaluating sensory response 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**

Initially you will be provided specific instructions on your position within the laboratory and how you interact with the sample and the computer screen. It is important that you maintain eye contact with the computer screen/video camera as changes in head position/eye contact affects the video information available for the research. As such, please keep your face positioned towards the touch screen monitor as you taste the sample. Please try to refrain from looking to the sides or down to the floor. Please do not touch your face after consuming each sample.

You then will receive four samples (water solutions which may or may not impart a bitter taste), presented one at a time. Following the guidance on the touch screen monitor, you will taste each sample and then answer a few questions about the sample.



You will evaluate each sample by putting the whole amount (approximately 1 oz) into your mouth and swallowing the sample. There will be a 20-30 second pause before you will be asked to move on to the next sample. You will be asked to answer two questions (degree of liking, intensity of sample taste) by responding on the touchscreen monitor.

There will be one session to complete the pre-screening. After completion of the session, individuals may be invited back to voluntarily participate in future research studies which follow similar procedures.

### **III. Risks**

There are no more than minimal risks for participating in this study. Some individuals may be uncomfortable about being videotaped or recorded. If you are aware of any allergies to sucrose (table sugar), sodium chloride (table salt), caffeine, or citric acid, please inform the investigator.

### **IV. Benefits**

Your participation in this study will provide valuable information about consumer response to basic food tastes and the application of facial recognition software as a sensory evaluation application tool, 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**

Upon completion of the session, you will be compensated with a \$2 gift card, snacks. As part of the “Serving Science and Society” campaign from the FST Sensory Lab, you may select 2 cans of food that you may choose to keep or donate, through the FST Sensory Lab, to the Montgomery County Emergency Action Program.. If you choose to withdraw from this study without participating or at any time through the sessions, you may still have a snack.

### **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 any of the food ingredients used in the study, or 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 on the monitor, which will direct me with guidelines about how to evaluate the samples, and provide my responses.
- Indicate whether or not you would be interested in participating in future studies if you are selected as a candidate for such future studies.

## **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](mailto:duncans@vt.edu)

Virginia Fernandez-Plotka tplotka@vt.edu

Elizabeth Arnade elizaaa@vt.edu

Kristen Leitch kaleitch@gmail.com

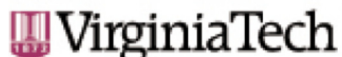
David Moore

Chair, Virginia Tech Institutional Review (540) 231-4991; moored@vt.edu

Board for the Protection of Human Subjects

Office of Research Compliance

## Appendix L- IRB Approval Letter 12-1100



Office of Research Compliance  
Institutional Review Board  
2000 Kraft Drive, Suite 2000 (0497)  
Blacksburg, VA 24060  
540/231-4606 Fax 540/231-0959  
email irb@vt.edu  
website <http://www.irb.vt.edu>

### MEMORANDUM

**DATE:** January 3, 2013  
**TO:** Susan E Duncan, Elizabeth Amalia Arnade, Kristen Leitch, Virginia C Fernandez-Plotka  
**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)  
**PROTOCOL TITLE:** Measuring Facial Emotional Response to the Basic Tastes  
**IRB NUMBER:** 12-1100

Effective January 2, 2013, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the New Application 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) 6,7**  
Protocol Approval Date: **January 2, 2013**  
Protocol Expiration Date: **January 1, 2014**  
Continuing Review Due Date\*: **December 18, 2013**

\*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*

## **Appendix M-IRB Consent Form 12-1100**

### **Virginia Polytechnic Institute and State University**

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

**Title Project:** Emotional Response to Basic Tastes

**Investigators:** Susan E. Duncan, Elizabeth Arnade, Virginia Fernandez-Plotka, Kristen Leitch

#### **I. Purpose of this Research/Project**

You are invited to participate in a study to characterize the emotional response to four basic tastes in food- sweet, salty, sour and bitter. This study will help identify similarities and/or differences in emotional response to basic tastes.

You will be videotaped while you are evaluating the samples. Videos will be analyzed for results using facial recognition software (FaceReader). This software designed to collect real time emotional response by videotaping facial features as a reaction to information or stimuli, is a novel method for evaluating sensory response 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**

You will receive five samples (one water and 4 basic taste solutions), presented one at a time. Following the guidance on the touch screen monitor, you will taste each sample and then answer a few questions about the sample.

You will evaluate each sample by putting the whole amount (approximately 1 oz) into your mouth and swallowing the sample. There will be a 20-30 second pause before you will be asked to move on to the next sample. You will be asked to answer two questions (degree of liking, intensity of sample taste) by responding on the touchscreen monitor.

It is important that you maintain eye contact with the computer screen/video camera as changes in head position/eye contact affects the video information available for the research. As such, please keep your face positioned towards the touch screen monitor as you taste the sample. Please try to refrain from looking to the sides or down to the floor. Please do not touch your face after consuming each sample.

There will be at least two sessions (separate days) to complete the entire testing sequence. It is important that you participate in both sessions. The researchers will work with you to find an appropriate time within your schedule. If you cannot commit to participating in two sessions, please withdraw at this time.

### **III. Risks**

There are no more than minimal risks for participating in this study. Some individuals may be uncomfortable about being videotaped or recorded. If you are aware of any allergies to sucrose (table sugar), sodium chloride (table salt), caffeine, or citric acid, please inform the investigator.

### **IV. Benefits**

Your participation in this study will provide valuable information about consumer response to basic food tastes and the application of facial recognition software as a sensory evaluation application tool, 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**

If you agree to participate in both sessions, you will be compensated with a \$2 gift card, two cans of food, and snacks for each session completed (estimated total value of \$5). You may choose to contribute the canned food to the Montgomery County Emergency Assistance Program (MCEAP/food bank), as part of the FST Sensory Laboratory “Serving Science and Society” incentive program. If you choose to withdraw from this study without participating or at any time through the sessions, you may still have a snack and participate in the “Serving Science and Society” incentive program.

### **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 any of the food ingredients used in the study, or 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 on the monitor, which will direct me with guidelines about how to evaluate the samples, and provide my responses.
- Complete two sessions.

## **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:

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