Application of Automated Facial Expression Analysis and Qualitative Analysis to Assess Consumer Perception and Acceptability of Beverages and Water

Courtney Alissa Crist

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Food Science and Technology

Susan E. Duncan, Chair
Andrea M. Dietrich
Sean F. O'Keefe
Rick D. Rudd

March 22, 2016
Blacksburg, Virginia

Keywords: automated facial expression analysis, milk, water, qualitative, theory of planned behavior, emotion, affect, bitter

Application of Automated Facial Expression Analysis and Qualitative Analysis to Assess Consumer Perception and Acceptability of Beverages and Water

Courtney Alissa Crist

ABSTRACT (ACADEMIC)

Sensory and consumer sciences aim to understand the influences of product acceptability and purchase decisions. The food industry measures product acceptability through hedonic testing but often does not assess implicit or qualitative response. Incorporation of qualitative research and automated facial expression analysis (AFEA) may supplement hedonic acceptability testing to provide product insights. The purpose of this research was to assess the application of AFEA and qualitative analysis to understand consumer experience and response. In two studies, AFEA was applied to elucidate consumers' emotional response to dairy (n=42) and water (n=46) beverages. For dairy, unflavored milk ($\bar{x}$=6.6±1.8) and vanilla syrup flavored milk ($\bar{x}$=5.9±2.2) ($p>0.05$) were acceptably rated (1=dislike extremely; 9=like extremely) while salty flavored milk ($\bar{x}$=2.3±1.3) was least acceptable ($p<0.05$). Vanilla syrup flavored milk generated emotions with surprised intermittently present over time (10 sec) ($p<0.025$) compared to unflavored milk. Salty flavored milk created an intense disgust response among other emotions compared to unflavored milk ($p<0.025$). Using a bitter solutions model in water, an inverse relationship existed with acceptability as bitter intensity increased (r_s=-0.90; $p<0.0001$). Facial expressions characterized as disgust and happy emotion increased in duration as bitter intensity increased while neutral remained similar across bitter intensities compared to the control ($p<0.025$). In a mixed methods analysis to enumerate microbial populations, assess water quality, and qualitatively gain consumer insights regarding water fountains and water filling stations, results inferred that water quality differences did not exist between water fountains and water filling stations (metals, pH, chlorine, and microbial) ($p>0.05$). However, the exterior of water fountains were microbially (8.8 CFU/cm^2) and visually cleaner than filling stations ($10.4x10^3$ CFU/cm^2) ($p<0.05$). Qualitative analysis contradicted quantitative findings as participants preferred water filling stations because they felt they were cleaner and delivered higher quality water. Lastly, The Theory of Planned Behavior was able to assist in understanding undergraduates' reusable water bottle behavior and revealed 11 categories (attitudes n=6; subjective norms n=2; perceived behavioral control n=2; intentions n=1). Collectively, the use of AFEA and qualitative analysis provided additional insight to consumer-product interaction and acceptability; however, additional research should include improving the sensitivity of AFEA to consumer product evaluation.

Application of Automated Facial Expression Analysis and Qualitative Analysis to Assess Consumer Perception and Acceptability of Beverages and Water

Courtney Alissa Crist

ABSTRACT (PUBLIC)

Sensory and consumer sciences aim to understand the influences of consumer product acceptability and purchase decisions. The food industry measures product acceptability through testing but it often does not include emotions or verbal response analysis. Incorporation of qualitative research and automated facial expression analysis (AFEA) may supplement acceptability testing to provide product insights. The purpose of this research was to assess the application of AFEA and qualitative analysis to understand consumer experience and response. In two studies, AFEA was applied to determine consumers' emotional response to dairy (n=42) and water (n=46) beverages. For dairy, unflavored milk ($\bar{x}$=6.6±1.8) and vanilla syrup flavored milk ($\bar{x}$=5.9±2.2) ($p>0.05$) were positively rated (1=dislike extremely; 9=like extremely) while salty flavored milk ($\bar{x}$=2.3±1.3) was negatively rated ($p<0.05$). Vanilla syrup flavored milk generated emotions with surprised intermittently present over time (10 sec) ($p<0.025$) compared to unflavored milk. Salty flavored milk created an intense disgust response among other emotions compared to unflavored milk ($p<0.025$). Using a bitter solutions model in water, an inverse relationship existed with acceptability as bitter intensity increased (r_s=-0.90; $p<0.0001$). Facial expressions characterized as disgust and happy emotion increased in duration as bitter intensity increased while neutral remained similar across bitter intensities compared to the control ($p<0.025$). In an analysis to count microbial populations, determine water quality, and gain consumer insights regarding water fountains and water filling stations, results found that water quality differences did not exist between water fountains and water filling stations (metals, pH, chlorine, and microbial) ($p>0.05$). However, the exterior of water fountains were more sanitary (8.8 CFU/cm^2) and visually cleaner than filling stations ($10.4x10^3$ CFU/cm^2) ($p<0.05$). From focus groups analyses, participants preferred water filling stations because they felt they were cleaner and delivered higher quality water. Lastly, The Theory of Planned Behavior was able to assist in understanding undergraduates' reusable water bottle behavior and revealed 11 categories (attitudes n=6; subjective norms n=2; perceived behavioral control n=2; intentions n=1). Collectively, the use of AFEA and qualitative analysis provided additional insight to consumer-product interaction and acceptability; however, additional research should include improving the sensitivity of AFEA to consumer product evaluation.

DEDICATION

I have several grandmothers that were born in 1895. These were all strong, self-supporting women who emphasized the importance of education. My great-great-grandmother “Granny” (Laura May Hornsby) was the first woman to attend college at Nashville's Radnor College in 1911 and used that education to become a nurse in Alabama. In families where higher education is the norm and not the exception, I hope my grandmothers would be proud that I was the first woman to attain a PhD and the second to attain a doctorate, my cousin Susan Zwiebel, MD, being the first. I follow a long line of family members in education, two of whom were in higher education, Raymond Catland (Cal Tech) and Felix Massey (University of Tennessee). My dissertation is dedicated to their hard work and value of education. I feel the support of my family generations and I would not have this opportunity without them.

ACKNOWLEDGEMENTS

I would like to thank Dr. Susan Duncan for her support, guidance and wisdom over the last four years. You have provided me many opportunities to explore the realms of higher education as well as different areas of research. You have helped me push my boundaries and further diversify my skills and experiences. I am a more well-rounded researcher and teacher because of you. I would like to thank Dr. Rick Rudd for his support and guidance. You have always looked out for my best interest. I recognize many of the opportunities I've had at Virginia Tech would not have happened without your support. I would like to thank Dr. Sean O'Keefe for his willingness to always help and provide explanations. I appreciate your straightforwardness and honesty. I have enjoyed working with you and being a student in your classes. I would like to thank Dr. Andrea Dietrich for her support and guidance with my water research. I can say that I have a new respect for water. I would like to thank Dr. Dan Gallagher who has been an integral part of my research progress. I will forever appreciate your assistance with FaceReader output and your contribution to my statistical knowledge and capabilities.

I wish to thank Dr. Byron Williams, for his continued guidance, wisdom, expertise and fearless leadership. I would like to thank Dr. Wes Schilling for allowing me to work in his research lab during my undergraduate career. The experience I gained was invaluable, and without which, I would not be as successful.

I would like to thank the Duncan Lab Group. Jeri Kostal was my first VT grad friend and I am so grateful for your friendship. I wish to thank Kristen Leitch, Alexandra Walsh, Aili Wang (sister), Dr. Laurie Bianchi, Georgianna Mann (gym spouse), Kemia Amin, Hayley Potts, Daryan Johnson, and Kayla Moberg for their support, encouragement, camaraderie, and comedic relief. A special thanks to my Virginia Tech family. I have very much enjoyed the dynamic of the department and talking with everyone. A fluffy thank you to Lily Yang – no one understands our friendship but we really are yin/yang. Thank you to Matt Schroeder who helped me with qualitative research; also, thank you for being a wonderful friend and neighbor. Thank you to Diana Woodrum and Taylor Duncan for their support, data collection assistance, and Excel wizardry. Thank you to the Graduate Teaching Scholars and Water INTERface crew. Thank you to Kim Waterman, Tina Plotka, Joe Boling, and Dr. Hengjian Wang for their support and assistance as I navigated through the stages of research. Thank you to Joell Eifert, Dr. Melissa Chase, and Dr. Renee Boyer for their guidance, conversations, and opportunities in Extension.

I am very grateful for my Mississippi family: Dr. Christine Cord, Stacy Maher, Lindsey Lee, Krista Eberle, and Brittany Waller. Life would be less interesting without your friendship and I am grateful we have survived the distance. Thank you to my Georgia family, while they still don't always understand what I do, they continue to support me over the distance. Thank you to my very best friend, Mary Frances Pinson.

I want to thank my parents, Bruce and Susan Crist, for their unyielding support and guidance. I appreciate their patience while I continue to find my way in the world. I am very grateful that you are my parents – you're my heroes and I love you my whole arm span. Dad – you're my favorite food scientist. Thank you to my brother Thaddeus who has so often offered to help and be supportive. I am happy we have had the opportunity to experience some live music together and I look forward to our events this year and beyond. Also, thank you to Aunt Debi, Uncle Jim, and Cousin Charlie for all your support. I have enjoyed being geographically closer to you all and I have enjoyed being a “Schonberger” every once in a while. A very special thanks to my Uncle Jim because he helped cross ‘seeing The Rolling Stones’ off my bucket list. Lastly, I would have not been able (or functional) without the assistance of Lester Schonberger. You are my person! I most definitely would not be where I am without your love, support and baked goods. You are the Clairee to my Ouiser.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

Introduction

The world is shaped by sensory interactions and perceptions of surroundings. Individual experiences, emotions and perception influence food acceptability and purchase decisions. Sensory and consumer sciences are largely based on understanding and enticing the senses to influence consumer decisions to purchase food or beverages. In large, the food industry measures consumer acceptability through hedonic testing. While the hedonic scale is valuable to the industry, it does little to understand the subconscious reasoning for the attachment or perception associated with products. Limitations associated with standard sensory testing and consumer preference involve the inability to measure initial reactions and interaction with food products (De Wijk, Kooijman, Verhoeven, Holthuysen, & De Graaf, 2012). Eating is primarily a positive and intimate experience, as pleasant emotions are reported from most eating experiences (Desmet & Schifferstein, 2008). Insights to consumer thought processes can be explored using qualitative methods or facial analysis techniques. These methods are relatively different; however, both allow insight to a phenomenon researchers cannot measure through standard hedonic testing.

Emotions have been cited to be an important subconscious influence on the consumer decision making process (Hill, 2008). While there is no consensus for a definition of emotions, it is recognized that emotions can influence consumers to form strong product associations (Lindstrom, 2008). Media directed at consumers use emotional tactics to gain ground with product acceptability. Bagozzi, Gopinath, and Nyer

(1999) stated that emotions are utilized in marketing, as “they influence information processing, mediate responses to persuasive appeals, measure the effects of marketing stimuli, initiate goal setting, enact goal-directed behaviors, and serve as ends and measures for consumer welfare.”

The consumer market is saturated with products and competition is high among brands. Additionally, new product development failure is high in the food industry as the failure rate is estimated to be 80-90% within the first year of product release (Moskowitz, Beckley, & Resurreccion, 2011). Food product characteristics set brands apart from their competitors. Unsurprisingly, a consumer’s first interaction with food or beverage products is largely based on appearance, including the package (Cardello, 1994). Product color and impact on food acceptability has been largely investigated. Moreover, the influence of packaging contributes to product acceptability. Products are becoming more than simply food; they can be a statement about consumer livelihood and morals. There are social, ethical and environmental issues associated now with products. Direct messaging, or underlying/implied messaging, influences consumer decision making. Tapping into consumer acceptability using facial analysis and qualitative analysis has the potential to provide insights to consumer approval in addition to standard hedonic testing. Facial analysis software measures consumer emotion to a product, video, or other stimulant based on the universal emotions of neutral, happy, scared, sad, angry, disgusted and surprised. Qualitative application provides insight to an individual’s experience based on explicit responses of feelings or opinions such as self-reports conversations, focus groups, and questionnaires. Together these research tools can offer a glimpse to consumer perception and opinions to understand behavior and attitudes.

As seen in the food industry, consumers are increasingly aware and curious about the source of their food and beverages and the path taken from the original source to their hands. Water is declared a fundamental human right (United States Environmental Protection Agency, 2009) and access to drinking water is relatively easy in America. Water is widely available and encouraged to drink by health professionals, yet some do not drink enough water on a daily basis. Consumer perception and consumption of water can be influenced by surroundings, preferences, regulation, conservation, and quality. On college campuses there are several options available for obtaining water. Potable water, even in its most basic delivery infrastructure, should be inviting and encouraging for consumption. However, perceptions of exterior water delivery source could negatively influence and deter students from drinking water, as seen in elementary school students (Patel, Bogart, Schuster, Uyeda & Rabin, 2010). Water consumption benefits have been linked to improving health (Ebbeling, Feldman, Osganian, Chomitz, Ellenbogen, & Ludwig, 2006; Tate, Turner-McGrievy, Lyons, Stevens, Erickson, Polzien, Diamond, Wang, & Popkin, 2012). To increase water consumption for health using tap water, we must provide a suitable infrastructure with perceived health, safety and quality.

With the altering change of environmental issues, banning the disposable water bottle is becoming popular in large institutions and cities to reduce the plastic waste burden (Cohen, 2012; Fishman, 2012). The water bottle beverage industry is large and preliminary indications estimated that the bottled water market was set to exceed 10 billion gallons in 2013 (Beverage Market Corporation, 2013). Water recently became the top beverage consumed, surpassing sugar sweetened beverages and carbonated counterparts. Consumers are looking for other beverage sources to satiate their thirst needs. The market shift creates a unique situation on college campuses and cities due to the demand for water and banning the disposable water bottle.

The concept of bottled water gained momentum in the 1990's and consumption of bottled water has increased significantly over time. However, bottled water is not without controversy. Safety, conservation, and environmental concerns plague the bottled water industry. The processing and recycling of bottled water is deemed environmentally costly as resources could be used to fuel other industrial segments. Water filling stations and fountains provide the public with a convenient, safe, and affordable source of water not to mention sustainable, environmentally friendly and local. Unfortunately, many of these sources could be perceived as less safe and of lower quality.

Water is declared a fundamental human right and water disinfection is considered one of the top public health advances of the 20th century (United States Environmental Protection Agency, 2009). Water, in all its forms, has been in the news recently regarding desalination, flooding, droughts, ban on bottles, water bottles in landfills, plastic islands in the ocean, water consumption, prevention of water bottling plants, sugar sweetened beverage ban in NYC, and obesity rates. Water is linked to the livelihood and health of a nation. The health and wealth of a nation largely depends on its access, acceptability and prevalence of water. Many view water as a disposable resource that will continue to flow from the tap without limitation. Regardless, consumers are largely unaware or are disconnected from the water, and its origins, that they access every day.

Many water related interventions focus on providing reusable water bottles or new water systems to participants and studying how they utilize or underutilize them. Emphasis and research is not placed on understanding water consumption choices and behaviors with those who already use reusable water bottles, especially among college students. Patel et al. (2012) stressed that further studies should evaluate student perceptions and appeal of different water delivery systems at every age. Patel et al. (2010) studied the influence of water fountain appeal and flavor to water consumption in an elementary school setting. Many of the children reported they were deterred by the 'state' of the water fountain, involving cleanliness, flavor, color and temperature. The means to which water is provided directly influences perception on the quality and appeal of water. Delivery systems that have a stigma or appearance of being unclean will not be appealing to drink from, thus limiting the amount of water consumed by a person. Many students on a college campus use reusable water bottles. While this is not a new concept to carry water for consumption, the use was primarily meant for longer journeys rather than a few hours/day on campus. With a steady supply of safe water on campus, this practice of carrying water is perplexing since the water supply is readily accessible, unlimited, and free. While several reasons for this behavior may be conjectured; the attitudes, perceived behavior control, intentions and social norms that influence this behavior have not been researched in detail. Many can argue that there are social and environmental reasons for the increased use of reusable water bottles. Social activism, including environmentalism and the ban on the bottle, are currently occurring in regards to one-use, disposable water bottles. On the other hand, reusable water bottles have not been thoroughly explored. In recent news the safety of the plastic material as well as microbiological factors are of concern.

Information can be gained from those currently using these products in an effort to improve interventions as it relates to increasing water consumption, improving health and drinking water perceptions. Focus groups with current undergraduate students who utilize or avoid water delivery sources and use reusable water bottles can elucidate a potential pathway for improving the perception of water by the means it is delivered. College campuses are notorious for temptations of excess calories in regards to food and beverages. Improvement of the appeal and delivery of tap water on college campus could reduce the influence and prevalence of sugar sweetened beverage consumption.

Using water as product, part of this dissertation explored the relationship and perception of water delivery sources (water fountains, water filling stations, and tap water faucets). Additionally, students often carry reusable water bottles and have an adverse disposition regarding disposable water bottles. Targeting undergraduates on campus, focus groups and emotional ballots were used to understand water behavior and the emotional profile of water delivery sources.

Information gained from opinions on water delivery could shed light on potential ways to change consumer viewpoints of water. For the food industry, this could mean potential opportunities to deliver, manage water and create new water products in institutions. A focus on water consumption and availability could reduce the prevalence of obesity and sugar sweetened beverage intake. New opportunities for water delivery in institutions could lessen the burden on landfill waste, increase aesthetics surrounding water, improve brand image, create a better product to consumer experience, and promote health and sustainability. This research applied the principles of the Theory of Planned Behavior to assess and determine factors that influence water consumption on campus among college students.

Water is of great importance to the food and beverage industry and bottle water provides great revenue (12.3 billion dollars in 2013) (Rodwan, 2014). Installment of water filling kiosks on college campuses could be a potential market as students carry reusable water bottles. Research studying the perception and consumption on college campuses could elucidate barriers to water consumption. By identifying barriers, infrastructure upgrades and health promotion techniques can encourage increased water consumption. This research provides insight to the public water infrastructure to improve water consumption and positive perception of water delivery sources. Additionally, studying current perceptions, behavior and opinions could allude to future barriers, as well as, concerns about the future of the water supply.

The overall objective of this research was to elucidate the consumer decision making process and perceptions when selecting foods and beverages. The aim is to understand the underlying perceptions and/or emotional response related to food and beverages when determining acceptable sources for consumption. A mixed methods approach, using qualitative and quantitative methods, helped explore the external influences and the underlying emotions. This research will aid in improving food science methodology for determining consumer acceptability. Additionally, this research will aid in understanding water consumption, preferences, perceptions and opinions on college campuses.

This research focused on the following research objectives:

A: Develop standardized data capture methodology for automated facial expression analysis (AFEA) and appropriate statistical method for analyzing AFEA output.

B: Evaluate and validate the relationship of hedonic consumer acceptability as it relates to facial emotional measurements using two studies: (1) dairy flavorings and (2) water (bitter solutions) model.

C: Determine the attitudes, subjective norms, perceived behavioral control and intention to explain behavior associated with water consumption and reusable water bottles on campus using a focus group script rooted in The Theory of Planned Behavior.

D: Determine emotional connections of water using photos of different water delivery sources.

E: Elucidate or eliminate the existence of water variability between water fountains and water filling stations on the Virginia Tech campus though water sampling.

F: Explore refilling preferences and usage on campus as it relates to water consumption and selection.

References

Bagozzi, R. P., Gopinath, M., & Nyer, P.U. (1999). The role of emotions in marketing. Journal of the Academy of Marketing Science. 27 (2), 184-206.

Beverage Market Corporation. (2013). Bottled water shows strength yet again, new report from BMC shows. Beverage Market Corporation press release. Retrieved from http://beveragemarketing.com/news-detail.asp?id=260

Cardello, A. V. (1994). Consumer expectation and their role in food acceptance. In H. J. MacFie & D. M. H. Thomson (Eds.), Measurement of food preferences (pp. 253-297). London, UK: Chapman and Hall.

Cohen, J. S. (2012). Loyola to ban sale of bottled water on campus. Chicago Tribune News. Retrieved from http://articles.chicagotribune.com/2012-05-08/news/ct-met-loyola-bottled-water-ban-20120508_1_illinois-beverage-association-bottled-water-tim-bramlet

De Wijk, R. A., Kooijman, V., Verhoeven, R. H. G., Holthuysen, N. T. E., & De Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. Food Quality and Preference, 26(2), 196-203.

Desmet, P. M. A. & Schifferstein, H. N. J. (2008). Sources of positive and negative emotions in food experience. Appetite, 50, 290-301.

Ebbeling, C. B., Feldman, H. A., Osganian, S. K., Chomitz, V. R., Ellenbogen, S. J. & Ludwig, D. S. (2006). Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. Pediatrics, 117, 673-80.

Fishman, C. (2012). U.S. bottled water sales are booming (again) despite opposition. National Geographic. Retrieved from http://newswatch.nationalgeographic.com/2012/05/17/u-s-bottled-water-sales-are-booming-again-despite-opposition/

Hill, D. (2008). Emotionomics : leveraging emotions for business success. London, UK; Philadelphia, PA: Kogan Page.

Lindstrom, M. (2008). Buy-ology: truth and lies about why we buy. New York, NY: Doubleday.

McNeil, D.G. (2013). Coca-Cola plans kiosks with water and internet. The New York Times. Retrieved from http://www.nytimes.com/2013/10/01/health/coca-cola-plans-kiosks-with-water-and-internet.html?_r=1&

Moskowitz, H., Beckley, J. H., & Resurreccion, A.V.A. (2012). So what can sensory do for my company? (pp. 207-228). In sensory and consumer research in food product design and development. Ames, IA: John Wiley & Sons.

Patel, A. I., Bogart, L. M., Schuster, M. A. Uyeda, K. E. & Rabin, A. (2010). Perceptions about availability and adequacy of drinking water in large California school district. Prevention Chronic Disease: Public Health Research, Practice and Policy, 7 (2), 1-10.

Patel, A. I., Chandran, K., Hampton, K. E., Hecht, K., Grumbach, J. M., Kimura, A. T., Braff-Guajardo, E., & Brindis, C. D. (2012). Observations of drinking water access in school food service areas before implementation of federal and state school water policy, California, 2011. Prevention Chronic Disease: Public Health Research, Practice and Policy, 9, e121.

Rodwan, J. G. (2014). The U.S. bottled water market reached new heights in 2013 (2014, July/August). Retrieved from http://www.bottledwater.org/public/2011%20BMC%20Bottled%20Water%20Stats_2.pdf#overlay-context=economics/industry-statistics

Tate, D.F., Turner-McGrievy, G. Lyons, E., Stevens, J., Erickson, K., Polzien, K., Diamond, M., Wang, X., & Popkin, B. (2012). Replacing caloric beverages with water or diet beverages for weight loss in adults: main results of the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. American Journal of Clinical Nutrition, 95, 555-563.

United States Environmental Protection Agency (EPA) (2009). Drinking water costs & federal funding. Retrieved from http://water.epa.gov/lawsregs/guidance/sdwa/upload/2009_08_28_ sdwa_fs_30ann_dwsrf_web.pdf

CHAPTER II

Literature Review

New Product Development and Product Acceptability Testing

The application of hedonic testing is standard procedure in sensory and consumer science to determine acceptability and preference. The frequent use of the hedonic scale can be attributed to its ease for consumers to understand (Meiselman & Shutz, 2003) while allowing researchers to gain product acceptability insight. The hedonic scale was developed by the United States Army in 1949 (Peryam & Girardot, 1952) and improved while collaborating with the University of Chicago (Jones, Peryam, & Thurstone, 1955). While useful to determine consumer insight, hedonic testing often has poor success correlation in the marketplace as product failure rates are high. Typically, new food products do not survive a year in the marketplace which is significantly costly to profits and resources (Fuller, 2011). Products that are well liked at the pilot stage often do not reach the same marked consumer success in the market. According to Lord (2000), 72% of true new products and 55% of line extensions fail. An additional estimation states that new product failure rate is 80-90% within the first year (Moskowitz, Beckley, & Resurreccion, 2011). Furthermore, Morris (1993) attributes the cost of product failure across the industry to be $20 billion dollars which includes missed sales, revenues, resources and profits (Moskowitz, 2011). The cost of new product development in the functional foods division is estimated to be 1 to 2 million dollars (Siró, Kapolna, Kapolna & Lugasi, 2008). Companies are actively seeking ways to improve their connection and relationship with consumers in a saturated competitive environment.

In recent years there has been a desire to develop more relevant analysis to supplement hedonic testing. Several explicit and implicit methodologies have been developed to incorporate attitudes, mood, emotional and physiological cues in measuring affective behaviors to products and environment (Koster & Mojet, 2015). Explicit methodologies rely on conscious actions for consumer evaluation related data for emotional and/or mood evaluation using check all that apply (CATA) and food emotional lexicons (King & Meiselman, 2010; Koster & Mojet, 2015). Implicit measures, including the science of emotions, have the potential to reshape the methodology of consumer insight. Emotional analysis to food products is becoming an innovative application although the body of literature of its application to foods is very limited. Eating is primarily a positive and intimate experience, as pleasant emotions are reported from most eating experiences (Desmet & Schifferstein, 2008). Consumer behaviors are driven by unconscious decisions unbeknownst to the consumer and are often driven by environmental cues and stimuli; however, unconscious stimuli are hard to measure and predict in relation to consumer choice (Dijksterhuis & Smith, 2005). Consumer bias can interfere in standard sensory and consumer testing due to conscious state of processing and evaluation (De Wijk, Kooijman, Verhoeven, Holthuysen, & De Graaf, 2012). Moreover, several limitations are associated with standard sensory testing and consumer preference because initial reactions and interaction with food products are not evaluated (De Wijk et al., 2012). This observation was originally seen in work by Cardello (1994), who explored the role of expectations on product liking and found that products are evaluated based on a directionality of expectation (Meiselman & Schutz, 2003). Wendin, Allesen-Holm, and Bredie (2011) stated that in addition to typical sensory analysis, facial expressions and response could provide additional cues to a stimulus.

Emotion Methodology

Several methodologies have been developed to incorporate emotional and physiological response to products and environment. Mood analysis and emotional analysis have different definitions and methodologies. King and Meiselman (2010) distinguished affective behaviors as: "(1) attitudes which include an evaluative component, (2) emotions, which are brief, intense and focused on a referent, and (3) moods, which are more enduring, build up gradually, are more diffuse, and not focused on a referent." Methodologies relating to mood include the Profile of Mood States (POMS) which uses 65 mood terms rated on a 5-point scale on six dimensions (tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment) (King & Meiselman, 2010). Additionally, the Multiple Affect Adjective Check List (MAACL)-revised has five categories with a total of 65 adjectives. The MACCL revised has two positive scales (sensation seeking and positive affect) and three negative scales (anxiety, depression, and hostility) (King and Meiselman, 2010). Emotional lexicons have been developed in strict regard to food. King and Meiselman (2010) created the EsSense Profile that measures 39 emotions, mostly positive. The EsSense Profile measures short and intense responses to products (King, Meiselman, & Carr, 2010). Furthermore, physiological measures such as facial electromyography (Hu, Player, Mcchesney, Dalistan, Tyner, & Scozzafava, 1999), skin conductance responses (De Wijk et al., 2012), heart rate (De Wijk et al., 2012), and finger temperature (De Wijk et al., 2012) can be applied to determine panelists response to products. Other noncognitive measures, like functional magnetic resonance imaging (fMRI) have used similar approaches to understanding responses to hunger (Piech, Lewis, Parkinson, Owen, Roberts, Downing, & Parkinson, 2009) and electroencephalogram (EEG) in foods (Stockburger, Renner, Weike, Hamm, & Schupp, 2009).

Emotional analysis can be evaluated using manual facial coding. Most notably, the facial action coding system (FACS) discriminates facial movements characterized by action unties (AU) on a 5-point intensity scale (Ekman & Friesen, 1978).). The FACS approach requires trained reviewers, is a time intensive approach, and provides limited data analysis options. Automated facial expression analysis (AFEA) was developed to reduce the challenges of FACS and provide more rapid evaluation. There are several commercially available software systems that can generate AFEA including Noldus FaceReader (http://www.noldus.com), Emotionomics (http://www.sensorylogic.com), Affdex (http://www.affectiva.com), NVisio (http://nviso.ch) and PrEmo (http://www.tustudiolab.nl/desmet.premo). FaceReader (Noldus Information Technology, Wageningen, Netherlands) is based on the Viola-Jones algorithm (Viola & Jones, 2001) to detect the face with eye detection used to determine the plane rotation of the face (Sung & Poggio, 1998; Noldus Information Technology, 2014). A 3D modeling application is used based on the Active Appearance Method (AAM) that detects about 500 key points on the face associated with emotional movement (Cootes & Taylor, 2000; Noldus Information Technology, 2014). The face reading software contains "an artificial neural network" (Bishop, 1995) developed from thousands of photos analyzed by face reading experts which detects the universal emotions happy, sad, disgusted, surprised, angry, scared and neutral on a scale from 0 (not expressed) to 1 (fully expressed) (Noldus

Information Technology, 2014). The AFEA software used in this study reached a "FACS index of agreement of 0.67 on average on both the Warsaw Set of Emotional Facial Expression Pictures (WSEFEP) and Amsterdam Dynamic Facial Expression Set (ADFES), which is close to a standard agreement of 0.70 for manual coding" (Lewinski, den Uyl, & Butler, 2014). Happy is categorized as the only positive emotion with sad, angry, scared and disgusted being negative. Surprised could be considered either negative or positive. Using the "valence hypothesis" to classify emotions, positive emotions include happy and surprise, while negative include fear, disgust, anger, and sadness (Davidson, 1995; Alves, Fukusima, & Aznar-Casanova, 2008). In addition, the "motivational approach-withdrawal hypothesis" classifies happiness, surprise, and anger as "approach" emotions (toward stimuli), while sadness, fear, and disgust as "withdrawal" emotions (away from aversive stimuli) (Demaree, Everhart, Youngstrom, & Harrison, 2005; Alves et al., 2008; Davidson, Ekman, Saron, Senulis, & Friesen, 1990).

Application of Automated Facial Expression Analysis to Foods and Beverages

Automated facial expression analysis (AFEA) using FaceReader has limited research in food consumption analysis applications. This research area is in its infancy, providing an opportunity for establishing best methods for beverage and food applications and for data interpretation. de Wijk, Kooijman, Verhoeven, Holthuysen, and De Graaf (2012) used AFEA (FaceReader, Noldus Information Technology, Wageningen, Netherlands) to determine the emotional response to liked and disliked food items based on first sight of the food as well as during detailed visual smell or taste assessment of the foods. In a subsequent study, De Wijk, He, Mensink, Verhoeven, and

De Graaf (2014) investigated facial expression among commercial breakfast drinks. Additionally, Danner, Sidorkina, Joechl, and Duerrschmid (2014) used the same software to determine facial expressions to different kinds of orange juice, reporting that automated analysis was a sufficient method to differentiate among samples. Also, Danner, Haindl, Joechl, and Duerrschmid (2014) investigated the emotional response of different kinds of juices. Arnade (2013) found high variability among individual emotional response to chocolate milk and white milk. However, even with extreme variability, panelists elicited a longer happy response from samples while sad and disgusted had shorter response times (Arnade, 2013). In a separate study using high and low concentrations of basic tastes, Arnade (2013) found, in both high and low concentration sessions, that the mean for sad emotion was higher than that of the angry, scared, disgusted, and happy emotions. The differences among basic tastes were not as significant as expected, thus questioning the accuracy of current methods for emotional capture or statistical analysis (Arnade, 2013). However, Leitch, Duncan, O'Keefe, Rudd, and Gallagher, (2015) found temporal trends using time series analysis of emotions. Leitch et al. (2015) observed differences between sweeteners and the water baseline using time series analysis (5 sec), and also found that the utilization of time series graphs provided for better interpretation of data and results. Moreover, emotional changes can be observed over time and emotional response treatment differences may be determined at different time points or intervals. For example, Leitch et al. (2015) observed that the approach emotions (angry, happy and surprised) were observed between the artificial sweetener-water comparisons but were observed at different times over the 5 sec observation window. However, Leitch et al. (2015) did not establish directionality of expression, making it difficult to understand the emotional difference between the control (water) and the treatment (unsweetened tea) using their graphical interpretation and presentation.

Limitations of automated facial coding can include facial occlusion, which unavoidably occurs during beverage or food testing. Important time frames are lost as the initial frames post consumption are inhibited by the sample vector (cup, spoon, straw, etc.). It has been stressed that these first few microseconds are valuable in determining the participant's unconscious response to tasted products. Reducing video analysis failures is essential for attaining valid data and effectively using time and personnel resources. Critical steps and troubleshooting steps in the protocol include optimizing the participant sensory environment (lighting, video camera angle, chair height, thorough participant guidance instructions, etc.). Also, participants should be screened and excluded if they fall into a software incompatibility category (i.e. thick framed glasses, heavily bearded faces and skin tone) The action of chewing or swallowing could affect the ability to accurately analyze the face continuously. Danner et al. (2014) warned "motor artifacts, caused by eating and drinking, are easily misinterpreted by the FaceReader software as emotion and can compromise the measurement of facial expressions to a high degree." These factors will influence AFEA fit modeling, emotional categorization, and data output. Lastly, there is no consensus about an approach to statistical analyze and interpret video output. FaceReader was not developed to be directly applied to food. The use and application to food is new and has not been reported in many publications as it relates to food emotional response post consumption

Flavorings

The basic taste bitter was selected as it has a unique reaction to humans. Typically, bitter is not a preferred basic taste and is associated with a distinct facial response. While this response is typically stronger in infants, adults still respond. Food products that are associated with a bitter note include quinine (tonic water), caffeine (coffee), tannins (wine and tea) and medicine. Bitter, as well as other basic tastes, generally have a facial response association. For example, Wendin et al. (2011) summarized literature findings stating facial reactions include “mouth opening, lips raised, mouth angles down, brow lowering, frowning and nose wrinkle”. In a basic taste study, Arnade (2013) found consumers preferred the low bitter solution to the high bitter solution. Wendin et al. (2011) using caffeine also found that participants were able to discern intensity differences with different concentrations (low, medium and high bitter (caffeine solutions). Bitterness is typically unpleasant unless one has adapted to appreciate bitterness (Chaudhari & Roper, 2010; Erickson & Schulkin, 2003). Water is not a highly emotional beverage due to its neutral reaction (Steiner, 1979; Steiner, Glaser, Hawilo, & Berridge, 2001) and has served as a control baseline (Leitch et al., 2015; Garcia-Burgos & Zamora, 2015).

Fluid milk consumption has declined (Stewart, Dong, & Carlson, 2013; Popkin, 2010) due in part to beverage competition, especially similar, non-dairy based beverages (i.e. soy, almond, rice, coconut, hazelnut, hemp) (Package Facts, 2015; Anonymous, 2015) and there is concern that the decline will continue with subsequent generations (Stewart et al., 2013). Some consumers do not enjoy the flavor of milk even with the known benefits of dairy consumption. Low calorie flavorings of milk could add a value-added appeal to purchasing milk. School children prefer flavored milk to plain milk, and when only plain milk is offered, consumption decreases in schools (Patterson & Saidel, 2009). Flavor and other sensory attributes are more important to children and consumers than health when choosing foods and beverages for consumption (Pelsmaeker, Schouteten, & Gellynck, 2013). Vanilla, as an odor, has been associated with the terms "relaxed", "serene", "reassured", "happiness", "well-being", "pleasantly surprised" (Porcherot, Delplanque, Ravior-Derrien, Le Calve', Chrea, Gaudreau, & Cayeux, 2010) and "pleasant" (Warrenburg, 2005). Arnade (2013) determined that chocolate milk was more acceptably liked than plain milk. Additionally, using a check-all-that-apply (CATA) ballot, emotional terms associated to chocolate milk were positive in nature ("satisfied, happy, warm, nostalgic, and joyful, calm, good"), while terms selected for milk (calm, good, disgusted) were not as positive (Arnade, 2013). Milk is susceptible to oxidation which can produce off-flavors influence consumer acceptability. In a study evaluating the influence of light oxidation of milk, consumer acceptability decreased over time and the selection of "disgust" using CATA increased (Walsh, Duncan, Potts & Gallagher, 2015). Intense salty has been associated with disgust and surprised (Bredie, Tan, & Wendin, 2014; Wendin, Allesen, & Bredie, 2011). However, some studies have stated that salty flavor does not elicit facial response (Arnade, 2013; Rosenstein & Oster, 1988; Rosenstein & Oster, 1997; Rozin & Fallon, 1987).

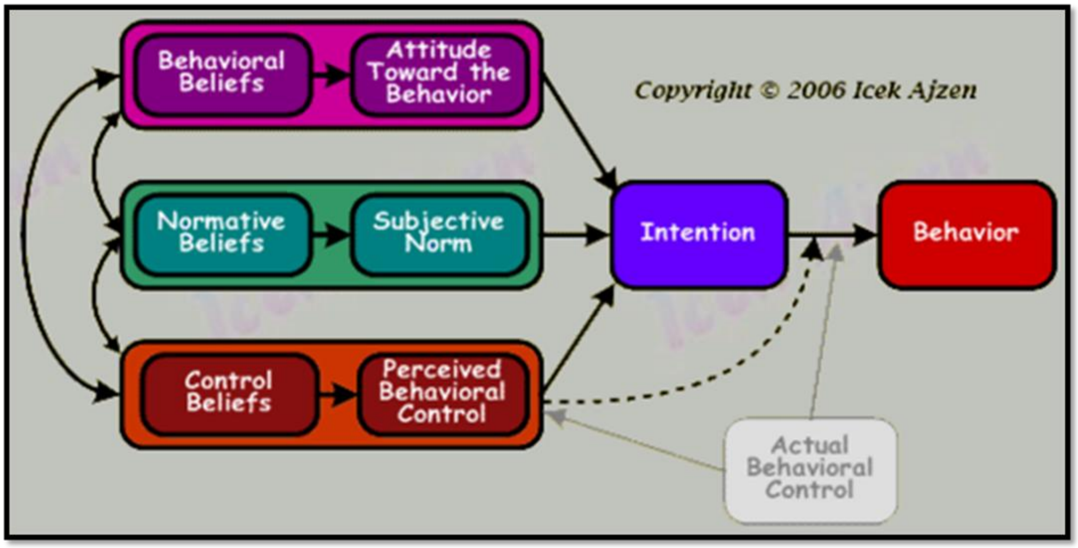
Theory of Planned Behavior

Qualitative research is used to explore a social phenomenon to gain insight and understand lived experiences, including sensory experiences. Qualitative research tends to focus on social science theories that contributes to or supports a theory (Rossman &

Rallis, 2012a). Qualitative research is very different from controlled experiments, as there is no designated control. Qualitative research focuses on observational inquiries. Formal hypotheses are not developed since qualitative research aims to describe and interpret; however, researchers have an understanding of the foundations, frameworks and concepts to which they are investigating (Rossman & Rallis, 2012a). Rossman & Rallis (2012a) state "the ultimate goal of qualitative research is learning, that is, the transformation of data into information that can be used." Three broad categories are found in qualitative literature: ethnographies, phenomenological studies, and sociocommunication studies (Rossman & Rallis, 2012b). Ethnography focuses on culture in regard to how certain beliefs and values guide actions (Rossman & Rallis, 2012b). Data gathering tools are diverse and incorporate many methods including observations, formal and informal interviews as well as the researchers' own personal perspective and experience (Rossman & Rallis, 2012b).

The Theory of Planned Behavior (TPB) has been used to explain a variety of social phenomena. Research has incorporated the theory into several areas to explain social behavior and decision making processes. In relation to beverage and food consumption, investigations have used the theory to explain motivations, attitudes and behavior related to avoidance or increased consumption of commodities. Using the theory, many studies have evaluated the connection between behavior and consumption especially involving alcohol (Todd & Mullan, 2011; Huchting, Lac, & LaBrie, 2008), safe food handling (Mullan, Wong, & Kothe, 2013), vitamins (Conner, Kirk, Cade., & Barrett, 2001), diets/food intake (Sainsbury & Mullan, 2011; De Bruijn, 2010; Bogers, Brug, van Assema, & Dagnelie, 2004), eating disorders (Pickett, Ginsburg, Mendez, Lim, Blankenship, Foster, Lewis, Ramon, Saltis, & Sheffield., 2012) and sugar sweetened beverages (SSB) (Krzeski, 2011; Zoellner, Estabrooks, Davy, Chun, & You, 2012); Zoellner, Krzeski, Harden, Cook, Allen, K., & Estabrooks, 2012). Little work has been done involving water consumption alone, attitudes on college campuses and motivations to select water for consumption. College campuses are ever evolving with the balance of drink choices including water options. College campuses typically have many sources for water including fountains, tap, refilling stations, and bottles from vending. Water is in a saturated market on college campuses, as students have endless supplies and opportunities to drink other beverages from coffee, energy drinks, SSB, and alcohol. Of notice is the increase in carrying water for personal use throughout the day. Studies in the Southwest Virginia area and the Virginia Tech campus have mainly focused on alcohol consumption and beverage consumption specifically on SSB.

The TPB is deemed an extension of the theory of reasoned action (Ajzen, 1991). The main focus of the TPB is an individual's intention to perform a behavior. Ajzen (1991) defines the TPB as having three main independent components: specific attitudes, subjective norms, and perceived behavioral control (Figure 2.1). Each of these variables influences the other and ultimately consumer behavior, motivations and intention. Attitude refers to the unfavorable or favorable position of behavior being investigated (Ajzen, 1991). Subjective norm is reference to perceived social pressure to act or not act the behavior in question (Ajzen, 1991). Lastly, perceived behavioral control is defined by the perceived ease or difficulty to perform the behavior (Ajzen, 1991). Perceived behavioral control incorporates both past and future experiences into behavior (Ajzen, 1991). Ajzen (1991) defines intentions as "indications of how hard people are willing to try, of how much an effort they are planning to exert, in order to perform the behavior." "Perceived behavioral control refers to people's perception of the ease or difficulty of performed the behavior of interest" (Ajzen, 1991). Typically, individual perception of control influences and impacts individual's intentions and actions (Ajzen, 1991). Ajzen (1991) summarized that "predictors, intentions and perceived behavior control correlate to behavioral performance."



Theory of Planned Behavior as described in [a]

Figure 2.1 [a] Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior Human Decision Processes*. *50*, 179-211.

Scholderer and Trondsen (2008) applied the TPB to fish consumption for their research questions determined that fish consumption could be related to "three of these barriers (quality, taste, and smell) as outcome beliefs, one as a normative belief (family preferences), three as control beliefs (price, variety and availability), and two as expressions of self-efficacy (meal preparation skills and convenience)." Pickett et al. (2012) found that the TPB has the ability to explain and predict behaviors associated with diet and health as it relates to eating disorders. Additionally in a study with fruits and vegetables, participants' attitude and perceived behavioral control were valuable in predicting the intentions and behavior related to consumption (Baker, Blanchard, Courneya, Kupperman, Nehl, Rhodes, & Sparling, 2009). The TPB has the potential to be extended to other areas of research in food and beverages to understand the meaning behind actions and decision making processes.

Water Regulation

Bottled Water Standard of Identity

Domestic bottled water across interstate shipping is regulated by the Food and Drug Administration in addition to imported water. The Code of Federal Regulations describes bottled water as "water that is intended for human consumption and that it sealed in bottles or other containers with no added ingredients except that is may optionally contain safe and suitable antimicrobial agents" (21 CFR 2 165.110). There are several sources and processes for water which include: artesian water, ground water, mineral water, purified water, deionized water, distilled water, reverse osmosis water, sparkling bottled water, spring water (21 CFR 2 165.110(a)). Most bottled water contains dissolved substances with respective allowable levels of substances (Skipton & Albrecht, 2010). Bottled water sold within state may be regulated by a state agency or may be exempt.

Tap, Municipal, Or Public Drinking Water Regulation

The aim of every water distribution agency is to provide consumers with safe and acceptable water. A public water supply is a system that supplies water for human consumption to at least 15 service connections or supplies 25 individuals (Skipton & Albrecht, 2010). In contrast, a private water supply services less than the definition of a public supply and is not regulated by a state or federal agency. Public water is monitored and regulated by the Environmental Protection Agency with allowable contaminants (about 100 contaminants) limits established by the Safe Drinking Water Act. Parameters of the Safe Drinking Water Act deem water must be sampled and tested routinely. Federal water regulations may be found in the Code of Federal Regulations 40 CFR 141-143. Chlorine and chloramine are most commonly used as a disinfectant to treat municipal drinking water. Oftentimes, residual chlorine is added to treated water as a disinfectant needed in water pipeline distribution. Chlorine is an effective disinfectant; however, it can often leave a residual chlorinated off-flavor. Krasner and Barrett (1984) determined free residual chlorine taste threshold in water to be 0.24mg/l. Customers who reside closer to the treatment plant typically can taste the residual chlorine in their water. Contaminants can enter water as water travels through plumbing or through the corrosion of pipes, fixtures, faucets, fixtures and solder (USEPA Lead and copper rule, 2005). In 2013, The United States Environmental Protection Agency (EPA) announced that it would need $384 billion for infrastructure improvements through 2030 to continue to provide safe drinking water to 297 million Americans (Williams, 2013; United States Environmental Protection Agency, 2013). These results are based on a 2011 Drinking Water Infrastructure Needs Survey that assesses the needs of public water systems across the country. Tap water costs vary by city, region and state. Typically, tap water costs around $2 per 1,000 gallons (United States Environmental Protection Agency (EPA), 2009). While safe drinking water is monitored through intensive parameters, aesthetic parameters such as color, flavor and aroma are difficult to monitor and standardize. Aesthetics can influence consumer safety perception of their tap water resulting in habit change towards other sources of water. However, by choosing tap water citizens are supporting these improvements and aiding the continuance public drinking water (Hu, Morton, and Mahler, 2011).

American Beverage Industry

Bottled Water Consumption Statistics

According to Beverage Marketing Corporation (BMC), overall bottled water consumption increased by 6.2% to 9.67 billion gallons in 2012. Bottled water sales increased 6.7% to $11.8 billion (Latif, 2013; Beverage Market Corporation, 2013). Preliminary indications estimate that the bottled water market will exceed 10 billion gallons in 2013 (Beverage Market Corporation, 2013). Domestic non-sparkling water represents 96% of total volume in 2012 at 9.3 billion gallons (Beverage Market Corporation, 2013). Reports indicate that consumers drink 21 gallons of bottled water each year compared to 37 gallons of other water (tap, sparkling, flavored and enhanced water) (Associated Press, 2013). The retail premium segment, water in single serve polyethylene terephthalate (PET) bottles, leads the development of bottled water (Beverage Market Corporation, 2013). In 2012, single serve bottled water represented 65% of the overall market (Beverage Market Corporation, 2013). In 2012, the shares of volume by bottle segment was as follows: 65.1% Single Serve PET; Imports 1.1%; Domestic Sparkling 2.7%; Vending 8.3%; Retail 1 -2.5 Gallon 10.3%; Direct Delivery/Bulk 12.4%. (Beverage Market Corporation, 2013). Portland State University in Oregon (over 25,000 students) reported that in fiscal year 2011 the university sold approximately 54,540 bottles of water through retail, vending, dining and vending (Portland State University, 2012). Hu et al. (2011) found that younger people and females tend to purchase bottle water. Bottled water is typically much more expensive than tap water and can cost up to 1,900 times more than tap water (Scheer & Moss, 2011).

Tap Water Consumption

Tap water is provided through a variety of sources including fountains, faucets, and bottle refilling stations. Institutions or individuals can additionally filter water by a carbon filter or reverse osmosis treatment to make the water more palatable. Many consumers take extra steps to treat or filter their water in their home that has been associated with increasing their water consumption (Roche, Jones, Majowicz, McEwan, & Pintar, 2012). Roche et al. (2012) found that Canadians consumed 1.2 L (0.03-9.0 L) of tap water each day. Bottled water users consumed less water than non-bottle water users (Roche et al., 2012). Lee, Levy, Hightower, Imhoff, & Emerging Infections Program FoodNet Working Group (2002) reported that 30% of households used in-home water treatment methods in the United States. While tap water is abundantly available, non-caloric, and relatively low cost compared to bottled water and other beverages that are commonly selected and consumed. The pattern of behavior to consume and select SSB over non-caloric is receiving a lot of discussion related to obesity risk.

Controversy Surrounding Beverages

Sugar-sweetened Beverages (SSB)

In the recent years, the beverage industry has been entangled in a public relations mess involving public outcry, governmental bans and blame for the obesity epidemic.

There have been several campaigns to reduce the intake of SSB and curb obesity including taxation and cup size restriction. In 2012, New York City Board of Health supported a law banning the sale of large sodas and other sugary drinks at restaurants, street carts and movie theaters (Grynbaum, 2012). The legislation states that drinks larger than 16 ounces will be restricted. Drinks exempt are fruit juices, dairy-based drinks, alcoholic beverages and non-caloric sweeteners (Grynbaum, 2012).

Colleges and universities have not instituted a ban or restriction on SSB. Students have several opportunities to purchase SSB or other beverages across campus and the surrounding city. West, Bursac, Qiumby, Prewitt, Spatz, Nash, Mays, & Eddings (2006) reported that among two hundred and sixty-five undergraduates, 65% reported a daily intake of a sugar sweetened beverage with soda being the most common beverage. Colleges and universities are supported by contracts with beverage companies such as Pepsi and Coca-Cola. These contracts are a large source of revenue and advertising. The presence of SSB on college campuses, as well as in K-12, is intricately political. While it is encouraged to drink other nutritive beverages, little evidence has been linked to increased consumption, weight gain and sugar sweetened beverages presence in children at school (Cunningham & Zavodny, 2011).

Obesity Crisis and Beverage Contribution

United States Senator Tom Harkin (2007) acknowledged that Americans are burdened by the obesity crisis and the strain it is causing on the social and medical well-being of our society. Moreover, the Surgeon General stated that the overweight and obesity epidemic will thwart the health gains achieved in the 20th century in relation to heart disease, diabetes, several forms of cancer, and other chronic health problems

(United States Health and Human Services (USHHS), 2001). In 2005, the nation spent $190.2B on adult obesity related illnesses (Cawley & Meyerhoefer, 2013). Between 2009 and 2010, about 35% of both adult men and women were considered obese (Flegal, Carroll, Kit, & Ogden, 2012) while 16.9% of children were considered obese (Ogden, Carroll, Kit, & Flegal, 2012). In a study comparing SSB intake from the 1970s to the 1990s, Nielson and Popkin (2004) found that Americans are consuming more calories from beverages than their counterparts in the 1970s. Every day half of the American population consumes at least one sugary drink (Ogden, Kit, Carroll, & Park, 2011). Age and gender have an influence on daily intake of calories from beverages. Using the NHANES, it was determined that 597 and 350 calories were derived from SSB intake from men and women in their 20s, respectively (LaComb, Sebastian, Enns, & Goldman, 2011). Most Americans are oblivious to the caloric content of food and beverages (Bleich et al., 2009).

In a study with college students, health and calorie content did not deter the preferred beverage choices for most of the participants and they frequently cited age for their disregard for potential health implications of SSB consumption (Block, Gillman, Linakis, & Goldman, 2013). The disregard for health and nutritional information can be linked to a lack of knowledge about nutritional information and daily intake recommendations. Block et al. (2013) found that students did not know their total daily calorie allowance and could not assess the calorie amount in beverages. Unlike K-12 schools, college campuses are known to have widely available access to high calorie foods and beverages allowing for ease of excessive caloric intake. The most commonly consumed beverages among college students are water (72%), juice (72%), and sugar-sweetened soda (68%) (Block et al., 2013). While water is widely consumed by college students, most do not get the recommended daily intake nor wish to increase or change their consumption patterns. The Institute of Medicine recommended daily intake (RDI) for water is about 3 liters a day (2.7 for women and 3.7 for men) (Institute of Medicine, 2004). Of college students (n=265) surveyed about sweetened beverage consumption, 29% said they had no intention of reducing their sugar-sweetened beverage intake (West et al., 2006). In a study using beverage consumption data from the National Health and Nutrition Examination Survey (NHANES), Han & Powell (2013) found that heavy consumption (≥ 500 kcal/day) of sugar-sweetened beverages occurred among adolescents and young adults and soda was the most prevalent.

Many benefits are associated with increased water consumption and or SSB substitution. Suggested alternatives for SSBs are water or other nutritive alternatives such as milk (Van Horn, 2010). Studies in children and adults have found that SSB substitution with water can lead to better weight control among the overweight (Ebbeling, Feldman, Osganian, Chomitz, Ellenbogen, & Ludwig, 2006; Tate, Turner-McGrievy, Lyons, Stevens, Erickson, Polzien, Diamond, Wang, & Popkin., 2012). Moreover, Dennis, Dengo, Comber, Flack, Savla, and Davy. (2010) found that water (~2 cups) with a hypocaloric diet aided in weight loss, supporting the theory that increased water consumption in beneficial. Dennis, Flack, and Davy (2009) in a study with obese or overweight adults, found that water consumption at a breakfast meal reduces energy intake by approximately 13%. Drinking water was suggested to help promote weight loss in dieting women as increases in drinking water consumption was associated with weight and fat loss (Stookey, Constant, Popkin, & Gardner, 2008).

In a study surveying student beverage intake, students reported drinking more than one sugar-sweetened beverage a day although a majority (70%) reported that they had begun to reduce their consumption (Huffman & West, 2007). This indicates a potential avenue for educational opportunities for a healthier lifestyle. Twenty one million adults in the United States are enrolled in college (Synder & Dillow, 2012). Alarmingly, 35% are already overweight or obese based on height and weight (Lowry, Galuska, Fulton, Wechsler, Kann, & Collins, 2000). In a longitudinal study, Holm-Denoma et al. (2008) found that college men (n=266) and women (n=341) gained weight (3.5 and 4.0 pounds, respectively) during the first year of college. The college environment is an attractive location to change habits and educate students about healthy lifestyle especially since the greatest rise in obesity over in the 1990's was in young adults (Mokad, Serdula, Dietz, Bowman, Marks, & Koplan, 1999).

Interventions and Education

College students are at a transitional and developmental time in which they are establishing health behaviors for life (Baranowski, Cullen, Basen-Enquist, Wetter, Cummings, Martineau, Prokhorov, Chorely, Beech, & Hergenroeder, 1997). Despite conflicting evidence, education and health promotion is considered to be an intervention element in relation to reducing obesity (U.S. Preventive Services Task Force, 2005). In college food service settings, point-of-purchase messages have been shown to influence food purchases if healthy food options are priced comparably to less healthful foods (Buscher & Martin, 2001). The potential to intervene in college environments to reduce exposure to SSB could aid in promoting healthier options, such as water or dairy based beverages, as successes have been seen in children's educational intervention programs

(James, Thomas, Cavan, & Kerr, 2004). In focus groups, students (mean age = 19) stated that to capture their attention, powerful and shocking health messages could influence their purchase decisions and beverage choices (i.e. fat in the glass (NY) and image of sugar content per soda) (Block et al., 2013). Students emphasized that graphical educational images were more noticeable than textual (Block et al., 2013). As an example, Block et al. (2013) suggested presenting caloric content equivalency of food versus beverages (e.g. a 20-ounce sugar-sweetened soda and one-half of a Big Mac®). Additionally, for vending machines, pricing lower than other SSB options may motivate students to choose water (Block et al., 2013). In their concluding remarks, Bergen and Yeh (2006) suggest that motivational graphics or information with energy content labels and motivational posters placed on beverage vending machines may be an effective to influence SSB drink sales. In an extreme comparison, Emery, Szczypka, Powell, and Chaloupka (2007) suggests the development of public anti-obesity and anti-SSB advertisements similarly to the intensity of the national anti-tobacco advertisements.

Education appears to be a central theme in altering consumer behaviors. In addition to anti-SSB advertisements, promotions of water filling stations are gaining momentum. These displays advertise the location, use and benefits of using these stations and tap water instead of bottled water. Awareness campaigns can include graphics, displays, flyers, and phone aps. A nationally recognized campaign, Take Back the Tap, which is founded by Food and Water Watch, offers guidance and support for this initiative.

Bottled Water and Controversy

The U.S. has one of the safest tap water systems in the world, yet the U.S. is the largest market for bottled water at 9.7B gallons in 2012 (Beverage Market Corporation, 2013; Fishman, 2012). China and Mexico are second and third in terms of bottled water consumed, where tap water access is unavailable, limited or unsafe to drink (Fishman, 2012). In circumstances where the tap water is safe, water may not be appealing due to concerns based on appearance, taste, and temperature (Patel, Bogart, Schuster, Uyeda, & Rabin, 2010). Due to safety concerns of tap water and the appeal of bottled water, more than half of Americans drink bottled water (Olson, & Natural Resources Defense Council, 1999). However, in a survey by GE, 31% of Americans do not know the origin of their tap water (GE Water & Process Technologies and Xylem Inc., 2013). Even though bottled water consumption continues to increase, "Ban on the Bottle" movements have picked up speed in recent years. For example, The United States National Park Service issued a statement to its position on the water bottle ban and its commitment to sustainability. The National Park Service has a sustainability plan called the "Green Parks Plan" in which they address a variety of sustainability concerns to reduce their carbon footprint, including the disposable water bottle (United States Department of the Interior, 2011). In the statement, the National Park Service Director encouraged a recycling and reduction policy, with an option to eliminate water bottle sales due to the added labor and waste costs. While individual parks must outline a justification for water bottle elimination, they must also provide education materials as to why the park is recycling, reducing, or eliminating water bottles. Many parks have sought the elimination of water bottle sales within park boundaries. Most notably, The Grand Canyon has installed water refill stations with water educational displays for visitors. Additionally, Zion National Park installed water refill stations and provided reusable water bottles for purchase for its 2.7 million visitors each year. Zion National Park estimates that it has eliminated the sale of 60,000 bottles of water which is about 5,000 pounds of plastic (National Park Service, n.d.). The National Park Service is not the only entity to commit to water bottle use reduction. Some notable examples are beaches in California and local/state governments banning water bottle purchase. Larger cities like New York City and Paris are waging war against manufacturers who bottle water that claim public water is subpar to bottled water. New York City proudly promotes the quality of their water and offers portable fountains at events around the city (Associated Press, 2013).

Many college campuses are reducing or banning the water bottle. Loyola University in Chicago is encouraging students to drink tap water by giving all freshmen reusable bottles and installing more water refill stations around campus (Cohen, 2012). Additionally, in 2013 Loyola stopped selling bottled water in cafeterias and on-campus stores and removed bottled water from vending machines in 2013 (Fishman, 2012). Many other universities are following (University of Vermont, Washington University, DePauw University, Harvard School of Public Health and Pennsylvania State University). Penn State annually recycles over 200 tons of plastic water bottles (approximately 7.6 million water bottles) (Penn State Sustainability, n.d.). Entities are taking strides to reduce plastic waste on campus due to the environmental concern, waste costs and the low recycling rate of plastics.

Water Bottle Impact and *Responsibility*

The manufacture of disposable water bottles consumes important petroleum and water resources (Penn State Sustainability, n.d.). Plastics are made from petroleum resources which will eventually become scarce (Nampoothiri, Nair, & John, 2010). Additionally, it takes thousands of years for plastic to biodegrade (Nampoothiri et al., 2010). Speculatively, it takes 3 liters of water to produce 1 liter of bottled water during the water bottle filling process (Pacific Institute, n.d.). However in a study of the water footprint, differences in Italian bottled water and tap water, results indicated that bottled water and tap water have similar water footprints while having different life cycles (Niccolucci, Botto, Rugani, Nicolardi, Bastianoni, & Gaggi, 2011). While the water footprint may be similar, the petroleum usage and waste stream is not. In 2006, American production of water bottles required the equivalent of more than 17 million barrels of oil, not including the energy for transportation (Pacific Institute, n.d.). The largest category of plastics are found in containers and packaging (e.g. soft drink bottles, lids, shampoo bottles) with plastics in general making up almost 13% of the municipal solid waste stream, an increase from 1960 when it was less than 1% (United States Environmental Protection Agency, 2013b). In addition, 80% of the trash in the ocean is plastic (Wassener, 2011).

The industry has made strides to reduce their environmental contribution. Between 2000 and 2011, the average weight of a 16.9-ounce (half-liter) PET plastic bottled water container has declined 47.8%, resulting in a savings of 3.3 billion pounds of PET resin since 2000 (International Bottled Water Association, 2013). Additionally, the National Association for PET Container Resources and The Association of Postconsumer

Plastic Recyclers (2012) reported a gross recycling rate of 29.3% for U.S. beverage bottles in 2011. Moreover, the recycling rate for bottled water reached 38.6% in 2012 (International Bottled Water Association, 2013).

Perception

Consumer's acceptability of tap water is based largely on aesthetic qualities. Consumers associate off-flavors or off-odors with negative quality properties of tap water, such as contamination or health risks. This type of behavior or perception association is not uncommon to beverages and food. It is deeply rooted in our genetics to base food and beverage safety on aesthetic properties. However, this is not always an accurate or safe assumption for evaluation. The correlation between compounds and microorganisms of concern with negative sensory characteristics in water is not strong but should not be disregarded (Jardine, Gibson, & Hrudey, 1999).

Consumers often switch from tap water to bottled water for health risk concerns (higher safety, quality, or increased security), perception or organoleptic properties (better taste) (Ferrier, 2001; EPA, 2005). Consumer history and attitude towards public water is complicated. The perception of risk associated with drinking water is dependent on social, cultural, psychological factors and objective information (Turgeon, Rodriguez, Thériault, & Levallois., 2004). By definition, risk perception associated with drinking water is "an individual's subjective judgment based on aesthetic and non-aesthetic qualities" (Anadu & Harding, 2000). As such, consumer satisfaction or dissatisfaction with water flavor and source knowledge are both determining factors in consumer behavior (Levallois, Grondin, & Gingras, 1999).

Current American college students are no stranger to water fountains, as drinking fountains are the primary source of tap water in schools in the United States (Patel & Hampton, 2011). Most college freshmen have had experience with a water fountain. However, unlike previous generations, these students cannot recall a day where bottled water was not an option. In that regard it is difficult for water fountains to compete with the sleekness and positive perception attributed to a water bottle. Moreover, when tap water is safe, the water still may not appeal to consumers due to water quality concerns (e.g. taste, appearance, temperature) (Patel et al., 2010). Many studies have elucidated that a barrier to water consumption in schools is in fact related to the water fountain. For example, a California study reported that students will avoid water fountains when they are in disrepair, dirty and produce unpalatable water (Northcoast Nutrition and Fitness Collaborative, n.d.). In study surveying various stakeholders in California Schools, most stakeholders expressed concerns about the appeal, taste, appearance, and safety of fountain water as well as the environmental impact of bottled water (Patel et al., 2010). Poor maintenance of drinking water fountains discourages students from using school fountains (Northcoast Nutrition and Fitness Collaborative, n.d.; Patel et al., 2010). In order to increase water intake and appeal of tap water, the delivery systems will have to compete and exceed bottled water not only in appeal, but flavor, temperature and odor.

In an assessment of drinking water habits in elementary, middle and high schools across California, Patel et al. (2012) suggested that more appealing water delivery systems may be necessary to increase water consumption at mealtime. Schools are not the only entity wishing to improve water quality aesthetics. Water utilities are investing resources to produce high quality tap water, but the market is diminishing as part of the population refuses to drink tap water (Turgeon et al., 2004). In concluding remarks Turgeon et al. (2004) mentioned that parameters better associated with taste and odor would improve studies aimed at understanding of the public's perception of the quality of their drinking water.

Water Acceptability

Water Consumption, Preference and Risk Perception

In a study with college students about beverage choices, 93% of participants stated that taste was an important factor in determining beverage choice, followed by price (58%) and caloric content (30%) (Block et al., 2013). Consumers are attracted to products that contribute to their overall well-being and health (Ferrier, 2001). Additionally when inquiring about water, participants claimed that water is primarily consumed for hydration (Block et al., 2013). Water that was filtered was preferred even if tap water was provided free as students raised concern about the taste and appearance of tap water (Block et al., 2013). In a study of consumer perception of drinking water quality and risk, tap water risk perception can be explained by flavor, familiarity, context, and negative information from friends (Doria, Pidgeon, & Hunter, 2009). Moreover, if given the choice of water or a beverage that was flavored, most students would prefer a beverage with flavor when all external variables are held constant (Block et al., 2013). Water is deemed "tasteless" and "odorless"; however different mineral content and composition of water can alter the flavor to a more acceptable and palatable state. For sensory descriptive purposes, water is virtually hard to evaluate as it is considered "tasteless". However different mineral content has been associated with giving water various flavors as well as consumer preference and acceptability and sensory descriptors.

In a study using different bottled waters with varying mineral content and tap water, results suggested that the taste of water and total mineralization is associated with three major tastes/descriptors: bitter and metallic for low mineral content; neutral and fresh for medium mineral content, and more salty for high mineral content (Teillet, Schlich, Urbano, Cordelle, & Guichard, 2010). Furthermore, sensory ‘coolness’ of water tasting is linked to mean water preference (Teillet et al., 2010). Unlike tap water, bottled water provides a variety of flavor options as well as perceived benefits. In their concluding remarks, Doria et al. (2009) stated that water quality perception results from a complex interaction of various factors. Mackey, Baribeau, Crozes, Suffet, and Piriou (2004) reported that the switch from tap to bottled water is based largely on the safety, health and aesthetic quality of water.

Water flavor and risk perception moderately explains tap water consumption as well as bottled water consumption (Doria et al., 2009). Chlorine is most widely used to treat water and is associated with safety. Unfortunately, the limit of detection or threshold can be low for chlorine, thus negatively influencing treated water acceptability. Humans can be much more sensitive than laboratory equipment in regard to taste- and odor-generating compounds (Whelton, Dietrich, Gallagher, & Roberson, 2007b). Alternatively in a study with mineral content in water, water with low mineral content was liked least, whether the chlorine had been removed or not, while higher mineral content was preferred (Falahee & MacRae, 1995). Moreover, filtration appeared to make little difference in consumer acceptability of water (Falahee & MacRae, 1995). Chlorine is vital to the safety of water; however it negatively influences the acceptability of tap water (Puget, Beno, Chabanet, Guichard, & Thomas-Danguin, 2010). Water suppliers are continually looking for ways to determine consumer satisfaction with the taste and odor of water that supplies their homes. Providing tap water for consumption is subtle balance between sensitivity, actual chlorine content of tap water, and tap water representation with the last two parameters under the control of the water authorities (Puget et al., 2010). Regardless, water authorities should continue as a public service that delivers good quality drinking water (Ferrier, 2001).

Memory, emotions and experience can also determine water preference and acceptability. Consumers draw from past experiences and history when interacting with food and beverage products, new treatment or new delivery. Additionally, consumer product interaction can be a deterrent or an attraction. Food and beverage interactions are a sum of many emotions, sensory qualities, perceptions, and past history. Gibson (2006) investigated the sensory, psychological (mood), and physiological mechanisms that drive emotional determinants of food selection and determined that eaters have learned consciously or subconsciously how to feed their mood. Water is essentially everywhere and region and culture often determine water preferences. Bhumiratana (2010) stated that "cultural experience dictates perceptual judgments, detection, recognition and identification, and acceptability." Subtle differences in water can exhibit a change in acceptability. Most tap water consumers are acclimated to their regional water and observe differences upon relocation. These subconscious memories of water can elicit a strong recall even with the subtle flavor of water (Westcott, 2013).

Water Flavor

Humans perceive flavor through a variety of senses and evaluation. Meilgaard, Civille & Carr (2007) describes the process of food evaluation in the following order:

appearance, odor/aroma/fragrance, consistency and texture, and flavor (aromatics, chemical feelings, taste). Water is undoubtedly judged in a similar order. Through sensory assessment consumers can quickly assess their perceptions about water safety and quality. Consistency is important for public water acceptability and trust. Water utilities across the United States produce different water based on their location and water source. Azoulay, Garzon, & Eisenberg, (2001) reported major variation in tap water variation among US cities in regards to mineral content. Water quality and flavor can vary by location, mineral content, treatment, and source (EPA, 2005). Water is pulled most commonly from surface water (lakes and rivers) or ground water. Ground water quality and water safety are highly associated with bottled water use but not surface water quality (Hu et al., 2011). Azoulay et al. (2001) found that levels of Ca^{2+}, Mg^{2+} and Na^{+} were higher in groundwater sources than surface water sources.

Environmental changes can also alter the flavor of water and flavor can be influenced by season. Water utilities should value consistency and investigate potential water quality differences. Total dissolved solids (TDS) and temperature have a large influence on water flavor. Minerals are the largest determinant of water flavor. Common cations in TDS are calcium, magnesium, potassium, and sodium in addition to anions such as carbonate, bicarbonate, chloride, nitrate, sulfate, and silicates (Gallagher & Dietrich, 2010). Notably, calcium (Ca^{2+}), magnesium (Mg^{2+}), and sodium (Na^{+}) are abundant in drinking water and they have important physiological functions (Azoulay et al., 2001). The US Environmental Protection Agency sets a secondary maximum contaminant levels (SMCL) for TDS concentration at 500-mg/L (EPA, 2013c; Gallagher & Dietrich, 2010). TDS levels are considered high when between 250-500 mg/L and low if less than 100 mg/L. To avoid a mineral taste, it is recommended that tap water has TDS less than 250 mg/L (Gallagher & Dietrich, 2010). Unfortunately, water from different regions exhibits different TDS levels. Consumers often acquire a preference for the water to which they are accustomed. The most common example of this preference is water choice differences among Europeans and Americans. American water sources typically contain less mineral content than European sources, making it more likely for Americans to drink mineral-deficient bottled water since mineral-rich water can be associated with an unfavorable taste (Azoulay et al., 2001). Within the United States, Hu et al. (2011) found that consumers of the Midwest and west mountain regions were less likely to be bottled water users while residents of the southeast, southern pacific and south were more likely to be bottled water consumers.

The flavor of water is largely dependent on the state and mineral content of water. Tap water is generally served between 4°C and 30°C but Americans generally prefer it cold (Gallagher and Dietrich, 2010). Chilled water appears to lower the threshold for mineral taste detection. For example, consumers who drank high TDS water (750-1000 mg/L) when chilled detected the mineral taste less (Gallagher and Dietrich, 2010). Good tasting and acceptable tap water has a balance of minerals, chilled water temperature, and near-neutral pH (Burlingame et al., 2007). On a cellular level, anions and cations previously mentioned are responsible for the taste sensations on the taste buds and are influenced by concentration, pH and temperature (Burlingame et al., 2007). In the right proportion and balance, potassium, magnesium, calcium and sodium with bicarbonates would provide good tasting water (Burlingame et al., 2007). The role of minerals is water flavor is summarized in Table 2.1.

Table 2.1 Factors that influence water quality and flavor characteristics.

Constituent	**Influence on Taste**	**Taste Threshold Concentration or Recommendations**	**Taste Impact**	**Source**
Chloride Cl^-	Neutral or Negative	-200-300 mg/L threshold	-Acceptance decreases when Na^+ and K^+ present. -Calcium and magnesium as well. -Odor and acidic taste.	Whelton, Dietrich, Burlingame, Schechs, & Duncan, 2007b; WHO, 2004; Westcott, 2013
Sulfate SO_4^{-2}	Negative	-Threshold 250 mg/L for sodium sulfate and 1,000 mg/L for calcium sulfate. -Most tap water <100 mg/L	-Minimal impact -Avoid usage; Ca^{+2} and Mg^{+2} preferred over sodium forms.	Whelton et al., 2007b; Renfrew, 1990
Bicarbonate HCO_3^- Carbonate CO_3^{-2} Carbonic Acid H_2CO_3	Positive or Neutral	- at neutral pH (6.3-8.3) bicarbonate is more important (associated with cations sodium, calcium, magnesium, and potassium) - < 150 mg/L of bicarbonate - Carbonate > 8.3 pH	-Bicarbonate taste preferred to carbonate and carbonic acid. - Bicarbonate is less flavorful than carbonate.	Whelton et al., 2007b; Burlingame et al., 2007; Renfrew, 1990; Gallagher and Dietrich, 2010.
Calcium Ca^{+2}	Positive or Neutral	100-300 mg/L (dependent on associated anion)	-Acceptance dependent on Cl^-. -High amounts of calcium chloride = bitter.	Whelton et al., 2007b; WHO, 2004; Burlingame et al., 2007; Smith and Margolskee, 2001
Sodium Na^+	Positive or Neutral	- <50 mg/L for most drinking water - <200 mg/L recommended - threshold varies (30 to 460 mg/L)	-Acceptance decreases when Cl^- present. - Salty (High TDS or seawater/brackish)	Whelton et al., 2007b; Renfrew, 1990; WHO, 2004; USEPA, 2003; Burlingame et al., 2007
Potassium K^+	Positive	- <5 mg/L in most tap water	Acceptance decreases when Cl^- present.	Whelton et al., 2007b; Renfrew, 1990
Magnesium Mg^{+2} (associated with anions carbonate, bicarbonate, sulfate, chloride)	Neutral or Negative	-Detected at 100-500 mg/L -Acceptable 1,000 mg/L -up to 120 mg/L in tap water but mostly below 20 mg/L	-Acceptance decrease at high levels. High levels = astringent or bitter taste. -Magnesium Chloride = bitter.	Whelton et al., 2007b; Burlingame et al., 2007; Lockhart et al., 1955; Renfrew, 1990; Westcott, 2013; Smith and Margolskee, 2001
Copper Cu^{+2} Iron Fe^{+2}	Negative		-Use low levels; -Copper: Do not exceed 1.0 mg/L. -Iron: Do not exceed 0.3 mg/L.	Whelton et al., 2007b; Burlingame et al., 2007; Burlingame et al., 2007; Cuppett et al., 2006

			-Metallic Taste -Astringency -Copper = bitter	
Manganese Mn^{+2} Zinc Zn^{+2}	Negative		Use low levels; Do not exceed 0.1-1.0 mg/L. -Zinc: Do not exceed 5 mg/L. -Metallic Taste -Astringency -Manganese: threshold detection 0.05 mg/L	Whelton et al., 2007b; Burlingame et al., 2007
pH Hydrogen atoms	Neutral or Negative		-Near neutral pH preferred; High/Low pH could promote carbonate and carbonic acid. - Sour is not common in water lexicon.	Whelton et al., 2007b; Burlingame et al., 2007
TDS (measure of the total ion concentrations including **cations**: calcium, magnesium, potassium, sodium, aluminum, iron, manganese; **anions**: bicarbonate, carbonate, chloride, sulfate, and nitrate.	Variable	Low <100 Moderate 101-250 High 251-500 -Water close to 0 has a flat taste -Tap Water <500 mg/L -Taste: 80 mg/L excellent 81-450 mg/L good 541-800 mg/L fair 801-1,000 mg/L poor >1000 mg/L unacceptable	High levels can approach mineral water. Note: Different populations have different preferences for mineral content.	Whelton et al., 2007b; Burlingame et al., 2007; Bruvold and Daniels, 1990.
Hard Water Soft Water	Neutral or Negative	-Soft (Calcium Carbonate) 0-60 mg/L -Moderately Hard 61-120 mg/L -Hard 121-180 mg/L -10-100 mg/L (Good Tasting Water)	-Hard Water gives chalky mouthfeel. -Soft water has less 'taste'. -Ground water is usually hard. -Surface water is typically soft with fewer minerals and more acidic. - Acceptance decreased for hard waters/high pH.	Westcott, 2013; Burlingame et al., 2007; Renfrew, 1990; Whelton et al., 2007b
Ecology: Cyanobacteria (Blue/Green Algae) or actinomycetes			Damp or Earth Smell	Westcott, 2013
Organic Compounds			Bitter	Burlingame et al., 2007

(Caffeine)				
Lead Salts			Sweet	Burlingame et al., 2007
Temperature			20-40°C	Burlingame et al., 2007
Silica	Unknown	-Associated with calcium and magnesium. -Most tap water <30 mg/L silicon dioxide.	Unknown	Burlingame et al., 2007; Renfrew, 1990

Water Value

College students have varying opinions on the access to water and other beverages. In one study some students valued access to free beverages (water) and were at times a motivated to drink water. Additionally, these students did not purchase water because you can get it for free (Block et al., 2013). With the exception of the perspective stated above, agribusiness has a focus on value-added products. Bottled water can be seen as a value-added commodity due to its packaging, additional filtration and other advertised potential health benefits. The value added food, and in this case beverages, concept is consumer targeted. Targeted consumers perceive these value-added products as having more quality (Grunert, 2005). Grunert (2005) defines that "quality has an objective and subjective dimension… subjective quality is the quality perceived by consumers… only when producers can translate consumer wishes into physical product characteristics, and only when consumers can then infer desired qualities from the way the product has been built, will quality be a competitive parameter for food products" (Grunert, 2005).

In a different perspective, tap water can serve as a "generic or retailer brand" while bottled water has an appeal of a "manufacturer brand". Some consumers can perceive quality variation in these different sources. Branding often suggests a guarantee of flavor and quality. Most often both bottled and municipal sources of water provide consistent quality and sensory characteristics. However, in some instances tap water can have quality variation that occurs due to environmental changes. As such, the analogy to brands and value-added products can be supported by this theory of quality differentiation. However, even in regard to flavor differences, tap water is still suitable for drinking purposes. Unfortunately, there is a disconnection with consumer purchasing behavior at a store and water coming from the tap. This lack of knowledge about the source history could spur consumers to purchase water for the perceived quality and consistency. In other words, a lack of brand history and historical perception of brand quality results, in many cases, in consumers taking a retail brand as a cue indicating low rather than high quality (Grunert, 2005).

War over the Water Fountain

Water drinking fountains are the most common methods of tap water delivery in schools (Patel & Hampton, 2011). Although their presence is associated with schools, Patel et al. (2010) indicated that there is an inadequate number in schools, fountains are located in an inconvenient location, or maintenance is poor (Patel et al., 2010; Northcoast Nutrition and Fitness Collaborative, n.d.). Interviews revealed that 70% of students thought water fountains looked “disgusting” and dispensed water that tasted “gross” (Northcoast Nutrition and Fitness Collaborative, n.d.). As such, students have concern about the appeal and safety of school drinking water from plumbing (Patel et al., 2010). Even in the event that tap water is adequately safe for consumption, the appearance of water delivery units can deter students from consuming water. Further complicating water intake, these water outlets might dispense poor water based on aesthetic qualities like temperature and flavor. Additional barrier to water consumption in schools are the perceptions of purity, students not carrying reusable bottles and inconvenient locations of water refill stations (Portland State University, 2012).

Water Characteristics from Water Fountains and Water Filling Stations

Water fountains and water filling stations are often found near one another as well as near restrooms. Typically, water fountains dispense chilled water. Oftentimes, water filling stations are not chilled unless temperature exceeds 65°F (Penn State, 2012). Water fountains are chilled as consumption is immediate. Consumers who use filling stations often carry around a reusable bottle over a period of time in which the water reaches room temperature. Oftentimes, filling stations can save energy by not chilling water for reusable containers. Filters are frequently used at water refill stations and do contribute to a university waste stream. In a study at Penn State, 40% of students could not tell a difference between filtered and unfiltered water (Penn State, 2012).

Design optimization of water delivery using devices like water filling stations can have a positive impact on use and appeal. Appearance is vital to the success of any new invention or the success of a new product. Water refilling stations should be built and installed where they will be seen and attract consumers. An attractive and clean appearance will encourage use and improve consumption.

Water Packaging and Reusable Water Bottles and Interventions

One-use water bottles are typically contained in polyethylene terephthalate **(**PET) and can be sold individually or in multi-packs. Reusable water containers can be made from a variety of materials including plastic (high-density polyethylene (HDPE), low-density polyethylene (LDPE), copolyester, or polypropylene (PP)), glass and metal (stainless steel or aluminum). As environmental concerns have increased, consumers have begun to use multi-use water containers to reduce their footprint. Additionally, multi-use containers are used in water intervention studies in children. Research emphasis is not placed on those who currently use containers. Potential knowledge value can be gained from those who utilize reusable water bottles.

Within the reusable water bottle niche, consumers have selected water containers for a variety of reasons. There is power in the packaging and a lifestyle associated and exhibited by those who carry reusable containers. Moreover, consumers can individualize their containers providing an extension of their personality. Consider this a reverse packaging for food science. Packaging is often vital for marketing and attracting consumers. Individual reusable water bottles are, in effect, an individual expression through packaging without repurchase. Typically food and beverage packaging is used for content containment, communication, protection, and convenience (Robertson, 2006). Refilling reusable water bottles could be considered a multisensory experience. Users interact with the station (fountain or filling station), observe the water, touch their bottle, notice the temperature and then consume the water.

In their discussion, Fenko, Schifferstein, and Hekkert, (2010) states when consumers have a relationship with their products over time, emotional experiences in relation to the product grow significant. Over an extended time users, become more familiar with products and can even personalize products to their own liking to a certain degree. The concept of personalized products is not new to companies. For example, Nike and Dell have successfully incorporated personalized options into their product design, thus deepening the link of consumer to manufacturer. Companies often see improved response to this option as consumers are interested in personalizing products that define them. Reusable water bottles could be placed in a similar category. However, many consumers personalize water bottles themselves with stickers or other symbols. Conversely, other users may not be able to commit to such self-expression and simply leave the product in its original state (Mugge, Schifferstein, & Schoormans, 2004). Regardless, self-expression can be channeled through our selection of products, even something as small as a reusable water container.

Water and Sustainability Practices at Virginia Tech

Over the summer of 2013, Virginia Tech hosted the International Union of Pure and Applied Chemistry's (IUPAC) Work Polymer Congress which attracted over 1,200 participants (Outreach and International Affairs at Virginia Tech, 2013). The conference planning committee estimated that for the conference 15,000 units of bottled water would be required over the conference (Outreach and International Affairs at Virginia Tech, 2013). Instead of purchasing water units, the Virginia Tech Outreach and International Affairs, with the aid of corporate sponsors, installed two new water refill stations on campus (Outreach and International Affairs at Virginia Tech, 2013). Not only will these water refill station additions help bolster Virginia Tech's commitment to sustainability, it will shed light on the importance and impact water refill stations have on the community. Virginia Tech is not the only organization eliminating the use of single serve bottled water at events. Many local governments have decided to eliminate the use of bottled water at meetings due to the cost associated with bottled water, especially when that funding may be useful elsewhere. Virginia Tech currently has refill station in several buildings on campus with high traffic (Burruss Hall (2); East Ambler Johnston (3); Graduate Life Center at Donaldson Brown (1); Library (2); Squires Student Center (9); HABB1 (1); McComas; and War Memorial.

Water fountains and fillings stations can benefit campuses through waste reduction and green image. Virginia Tech is proud of its commitment to green practices. In 2013, The Princeton Review ranked Virginia Tech among the most environmentally responsible universities in the United States and Canada. (Norman, 2013). The importance and value of green practices is paramount to current and incoming students as found by the Princeton Review, which suggested that that nearly two-thirds of all incoming freshmen include sustainability as a factor when making a decision to attend a specific institution (Norman, 2013).

References

Affdex http://www.affectiva.com

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior Human Decision Processes*. *50*, 179-211.

Alves, N. T., Fukusima, S. S. & Aznar-Casanova, J. A. (2008). Models of brain asymmetry in emotional processing. *Psychology & Neuroscience*, *1*(1), 63-66.

American Water Works Association (AWWA). (2002). *Simplified procedures for water examination - manual of water supply practices, M12* (5^{th} ed.). Washington DC: AWWA.

Anadu, E. C. & Harding, A. K. (2000). Risk perception and bottled water use. *Journal of American Water Works Association. 92* (11): 82-92.

Anonymous. (2015). Almond milk continues to lead dairy alternatives segment. *Beverage Industry*. *7*(106), S0I14.

Arnade, E.A. (2013). *Measuring consumer emotional response to tastes and foods through facial expression analysis* (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA.

Associated Press. (2013). Move over, soda – the bottled water business is booming. *New York Daily News*. Retrieved from http://www.nydailynews.com/life-style/health/move-soda-americans-love-water-article-1.1285287#ixzz2bUmelQr8

Azoulay, A., Garzon, P., & Eisenberg, M. J. (2001). Comparison of the mineral content of tap water and bottled waters. *Journal of General Internal Medicine, 16*:168-175.

Baker, F., Blanchard, C., Courneya, K., Kupperman, J., Nehl, E., Rhodes, R., & Sparling, P. (2009). Do ethnicity and gender matter when using the theory of planned behavior to understand fruit and vegetable consumption? *Appetite, 52*(1), 15-20.

Baranowski, T., Cullen, K.W., Basen-Enquist, K., Wetter, D.W., Cummings, S., Martineau, D. S., Prokhorov, J. C., Chorely, J., Beech, B., & Hergenroeder, A. C. (1997). Transitions out of high school: time of increased cancer risk? *American Journal of Preventative Medicine, 26*, 694-703.

Bergen, D., & Yeh, M. C. (2006). Effects of energy-content labels and motivational posters on sales of sugar-sweetened beverages: stimulating sales of diet drinks among adults study. *Journal of the American Dietetic Association, 2006* (106), 1866-1869.

Beverage Market Corporation. (2013). Bottled water shows strength yet again, new report from BMC shows. *Beverage Market Corporation press release*. Retrieved from http://beveragemarketing.com/news-detail.asp?id=260

Bhumiratana, N. (2010). *The development of an emotion lexicon for the coffee drinking experience* (Doctoral dissertation). Kansas State University. Manhattan, KS.

Bishop, C. M. (1995). *Neural networks for pattern recognition*. New York, NY: Oxford University Press.

Block, J. P., Gillman, M. W., Linakis, S. K. & Goldman, R. E. (2013). “If it tastes food, I’m drinking it”: qualitative study of beverage consumption among college students. *Journal of Adolescent Health, 52*(6), 702-706.

Bogers, R. P., Brug, J., van Assema, P., & Dagnelie, P. C. (2004). Explaining fruit and vegetable consumption: the theory of planned behavior and misconception of personal intake levels. *Appetite, 42*(2), 157-166.

Bredie, W. L. P., Tan, H. S. G., & Wendin, K. (2014). A comparative study on facially expressed emotions in response to basic tastes. *Chemosensory Perception, 7*(1), 1 – 9, doi: 10.1007/s12078-014-9163-6.

Bruvold, W. H. & Daniels, J. I. (1990). Standards for mineral content in drinking water. *Journal American Water Works Association, 82*:2:59.

Burlingame, G. A., Dietrich, A .M., & Whelton, A .J. (2007). Understanding the basics of tap water taste. *Journal American Water Works Association, 99*(5), 100-111.

Buscher, L. A. & Martin, K. A. (2001). Point-of-purchase message framed in terms of cost, convenience, taste and energy improve healthful snack selection in a college foodservice setting. *Journal of the American Dietetic Association, 101*, 909-13.

Cardello, A. V. (1994). Consumer expectation and their role in food acceptance. In H. J. MacFie & D. M. H. Thomson (Eds.), Measurement of food preferences (pp. 253-297). London, UK: Chapman and Hall.

Cawley, J. & Meyerhoefer, C. (2012). The medical care costs of obesity: an instrumental variables approach. *Journal of Health Economics, 31*, 219-230.

Chaudhari, N. & Roper, S. D. (2010). The cell biology of taste. *Journal of Cell Biology, 190*(3), 285-296.

Cohen, J. S. (2012). Loyola to ban sale of bottled water on campus. *Chicago Tribune News*. Retrieved from http://articles.chicagotribune.com/2012-05-08/news/ct-met-loyola-bottled-water-ban-20120508_1_illinois-beverage-association-bottled-water-tim-bramlet

Conner, M., Kirk, S. F .L., Cade., J. E., & Barrett, J. H. (2001). Why do women use dietary supplements? The use of the theory of planned behavior to explore beliefs about their use. *Social Sciences & Medicine, 52*(4), 621-633.

Cootes, T. & Taylor, C. (2000). *Statistical models of appearance for computer vision*. In FaceReader methodology white paper. University of Manchester, UK: Wolfson Image Analysis Unit, Imaging Science and Biomedical Engineering. Retrieved from http://www.noldus.com/human-behavior-research/products/facereader

Cunningham, S. A. & Zavodny, M. (2011). Does the sale of sweetened beverages at school affect children's weight? *Social Science & Medicine. 73*(9), 1332-1339.

Cuppett, J. D., Duncan S.E., & Dietrich A. M. (2006). Evaluation of copper speciation and water quality factors that affect aqueous copper tasting response. *Chemical. Senses, 31*(7), 689.

Danner, L., Sidorkina, L., Joechl, M., & Duerrschmid, K. (2013). Make a face! implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference, 32*(B), 167-172. doi:10.1016/j.foodqual.2013.01.004.

Davidson, R. J. (1995). Cerebral asymmetry, emotion, and affective style. In R. J. Davidson & K. Hughdahl (Eds.), *Brain Asymmetry* (361-387). Boston, MA: MIT Press.

Davidson, R. J., Ekman, P., Saron, C. D., Senulis, J. A., & Friesen, W. V. (1990). Approach withdrawal and cerebral asymmetry: emotional expression and brain physiology I. *Journal of Personality and Social Psychology, 58*(2), 330–341.

De Bruijn, G. J. (2010). Understanding college students' fruit consumption. integrating habit strength in the theory of planned behavior. *Appetite. 54*(1), 16-22.

De Wijk, R.A., Kooijman, V., Verhoeven, R.H.G., Holthuysen, N.T.E., & De Graaf, C. 2012. Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. *Food Quality and Preference, 26*(2), 196-203.

Demaree, H. A., Everhart, D. E., Youngstrom, E. A., & Harrison, D. W. (2005). Brain lateralization of emotional processing: historical roots and a future incorporating "dominance". *Behavioral and Cognitive Neuroscience Review, 4*, 3-20.

Dennis, E. A., Flack, K. D., & Davy, B. M. (2009). Beverage consumption and adult weight management: a review. *Eating Behaviors, 10*(4), 237-246.

Dennis, E. A., Dengo, A. L., Comber, D. L., Flack, K. D., Savla, J., Davy, K. P., & Davy, B. M. (2010). Water consumption increases weight loss during a hypocaloric diet intervention in middle-aged and older adults. *Obesity, 18*, 300-307.

Desmet, P. M. A. & Schifferstein, H. N. J. (2008). Sources of positive and negative emotions in food experience. *Appetite, 50*, 290-301.

Dijksterhuis, A. & Smith, P. K. (2005). What do we do unconsciously? and how? *Journal of Consumer Psychology, 15*(3), 225-229.

Doria, M. F., Pidgeon, N., & Hunter, P. R. (2009). Perceptions of drinking water quality and risk and its effect on behavior: a cross national study. *Science of the Total Environment, 407*(2009), 5455-5464.

Ebbeling, C. B., Feldman, H. A., Osganian, S. K., Chomitz, V. R., Ellenbogen, S. J. & Ludwig, D. S. (2006). Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. *Pediatrics. 117*, 673-680.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: a technique for the measurement of facial movement*. Palo Alto, California: Consulting Psychologists Press.

Emery S., Szczypka, G., Powell, L. M., & Chaloupka, F. J. (2007). Public health obesity-related TV advertising: lessons learned from tobacco control advertising. *American Journal of Preventative Medicine*, *33*(4S), S257-S263.

Emotionomics. Retrieved from http://www.sensorylogic.com

Erickson, K. & Schulkin, J. (2003). Facial expressions of emotion: A cognitive neuroscience perspective. *Brain and Cognition*, 52(1), 52-60.

Falahee, M. & MacRae, A. W. (1995). Consumer appraisal of drinking water: multidimensional scaling analysis. *Food Quality and Preference, 6*(1995), 327-332.

Fenko, A. Schifferstein, H. N. J. & Hekkert, P. (2009). Shifts in sensory dominance between various states of user-product interactions. *Applied Ergonomics, 41*(2010), 34-40.

Ferrier, C. (2001). Bottled water: understanding a social phenomenon. *AMBIO: A Journal of the Human Environment, 30*(2), 118-119.

Fishman, C. (2012). U.S. bottled water sales are booming (again) despite opposition. *National Geographic*. Retrieved from http://newswatch.nationalgeographic.com/2012/05/17/u-s-bottled-water-sales-are-booming-again-despite-opposition/

Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *The Journal of the American Medical Association, 307*, 491-497.

Fuller, G.W. (2011). Going to market: success or failure. *In new food product development: from concept to marketplace (*3rd ed.) (pp. 275-300). Boca Raton, FL: CRC Press.

Gallagher, C. D. & Dietrich, A. M. (2010). *TDS and temperature affect consumer taste preferences*. Retrieved from www.awwa.org/opflow

Garcia-Burgos, D. & Zamora, M. C. (2015). Exploring the hedonic and incentive properties in preferences for bitter foods via self-reports, facial expressions and instrumental behaviours. *Food Quality and Preference, 39*, 73-81.

GE Water & Process Technologies and Xylem Inc. (2013). Surveys reveal consumers' views on water scarcity and infrastructure. *Membrane Technology, 2*(2013), 9-10.

Gibson, E.L. (2006). Emotional influences on food choice: sensory, physiological and psychological pathways. *Physiology & Behavior*, *89*, 53-61.

Grunert, K.G. (2005). Food quality and safety: consumer perception and demand. *European Review of Agricultural Economics, 32*(3), 369-391. Doi:10.1093/eurrag/jbi011.

Grynbaum, M. M. (2012). Health panel approves restriction on sale of large sugary drinks. *The New York Times*. Retrieved from http://www.nytimes.com/2012/09/14/nyregion/health-board-approves-bloombergs-soda-ban.html?_r=0

Han, E. & Powell, L. M. (2013). Consumption patterns of sugar-sweetened beverages in the United States. *Journal of the Academy of Nutrition and Dietetics, 113*(1), 43-53

Harkin, T. (2007). Preventing childhood obesity: the power of policy and political will. *American Journal of Preventative Medicine, 33*(4S), S165-S166.

Holm-Denoma, J. M., Joiner, T. E., Vohs, K. D., & Heatherton, T. F. (2008). The "freshman fifteen" (the "freshman five" actually): predictors and possible explanations. *Health Psychology, 27*(1), S3-S9.

Hu, Z., Morton, L. W., & Mahler, R. L. (2011). Bottled water: united states consumers and their perceptions of water quality. *International Journal of Environmental Research and Public Health, 8*, 565-578.

Hu, S., Player, K. A., Mcchesney, K. A., Dalistan, M. D., Tyner, C. A. & Scozzafava, J. E. (1999). Facial EMG as an indicator of palatability in humans. *Physiology and Behavior, 68*(1-2), 31-35.

Huffman, L. & West, D. S. (2007). Readiness to change sugar sweetened beverage intake among college students. *Eating Behaviors, 8*, 10-14.

Huchting, K., Lac, A., and LaBrie, J. W. (2008). An application of the theory of planned behavior to sorority alcohol consumption. *Addictive Behaviors, 33*, 538-551.

Institute of Medicine of the National Academies. (2004). *Dietary reference intakes: water, potassium, sodium, chloride, and sulfate*. Retrieved from http://www.iom.edu/Reports /2004/Dietary-Reference-Intakes-Water-Potassium-Sodium-Chloride-and-Sulfate.aspx

International Bottled Water Association (2013). *New reports show increased bottled water recycling and smaller environmental footprint*. Retrieved from http://www.bottledwater.org/new-reports-show-increased-bottled-water-recycling-and-smaller-environmental-footprint

James, J., Thomas, P., Cavan, D., and Kerr, D. (2004). Preventing childhood obesity by reducing consumption of carbonated drinks: cluster randomized controlled trial. *British Medical Journal, 328,* 1237-1242.

Jardine, C. G., Gibson, N. and Hrudey, S. E. (1999). Detection of odor and health risk perception of drinking water. *Water Science Technology*, *40*(6), 91-98.

Jones, L. V., Peryam, D. R., and Thurstone, L. L., (1955). Development of a scale for measuring soldiers' food preferences. *Food Research*, *20*(5), 512-520.

King, S. C. and Meiselman, H. L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21*, 168-177.

King, S. Meiselman, H. L., Carr, B. T. (2010). Measuring emotions associated with foods in consumer testing. *Food Quality and Preference, 21*, 114-116.

Köster, E. P. & Mojet, J. (2015). From mood to food and from food to mood: a psychological perspective on the measurement of food-related emotions in consume research. *Food Research International 76*, 180-191.

Krasner, S. W. & Barrett, S. E. (1984). Proceedings of the American Water Works Association: *Aroma and flavor characteristics of free chlorine and chloramine.* Denver, CO: Water Quality Technical Conference (WQTC).

Krzeski, E. (2011). Using the theory of planned behavior to understand drink choices in southwest virginians (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

LaComb, R. P., Sebastian, R. S., Enns, C. W., & Goldman, J. D. (2011). Beverage choices of U.S. adults: what we eat in america [NHANES 2007-2008]. In *Food Surveys Research Group Dietary Data Brief No. 6*. Retrieved from http://ars.usda.gov/Services/docs.htm?docid=19476.

Latif, R. (2013). U.S. bottled water sales totaled $11.8 billion in 2012. *BEVNET*. Retrieved from http://www.bevnet.com/news/2013/u-s-bottled-water-sales-totaled-11-8-billion-in-2012

Lee, S., Levy, D., Hightower, A., Imhoff, B. & Emerging Infections Program FoodNet Working Group. (2002). *Drinking water exposures and perceptions among 1998-1999 FoodNet survey respondents*. Atlanta, GA: US Centers for Disease Control and Prevention. Retrieved from http://www.cdc.gov/iceid/asm-iceid_program.pdf

Leitch, K. A., Duncan, S. E., O'Keefe, S., Rudd, R., & Gallager, D. L. (2015). Characterizing consumer emotional response to sweeteners using an emotion terminology questionnaire and facial expression analysis. *Food Research International 76,* 283-292.

Levallois, P., Grondin, J., & Gingras, S. (1999). Evaluation of consumer attitudes on taste and tap water alternatives in quebec. *Water Science and Technology, 40*(6), 135-139.

Lewinski, P., den Uyl, T. M., & Butler, C. (2014). Automated facial coding: validation of basic emotions and FACS AUs in FaceReader. *Journal of Neuroscience Psychology and Economics,* 7(4), 227 – 236, doi: 10.1037/npe0000028.

Lockhart, E. E., Tucker, C. L., & Merritt, C. (1955). The effect of water impurities on the flavor of brewed coffee. *Journal of Food Science, 20*(6), 598-605

Lord, J. B. (2000). New product failure and success. In A. L. Brody, & J. B. Lord (Eds.), *Developing new products for a changing market place* (pp. 55-86). Boca Raton, FL: CRC Press.

Lowry, R., Galuska, D. A., Fulton, J., Wechsler, H., Kann, L., & Collins, J. (2000). Physical activity, food choice, and weight management goals and practices among U.S. college students. *American Journal of Preventive Medicine, 18*, 18-27.

Mackey, E. D., Baribeau, H., Crozes, G. F., Suffet, I. H., Piriou, P. (2004). Public thresholds for chlorinous flavors in U.S. tap water. *Water Science and Technology, 49*(9), 335-340.

Meilgaard, M. C., Civille, G. V. & Carr, B. T. (2007). Sensory evaluation techniques (4th ed.). Boca Raton, FL: CRC Press.

Meiselman, H.L. and Schutz, H.G. (2003). History of food acceptance research in the US army. *Appetite, 40*, 199-216.

Mokad, A. H., Serdula, M. K., Dietz, W. H., Bowman, B. A., Marks, J. S., & Koplan, J. P. (1999). The spread of the obesity epidemic in the united states, 1991-1998. *Journal of the American Medical Association, 282*, 1519-22.

Morris, C.E. (1993). Why new products fail. *Food Engineering, 65*(6), 132-136.

Moskowitz, H., Beckley, J. H., & Resurreccion, A.V.A. (2012). So what can sensory do for my company? (pp. 207-228). *In Sensory and Consumer Research in Food Product Design and Development*. Ames, IA: John Wiley & Sons.

Mugge, R., Schifferstein, H. N .J., & Schoormans, J. P. I. (2009). Incorporating consumers in the design of their own products. the dimensions of product personalization. *CoDesign: International Journal of CoCreation in Design and the Arts, 5*(2), 79-97.

Mullan, B. A., Wong, C. & Kothe, E .J. (2013). Predicting adolescents' safe food handling using extended theory of planned behavior. *Food Control, 31*(2), 454-460.

Nampoothiri, K. M., Nair, N. R., & John, R. P. (2010). An overview of the recent developments in polyactide (PLA) research. *Bioresources Technology, 101*, 8493-8501.

National Association for PET Container Resources and The Association of Postconsumer Plastic Recyclers (2012). 2011 *Report on postconsumer PET container recycling activity*. Retrieved from http://www.napcor.com/pdf/NAPCOR_2011RateReport.pdf

National Park Service, United States Department of the Interior. (2011). *Disposable plastic water bottle recycling and reduction*. Retrieved from http://www.nps.gov/policy/plastic.pdf

National Park Service, United States Department of the Interior. (n.d.). Sustainability *Success story: water-filling stations at zion national park.* Retrieved from http://www.nps.gov/sustainability/parks/downloads/GPP%20Success_ZION_bottles_4_17_12.pdf

Niccolucci, V., Botto, S., Rugani, B., Nicolardi, V., Bastianoni, S. and Gaggi, C. 2011. The real water consumption behind drinking water: the case of Italy. Journal of Environmental Management. 92 (2011) 2611-2618.

Nielson, S, J. and Popkin, B. M. (2004). Changes in the beverage intake between 1977 and 2001. *American Journal of Preventative Medicine, 27*, 205-210.

Noldus FaceReader (n.d.). Retrieved from http://www.noldus.com

Noldus Information Technology (2014). *FaceReader™ 5 Technical Specifications*. Wageningen, The Netherlands: Noldus Information Technology. Retrieved from http://www.webshop. noldus.com/media/techspec/facereader_techspec.pdf

Norman, C. R. (2013). *For fourth consecutive year, virginia tech ranked among the 'greenest colleges' in nation*. Retrieved from http://www.vtnews.vt.edu/articles/2013/05/050613-vpa-princetongreenaward.html

Northcoast Nutrition and Fitness Collaborative (n.d.). *Water woes*. Retrieved from http://www.northcoastnutrition.org/rethink-your-drink-information-and-resources

nVisio software services (n.d.). Retrieved from http://nviso.ch

Olson, E.D. & Natural Resources Defense Council (1999). *Bottled water: pure to drink or pure hype?* Retrieved from: http://www.nrdc.org/water/drinking/bw/exesum.asp

Ogden, C. L., Carroll, M. D., Kit, B. K. & Flegal, K. M. (2012). Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *Journal of the American Medical Association, 307*, 483-490.

Ogden, C. L., Kit, B. K., Carroll, M. D., & Park, S. (2011). Consumption of sugar drinks in the united states, 2005-2008. *National Center for Health Statistics Data Brief, 2011*, 1-8.

Outreach and International Affairs at Virginia Tech (2013). *International conference and OIA donate water refill stations to campus.* Retrieved from http://www.outreach.vt.edu/Story.aspx?StoryID=598

Package Facts (2015). *Innovation in vegetarian protein products lead by meat alternatives and ancient grains.* Retrieved from http://www.packagedfacts.com/about/release.asp?id= 3823

Pacific Institute (n.d.). *Bottled water and energy fact sheet*. Retrieved from http://www.pacinst.org/publication/bottled-water-and-energy-a-fact-sheet/

Patel, A. I., Bogart, L. M., Schuster, M. A. Uyeda, K. E. & Rabin, A. (2010). Perceptions about availability and adequacy of drinking water in large California school district. *Prevention Chronic Disease: Public Health Research, Practice and Policy, 7* (2), 1-10.

Patel, A. I., Chandran, K., Hampton, K. E., Hecht, K., Grumbach, J. M., Kimura, A. T., Braff-Guajardo, E., & Brindis, C. D. (2012). Observations of drinking water access in school food service areas before implementation of federal and state school water policy, California, 2011. *Prevention Chronic Disease: Public Health Research, Practice and Policy, 9,* e121.

Patel, A. I. & Hampton, K. E. (2011). Encouraging consumption of water in school and child care settings: access, challenges, and strategies for improvement. *American Journal of Public Health, 101*(8): 1370-1379.

Patterson, J. & Saidel, M. (2009). The removal of flavored milk in schools results in a reduction in total milk purchases in all grades, K-12. *Journal of the American Dietetic Association*, *109*(9), A97.

Pelsmaeker, S. de, Schouteten, J, & Gellynck, X. (2013). The consumption of flavored milk among a children population. the influence of beliefs and the association of brands with emotions. *Appetite, 71*(2013), 279-286.

Penn State Campus Sustainability Office. (2012). *Water bottle filling stations at penn state university*. Retrieved from http://sustainability.psu.edu/sites/default/files/documents/ HydrationStat Business PlanFinal.pdf

Penn State Sustainability Office (n.d.). *Bottle refilling stations*. Retrieved from http://sustainability .psu.edu/live/what-penn-state-can-do/recycling-and-waste-management/bottle-refilling-stations

Peryam, D. R., & Girardot, N. F. (1952). Advanced tatse-test method. *Food Engineering*, *July*, 58-61

Pickett, L. L., Ginsburg, H .J., Mendez, R. V., Lim, D. E., Blankenship, K. R., Foster, L. E., Lewis, D. H, Ramon, S. W., Saltis, B. M., & Sheffield, S. B. (2012). Ajzen's theory of planned behavior as it relates to eating disorders and body satisfaction. *North American Journal of Psychology, 14*(2), 339-354.

Piech, R. M., Lewis , J., Parkinson, C. H., Owen, A. M., Roberts, A. C., Downing., P. E., & Parkinson, J. A. (2009). Neural correlates of appetite and hunger-related evaluative judgments. *PLoS ONE, 4*(8), 1-8 e6581 .

Porcherot, C., Delplanque, S., Ravior-Derrien, S., Le Calve', B., Chrea, C. Gaudreau, N., & Cayeux, I., (2010). How do you feel when you smell this? optimization of a verbal measurement of odor-elicited emotions. *Food Quality and Preference, 21*, 938-947, doi:10.1016/j.foodqual.2011.07.006.

Portland State University. (2012). *Report of the PSU sustainable drinking water task force*. Retrieved from: http://www.pdx.edu/planningsustainability/sites/www.pdx.edu.planning-sustainability/files/SDW%20Task%20Force%20Report%20-%201.24.12.pdf

PrEmo, SusaGroup (n.d.). Retrieved from http://www.tustudiolab.nl/desmet.premo

Puget, S., Beno, N., Chabanet, C., Guichard, E., & Thomas-Danguin, T. (2010). Tap water consumers differ from non-consumers in chlorine flavor acceptability but not sensitivity. *Water Research, 44*, 956-964.

Renfrew, M. M. (1990). *The water encyclopedia* (2nd ed.). van der Lesden, F. Troise, F. L. & Todd, D. K. (Eds.). Chelsea, MI: Lewis Publishers Inc.

Robertson, G.L. (2006). *Food packaging: principles and practice* (2nd ed.)(p. 550). Boca Raton, FL: CRC Press.

Roche, S. M., Jones, A. Q., Majowicz, S. E., McEwan, S. A. & Pintar, K. D. M. (2011). Drinking water consumption patterns in canadian communities (2001-2007). *Journal of Water and Health, 10*(1), 69-86.

Rosenstein, D. & Oster, H. (1988). Differential facial responses to four basic tastes in newborns. *Child Development, 59*(6), 1555 – 1568, doi: 10.2307/1130670.

Rosenstein, D. & Oster, H. (1997).Differential facial responses to four basic tastes in newborns. In Ekman, P. & Rosenberg, E., (Eds.). *What the face reveals: basic and applied studies of spontaneous expression using the facial action coding system (FACS)* (pp. 302-327). New York,NY: Oxford University Press, Inc.

Rossman, G. B. and Rallis, S. F. (2012a). *Qualitative research in learning. in learning in the field: an introduction to qualitative research* (pp. 1-28). Thousand Oaks, CA: Sage Publications.

Rossman, G. B. and Rallis, S. F. (2012b). *Major qualitative research genres. in learning in the field: an introduction to qualitative research* (pp. 87-110). Thousand Oaks, CA: Sage Publications.

Rozin, P. & Fallon, A. E. (1987). A perspective on disgust. *Psychological Revue, 94*(1), 23 – 41, doi:10.1037/0033-295X.94.1.23.

Sainsbury, K. & Mullan, B. (2011). Measuring beliefs about gluten free diet adherence in adult coeliac disease using the theory of planned behavior. *Appetite, 56*(2), 476-483.

Siró, I., Kápolna, E., Kápolna, B., & Lugasi, A. (2008). Functional food. product development, marketing and consumer acceptance – A review. *Appetite, 51*, 456-467.

Scheer, R & Moss, D. (2011). *Drinking from a bottle instead of the tap just doesn't hold water. Scientific American.* Retrieved from http://www.scientificamerican.com/article.cfm?id=bottled-water-ridiculous-waste.

Scholderer, J. & Trondsen, T. (2008). The dynamics of consumer behavior: on habit, discontent, and other fish to fry, *Appetite, 51*(3), 576-591.

Skipton, S. O. & Albrecht, J. A. (2010). *Drinking Water: bottled, tap, and vended*. Lincoln, NE: University of Nebraska Extension Service. Retrieved from http://www.ianrpubs.unl.edu/epublic/live/g1448/build/g1448.pdf

Smith, D. V. & Margolskee, R. F. (2001). Making sense of taste. *Scientific American, 284*(3), 32.

Snyder T. D. & Dillow S. A. (2012). *Digest of Education Statistics 2011* (NCES Publication 2012-001) (pp. 309-538). Washington DC: National Center for Education Statistics, Institute of Education Sciences, United States Department of Education

Steiner, J. (1979). Human facial expressions in response to taste and smell stimulation. In H. Reese & L. Lipsitt (Eds.), *Advances in child development and behavior*. New York, NY: Academic Press.

Steiner, J., Glaser, D., Hawilo, M. E., & Berridge, K. C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience and Biobehavioral Reviews, 25*, 53-74.

Stewart, H., Dong, D., & Carlson, A. (2013). *Why are Americans consuming less fluid milk? a look at generational differences in intake frequency* [ERR-149]. U.S. Department of Agriculture, Economic Research Service, May 2013.

Stockburger, J. Renner, B., Weike, A. I., Hamm, A. O., & Schupp, H. T. (2009). Vegetarianism and food perception. selective visual attention to meat pictures. *Appetite, 52*, 513-516.

Stookey, J. D., Constant, F., Popkin, B. M., and Gardner, C. D. (2008). Drinking water is associated with weight loss in overweight dieting women independent of diet and activity. *Obesity, 16*(11), 2481-2488.

Sung, K. K., & Poggio, T. (1998). Example-based learning for view-based human face detection. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *20*(1), 39-51.

Tate, D. F., Turner-McGrievy, G., Lyons, E., Stevens, J., Erickson, K., Polzien, K., Diamond, M., Wang, X., & Popkin, B. (2012). Replacing caloric beverages with water or diet beverages for weight loss in adults: main results of the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. *American Journal of Clinical Nutrition, 95*(3), 555-563.

Teillet, E. Schlich, P., Urbano, C., Cordelle, S. & Guichard. 2010. Sensory methodologies and the taste of water. Food Quality and Preference. 21 (2010) 967-976.

Todd, J. & Mullan, B. (2011). Using the theory of planned behaviour and prototype willingness model to target binge drinking in female undergraduate university students. *Additive Behaviors, 36*, 980-986.

Turgeon, S., Rodriguez, M. J., Thériault, M., & Levallois, P. (2004). Perception of drinking water in the quebec city region (canada): the influence of water quality and consumer location in the distribution system. *Journal of Environmental Management, 70*, 363-373.

United States Department of Health and Human Services (DHHS). (2001). *The surgeon general's call to action to prevent and decrease overweight and obesity*. Washington, DC: Government Printing Office. Retrieved from Office of the Surgeon General's website: http://www.surgeongeneral.gov/news/2001/12/obesity.html

United States Department of Health and Human Services (USHHS) (2001). *The surgeon general's call to action to prevent and decrease overweight and obesity*. Retrieved from http://nepc.colorado.edu/files/CERU-0112-81-OWI.pdf

United States Environmental Protection Agency (USEPA). (2003). *Drinking water advisory: consumer acceptability advice and health effects analysis on sodium* (EPA Publication No. EPA822-R-03-006). Washington, DC: U. S. Government Printing Office.

United States Environmental Protection Agency (EPA) (2009). *Drinking water costs and federal funding*. Retrieved from http://water.epa.gov/lawsregs/guidance/sdwa/upload/2009_08_28_sdwa_fs_30ann_dwsrf_web.pdf

United States Environmental Protection Agency (EPA) (2013). *EPA's 2011 drinking water infrastructure needs survey and assessment*. Retrieved from http://water.epa.gov/grants_funding/dwsrf/upload/epa816f13001.pdf

United States Environmental Protection Agency (EPA) (2005). *Lead and copper rule: a quick reference guide for schools and child care facilities that are regulated under the safe drinking water act.* Retrieved from http://www.epa.gov/ogwdw/schools/pdfs/lead/qrg_lcr_schools.pdf

United States Environmental Protection Agency (EPA) (2013b). *Plastics: wastes – resource conservation – common wastes and materials.* Retrieved from http://www.epa.gov/osw/conserve/materials/plastics.htm

United States Environmental Protection Agency (EPA) (2013c). *Secondary drinking water regulations: guidance for nuisance chemicals.* Retrieved from http://water.epa.gov/drink/contaminants/secondarystandards.cfm

United States Environmental Protection Agency (EPA) (2005). *Water health series: bottled water basics.* Retrieved from http://www.epa.gov/safewater/faq/pdfs/fs_healthseries_bottlewater.pdf

United States Environmental Protection Agency (EPA) (2009). *Water on tap: what you need to know*. Retrieved from http://water.epa.gov/drink/guide/upload/book_waterontap_full.pdf

United States Environmental Protection Agency - Office of Ground Water and Drinking Water (n.d.). *Electronic code of federal regulations*. [40 CFR 141-143] Retrieved from http://www.ecfr.gov/cgi-bin/text-idx?c=ecfr&tpl=/ecfrbrowse/Title40/40cfr131_main_02.tpl

United States Food and Drug Administration (2015). *Code of Federal Regulations* [21 CFR 21 2 165.110]. Retrieved from http://www.accessdata.fda.gov/scripts/cdrh /cfdocs/cfcfr/CFRSearch.cfm?fr=165.110

United States Preventive Services Task Force (2005). Screening and interventions for overweight in children and adolescents: recommendation statement. *Pediatrics, 116*(1), 2005-2009.

Van Horn, L. (2010). Development of the 2010 U.S. dietary guidelines advisory committee report: perspectives from a registered dietician. *Journal of the American Dietetic Association, 110*(11), 1638-1645.

Viola, P., & Jones, M. (2001). Rapid object detection using a boosted cascade of simple features. In *FaceReader methodology white pater*. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition. Kauai, HI. Retrieved from http://www.noldus.com/human-behavior-research/products/facereader

Walsh, A. M., Duncan, S. E., Potts, H., & Gallagher, D. L. (2015). Comparing quality and emotional responses as related to acceptability of light-induced oxidation flavor in milk. *Food Research International. 76*, 293 – 300.

Warrenburg, S. (2005). Effects of fragrance on emotions: moods and physiology. *Chemical Senses, 30*, i248 – i249, doi:10.1093/chemse/bjh208.

Wassener, B. (2011). How to rid the seas of 'plastic soup'?. *The New York Times*. Retrieved from http://green.blogs.nytimes.com/2011/05/23/pity-the-oceans-vast-stews-of-plastic-soup/?_r=0.

Wendin, K., Allesen-Holm, B. H., & Bredie, L. P. (2011). Do facial reactions add new dimensions to measuring sensory responses to basic tastes? *Food Quality and Preference, 22*, 346-354

Westcott, K. (2013). Is there really a north-south water taste divide? *BBC News*. Retrieved from http://www.bbc.co.uk/news/magazine-22247668.

West D. S., Bursac, Z., Qiumby, D., Prewitt, T. E., Spatz, T., Nash, C., Mays, G. & Eddings, K. (2006). Self-reported sugar-sweetened beverage intake among college students. *Obesity, 14*(10, 1825-1831.

Whelton, A .J., Dietrich, A. M., Burlingame, G. A., Schechs, M., Duncan, S. E. (2007a). Minerals in drinking water: impact on taste and importance to consumer health. *Water Science and Technology, 55*(5), 283-291.

Whelton, A .J., Dietrich, A. M., Gallagher, D. L., and Roberson, J. A. (2007b). Using customer feedback for improved water quality and infrastructure monitoring. *Journal American Water Works Association, 99*(11), 62-76.

Williams, M. (2013). *EPA: the united states needs $384 billion in drinking-water infrastructure improvements.* Retrieved from http://www.mountainx.com/article/50422/EPA-The-United-States-needs-384-billion-in-drinking-water-infrastructure-improvements

World Health Organization (WHO) (2004). *Guidelines for Drinking-Water Quality Vol. 1* (3rd ed.). Genvea, Switzerland: WHO.

Zoellner, J., Estabrooks, P. A., Davy, B. M., Chun, Y., & You, W. (2012). Exploring the theory of planned behavior to explain sugar-sweetened beverage consumption. *Journal of Nutrition Education and Behavior, 44,* 172-177.

Zoellner, J., Krzeski, E., Harden, S., Cook, E., Allen, K., & Estabrooks, P. A. (2012). Qualitative application of the theory of planned behavior to understand beverage consumption behaviors among adults. *Journal of the Academy of Nutrition and Dietetics, 112*(11), 1774-1784.

CHAPTER III

Protocol for Data Collection and Analysis Applied to Automated Facial Expression Analysis Technology and Temporal Analysis for Sensory Evaluation

**This manuscript has been accepted for publication in the Journal of Visualized Experiments, (March 1, 2016). The focus of this methodology paper is in helping the reader follow the steps in setting up for success in video capturing facial expressions, the subsequent automated facial expression analyses and evaluating population differences and temporal effects that food stimuli may have on implicit emotions.*

Abstract

We demonstrate a method for capturing emotional response to beverages and liquefied foods in a sensory evaluation laboratory using automated facial expression analysis (AFEA) software. Additionally, we demonstrate a method for extracting relevant emotional data output and plotting the emotional response of a population over a specified time frame. By time pairing each participant's treatment response to a control stimulus (baseline), the overall emotional response over time and across multiple participants can be quantified. AFEA is a prospective analytical tool for assessing unbiased response to food and beverages. At present, most research has mainly focused on beverages. Methodologies and analyses have not yet been standardized for the application of AFEA to beverages and foods; however, a consistent standard methodology is needed. Optimizing video capture procedures and resulting video quality aids in a successful collection of emotional response to foods. Furthermore, the methodology of data analysis is novel for extracting the pertinent data relevant to the

emotional response. The combinations of video capture optimization and data analysis will aid in standardizing the protocol for automated facial expression analysis and interpretation of emotional response data.

1. Introduction

Automated facial expression analysis (AFEA) is a prospective analytical tool for characterizing emotional responses to beverages and foods. Emotional analysis can add an extra dimension to existing sensory science methodologies, food evaluation practices, and hedonic scale ratings typically used both in research and industry settings. Emotional analysis could provide an additional metric that reveals a more accurate response to foods and beverages. Hedonic scoring may include participant bias due to failure to record reactions (De Wijk, Kooijman, Verhoeven, Holthuysen & De Graaf, 2012).

AFEA research has been used in many research applications including computer gaming, user behavior, education/pedagogy, and psychology studies on empathy and deceit. Most food-associated research has focused on characterizing emotional response to food quality and human behavior with food. With the recent trend in gaining insights into food behaviors, a growing body of literature reports use of AFEA for characterizing the human emotional response associated with foods, beverages, and odorants (De Wijk et al., 2012; De Wijk, He, Mensink, Verhoeven, & De Graaf, 2014; He, Boesveldt, De Graaf, & De Wijk, 2012; He, Boesveldt, De Graaf, & De Wijk, 2014; Danner, Sidorkina, Joechl, & Duerrschmid, 2014; Danner, Haindl, Joechl, & Duerrschmid, 2014; Arnade, 2013; Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015; Crist , Arnade, Leitch, Duncan, O'Keefe, Dunsmore, & Gallagher, 2014; Garcia-Burgos & Zamora, 2013; Garcia-Burgos & Zamora, 2015; Lewinski, Fransen, & Tan, 2014).

AFEA is derived from the Facial Action Coding System (FACS). The facial action coding system (FACS) discriminates facial movements characterized by action units (AUs) on a 5-point intensity scale (Ekman & Friesen, 1978). The FACS approach requires trained review experts, manual coding, significant evaluation time, and provides limited data analysis options. AFEA was developed as a rapid evaluation method to determine emotions. AFEA software relies on facial muscular movement, facial databases, and algorithms to characterize the emotional response (Viola & Jones, 2001; Sung, & Poggio, 1998; Noldus Information Technology, 2014ab; Cootes & Taylor, 2000; Bishop, 1995). The AFEA software used in this study reached a "FACS index of agreement of 0.67 on average on both the Warsaw Set of Emotional Facial Expression Pictures (WSEFEP) and Amsterdam Dynamic Facial Expression Set (ADFES), which is close to a standard agreement of 0.70 for manual coding" (Lewinski, den Uyl & Butler, 2014) . Universal emotions included in the analysis are happy (positive), sad (negative), disgusted (negative), surprised (positive or negative), angry (negative), scared (negative) and neutral each on a separate scale of 0 to 1 (0=not expressed; 1=fully expressed) (Noldus Information Technology, 2014ab). In addition, psychology literature includes happy, surprised, and angry as "approach" emotions (toward stimuli) and sad, scared, and disgusted as "withdrawal" emotions (away from aversive stimuli) (Alves, Fukusima, & Aznar-Casanova, 2008).

One limitation of the current AFEA software for characterizing emotions associated with foods is interference from facial movements associated with chewing and swallowing as well as other gross motor motions, such as extreme head movements. The software targets smaller facial muscular motions, relating position and degree of movement, based on over 500 muscle points on the face (Noldus Information Technology, 2014ab; Cootes & Taylor, 2000). Chewing motions interfere with classification of expressions. This limitation may be addressed using liquefied foods.

However, other methodology challenges can also decrease video sensitivity and AFEA analysis including data collection environment, technology, researcher instructions, participant behavior, and participant attributes.

A standard methodology has not been developed and verified for optimal video capture and data analysis using AFEA for emotional response to foods and beverages in a sensory evaluation laboratory setting. Many aspects can affect the video capture environment including lighting, shadowing due to lighting, participant directions, participant behavior, participant height, as well as, camera height, camera angling, and equipment settings. Moreover, data analysis methodologies are inconsistent and lack a standard methodology for assessing emotional response. Here, we will demonstrate our standard operating procedure for capturing emotional data and processing data into meaningful results using beverages (flavored milk, unflavored milk and unflavored water) for evaluation. To our knowledge only one peer reviewed publication, from our lab group, has utilized time series for data interpretation for emotions analysis (Leitch et al., 2015); however, the method has been updated for our presented method. Our aim is to develop an improved and consistent methodology to help with reproducibility in a sensory evaluation laboratory setting. For demonstration, the objective of the study model is to evaluate if AFEA could supplement traditional hedonic acceptability assessment of flavored milk, unflavored milk and unflavored water. The intention of this video protocol is to help establish AFEA methodology, standardize video capture criteria in a sensory evaluation laboratory (sensory booth setting), and illustrate a method for temporal emotional data analysis of a population.

2. Protocol

Ethics Statement: This study was pre-approved by Virginia Tech Institutional Review Board (IRB) (IRB 14-229) prior to starting the project.

Caution: Human subject research requires informed consent prior to participation. In addition to IRB approval, consent for use of still or video images is also required prior to releasing any images for print, video, or graphic imaging. Additionally, food allergens are disclosed prior to testing. Participants are asked prior to panel start if they have any intolerance, allergies or other concerns.

Note: Exclusion Criteria: Automated facial expression analysis is sensitive to thick framed glasses, heavily bearded faces and skin tone. Participants who have these criteria are incompatible with software analysis due to an increased risk of failed videos. This is attributed to the software's inability to find the face.

1. Sample Preparation and Participant Recruitment

1.1) Prepare beverage or soft food samples.

1.1.1) Prepare intensified dairy solutions using 2% milk and suggested flavors from Costello and Clark (2009) as well as other flavors. Prepare the following solutions: (1) unflavored milk (2% reduced fat milk); (2) unflavored water (drinking water); (3) vanilla extract flavor in milk (0.02g/ml) (imitation clear vanilla flavor); and (4) salty flavor in milk (0.004g/ml iodized salt).

Note: These solutions are used for demonstration purposes only.

1.1.2) Pour half ounce aliquots (~15g) of each solution into 2 oz. transparent plastic sample cups and cap with color coded lids.

Note: It is recommended to use transparent cups; however, it is up to the researcher's discretion.

1.2) Recruit participants from the campus or the local community to participate in the study.

Note: Participant sample size needed for a study is up to the discretion of the researcher. We recommend a range of 10 to 50 participants.

1.3) Obtain human subject consent prior to participation in the study.

2. Preparation of Panel Room for Video Capture

Note: This protocol is for data capture in a sensory evaluation laboratory. This protocol is to make AFEA data capture useful for a sensory booth setting.

2.1) Use individual booths with a touchscreen monitor in front of them (face level) to keep their focus forward and to prevent looking down.

2.2) Use adjustable height chairs with back support.

Note: These are essential for allowing participants to be vertically adjusted and placed in a suitable range for video capture. Use stationary chairs (no rolling feature) with adjustable back height support so the participant's movements are reduced.

2.3) Set overhead lighting at "100% daylight" for optimal facial emotional video capture (Illuminant 6504K; R=206; G=242; B=255).

Note: To avoid intense shadowing, diffuse frontal lighting is ideal while the light intensity or color is not as relevant (Noldus Information Technology, 2014ab). Ultimately, it is up to the discretion of the researcher, individual protocol/methodology, and environment to control lighting for capture.

2.4) Affix an adjustable camera above the touchscreen monitor for recording.

2.4.1) Use a camera with a resolution of at least 640 x 480 pixels (or higher) (Noldus Information Technology, 2014ab). Discuss the required camera capabilities with the software provider before purchase and installation (Noldus Information Technology, 2014ab). Note: The aspect ratio is not important (Noldus Information Technology 2014ab).

2.4.2) Set camera capture speed to 30 frames per second (or other standard speed) for consistency.

2.4.3) Connect and ensure media recording software is set up to the camera to record and save participant videos.

3. Participant Adjustment and Verbal Directions

3.1) Have only one participant at a time evaluate the samples in the sensory booth.

Note: Testing more than one participant at the same time may interfere with the testing environment and disrupt the concentration of the participant or create bias.

3.2) Upon arrival, give participants verbal instructions about the process and standard operating procedures.

3.2.1) Have the participants sit straight up and against the back of the chair.

3.2.2) Adjust chair height, position of the chair (distance from the camera), and camera angle so that the participant's face is captured in the center of the video recording, with no shadows on chin or around eyes.

Note: In the sensory booth, the participant's head is roughly 20 inches – 24 inches away from the camera and the monitor with the face centered in the camera video feed.

3.2.3) Instruct participants to remain seated as positioned and focused facing towards the monitor display. Additionally, instruct participants to refrain from any sudden movements post-sample consumption during the 30 second evaluation period per sample.

3.2.4) Instruct the participant to consume the entire beverage or liquefied food sample and swallow.

3.2.5) Instruct the participant to quickly move the sample cup below the chin and down to the table immediately after the sample is in the mouth. This is to eliminate facial occlusion. Remind them to keep looking toward the monitor.

Note: The sample carrier to deliver the sample is up to the discretion of the researcher. A straw or cup may be used. Regardless, initial facial occlusion is unavoidable because the face will be occluded or distorted due to consumption.

3.3) Instruct the participant to follow the instructions as they appear on the touchscreen monitor. Note: Instructions are automatically sequenced as programmed into the automated sensory software.

4. Individual Participant Process for Video Capture

4.1) Confirm video camera is optimally capturing participant’s face while the participant is seated comfortably in the booth (before sample presentation) by viewing the computer monitor on which the video capture is displayed. Begin recording by clicking the record button on the computer monitor.

4.2) Instruct participants to sip water to cleanse their palate.

4.3) Provide treatments one at a time, starting with a baseline or control treatment (unflavored water). Identify each sample by a unique colored index card placed on top of each sample relating to the sample color code for sample treatment identification within the video.

Note: Programmed guidance on the touchscreen monitor instructs participants. The instructions direct the participant through a series of standardized steps for each treatment sample.

4.4) Via the touchscreen monitor, direct the participant to:

4.4.1) Hold up the associated color index card pre-consumption for sample identification in the video.

Note: The color card is a way researchers can identify treatments in the video and mark the appropriate time frame (time zero) for sample evaluation.

4.4.2) After holding the card briefly, place the card back on the tray.

4.4.3) Fully consume the sample and wait approximately 30 seconds, enforced through the programmed guidance on the monitor, while facing towards the camera.

Note: The 30 second controlled sampling period encompasses a time span adequate for the entire sampling evaluation period (i.e. showing the index card, opening a sample (removing the lid), consumption, and emotional capture).

4.4.4) Enter their hedonic acceptability score on the touchscreen monitor (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5=neither like nor dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=like extremely).

4.4.5) Rinse mouth with drinking water before the next sample process.

5. Evaluating Automated Facial Expression Analysis Options

Note: Many facial expression analysis software programs exist. Software commands and functions may vary. It is important to follow the manufacturer's user guidelines and reference manual (Noldus Information Technology, 2014ab).

5.1) Save recordings in a media format and transfer to the automated facial expression analysis software.

5.2) Analyze participant videos using automated facial analysis software.

5.2.1) Double click on the software icon on the computer desktop.

5.2.2) Once the program is open, click “File”, select “New…”, and select “Project…”

5.2.3) In the pop up window, name the project and save the project.

5.2.4) Add participants to the project by clicking the “Add participants” icon (Person with a (+) sign). More participants can be added by repeating this step.

5.2.5) Add participant’s video to the respective participant for analysis.

5.2.5.1) On the left side of the screen click the icon of the film reel with a plus (+) sign to add a video to analyze.

5.2.5.2) Click the “magnifying glass” under the participant of interest to browse the video to add.

5.3) Analyze videos frame-by-frame under continuous calibration analysis settings in the software.

5.3.1) Click the pencil icon to adjust settings at the bottom of the window, under the “settings” tab for each participant video.

5.3.1.1) Set “Face Model” to General. Set “Smoothen classifications” to Yes. Set “Sample Rate” to Every frame.

5.3.1.2) Set “Image rotation” to No. Set “Continuous calibration” to Yes. Set “Selected calibration” to None.

5.3.2) Save project settings.

5.3.3) Press the batch analysis icon (the same red and black target-like symbol) near the bottom of the screen to analyze the project videos.

5.3.4) Save the results once analysis is completed.

Note: Other video settings exist in the software if researcher preference warrants another analysis method.

5.3.5) Consider videos failures if serious facial occlusions or the inability to map the face persists during the specified post-consumption window (Figure 3.1). Additionally, if the model fails data will say “FIT_FAILED” or “FIND_FAILED” in the exported output files (Figure 3.2). This represents lost data since the software cannot classify or analyze the participant’s emotions.

Note: AFEA translates facial muscle motion to neutral, happy, disgusted, sad, angry, surprised and scared on a scale from 0 (not expressed) to 1 (fully expressed) for each emotion.

5.4) Export the AFEA data output as log files (.txt) for further analysis.

5.4.1) Once analyses are complete, export the whole project.

5.4.1.1) Click “File”, “Export”, “Export Project Results”.

5.4.1.2) When a window opens, choose the location of where the exports should be saved and save the log files (.txt) to a folder.

5.4.1.3) Convert each participant log life to a data spreadsheet (.csv or .xlsx) to extract relevant data.

5.4.1.3.1) Open data spreadsheet software and select the “Data” tab.

5.4.1.3.2) On the “Data” tab, in the “Get External Data” group, click “From Text”.

5.4.1.3.3) In the “Address bar”, locate, double-click the participant text file to import, and follow the on screen wizard instructions.

5.4.1.3.4) Continue the export process for all relevant participant files.

6. Timestamp Participant Videos for Data Analysis

6.1) Using the AFEA software, manually review each participant's video and identify post-consumption time zero for each sample. Record the timestamp in a data spreadsheet. Post-consumption is defined when the sample cup is below the participant's chin and no longer occludes the face.

Note: The placement of the timestamp is critical for evaluation. The point where the cup no longer occludes the face is the optimal recommendation and timestamps need to be consistent for all participants.

6.2) Save the timestamp data spreadsheet (.csv) as a reference for extracting relevant data from videos.

Note: Participant videos may also be coded internally in the software as "Event Marking".

7. Time Series Emotional Analysis

Note: Consider the "baseline" to be the control (i.e. unflavored water in this example). The researcher has the ability to create a different "baseline treatment stimulus" or a “baseline time without stimulus” for paired comparison dependent on the interests of the investigation. The method proposed accounts for a “default” state by using a paired statistical test. In other words, the procedure uses statistical blocking (i.e. a paired test) to adjust for the default appearance of each participant and therefore reduces the variability across participants.

7.1) Extract relevant data from the exported files (.csv or .xlsx).

7.1.1) Identify a time frame relevant to the study evaluation (seconds).

7.1.2) Manually extract respective data (time frame) from the exported participant files consulting the participant timestamp (time zero).

7.1.3) Compile each participant’s treatment data (participant number, treatment, original video time, and emotion response) per emotion (happy, neutral, sad, angry, surprised, scared, and disgusted) for the select time frame (seconds) in a new data spreadsheet for future analysis (Figure 3.3).

7.1.4) Continue this process for all participants.

7.2) Identify the corresponding time zero from the timestamp file for each participant-treatment pair and adjust video time to a true time “0” for direct comparison (Figure 3.4, Figure 3.5).

Note: Participant data is collected in a continuous video therefore each treatment "time zero" is different (i.e. unflavored water video time zero is 02.13.5 and unflavored milk video time zero is 03:15.4) in Figure 3.4. Due to the different treatment "time zeroes", the video times need to be readjusted and realigned to start at "0:00.0" or other standard start time in order for direct time comparison of treatment emotional response data.

7.3) For each participant, emotion, and adjusted time point, extract the paired treatment (e.g. unflavored milk) and control treatment (e.g. unflavored water) quantitative emotional score. In other words, align a participant's treatment and control time series of responses for each emotion (Figure 3.5).

7.4) Compile all participant's information (participant, adjusted time, and paired treatment (e.g. unflavored water and unflavored milk) at each time point (Figure 3.6).

Note: The steps below demonstrate the steps for a paired Wilcox test by hand. Most data analysis software programs will do this automatically. It is recommended to discuss the statistical analysis process with a statistician.

7.5) Once the samples are reset and aligned with new adjusted video times, directly compare between the emotional results of a respective sample and the control (unflavored water) using sequential paired nonparametric Wilcoxon tests across the participants (Figure 3.7).

Note: The new time alignment of the samples will allow for direct comparison within the 5 seconds post-consumption time frame. If a paired observation is not present in a treatment, drop the participant from that time point comparison.

7.5.1) Calculate the difference between the control and the respective sample for each paired comparison using data spreadsheet management software.

Note: The comparison will be dependent on the frame rate selected for emotional analysis in the software. The protocol demonstrates 30 individual comparisons per second for 5 seconds (selected time frame).

Note: Use Figure 3.7 as a reference for columns and steps.

7.5.1.1) Subtract the value of milk (e.g. unflavored milk) from the value of the control (e.g. unflavored water) to determine the difference. In the data spreadsheet management software in a new column titled "Treatment Difference", enter "=(C2)–(D2)", where "C2" is the control emotional values and "D2" is the selected treatment emotional values. Continue this process for all time points.

7.5.1.2) Calculate the absolute value of the treatment difference. In the data spreadsheet management software in a new column, enter "=ABS(E2)", where "E2" is the Treatment Difference. Continue this process for all time points.

7.5.1.3) Determine the rank order of the treatment difference. In the data spreadsheet management software in a new column, enter “=RANK(G2, $G$2:$G$25, 1)” where “G2” is the Absolute Difference and “1” is “ascending”. Continue this process for all time points.

7.5.1.4) Determine the signed rank of the rank order on the spreadsheet. Change the sign to negative if the treatment difference was negative (Column I).

7.5.1.5) Calculate the positive sum (=SUMIF(I2:I25, ">0", I2:I25) and negative sum =SUMIF(I2:I25,"<0",I2:I25) of the rank values.

7.5.1.6) Determine the test statistic. The test statistic is the absolute value lower sum.

7.5.1.7) Consult statistical tables for Wilcoxon Signed Ranked Test Statistic using the number of observations included at the specific time and a selected alpha value to determine the critical value.

7.5.1.8) If the test statistic is less than the critical value reject the null hypothesis. If it is greater, accept the null hypothesis.

7.6) Graph the results on the associated treatment graph (i.e. unflavored milk compared to unflavored water) for the times when the null hypothesis is rejected. Use the sign of the difference to determine which treatment has the greater emotion (Figure 3.8).

7.6.1) In the data spreadsheet management software, create a graph using the values of presence or absence of significance.

7.6.1.1) Click “Insert” tab.

7.6.1.2) Select “Line”

7.6.1.3) Right click on the graph box.

7.6.1.4) Click “select data” and follow the screen prompts to select and graph relevant data (Figure 3.8).

Note: The graphs will portray emotional results where the sample or control is higher and significant. Graph dependent, the emotion is higher at that specific time allowing the ability to discern how participant’s emotions evolve over the 5 second time period between two samples.

Note: Statistical support with a statistician is highly recommended to extract relevant data. Development of statistical coding is required to analyze emotional results.

3. Representative Results

The method proposes a standard protocol for AFEA data collection. If suggested protocol steps are followed, unusable emotional data output (Figure 3.1) resulting from poor data collection (Figure 3.2: A; Left Picture) may be limited. Time series analysis cannot be utilized if log files (.txt) predominantly contain “FIT_FAILED” and “FIND_FAILED” as this is bad data (Figure 3.1). Furthermore, the method includes a protocol for direct statistical comparison between two treatments of emotional data output over a time frame to establish an emotional profile. Time series analysis can provide emotional trends over time and can provide a value-added dimension to hedonic acceptability results. Additionally, time series analysis can show changes in emotional levels over time, which is valuable during the eating experience.

Unflavored milk, unflavored water and vanilla extract flavor in milk were not different ($p>0.05$) in mean acceptability scores and were rated as “liked slightly” (Figure 3.9). Hedonic results infer that there were not any acceptability differences between unflavored milk, unflavored water and vanilla extract flavor in milk. However, AFEA time series analysis indicated unflavored milk generated less disgusted ($p<0.025$; 0 sec), surprised ($p<0.025$; 0-2.0 sec), less sad ($p<0.025$; 2.0-2.5 sec) and less neutral ($p<0.025$; ~3.0-3.5 sec) responses than did unflavored water (Figure 3.10). Additionally, vanilla extract flavor in milk introduced more happy expressions just before 5.0 seconds ($p<0.025$) and less sad ($p<0.025$; 2.0-3.0 and 5.0 sec) than unflavored water (Figure 3.11). Vanilla, as an odor, has been associated with the terms “relaxed”, “serene”, “reassured”, “happiness”, “well-being”, “pleasantly surprised” (Porcherot, Delplanque, Ravior-Derrien, Le Calve’, Chrea, Gaudreau, & Cayeux, 2010) and “pleasant” (Warrenburg, 2005). Salty flavor in milk had lower ($p<0.05$) mean hedonic acceptability scores (disliked moderately) (Figure 3.9) and salty flavor in milk generated more disgust ($p<0.025$) later (3.0-5.0 sec) than unflavored water (Figure 3.12). Intense salty has been associated with disgust and surprise (Bredie, Tan, & Wendin, 2014; Wendin, Allesen-

Holm, & Bredie, 2011). However, some studies have stated that salty flavor does not elicit facial response (Arnade 2013; Rosenstein, & Oster, 1988; Rosenstein, & Oster, 1997; Rozin, & Fallon, 1987).

Figure Legends

Figure 3.1: Example of sub-optimal data capture due to participant incompatibility with AFEA software resulting in loss of raw emotional data response points in the exported output files [FIT_FAILED; FIND_FAILED]. Video failures occur when serious facial occlusions or the inability to map the face persists during the specified post-consumption window.

Figure 3.2: Example of sub-optimal data capture due to participant software modeling. The figure presents sub-optimal data capture due to participant software modeling incompatibility and failure of face mapping to determine emotional response (**A**). Example of successful fit modeling and ability to capture participant's emotional response (**B**).

Figure 3.3: Example of extracted participant data compiled in a new data spreadsheet. Participant data (participant number, treatment, original video time, and emotion response) is identified per emotion (happy, neutral, sad, angry, surprised, scared, and disgusted) for the select time frame (seconds). This spreadsheet is utilized for subsequent analyses.

Figure 3.4: Example of extracted participant data compiled for subsequent analysis. The extracted participant data (**A1 and B1**) is compiled (**A2 and B2**), graphed (**A3 and B3**) and aligned (**A4 and B4**) as a visual for direct comparison. The respective time zero for control (**A4: Surprised Unflavored Water**) and treatment (**B4: Surprised Unflavored Milk**) are displayed for comparing the surprised emotional results. This example represents and identifies the corresponding time zero from the timestamp file for each participant-treatment pair.

Figure 3.5: Example of extracted participant data with adjusted time frame. The extracted participant data is presented with adjusted time frame with a true "time zero" (**A1 and B1).** The time adjustment allows for direct comparison between a control (**A: Surprised Unflavored Water**) and a treatment **(B2: Surprised Unflavored Milk**) (**A2 and B2**). This example represents and identifies the corresponding true "time zero" (adjusted) from the timestamp file for each participant-treatment pair.

Figure 3.6: Example of the process for compiling all participants' data. The participant, adjusted time, and paired treatment (e.g. unflavored water and unflavored milk) at each time point is compiled to prepare for statistical analysis.

Figure 3.7: Data spreadsheet example comparing a control (Unflavored Water) and a treatment (Unflavored Milk) using Wilcoxon tests across participants at a specific time point. The figure represents direct comparison between the emotional results of a

respective sample and the control (unflavored water) using sequential paired nonparametric Wilcoxon tests across the participants.

Figure 3.8: Example of the data spreadsheet to graph the results if ($p<0.025$) on the associated treatment graph (i.e. unflavored milk compared to unflavored water). Results of sequential paired nonparametric Wilcoxon tests across the participants are graphed for the times where the null hypothesis is rejected.

Figure 3.9: Mean acceptability (hedonic) scores of unflavored water, unflavored milk, vanilla extract flavor in milk and salty flavor in milk beverage solutions. Acceptability was based on a 9-point hedonic scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely; mean +/- SD) (1). Treatment means with different superscripts significantly differ in liking ($p<0.05$). Unflavored milk, unflavored water and vanilla extract flavor in milk were not different ($p>0.05$) in mean acceptability scores and were rated as "liked slightly". Salty flavor in milk had a lower ($p<0.05$) mean acceptability scores (disliked moderately).

Figure 3.10: Time series graphs of classified emotions on automated facial expression analysis data over 5.0 seconds comparing unflavored milk and unflavored water. Based on sequential paired nonparametric Wilcoxon tests between unflavored milk and unflavored water (baseline), results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion. Presence of a line indicates a significant difference ($p<0.025$) at the

specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$). Absence of lines in unflavored milk **(A)** reveals no emotional categorization compared to unflavored water ($p<0.025$) over 5.0 seconds. In the unflavored water **(B)**, emotional results compared to unflavored milk reveal disgusted (crimson line) at 0 sec, surprised (orange line) occurs between 0 – 1.5 sec, sad (green line) occurs around 2.5 sec, and neutral (red line) occurs around 3 – 3.5 sec ($p<0.025$).

Figure 3.11: Time series graphs of classified emotions based on automated facial expression analysis data over 5.0 seconds comparing vanilla extract flavor in milk and unflavored water (baseline). Based on sequential paired nonparametric Wilcoxon tests between vanilla extract flavor in milk and unflavored water, results are plotted on the respective treatment graph if treatment median is higher and of greater significance ($p<0.025$) for each emotion. Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$). Vanilla extract flavor in milk **(A)** shows happy just before 5 sec (blue line) while unflavored water **(B)** displays more sad around 2 – 2.5 and 5 sec (green line) ($p<0.025$).

Figure 3.12: Time series graphs of classified emotions based on automated facial expression analysis data over 5.0 seconds comparing salty flavor in milk and unflavored water. Based on sequential paired nonparametric Wilcoxon tests between salty flavor in milk and unflavored water (baseline), results are plotted on the respective

treatment graph if treatment median is higher and of greater significance ($p<0.025$) for each emotion. Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$). Salty flavor in milk **(A)** has significant disgust from 3 – 5 seconds (crimson line) while unflavored water **(B)** has disgust at the beginning (crimson line) and more neutral from 2 – 5 seconds (red line) ($p<0.025$).

4. Discussion

AFEA application in literature related to food and beverage is very limited (De Wijk et al., 2012; De Wijk et al., 2014; He et al., 2012; He et al., 2014; Danner et al., 2014; Danner et al., 2014; Arnade 2013; Leitch et al., 2015; Crist et al., 2014; Garcia-Burgos & Zamora 2013; Garcia-Burgos & Zamora 2015). The application to food is new, creating an opportunity for establishing methodology and data interpretation. Arnade (2013) found high individual variability among individual emotional response to chocolate milk and white milk using area under the curve analysis and analysis of variance. However, even with participant variability, participants generated a happy response longer while sad and disgusted had shorter time response (Arnade 2013). In a separate study using high and low concentrations of basic tastes, Arnade (2013), found that the differences in emotional response among basic tastes as well as between two levels of basic taste intensities (high and low intensity), were not as significant as expected, thereby questioning the accuracy of current AFEA methodology and data analysis. Sensory evaluation of foods and beverages is a complex and dynamic response process (Delarue, & Blumenthal, 2015). Temporal changes can occur throughout oral processing and swallowing thus potentially influencing the acceptability of the stimuli over time (Delarue & Blumenthal 2015). For this reason, it may beneficial to measure evaluator response throughout the entire eating experience. Specific oral processing times have been suggested (initial contact with tongue, mastication, swallowing, etc.)(Sudre, Pineau, Loret, & Marin, 2012), but none are standardized and times are largely dependent on the project and the researcher's discretion (Delarue & Blumenthal, 2015).

The proposed emotional time series analysis was able to detect emotional changes and statistical differences between the control (unflavored water) and respective treatments. Moreover, emotional profiles associated with acceptability may aid in anticipating behavior related to foods and beverages. Results show that distinguishable time series trends exist with AFEA related to flavors in milk (Figure 3.10, 3.11, and 3.12). The time series analysis assists in differentiating food acceptability across a population by integrating characterized emotions (Figure 3.10, 3.11, and 3.12) as well as supporting hedonic acceptability trends (Figure 3.9). Leitch et al. (2015) observed differences between sweeteners and the water baseline using time series analysis (5 sec), and also found that the utilization of time series graphs provided for better interpretation of data and results. Moreover, emotional changes can be observed over time and emotional response treatment differences may be determined at different time points or intervals. For example, Leitch et al. (2015) observed that the approach emotions (angry, happy and surprised) were observed between the artificial sweetener-water comparisons but were observed at different times over the 5 sec observation window. However, Leitch et al. (2015) did not establish directionality of expression, making it difficult to understand the emotional difference between the control (water) and the treatment (unsweetened tea) using their graphical interpretation and presentation. The modified and improved time series analysis methodology presented in our study allows for statistical difference directionality. The directionality and results plotting allows researchers to visualize where statistically relevant emotional changes occur over the selected time frame.

Reducing video analysis failures is essential for attaining valid data and effectively using time and personnel resources. Critical steps and troubleshooting steps in the protocol include optimizing the participant sensory environment (lighting, video camera angle, chair height, thorough participant guidance instructions, etc.) Also, participants should be screened and excluded if they fall into a software incompatibility category (i.e. thick framed glasses, heavily bearded faces and skin tone) (Figure 2). These factors will influence AFEA fit modeling, emotional categorization, and data output. If a significant portion of a participant's data output consists of "FIT_FAILED" and "FIND_FAILED", data should be reevaluated for inclusion in the time series analysis (Figure 3.1). Time series analysis cannot be utilized if data output log files predominantly contain "FIT_FAILED" and "FIND_FAILED" as this is bad data (Figure 3.1). Shadowing on the face due to lighting settings may severely inhibit video capture quality, resulting in poor video collection. To avoid intense shadowing, diffuse frontal lighting is ideal while the light intensity or color is not as relevant (Noldus Information Technology, 2014ab). Intense overhead lighting should be reduced as it can promote shadows on the face (Noldus Information Technology, 2014ab). A dark background behind the participant is recommended (Noldus Information Technology, 2014ab). It is suggested from the AFEA software manufacturer to place the setup in front of a window to have diffuse daylight lighting (Noldus Information Technology, 2014ab). Also, if using a computer monitor, two lights may be placed on either side of the user's face for illumination and shadow reduction (Noldus Information Technology, 2014ab). Additionally, professional photo lights may be used to counteract undesirable environment lighting (Noldus Information Technology, 2014ab). Ultimately, it is up to the discretion of the researcher, individual protocol/methodology, and environment to control lighting for capture. It is recommended to discuss the data capture environment and the tools with the software provider before purchase and installation. Furthermore, chair height and camera angle are important to adjust individually for each participant. The participant should be comfortable but at a height where the camera is straight on the face. An attempt to reduce the camera angle on the face is encouraged for optimizing the AFEA video capture. Lastly, it is imperative to give verbal instructions to the participants prior to sampling. Participant behavior during video capture may limit data collection due to facial occlusion, movements, and camera avoidance.

For participant sample size needed for a study, the authors recommend a range of 10 to 50 participants. Although a small number will provide almost no statistical power, at least 2 participants are needed in general for time series analysis. Participant variability is high, and in the early stages of this research there is no guidance to offer with sample size. Sample size will vary depending on flavors, flavor intensity, and expected treatment acceptability. Samples with smaller flavor differences will require more participants. The 30 second controlled sampling period encompasses a time span adequate for the entire sampling evaluation period (i.e. showing the index card, opening a sample (removing the lid), consumption, and emotional capture). The entire 30 seconds is not used in data analysis. The benefit of this designated 30 second capture time is that the researcher can decide the pertinent evaluation time to be used in data analysis. The 30 second time window can assist in selecting a time frame of interest during a video sample while coding or timestamping videos. Ultimately, the time window is up to the discretion of the researcher. In our example, we used the 5 sec sampling window post-consumption. Furthermore, the present methodology defines time zero when the sample cup no longer occludes the face (cup at the chin). It is critically important to lessen the time between consumption and sample cup facial occlusion due to brief and changing emotions. Due to sample cup facial occlusion the initial time where the sample makes contact with the tongue is unreliable data (see Figure 3.1). Therefore, the point where the cup no longer occludes the face is the optimal recommendation. Timestamps need to be consistent for all participants. The color card is a convenient way for researchers to identify treatments in the video and mark the appropriate time frame (time zero) for sample evaluation. The color cards are especially helpful if treatments are in random order and serve as an extra validation of sample identification in the continuous video.

Limitations of this technique exist as participants may not follow directions or unavoidable shadowing on the participant’s face may cause face fit model failures (Figure 3.2). However, the suggested critical steps offer ways to mitigate and reduce these interferences. Additionally, time series analysis will not read exported log files with files predominantly containing “FIT_FAILED” and “FIND_FAILED” (Figure 3.1). These file cannot be salvaged and will not be able to be included in time series analysis. Also, the consumption of food and beverages still may alter the facial structure in such a way to distort the emotional categorization. Hard or chewy foods require extensive jaw motion. Use of a drinking straw and associated sucking, also causes facial occlusion (straw) and distorts the face (sucking). This observation is based on preliminary data from our laboratory research. The software facial model cannot discern the differences between chewing (or sucking) and motor expressions associated with emotional categorization. With food and beverage samples, the opportunity for facial occlusion is higher than that of viewing videos and pictures. Participants must bring the sample to the face and remove the container from the face thus interrupting the software model and potentially reducing valuable emotional information (See Figure 3.1). As mentioned previously, emotions happen quickly and for a short duration. It is important to reduce the facial occlusion in an effort to capture emotions. The proposed methodology makes treatment comparisons at one thirtieth of a second to find changes in emotional patterns and changes in emotional duration across time. With the proposed methodology, patterns of emotional longevity are important. Unfortunately, emotional categorization problems can occur. Most notably there is a problem categorizing happy and disgust (Danner et al., 2014; Crist et al., 2014; Weiland, Ellgring, & Macht, 2010; Ekman 1972; Griemel, Macht, Krumhuber, & Ellgring, 2006). Oftentimes, this is due to participants masking their distaste or surprised feeling by smiling (Danner et al., 2014; Weiland et al., 2010; Ekman 1972; Griemel et al., 2006) that could be due to a "social display rule" (Weiland et al., 2010). Furthermore, the AFEA software is limited to seven emotional categories (neutral, happy, sad, scared, surprised, angry and disgusted). Emotional response to foods and beverages may be more complex than the current AFEA classification of universal emotions and categorization may be different in response to a food or beverage stimuli. Manual coding using FACS has been applied to gustofacial and olfactofacial responses of basic tastes and an assortment of odors and appeared to be sensitive enough to detect treatment differences in regards to AUs (Weiland et al., 2010). FACS is tedious and very time consuming, however, the temporal application of absence or presence of AUs may be useful to assist with complex responses that AFEA might not classify correctly or if emotional results are unexpected. While time series data allows for facial classifications to occur simultaneously and with significant expression, caution should be used with translating results into a single emotion due to emotional complexity.

The proposed methodology and data analysis technique may be applied to other beverages and soft foods. AFEA software was able to identify emotions to flavored and unflavored samples. The proposed methodology and temporal analysis may aid with characterizing implicit responses thereby providing new advances in emotional responses and behaviors of a population relating to food. Future applications of this technique may expand into other beverage categories or soft foods. We have demonstrated methodology to attain video capture for emotional response and data analysis methodology. We aim to create a standard approach for both emotional AFEA capture and emotional time series analysis. The method approach has shown success in our research. We hope to expand and apply this approach for evaluating emotional response to foods and beverages and the relationship to choice and behaviors.

Acknowledgements

This project was funded, in part, by ConAgra Foods (Omaha, NE, USA), the Virginia Agricultural Experiment Station, the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture, and the Virginia Tech Water INTERface Interdisciplinary Graduate Education Program.

References

Alves, N. T., Fukusima, S. S., Aznar-Casanova, J. A. (2008). Models of brain asymmetry in emotional processing. Psychology and Neuroscience, 1(1), 63 – 66, doi:10.3922/j.psns.2008.1.010.

Arnade, E. A. (2013). Measuring consumer emotional response to tastes and foods through facial expression analysis (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA.

Bishop, C. M. (1995). Neural networks for pattern recognition. New York, NY: Oxford University Press.

Bredie, W. L. P., Tan, H. S. G., Wendin, K. (2014). A comparative study on facially expressed emotions in response to basic tastes. Chemosensory Perception, 7(1), 1 – 9, doi: 10.1007/s12078-014-9163-6.

Cootes, T. & Taylor, C. (2000). Statistical models of appearance for computer vision. In FaceReader methodology white paper. University of Manchester, UK: Wolfson Image Analysis Unit, Imaging Science and Biomedical Engineering. Retrieved from http://www.noldus.com/human-behavior-research/products/facereader

Costello, M. & Clark, S. (2009).Preparation of samples for instructing students and staff in dairy products evaluation. In Clark, Stephanie, Costello, Michael, Drake, MaryAnne., & Bodyfelt, Floyd (Eds.), The sensory evaluation of dairy foods (2nd ed.), (pp. 551-560). New York, NY: Springer Publishing Co.

Crist, C. A., Arnade, E. A., Leitch, K. A., Duncan, S. E., O'Keefe, S., Dunsmore, J. & Gallagher, D. L. (2014). Application of emotional facial analysis technology to consumer acceptability using a basic tastes model. Technical Abstracts and Proceedings of the 2014 Institute of Food Technologists Annual Meeting, 2014 June 21 – 24, New Orleans, LA.

Danner, L., Haindl, S., Joechl, M., Duerrschmid, K. (2014). Facial expression and autonomous nervous system responses elicited by tasting different juices. Food Research International, 64, 81 – 90, doi: 10.1016/j.foodres.2014.06.003.

Danner, L., Sidorkina, L., Joechl, M., Duerrschmid, K. (2014). Make a face! implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. Food Quality and Preference, 32, 167-172, doi:10.1016/j.foodqual.2013.01.004.

De Wijk, R. A., He, W., Mensink, M. G. J., Verhoeven, R. H. G., De Graaf, C. (2014). ANS responses and facial expression differentiate between the taste of commercial breakfast drinks. PLoS ONE, 9(4), 1 – 9, doi:10.1371/journal.pone.0093823.

De Wijk, R. A., Kooijman, V., Verhoeven, R. H. G., Holthuysen, N. T. E., De Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. Food Quality and Preference, 26(2), 196 – 203, doi:10.1016/j.foodqual.2012.04.015.

Delarue, J. & Blumenthal, D. (2015). Temporal aspects of consumer preferences. Current Opinion in Food Science, 3, 41 – 46, doi:10.1016/j.cofs.2014.12.001.

Ekman, P. (1972). Universal and cultural differences in facial expressions of emotion. In Cole, James (Ed.), Nebraska symposium on motivation 1971 (pp. 207-284). Lincoln, NE: University of Nebraska Press.

Ekman, P. & Friesen, W. V. (1978). Facial action coding system: a technique for the measurement of facial movement. Palo Alto, CA: Consulting Psychologists Press.

Garcia-Burgos, D. & Zamora, M. C. (2015).Exploring the hedonic and incentive properties in preferences for bitter foods via self-reports, facial expressions and instrumental behaviours. Food Quality and Preference, 39, 73 – 81, doi:10.1016/j.foodqual.2014.07.003.

Garcia-Burgos, D. & Zamora, M. C. (2013). Facial affective reactions to bitter-tasting foods and body mass index in adults. Appetite, 71, 178 – 186, doi:10.1016/j.appet.2013.08.013.

Griemel, E., Macht, M., Krumhuber, E., Ellgring, H. (2006). Facial and affective reactions to tastes and their modulation by sadness and joy. Physiology and Behavior, 89(2), 261 – 269, doi:10.1016/j.physbeh.2006.06.002.

He, W., Boesveldt, S., De Graaf, C., De Wijk, R. A. (2012). Behavioural and physiological responses to two food odours. Appetite, 59(2), 628, doi:10.1016/j.appet.2012.05.071.

He, W., Boesveldt, S. De Graaf, C., De Wijk, R. A. (2014). Dynamics of autonomic nervous system responses and facial expressions to odors. Frontiers in Psychology, 5(110), 1 – 8, doi:10.3389/fpsyg.2014.00110.

Leitch, K. A., Duncan, S. E., O'Keefe, S., Rudd, R., Gallagher, D. L. (2015). Characterizing consumer emotional response to sweeteners using an emotion terminology questionnaire and facial expression analysis. Food Research International, 76, 283 – 292, doi: 10.1016/j.foodres.2015.04.039.

Lewinski, P., den Uyl, T. M., Butler, C. (2014). Automated facial coding: validation of basic emotions and FACS AUs in FaceReader. Journal of Neuroscience Psychology and Economics, 7(4), 227 – 236, doi: 10.1037/npe0000028.

Lewinski, P., Fransen, M. L., Tan, E. S .H. (2014). Predicting advertising effectiveness by facial expressions in response to amusing persuasive stimuli. Journal of Neuroscience Psychology and Economics, 7(1), 1 – 14, doi: 10.1037/npe0000012.

Noldus Information Technology (2014). FaceReader Reference Manual (6th ed.). Wageningen, Netherlands: Noldus Information Technology.

Noldus Information Technology (2014). FaceReader™ 5 Technical Specifications. Wageningen, Netherlands: Noldus Information Technology. Retrieved from http://www.webshop.noldus.com/media/techspec/facereader_techspec.pdf

Porcherot, C., Delplanque, S., Ravior-Derrien, S., Le Calve', B., Chrea, C. Gaudreau, N., Cayeux, I., (2010). How do you feel when you smell this? optimization of a verbal measurement of odor-elicited emotions. Food Quality and Preference, 21, 938-947, doi:10.1016/j.foodqual.2011.07.006.

Rosenstein, D. & Oster, H. (1988). Differential facial responses to four basic tastes in newborns. Child Development, 59(6), 1555 – 1568, doi: 10.2307/1130670.

Rosenstein, D. & Oster, H. (1997). Differential facial responses to four basic tastes in newborns. In Ekman, Paul & Rosenberg, Erika (Eds.), What the face reveals: basic and applied studies of spontaneous expression using the facial action coding system (FACS) (pp. 302-327). New York, NY: Oxford University Press, Inc.

Rozin, P. & Fallon, A. E. (1987). A perspective on disgust. Psychological Revue, 94(1), 23 – 41, doi:10.1037/0033-295X.94.1.23.

Sudre, J., Pineau, N., Loret, C., Marin, N. (2012). Comparison of methods to monitor liking of food during consumption. Food Quality and Preference, 24(1), 179 – 189, doi:10.1016/j.foodqual.2011.10.013.

Sung, K. K. & Poggio, T. (1998). Example-based learning for view-based human face detection. IEEE Transactions on Pattern Analysis and Machine Intelligence, 20(1), 39 – 51, doi:10.1109/34.655648.

Viola, P. & Jones, M. (2001). Rapid object detection using a boosted cascade of simple features. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition. Kauai, HI, 1, 511 – 518, doi: 10.1109/CVPR.2001.990517.

Warrenburg, S. (2005). Effects of fragrance on emotions: moods and physiology. Chemical Senses, 30, i248 – i249, doi:10.1093/chemse/bjh208.

Weiland, R., Ellgring, H., Macht, M. (2010). Gustofacial and olfactofacial responses in human adults. Chemical Senses, 35(9), 841 – 853, doi:10.1093/chemse/bjq092.

Wendin, K., Allesen-Holm, B. H., Bredie, L. P. (2011). Do facial reactions add new dimensions to measuring sensory responses to basic tastes? Food Quality and Preference, 22, 346 – 354, doi:10.1016/j.foodqual.2011.01.002.

Time	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
00:00:11.233	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.266	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.299	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED
00:00:11.333	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.366	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.399	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.433	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.466	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED
00:00:11.499	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.533	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.566	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.599	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.633	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED	FIND_FAILED
00:00:11.666	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED	FIT_FAILED
00:00:11.699	0.019989670	0.000000261	0.000018869	0.971558200	0.015850060	0.000000001	0.020208770
00:00:11.733	0.067666590	0.000029299	0.000017076	0.939168100	0.014357830	0.000000001	0.018288260
00:00:11.766	0.113189400	0.000048001	0.000015453	0.905617900	0.012993350	0.000000001	0.016550260
00:00:11.799	0.156469300	0.000046585	0.000013985	0.866824900	0.011758540	0.000000001	0.014977420
00:00:11.833	0.178296000	0.000042158	0.000012656	0.848837600	0.010641080	0.000000000	0.013554060
00:00:11.866	0.239755100	0.000057209	0.000011453	0.781088800	0.009629825	0.000000000	0.012265970
00:00:11.899	0.255177400	0.000052833	0.000010365	0.768778600	0.008714665	0.000000000	0.011100290
00:00:11.933	0.248482100	0.000047812	0.000009380	0.774015600	0.007886480	0.000000000	0.010045390
00:00:11.966	0.280155900	0.000043268	0.000008488	0.743750700	0.007136996	0.000000000	0.009090736
00:00:11.999	0.290342300	0.000039156	0.000007682	0.726963000	0.006458740	0.000000000	0.008226809
00:00:12.033	0.294339200	0.000035435	0.000006952	0.715162900	0.005844944	0.000000000	0.007444987
00:00:12.066	0.356106300	0.000034275	0.000006291	0.647198100	0.005289475	0.000000446	0.006737460
00:00:12.099	0.410728100	0.000031534	0.000005693	0.585692600	0.004786798	0.000000403	0.006097176
00:00:12.133	0.461726600	0.000028538	0.000005152	0.530032000	0.004331891	0.000000365	0.005517738
00:00:12.166	0.511135600	0.000103751	0.000004662	0.479661000	0.004246662	0.000000330	0.004993365

Figure 3.1 Example of sub-optimal data capture due to participant incompatibility with AFEA software resulting in loss of raw emotional data response points in the exported output files [FIT_FAILED; FIND_FAILED].

[1]Video failures occur when serious facial occlusions or the inability to map the face persists during the specified post-consumption window.

Figure 3.2 Example of sub-optimal data capture due to participant software modeling.

[A]The figure presents sub-optimal data capture due to participant software modeling incompatibility and failure of face mapping to determine emotional response (A). [B]Example of successful fit modeling and ability to capture participant's emotional response (B).

Participant	Treatment	Original Video Time	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
2	Unflavored Water	02:13.5	0.361041	0.035674	0.243613	0.019348	0.090685	1.34E-05	0.01288
2	Unflavored Water	02:13.5	0.394417	0.032811	0.220791	0.017509	0.082067	1.21E-05	0.011656
2	Unflavored Water	02:13.6	0.422513	0.030378	0.200058	0.015845	0.074268	1.1E-05	0.010548
2	Unflavored Water	02:13.6	0.443792	0.027704	0.181086	0.01434	0.06721	9.93E-06	0.009546
2	Unflavored Water	02:13.6	0.459392	0.025071	0.163879	0.012977	0.060823	8.98E-06	0.008639
2	Unflavored Water	02:13.7	0.482617	0.022688	0.148305	0.011744	0.055042	8.13E-06	0.007818
2	Unflavored Water	02:13.7	0.499244	0.020532	0.134211	0.010628	0.049812	7.36E-06	0.007075
2	Unflavored Water	02:13.7	0.515359	0.018581	0.121457	0.009618	0.045078	6.66E-06	0.006402
2	Unflavored Water	02:13.8	0.534902	0.016815	0.109914	0.008704	0.040794	6.02E-06	0.005794
2	Unflavored Water	02:13.8	0.546744	0.015217	0.099468	0.007876	0.036917	5.45E-06	0.005243
2	Unflavored Water	02:13.8	0.569642	0.013771	0.090016	0.007128	0.033409	4.93E-06	0.004745
2	Unflavored Water	02:13.9	0.597125	0.012462	0.081461	0.006451	0.030234	4.47E-06	0.004294
2	Unflavored Water	02:13.9	0.623425	0.011278	0.07372	0.005838	0.027361	4.04E-06	0.003886
2	Unflavored Water	02:13.9	0.646088	0.010206	0.066714	0.005283	0.02476	3.66E-06	0.003517
2	Unflavored Water	02:14.0	0.670266	0.009236	0.060374	0.004781	0.022407	3.31E-06	0.003183
2	Unflavored Water	02:14.0	0.691836	0.008358	0.054636	0.004326	0.020278	2.99E-06	0.00288
2	Unflavored Water	02:14.0	0.712259	0.007564	0.049444	0.003915	0.018351	2.71E-06	0.002606
2	Unflavored Water	02:14.1	0.727949	0.006845	0.044745	0.003543	0.016607	2.45E-06	0.002359
2	Unflavored Water	02:14.1	0.74641	0.006195	0.040493	0.003206	0.015029	2.22E-06	0.002135
2	Unflavored Water	02:14.1	0.761989	0.005606	0.036645	0.002902	0.0136	2.01E-06	0.001932
2	Unflavored Water	02:14.2	0.773504	0.005073	0.033162	0.002626	0.012308	1.82E-06	0.001748
2	Unflavored Water	02:14.2	0.786532	0.004591	0.030011	0.002376	0.011138	1.65E-06	0.001582
2	Unflavored Water	02:14.2	0.799178	0.004155	0.027159	0.002151	0.01008	1.49E-06	0.001432
2	Unflavored Water	02:14.3	0.812703	0.00376	0.024578	0.001946	0.009122	1.35E-06	0.001296
2	Unflavored Water	02:14.3	0.824622	0.003403	0.022242	0.001761	0.008255	1.22E-06	0.001172
2	Unflavored Water	02:14.3	0.836282	0.003079	0.020128	0.001594	0.00747	1.1E-06	0.001061
2	Unflavored Water	02:14.4	0.847788	0.002787	0.018215	0.001442	0.00676	9.98E-07	0.00096
2	Unflavored Water	02:14.4	0.859263	0.002522	0.016484	0.001305	0.006118	9.03E-07	0.000869
2	Unflavored Water	02:14.4	0.869168	0.002282	0.014918	0.001181	0.005537	8.18E-07	0.000786

Participant	Treatment	Original Video Time	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
2	Unflavored Milk	03:15.4	0.574752	0.197987	0.068439	0.048811	1.30E-06	9.42E-05	0.0003678
2	Unflavored Milk	03:15.4	0.568977	0.179171	0.061935	0.044173	1.17E-06	0.000936	0.0003328
2	Unflavored Milk	03:15.5	0.568194	0.162144	0.056049	0.039975	1.06E-06	0.002583	0.0003012
2	Unflavored Milk	03:15.5	0.567381	0.146735	0.050722	0.036176	9.62E-07	0.004147	0.0002726
2	Unflavored Milk	03:15.5	0.570668	0.13279	0.045902	0.032738	8.70E-07	0.00471	0.0002467
2	Unflavored Milk	03:15.6	0.575155	0.12017	0.04154	0.029627	7.88E-07	0.006888	0.0002232
2	Unflavored Milk	03:15.6	0.583802	0.10875	0.037592	0.026811	7.13E-07	0.007961	0.000202
2	Unflavored Milk	03:15.6	0.603103	0.098415	0.03402	0.024263	6.45E-07	0.00876	0.0001828
2	Unflavored Milk	03:15.7	0.628143	0.089062	0.030787	0.021957	5.84E-07	0.008734	0.0001654
2	Unflavored Milk	03:15.7	0.655774	0.080599	0.027861	0.019871	5.28E-07	0.008307	0.0001497
2	Unflavored Milk	03:15.7	0.682572	0.072939	0.025213	0.017982	4.78E-07	0.007666	0.0001355
2	Unflavored Milk	03:15.8	0.708353	0.066007	0.022817	0.016273	4.33E-07	0.006981	0.0001226
2	Unflavored Milk	03:15.8	0.733301	0.059734	0.020649	0.014727	3.92E-07	0.006317	0.000111
2	Unflavored Milk	03:15.8	0.756479	0.054058	0.018686	0.013327	3.54E-07	0.005789	0.0001004
2	Unflavored Milk	03:15.9	0.778379	0.04892	0.01691	0.012061	3.21E-07	0.005265	9.09E-05
2	Unflavored Milk	03:15.9	0.79818	0.044271	0.015303	0.010915	2.90E-07	0.004866	8.22E-05
2	Unflavored Milk	03:15.9	0.816281	0.040064	0.013849	0.009877	2.63E-07	0.004403	7.44E-05
2	Unflavored Milk	03:16.0	0.832235	0.036257	0.012533	0.008939	2.38E-07	0.00404	6.74E-05
2	Unflavored Milk	03:16.0	0.847113	0.032811	0.011342	0.008089	2.15E-07	0.003656	6.10E-05
2	Unflavored Milk	03:16.0	0.860391	0.029693	0.010264	0.00732	1.95E-07	0.003328	5.52E-05
2	Unflavored Milk	03:16.1	0.872246	0.026871	0.009289	0.006625	1.76E-07	0.003012	4.99E-05
2	Unflavored Milk	03:16.1	0.882393	0.024317	0.008406	0.005995	1.59E-07	0.002726	4.52E-05
2	Unflavored Milk	03:16.1	0.891362	0.022006	0.007607	0.005425	1.44E-07	0.002467	4.09E-05
2	Unflavored Milk	03:16.2	0.898153	0.019915	0.006884	0.00491	1.31E-07	0.002232	3.70E-05
2	Unflavored Milk	03:16.2	0.905501	0.018022	0.00623	0.004443	1.18E-07	0.00202	3.35E-05
2	Unflavored Milk	03:16.2	0.911791	0.01631	0.005638	0.004021	1.07E-07	0.001828	3.03E-05
2	Unflavored Milk	03:16.3	0.91761	0.01476	0.005102	0.003639	9.70E-08	0.001654	2.74E-05
2	Unflavored Milk	03:16.3	0.922838	0.013357	0.004617	0.003293	8.80E-08	0.001497	2.48E-05
2	Unflavored Milk	03:16.3	0.928016	0.012088	0.004178	0.00298	7.90E-08	0.001355	2.25E-05

Figure 3.3 Example of extracted participant data compiled in a new data spreadsheet.

[1]Participant data (participant number, treatment, original video time, and emotion response) is identified per emotion (happy, neutral, sad, angry, surprised, scared, and disgusted) for the select time frame (seconds).
[2]This spreadsheet is utilized for subsequent analyses.

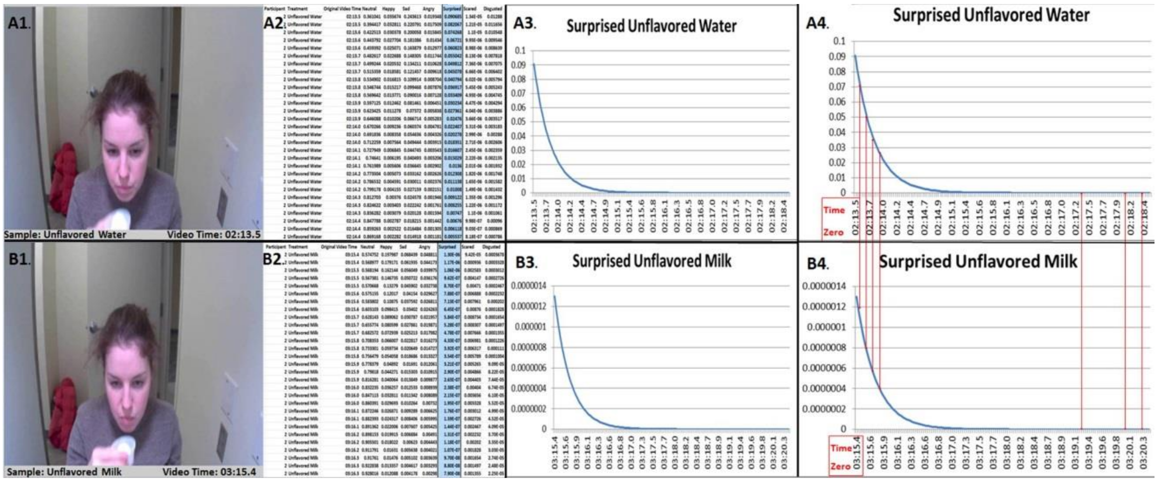


Figure 3.4 Example of extracted participant data compiled for subsequent analysis. The extracted participant data (A1 and B1) is compiled (A2 and B2), graphed (A3 and B3) and aligned (A4 and B4) as a visual for direct comparison.

[1]The respective time zero for control (A4: Surprised Unflavored Water) and treatment (B4: Surprised Unflavored Milk) are displayed for comparing the surprised emotional results.
[2]This example represents and identifies the corresponding time zero from the timestamp file for each participant-treatment pair.

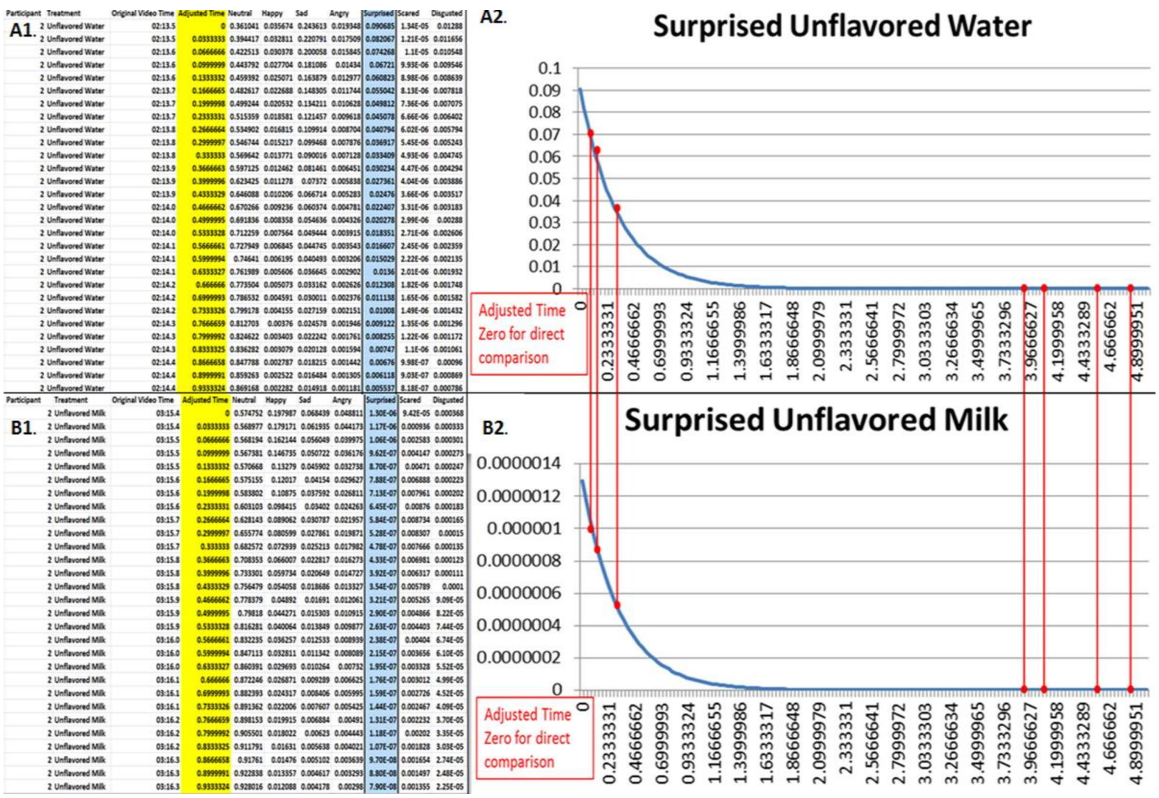


Figure 3.5 Example of extracted participant data with adjusted time frame.

[1]The extracted participant data is presented with adjusted time frame with a true “time zero” (A1 and B1).
[2]The time adjustment allows for direct comparison between a control (A: Surprised Unflavored Water) and a treatment (B2: Surprised Unflavored Milk) (A2 and B2). [3]This example represents and identifies the corresponding true “time zero” (adjusted) from the timestamp file for each participant-treatment pair.

		Unflavored Water	Unflavored Milk
Participant	Adjusted Time	Surprised	Surprised
2	0	0.09068511	1.30E-06
3	0	0.2875673	0.3276564
4	0		
2	0.0333333	0.08206697	1.17E-06
3	0.0333333	0.3551583	0.3913865
4	0.0333333		
2	0.0666666	0.07426786	1.06E-06
3	0.0666666	0.4162674	0.4485871
4	0.0666666		
2	0.0999999	0.06720988	9.62E-07
3	0.0999999	0.4714458	0.5001709
4	0.0999999		
2	0.1333332	0.06082268	8.70E-07
3	0.1333332	0.5209881	0.4526377
4	0.1333332		
2	0.1666665	0.05504249	7.88E-07
3	0.1666665	0.5653802	0.4096218
4	0.1666665		
2	0.1999998	0.04981158	7.13E-07
3	0.1999998	0.6061038	0.370694
4	0.1999998		
2	0.2333331	0.0450778	6.45E-07
3	0.2333331	0.6417572	0.3354655
4	0.2333331		
2	0.2666664	0.0407939	5.84E-07
3	0.2666664	0.6727543	0.3035849
4	0.2666664		
2	0.2999997	0.03691709	5.28E-07
3	0.2999997	0.7251481	0.2486251
4	0.2999997		

Figure 3.6 Example of the process for compiling all participants' data.

[1]The participant, adjusted time, and paired treatment (e.g. unflavored water and unflavored milk) at each time point is compiled to prepare for statistical analysis.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Participant	Adjusted Time Zero	Unflavored Water Surprised	Unflavored Milk Surprised	Treatment Difference	Positive	|Absolute Difference|	Rank Order	Signed Rank				
2	2	0.033	0.08206697	1.17E-06	8.21E-02	1	0.082065796	16	16				
3	3	0.033	0.3551583	0.3913865	-3.62E-02	-1	0.0362282	12	-12				
4	4	0.032	0.1449358	0.08848681	5.64E-02	1	0.05644899	15	15				
5	5	0.033	0.0528666	0.005964171	4.69E-02	1	0.046902429	13	13				
6	6	0.033	0.000151759	5.94E-05	9.23E-05	1	0.000092328	2	2				
7	7	0.033	0.007203472	0.1021246	-9.49E-02	-1	0.094921128	17	-17				
8	8	0.033	0.3267848	0.2935021	3.33E-02	1	0.0332827	11	11				
9	9	0.033	0.1294796	1.00E-09	1.29E-01	1	0.129479599	18	18				
10	11	0.033	0	0.006180286	-6.18E-03	-1	0.006180286	5	-5				
11	12	0.033	0.03632706	0.02186139	1.45E-02	1	0.01446567	9	9				
12	13	0.033	0.005947598	0.001962779	3.98E-03	1	0.003984819	4	4				
13	14	0.033	0.001328195	0.3016384	-3.00E-01	-1	0.300310205	24	-24				
14	15	0.033	0.08142006	0.03242102	4.90E-02	1	0.04899904	14	14		Positive Sum	229	
15	16	0.033	0.01452998	0.000325548	1.42E-02	1	0.014204432	8	8		Negative Sum	-71	
16	17	0.033	0.02329214	0.001191986	2.21E-02	1	0.022100154	10	10		Test Statistic	71	
17	18	0.033	0.00210097	0.01477786	-1.27E-02	-1	0.01267689	7	-7				The test statistic is less than the
18	19	0.033	0.002057716	0.000432547	1.63E-03	1	0.001625169	3	3		Critical Value	81	critical value and we reject the
19	21	0.033	0.1611539	0.02061119	1.41E-01	1	0.14054271	19	19		Test Statistic	71	null hypothesis. There is
20	23	0.033	0.2621396	0.000657592	2.61E-01	1	0.261482008	22	22				sufficient evidence to suggest
21	24	0.033	4.90E-05	3.26E-06	4.58E-05	1	0.000045791	1	1				that there is a difference
22	25	0.033	0.4312112	0.2154223	2.16E-01	1	0.2157889	21	21				between Unflavored Water and
23	26	0.033	0.1601236	1.70E-08	1.60E-01	1	0.160123583	20	20				Unflavored Milk in the Surprised
24	27	0.033	0.3181995	0.02441438	2.94E-01	1	0.29378512	23	23				emotion at adjusted time zero
25	28	0.033	0.1289932	0.1387634	-9.77E-03	-1	0.0097702	6	-6				0.033 seconds.

Figure 3.7 Data spreadsheet example comparing a control (Unflavored Water) and a treatment (Unflavored Milk) using Wilcoxon tests across participants at a specific time point.

[1] The figure represents direct comparison between the emotional results of a respective sample and the control (unflavored water) using sequential paired nonparametric Wilcoxon tests across the participants.

Emotion	Adjusted Time Zero	Unflavored Milk Signifcance	Unflavored Water Significance	Participants Evaluated (n)	Unflavored Water	Unflavored Milk	nTie
Surprised	0	0	1	24	18	6	0
Surprised	0.0333333	0	1	24	18	6	0
Surprised	0.0666666	0	1	24	18	6	0
Surprised	0.0999999	0	1	24	17	7	0
Surprised	0.1333332	0	1	24	18	6	0
Surprised	0.1666665	0	1	24	19	5	0
Surprised	0.1999998	0	1	25	20	5	0
Surprised	0.2333331	0	1	25	20	5	0
Surprised	0.2666664	0	1	25	20	5	0
Surprised	0.2999997	0	1	25	20	5	0
Surprised	0.333333	0	1	25	20	5	0
Surprised	0.3666663	0	1	25	20	5	0
Surprised	0.3999996	0	1	25	20	5	0
Surprised	0.4333329	0	1	25	20	5	0
Surprised	0.4666662	0	1	25	20	5	0
Surprised	0.4999995	0	1	25	20	5	0
Surprised	0.5333328	0	1	25	20	5	0
Surprised	0.5666661	0	1	25	20	5	0
Surprised	0.5999994	0	1	25	20	5	0
Surprised	0.6333327	0	1	25	20	5	0
Surprised	0.666666	0	1	25	20	5	0
Surprised	0.6999993	0	1	25	20	5	0
Surprised	0.7333326	0	1	25	20	5	0
Surprised	0.7666659	0	1	25	21	4	0
Surprised	0.7999992	0	1	25	21	4	0
Surprised	0.8333325	0	1	25	21	4	0
Surprised	0.8666658	0	1	25	21	4	0
Surprised	0.8999991	0	1	25	21	4	0
Surprised	0.9333324	0	1	25	21	4	0
Surprised	0.9666657	0	1	25	21	4	0

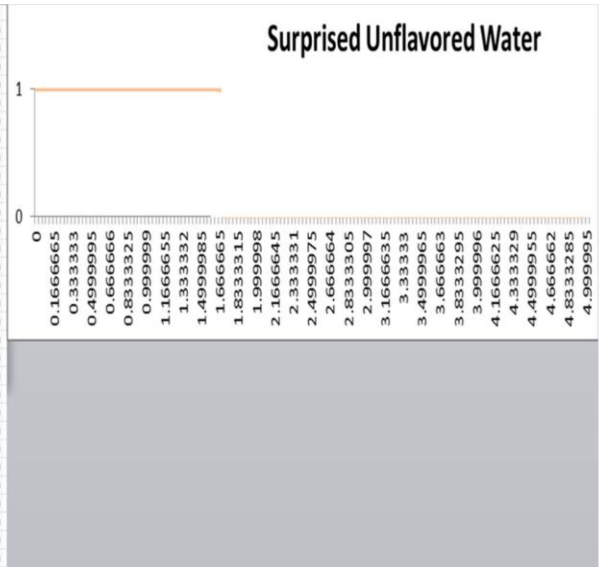


Figure 3.8 Example of the data spreadsheet to graph the results if (p<0.025) on the associated treatment graph (i.e. unflavored milk compared to unflavored water).

[1] Results of sequential paired nonparametric Wilcoxon tests across the participants are graphed for the times where the null hypothesis is rejected.

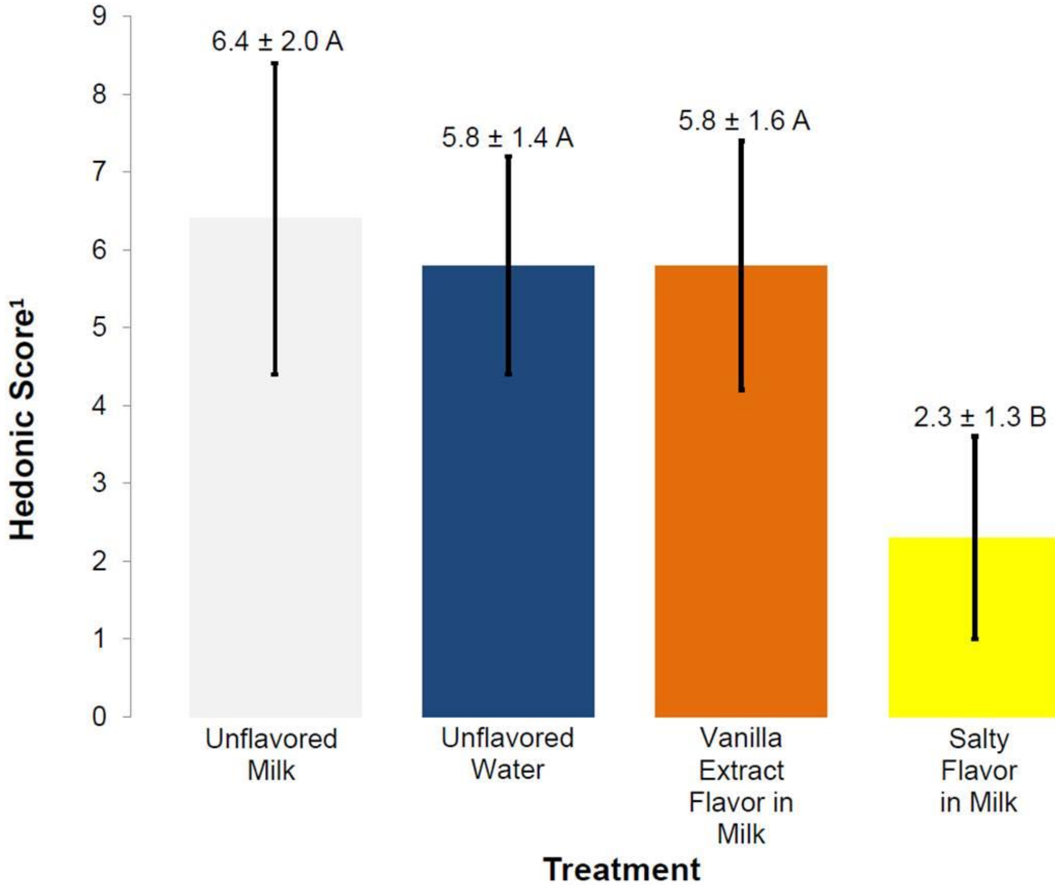


Figure 3.9 Mean acceptability (hedonic) scores of unflavored water, unflavored milk, vanilla extract flavor in milk and salty flavor in milk beverage solutions.

[A,B] Treatment means with different superscripts significantly differ in liking ($p<0.05$).
[1]Participants (n=25) rated acceptability on a 9-point hedonic scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely; mean ± SD).
[2] Solutions in Milk: unflavored milk (2% Milk); unflavored water (commercial drinking water); vanilla extract (0.02g/ml);salty (0.004g salt/ml)

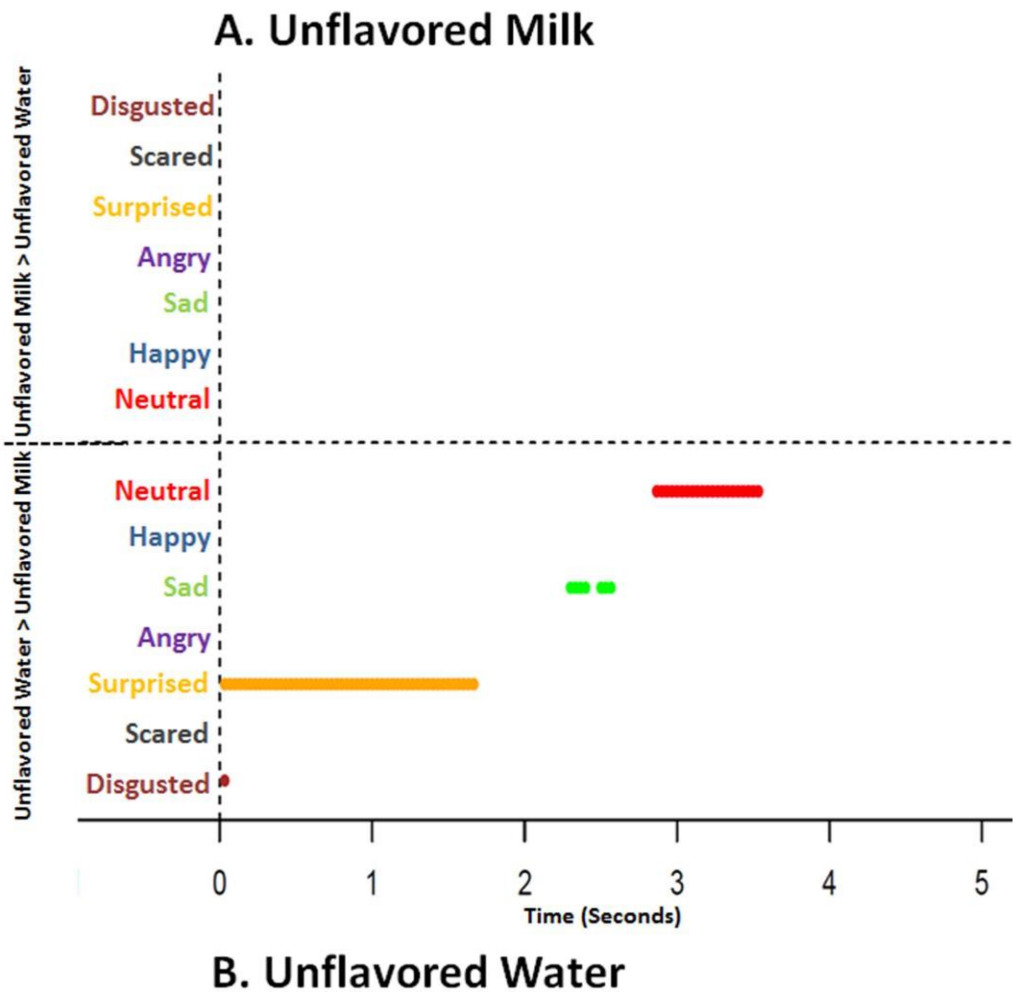


Figure 3.10 Time series graphs of classified emotions on automated facial expression analysis data over 5.0 seconds comparing unflavored milk and unflavored water.

[1]Based on sequential paired nonparametric Wilcoxon tests between unflavored milk and unflavored water (baseline), results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2]Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$). Absence of lines in unflavored milk (A) reveals no emotional categorization compared to unflavored water ($p<0.025$) over 5.0 seconds.
[3] Participants (n=25) evaluated solutions in Milk: unflavored milk (2% Milk); unflavored water (commercial drinking water)

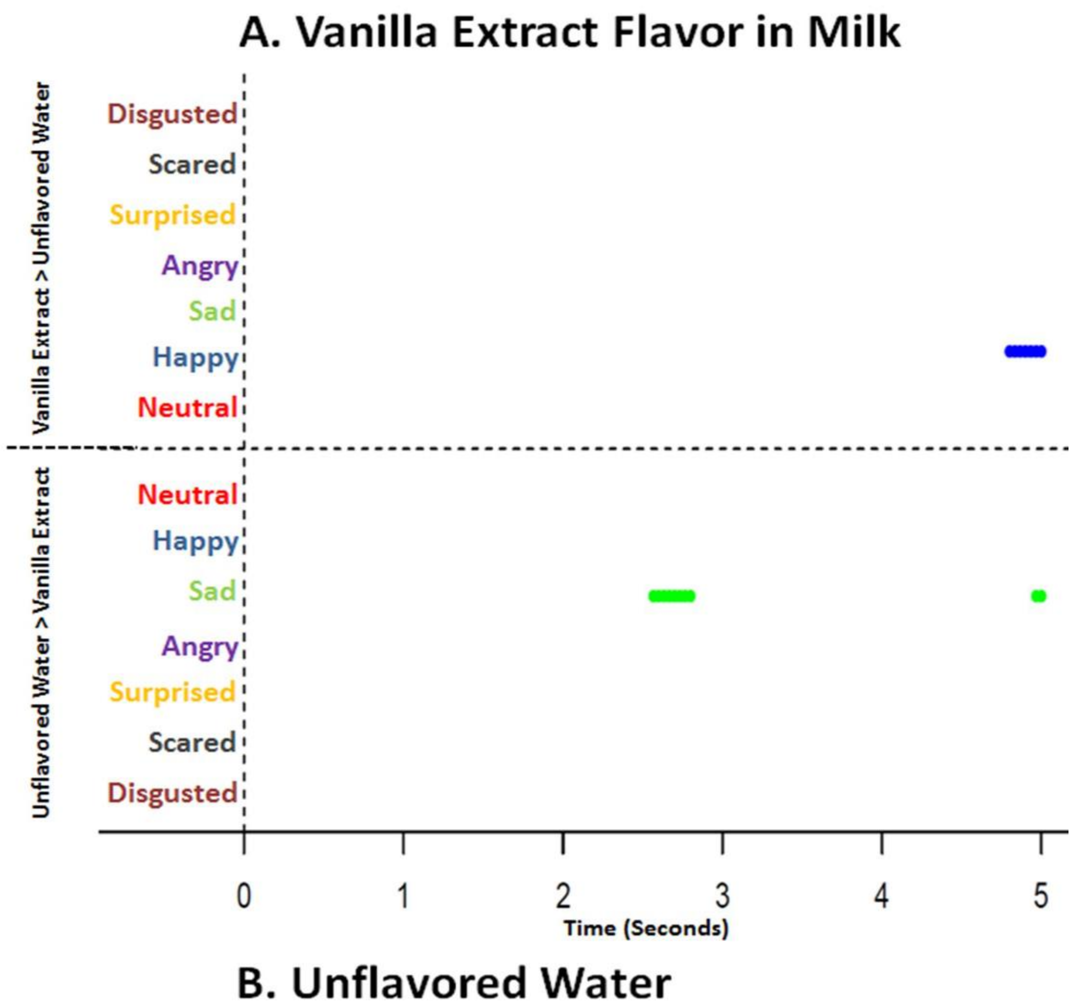


Figure 3.11 Time series graphs of classified emotions based on automated facial expression analysis data over 5.0 seconds comparing vanilla extract flavor in milk and unflavored water (baseline).

[1]Based on sequential paired nonparametric Wilcoxon tests between vanilla extract flavor in milk and unflavored water, results are plotted on the respective treatment graph if treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2]Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).
[3] Participants (n=25) evaluated solutions in Milk: unflavored water (commercial drinking water); vanilla extract flavored milk (0.02g/ml)

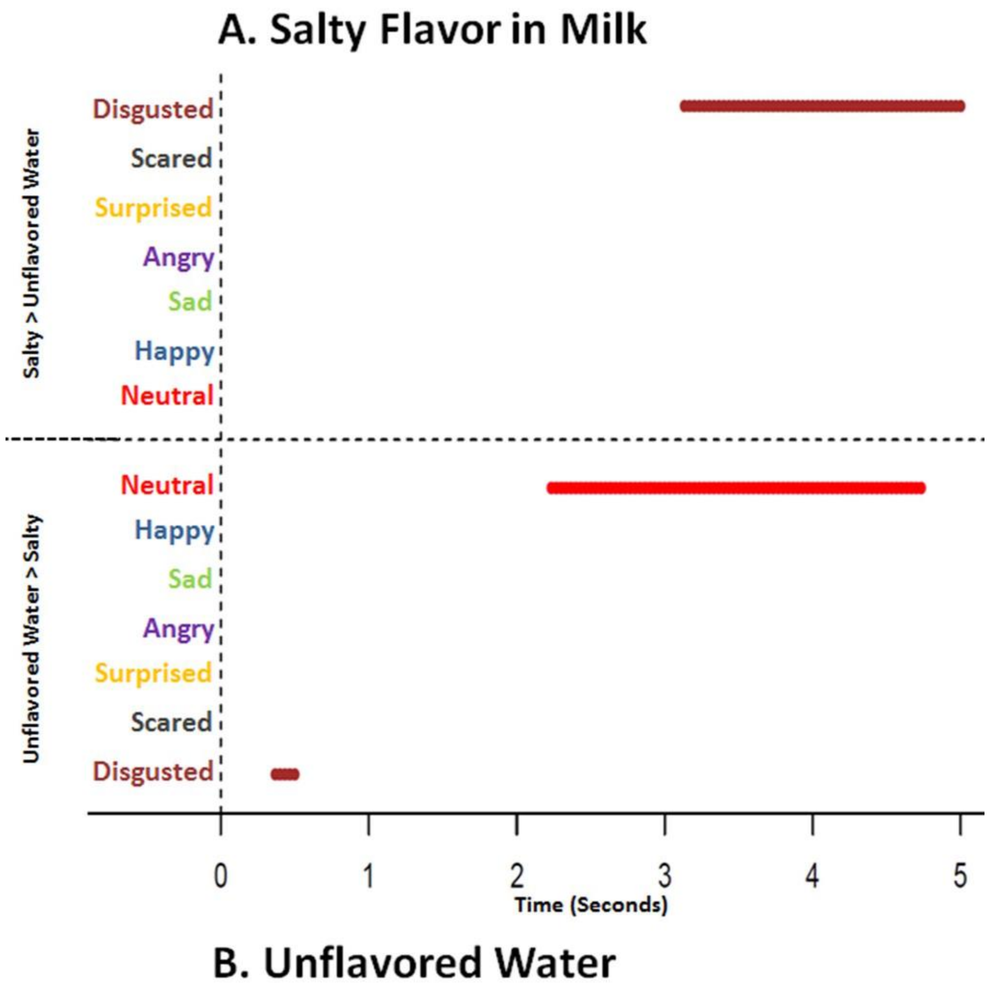


Figure 3.12 Time series graphs of classified emotions based on automated facial expression analysis data over 5.0 seconds comparing salty flavor in milk and unflavored water.

[1]Based on sequential paired nonparametric Wilcoxon tests between salty flavor in milk and unflavored water (baseline), results are plotted on the respective treatment graph if treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2]Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).
[3] Participants (n=25) evaluated solutions in Milk: unflavored water (commercial drinking water); salty flavor in milk (0.004g salt/ml)

CHAPTER IV

Characterizing Implicit Emotions to Flavored Milk Beverages using Automated Facial Expression Analysis

Abstract

The purpose of our study was to characterize implicit emotions associated with flavored and unflavored milk beverages of flavor acceptability. We explored the use of time series analysis of facial expressions for temporal emotions. Emotional differences, based on extreme differences in acceptability of flavors, were evaluated.

Participants (n=42) evaluated intensified-flavors in milk beverages (vanilla syrup, coconut syrup, vanilla extract, green tea, sour, malty, and salty) and an unflavored-milk (positive control 2% milk) and drinking water (negative control) for product acceptability. Sessions were video-recorded and analyzed using AFEA software that translates facial muscle motion to neutral, happy, disgusted, sad, angry, surprised and scared (scale: 0=not expressed; 1=fully expressed) for each emotion. For AFEA time series analysis, sequential paired nonparametric Wilcoxon tests were performed between unflavored-milk and treatments for 10 seconds post-consumption ($\alpha=0.05$). Separately, participants rated acceptability on a 9-point scale (9=like extremely; 1=dislike extremely).

Based on product acceptability analysis, unflavored milk, and milk flavored with vanilla syrup, coconut syrup, or vanilla extract were not different ($p>0.05$) and were rated as acceptable (mean scores of 5.5 or higher; 5=neither like nor dislike; 9=like extremely). Automated facial expression analysis of vanilla syrup flavored milk flavored and coconut

syrup flavored milk identified an initial sad expression ($p<0.025$), then surprised or happy responses, respectively, after 5 sec, compared to unflavored milk. Vanilla extract flavored milk elicited more surprised and less neutral and sad expression than unflavored milk ($p<0.025$). In contrast, salty and green tea flavored milks had lower mean hedonic scores (less than 3.5; $p<0.05$) than other flavored milk beverages. Green tea flavor elicited more sad, surprised, and angry expressions ($p<0.025$). Salty flavor in milk created an intense disgust response and other emotions ($p<0.025$). Unflavored milk had higher neutral response ($p<0.025$) than green tea and salty flavors in milk.

Expressed emotions for acceptable milk beverages were not as emotionally dynamic as observed for disliked flavored milk beverages, which had more prevalent negative emotional trends for longer periods of time. Time series trends may assist in differentiating acceptability due to predominance of emotions over 10 second duration. The methodology may aid with implicit consumer acceptability responses.

1. Introduction

Fluid milk consumption has declined in the United States since the 1970s (Stewart, Dong, & Carlson, 2013; Popkin, 2010) due in part to beverage competition, especially similar, non-dairy based beverages (i.e. soy, almond, rice, coconut, hazelnut, hemp) (Package Facts, 2015; Anonymous, 2015) and sugar sweetened beverages (SSB) (Bowman, Gortmaker, Ebbeling, Pereria, & Ludwig, 2004; Fisher, Mitchell, Smickiklas-Wright, & Birch, 2001; Blum, Jacobsen, & Donelly, 2005; Lasater, Piernas, & Popkin, 2011; Popkin, 2010; Vartanian, Schwartz, & Brownell, 2007). The Dietary Guidelines for Americans recommends 3 cup-equivalents for those over the age of 8; however, today, consumption is around 0.61 cup-equivalents per day (Stewart et al., 2013; U.S. Department of Agriculture and U.S. Department of Health and Human Services, 2010). Furthermore, there is concern that the decline will continue with subsequent generations (Stewart et al., 2013). While dairy check-off programs promote consumption (Kaiser & Dong, 2006; Kaiser, 2010), the dairy industry is targeting new products and new flavors for reinventing the appeal of milk and regaining their consumer audience.

Although there is wide recognition that milk is nutrient dense and provides many health benefits, some consumers express concerns about drinking milk. Issues such as saturated fat and cholesterol contents, antibiotics and growth hormones, animal welfare and other issues popularized in the media can create concerns and negatively influence consumption (Stewart, Dong, & Carlson, 2012). Beyond these concerns, some consumers do not enjoy the flavor of milk even with the known benefits of dairy consumption. Flavored milk, such as chocolate milk, are sweetened and have higher caloric content, creating controversy about the placement of flavored milk in school lunch programs. Low calorie flavorings of milk could add a value-added appeal to purchasing milk. School children prefer flavored milk to plain milk, and when only plain milk is offered, consumption decreases in schools (Patterson & Saidel, 2009). In studies with children and adolescents, consumption of flavored milk was associated with increased calcium content intake, compared to their non-milk consumption counterparts (Johnson, Frary, & Wang, 2002), as well as increased intake of other valuable nutrients and minerals (Murphy, Douglas, Johnson, & Spence, 2008). Flavor and other sensory attributes are more important to children and consumers than health when choosing foods and beverages for consumption (Pelsmaeker, Schouteten, & Gellynck, 2013).

Using surveys and check-all-that-apply (CATA) emotional ballots, researchers found children prefer flavored milk over plain milk and milk alternatives and select the "happy" emotional term in regards to actual flavored milk brands (Pelsmaeker et al., 2013). However, the dairy industry has been cautious about marketing innovative flavored milk beverages, perhaps to limit the risk of failed products. With 70-80% new grocery sector product failures, new methodology is needed for providing better understanding of consumer responses (Stanton, 2013). Traditional assessment of preference and acceptability of foods and beverages has relied on explicit (conscious) responses yet these responses do not provide reliable consumer insight to products (Köster, 2003). Hedonic testing (conscious evaluation response) may bias acceptability scoring and fail to capture initial reactions and interactions with products (De Wijk, Kooijman, Verhoeven, Holthuysen, & De Graaf, 2012). Consumer choices and behaviors can be unpredictable and influenced by implicit (unconscious) responses to external stimuli (Dijksterhuis & Smith, 2005), such as media messages about issues and opinions of friends, family or peer groups. Consumer emotional response to products may occur quickly (microseconds) and last for a short period (seconds to minutes) (Robbins & Judge, 2013). Characterizing emotions to a stimulus is challenging as the implicit response may be manifested in multiple ways. Implicit response methodology research and application is increasing with food and beverage product acceptability (Arnade, 2013; Crist, Arnade, Leitch, Duncan, O'Keefe, Dunsmore, & Gallagher, 2014; Danner, Sidorkina, Joechl, & Duerrschmid, 2013; Danner, Haindl, Joechl, & Duerrschmid, 2014; De Wijk et al., 2012; De Wijk, He, Mensink, Verhoeven, & De Graaf, 2014; Garcia-Burgos & Zamora, 2013; Garcia-Burgos & Zamora, 2015; Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015). Automated facial expression analysis (AFEA) may assist in differentiating products.

Emotional analysis may provide a deeper understanding of consumer response to products and the interpretation of a 'true' acceptability response. AFEA is a promising tool for charactering emotional response to beverages (Arnade, 2013; Crist et al., 2014; Danner et al., 2013; Danner et al., 2014; De Wijk et al., 2014; Leitch et al., 2015; Walsh, Potts & Duncan, 2015). AFEA software can detect the emotions happy, sad, scared, disgusted, angry, surprised (Ekman, Friesen, O'Sullivan, Chan, Diacoyanni-Tarlatzis, Heider, Krause, LeCompte, Pitcairn, Ricci-Bitti, Scherer, Tomita, & Tzavaras, 1987) and neutral, each on a scale of 0 (not expressed) to 1 (fully expressed) (Noldus Information Technology, 2014ab). Using the "valence hypothesis" to classify emotions, positive emotions include happy and surprise, while negative include fear, disgust, anger, and sadness (Davidson, 1995; Alves, Fukusima, & Aznar-Casanova, 2008). In addition, the "motivational approach-withdrawal hypothesis" classifies happiness, surprise, and anger as “approach” emotions (toward stimuli), while sadness, fear, and disgust as “withdrawal” emotions (away from aversive stimuli) (Demaree, Everhart, Youngstrom, & Harrison, 2005; Alves et al., 2008; Davidson, Ekman, Saron, Senulis, & Friesen, 1990). The eating experience is typically positive (Desmet & Schifferstein, 2008; Gibson, 2006; King & Meiselman, 2010); however, unexpected flavors, such as might occur from poor quality or spoilage, or unfamiliar or undesirable flavors can create a negative emotional experience. Variation in facial expression, which may occur due to participant preferences or sensitivities, can cause inconsistencies in interpreting facial expression (Köster, 2003). Wendin, Allesen-Holm, and Bredie (2011) found facial reactions increased as basic taste solution intensity increased, suggesting a more intense emotional response. Moreover, facial occlusions, chewing, swallowing, and/or other gross motor functions may disrupt data capture and yield poor results. Furthermore, participants may not follow instructions, unavoidable shadowing may occur on the face. Lastly, the development of statistical analysis methodology to AFEA data is important to assess the emotional response to a food or beverage stimuli. Arnade (2013) concluded that continued research regarding population size and statistical methodology is critical. Participant emotional response variability can be high and can influence the mean comparison tests even within a small number of observations (Arnade, 2013; Walsh, Duncan, Potts & Gallagher, 2015). There is a need to develop methodology to characterize implicit emotions using AFEA with additional emphasis on the analysis and interpretation of a population.

In our study, we were interested in characterizing emotions to unflavored and flavored milk beverages based on facial expression, as a measure of the rapid and uncontrolled implicit response, and as additional information to flavor acceptability. Our project objectives were to (1) identify flavorings in milk that created positive emotions and were acceptable to an adult population; (2) evaluate the use of AFEA for differentiating emotions associated with acceptable and unacceptable flavorings in milk; and (3) explore the use of time series analysis of facial expressions for temporal emotions.

Using a combination of implicit (AFEA) and explicit (hedonic rating) we aimed to elicit responses using intensified flavorings in milk. We hypothesized we would evoke more negative (disgust) reactions and lower acceptability with intensified solutions such as salty, as well as generate positive emotions (happy) and higher acceptability with generally accepted flavors, such as vanilla, for emotional analysis validation. We hypothesized that intensified flavorings would stimulate more facial expressions in participants. We also anticipated that flavored milk treatments will each give a different predominant emotion or a deviation from a neutral or natural state, compared to unflavored milk with the temporal profile providing additional insight into emotional characterization. The resulting emotional profile may be useful for identifying successful flavorings for milk for future research and development.

2. Materials and methods

2.1 Sample preparation

Intensified dairy solutions were prepared using unflavored milk following dairy judging flavor descriptions (Costello & Clark, 2009) and other flavors at intensities detectable by a proportion of the population. Flavors were created and evaluated by researchers to reach an agreed level of intensity without being flavor offensive. Controls were water (negative control) (Drinking Water; Kroger Brand, Cincinnati, OH) and unflavored milk (positive control) (2% Reduced Fat Milk, Kroger Brand, Cincinnati, OH or DZA Brands, LLC, Salisbury, NC). Flavored milk treatments were prepared in the same milk as used for the positive control, and included seven flavorings: sour (buttermilk) (0.02g/ml) (Cultured Low Fat Buttermilk, Kroger Brand, Cincinnati, OH); coconut syrup (0.02g/ml) (Coconut Premium Gourmet Syrup, Monin, Inc., Clearwater, FL); vanilla syrup (0.02g/ml) (Vanilla Premium Gourmet Syrup, Monin, Inc., Clearwater, FL); vanilla extract (0.02g/ml; alcohol by volume 15%) (Imitation Clear Vanilla Flavor, Kroger Brand, Cincinnati, OH); malty (*Solution 1*: 0.15g grape nuts /ml milk; *Solution 2*: 0.05g Solution1 /ml milk) (Kroger Brand, Cincinnati, OH); salty (0.004g/ml) (Iodized Salt, Kroger Brand, Cincinnati, OH); and green tea (*Solution 1*: Prepared as manufacturer's instructions in distilled water (~0.009g green tea/ml); *Solution 2*: 0.11g/ml) (100% Natural Green Tea, Kroger Brand, Cincinnati, OH). Half ounce aliquots (~15g) of each solution were poured into 2 oz. plastic sample cups (Monogram Company, Columbia, MD) and capped with color-coded lids.

2.2 Consumer sensory analysis

2.2.1 Participant recruitment

This study was pre-approved by Virginia Tech Institutional Review Board (IRB 14-229) prior to project start. Study recruitment was accomplished through email listservs to Virginia Tech faculty, staff, students and visitors. Recruited participants completed a pre-screening survey for personal attributes, dairy preferences, demographics and interest in the study. Exclusion criteria included report of facial hair, required use of glasses for vision, allergies, and age less than 18 years. Selected participants (n=49; mean age = 25.2

years; age range = 19-50 years; male=16; female=33) were Virginia Tech faculty, staff, students or visitors. Before sample evaluation, participants reviewed and consented to the study parameters, including video recording, before receiving additional instructions or samples. Seven (n=7) participant videos were not used due to incompatibility with software (n=3) and/or failure to follow directions during sampling (n=4); therefore, 42 participants were included in data analysis (n=42; mean age = 25.0; age range = 19-50; male = 13; female = 29).

2.2.2 Consumer self-reported acceptability responses

Only one panelist at a time evaluated the samples to standardize the sensory booth conditions for video capture. Participants were guided by instructions on the touch screen monitor by the automated sensory software (Sensory Information Management System (SIMS) 2000, Version 6, Sensory Computer Systems, Berkeley Heights, NJ). Prior to sample evaluation, specific protocols were described to the panelist by a researcher and provided visually on the monitor.

Panelists evaluated a total of nine solution samples (representing each treatment), presented one by one, at refrigeration temperature (35°F or 1.7°C). Each sample was identified by a unique color index card, placed on top of each sample relating to the sample color code. Water was presented first, followed by unflavored milk; then flavored treatments were presented individually in a sequential, randomized order. For each sample, participants first held up the associated color card for sample video identification, then fully consumed the sample and waited 30 seconds (enforced) while facing towards the camera without additional action. Participants then entered hedonic response (1=dislike extremely, 9=like extremely) on the monitor. Participants were instructed to rinse their palate with room temperature drinking water (Kroger Brand, Cincinnati, OH) before the first sample and in between each sample (~3 minutes between samples). Data capture was managed using the sensory software system (SIMS 2000, Version 6, Sensory Computer Systems, Berkeley Heights, NJ). Upon completion data was transferred to Excel (Microsoft Corporation, Inc., Redmond, WA) and JMP for statistical analysis (Statistical Analysis Software, Cary, NC).

2.2.3 Video capture

The camera (Axis M1054 (30 Hz frame rate; 640 x 480 resolution), Axis Communications, Lund, Sweden) was positioned above the touchscreen monitor and video capture focused on the participant's face. Daylight overhead lighting (100% daylight, Illuminant 6504K; R=206; G=242; B=255, Rhapsody, Acuity Brands Lighting, Inc., Conyers, GA) illuminated the booth and face for video-recording with minimal additional lighting from the monitor and overhead florescent lighting behind the booths. Video capture commenced once the panelist was comfortable at the booth and video capture was as optimal as possible (before sample presentation). Video was set to record at 30 frames per second (fps) on a desktop computer (Elo Touch Solutions, Milpitas, CA) with recording software (Media Recorder 2.5; Noldus Information Technology, Wageningen, The Netherlands) through the entire sensory session. Recordings were saved as video (MPEG-4) files.

2.2.4 Automated facial expression analysis, data processing and statistical analysis

Participant videos were analyzed using AFEA software (FaceReader™ 6, Noldus Information Technology, Wageningen, The Netherlands) for emotional response. It should be noted that AFEA software characterizes emotions (happy, sad, scared, disgusted, neutral, angry, and surprised). Videos were analyzed frame-by-frame using continuous calibration analysis settings in the software. The AFEA data output was exported as log files (.txt). The AFEA data from the 0 to 5 second interval for ANOVA and 0-10 second for time series interval post-consumption was used for analysis. Post-consumption was defined as when the sample cup no longer occluded the face at the panelist's chin. Participant videos were time stamped by sample and statistical code (R, version 3.1.1, R Core Team, 2014) isolated specified data within the software exported log files (.txt).

As mentioned earlier, seven videos were failures and were not included in statistical analysis. Data from n=42 participants were used for data analysis. Analysis of variance (ANOVA) with Tukey's multiple comparison of means (JMP, Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC) was used to determine differences in acceptability (hedonic scores) (α=0.05). Using R-generated means data from 0-5 sec post-consumption derived from AFEA output, Tukey's multiple comparisons of means was used for emotional data analysis (R, version 3.1.1, R Core Team, 2014) for each emotion for each treatment.

2.2.5 Automated facial expression analysis and time series analysis

For time series analysis, sequential paired nonparametric Wilcoxon tests (α=0.05) were performed between control (milk) and treatments based on the 30 Hz AFEA sampling frame rate. Results were translated into time series graphs for 10 seconds post-consumption. Emotions with significant differences at $p<0.025$ were graphed.

2.2.5.1. Automated facial expression analysis, hedonic classification, and time series analysis of selected treatments for emotional profile development

Selected solutions treatments vanilla syrup (“liked” n= 27; “disliked” n= 12), coconut syrup (“liked” n=28; “disliked” n=12), vanilla extract (“liked” n=22; “disliked” n=13), malty (“liked” n=12; “disliked” n=25), and sour (“liked” n=12; “disliked” n=25) were selected for analysis. The acceptability scores were divided by panelist hedonic rating as “liked” (consumer acceptability score=6, 7, 8, 9) and “disliked” (consumer acceptability scores = 4, 3, 2, 1). Associated panelist AFEA output files were evaluated using time series analysis under the same settings described above.

3. Results

3.1 Consumer acceptability response

Numerically, unflavored milk was rated the highest ($\bar{x}$=6.6±1.8; 6.0 = liked slightly) but did not differ ($p>0.05$) in acceptability from milk flavored with vanilla syrup ($\bar{x}$=5.9±2.2), coconut syrup ($\bar{x}$=5.9±2.1), and vanilla extract ($\bar{x}$=5.5±1.6; 5.0 = neither liked, nor disliked); water was rated within the same region of the scale ($\bar{x}$=5.8±1.6) (Figure 4.1). Unflavored milk, milk with vanilla syrup or coconut syrup, and water were rated higher in acceptability ($p<0.05$) than milk with malty ($\bar{x}$=4.3±2.1), sour ($\bar{x}$=4.3±2.0), green tea ($\bar{x}$=3.3±1.8) and salty ($\bar{x}$=2.3±1.3) flavors. Salty was liked the least (disliked moderately) but did not differ from green tea ($p>0.05$).

3.2 Automated facial expression analysis

Mean emotion intensities, as obtained from AFEA analysis of video and subsequent data output, were not different across treatments within emotions ($p>0.05$) (Table 4.1) based on ANOVA with Tukey's multiple comparison of means. For all treatments, neutral was the highest emotion expressed ($p<0.05$). Angry and sad were more expressed ($p<0.05$) than happy, disgusted, surprised and scared in milks flavored with malty, sour, and coconut syrup. Salty flavored milk generated more sad and angry expressions than happy, surprised, and scared ($p<0.05$) but did not differ from disgusted ($p>0.05$). Unflavored milk increased expression of angry more than happy, disgusted, surprised and scared ($p<0.05$). Additionally, unflavored milk generated more sad expression than surprised and scared ($p<0.05$). For coconut syrup, malty, and sour-flavored milks, the emotions happy, surprised, disgusted and scared were not different ($p>0.05$). Unflavored water elicited more angry expression than happy, surprised, disgusted, and scared ($p<0.05$). In unflavored water, sad expression was more elicited than scared ($p<0.05$). Green tea-flavored milk increased expression of angry compared to disgusted, surprised, happy, and scared ($p<0.05$). Green tea-flavored milk also contributed to more sad expression than surprised, happy and scared ($p<0.05$). For vanilla syrup and vanilla extract-flavored milks, angry and sad were more expressed than disgusted, surprised and scared ($p<0.05$). Milk with vanilla extract flavoring elicited more angry expression while vanilla syrup-flavored milk yielded more sad than happy expressions ($p<0.05$).

3.3 Time series analysis

3.3.1 Time series analysis using milk as control

As each flavored milk was compared to the unflavored milk, the significant emotions identified in unflavored milk altered; these differences resulted because each data set comparison was unique. Each emotion that is illustrated was significant ($p<0.025$) based on the emotional response to samples within the comparison.

Sad was expressed ($p<0.025$) more intensely within the first couple seconds in all flavored milks that were acceptable (vanilla syrup, coconut syrup, and vanilla extract), in contrast to the unflavored milk control (Figure 4.2). Recalling from ANOVA with Tukey's multiple comparison of means analysis, sad was one of the top three predominant emotions (Table 4.1). All three flavorings (vanilla syrup, coconut syrup, and vanilla extract) in milk generated positive, "approach" emotions after 6 seconds post-consumption in comparison to the unflavored milk control.

Vanilla syrup-flavored milk illustrated more surprise and happy expressions late in the time sequence, with less neutral and disgust, which occurred at higher levels early in the post-consumption period of the unflavored milk control, suggesting a positive, "approach" emotional response developed to the flavored milk ($p<0.025$) (Figure 4.2 I). For coconut syrup-flavored milk, happy was a predominant emotional trend (approach), also late in the time sequence (Figure 4.2 II) whereas the unflavored milk response was happy, angry and surprised in the early timeframe ($p<0.025$). Unflavored water had relatively few emotions expressed at a significant level when compared to the unflavored milk control (Figure 4.2 III). Neutral expression and sad were significantly higher ($p<0.025$) for unflavored water early in the post-consumption timeframe. Compared to unflavored water, withdrawal emotions (scared and disgust) and angry (approach) were significantly higher in unflavored milk ($p<0.025$). Vanilla extract-flavored milk had more approach emotional response (surprised) than unflavored milk ($p<0.025$) (Figure 4.2 IV). Moreover, vanilla extract-flavored milk also had a much less prevalent withdrawal state (angry and sad) than unflavored milk ($p<0.025$).

As observed for the more acceptable milk treatments, sad expressions were observed at about the 2-3 second mark for the flavored milks receiving low lower hedonic scores (malty, green tea, salty) in contrast to the unflavored milk control (Figure 4.3). The sour-flavored milk was an exception and did not illustrate this response (Figure 4.3 II). Most of the significant and unique emotional response to the unacceptable flavored milks occurred about 3 seconds or longer; the exception is the salty-flavored milk that had a high degree of significant emotional expressions throughout the timeframe (Figure 4.3 IV). There were more emotions expressed at higher significance in the unflavored milk control compared to the unacceptable flavored milks, when considering the responses in the acceptable milk comparisons.

The comparison of malty-flavored milk to unflavored milk illustrated that both had significant surprised responses but at different time points (Figure 4.3 I). Malty-flavored milk had less neutral compared to control milk ($p<0.025$) indicating a deviation from neutral early post-consumption. Generally, sour-flavored milk had more withdrawal emotions (sad, disgust, and scared) than unflavored milk ($p<0.025$) and less approach emotions (surprised and happy) than unflavored milk ($p<0.025$) (Figure 4.3 II). Additionally, sour-flavored milk had less neutral than unflavored milk ($p<0.025$) indicating a deviation from neutral.

Green tea-flavored milk elicited withdrawal emotions (sad, disgust and angry) more than unflavored milk ($p<0.025$) (Figure 4.3 III). Interestingly, the approach emotions happy and surprised were generated more in green tea-flavored milk than unflavored milk after 5 seconds ($p<0.025$). Also, green tea-flavored milk produced less neutral than unflavored milk ($p<0.025$) indicating a deviation from neutral as well as less and a very brief happy expression before 2 seconds ($p<0.025$). Lastly, salty-flavored milk generated more intense withdrawal emotions (sad, disgust, scared) than did unflavored milk ($p<0.025$) (Figure 4.3 IV). Surprisingly, salty-flavored milk also produced more intense approach emotions (surprised and happy) than unflavored milk after 5 seconds ($p<0.025$). Moreover, salty-flavored milk generated less neutral than unflavored milk ($p<0.025$) indicating a deviation from neutral. Disgust was a predominant emotion throughout the post-consumption period of salty-flavored milk.

3.3.2 Selected time series analysis based on hedonic score separation

Separation of hedonic acceptability responses within each treatment (high scores=6, 7, 8, 9; low scores=4, 3, 2, 1) allowed us to evaluate trends for their association to emotions (Figure 4.4 (Vanilla Syrup), 4.5 (Coconut Syrup), 4.6 (Vanilla Extract) 4.7 (Malty), 4.8 (Sour)). The emotional profiles with those of higher consumer acceptability ratings revealed that sad continued to be generated more in milks flavored with vanilla syrup, coconut syrup, vanilla extract and sour than in unflavored milk ($p<0.025$) (Figures 4.4 II, 4.5 II, 4.6 II and 4.8 II). In addition, happy was present in vanilla syrup and coconut syrup flavored milks more than in unflavored milk ($p<0.025$) (Figures 4.4 II and 4.5 II). Surprised was expressed in vanilla syrup and vanilla extract flavored milks more than in unflavored milk ($p<0.025$) (Figure 4.4 II and 4.5 II). Also, sour milk had more scared expression than in unflavored milk ($p<0.025$) (Figure 4.8 II).

Participants that disliked the flavored milk samples expressed more angry (vanilla syrup, vanilla extract and malty), sad (coconut syrup and malty), scared (coconut syrup and sour), happy (vanilla extract), neutral (vanilla extract), disgust (malty and sour) than in unflavored milk ($p<0.025$) (Figures 4.4 III, 4.5 III, 4.6 III, 4.7 III and 4.8 III). Moreover, they expressed less neutral (vanilla syrup and malty), surprised (vanilla extract and malty), angry (vanilla extract), sad (vanilla extract and sour), scared (vanilla extract), and happy (sour) than unflavored milk ($p<0.025$).

4. Discussion

4.1 Consumer acceptability response

The consumer acceptability results were surprising as unflavored milk was numerically the highest while the "pleasant flavors" followed with the flavored sugar syrup milks the next numerically highest. Our results contradict previous evidence of school children's preference for flavored milk compared to unflavored milk (Patterson & Saidel, 2009); however, our demographic was older. Additionally, most consumers are unfamiliar with flavored milk other than chocolate milk. In a study between plain milk and chocolate milk, chocolate milk was rated higher than plain (7.0±1.5 and 5.7±2.4, respectively) in college-aged participants (Arnade, 2013). Overall, our hypothesis is supported by these findings as it was expected that the pleasant flavors would be rated higher than the unpleasant flavors. Vanilla syrup, coconut syrup, and vanilla extract flavored milk beverages were liked more than salty and green tea flavored milk beverages.

4.2 Automated facial expression analysis

Trends were harder to isolate and identify among the flavored treatments indicating that ANOVA is not sensitive in separating mean emotional changes. This lack of sensitivity could be due to the number of data points analyzed at each frame over 5 sec. The individual points get muddied using ANOVA. Leitch et al. (2015), using similar data analysis, did not find differences within emotions across tea with different natural and artificial sweeteners treatments using ANOVA. In all treatments, neutral was the highest emotion expressed ($p<0.05$). Neutral was also elicited highest among a study using tea treatments (Leitch et al., 2015). While time frame could be a contributing factor to lack of trends, Ekman and Friesen (2003) suggest that it is atypical for emotions to last longer than 5 to 10 seconds with a stimulus. Arnade (2013) found that 20 seconds was too long for post-consumption analysis and that 5 or 10 seconds was sufficient for emotional analysis between unflavored and (chocolate) flavored low-fat (1%) milk.

4.3 Time series analysis

Time series analysis proved to be more sensitive to distinguishing differences and trends. Interestingly, both vanilla syrup and coconut syrup flavored milk beverages generated happy. Vanilla syrup and vanilla extract flavored milk elicited more surprised. The vanilla flavors and odors are considered pleasant (Warrenburg, 2005; Mojet, Dürrschmid, Danner, Jöchl, Heiniö, Holthuysen, & Köster, 2015) unless there is an adverse distaste. In a study with odors, vanilla was associated with "Happiness – Well-being – Pleasantly Surprised" and "Nostalgic – Amusement – Mouthwatering" (Porcherot, Delphanque, Raviot-Derrien, Le Calve, Chrea, Gaudreau, & Cayeux, 2010). Additionally, sugar (syrup) or sweet tastes have been shown to have positive affect (De

Graaf & Zandstra, 1999; Steiner, Glaser, Hawilo, & Berridge, 2001; Greimel, Macht, Krumhuber, & Ellgring, 2006). Also, vanilla syrup and vanilla extract flavored milk expressed less neutral, potentially indicating a deviation from a neutral state. Erickson and Schulkin (2003) indicated "a change in regulatory state results in a change in approach behavior and facial display suggesting enjoyment or disgust, depending on the valence of the situation." Coconut syrup and vanilla extract flavored milk produced less sad, but at different time points. In other research, products with positive or neutral responses generate less emotional facial expression responses (De Wijk et al., 2012; Danner et al., 2013; Danner et al., 2014; Wendin et al., 2011; Zeinstra, Koelen, Colindre, Kok, & De Graaf, 2009). Danner et al. (2013) found that the incidences of happy and disgusted in orange juice samples related to hedonic liking and disliking. Water is considered neutral and is not highly emotional (Steiner, 1979; Steiner et al., 2001) and can be utilized as a control or baseline in emotional research (Leitch et al., 2015; Garcia-Burgos & Zamora, 2015); however, in this study unflavored milk was used as a baseline (positive control).

For time series analysis, lower hedonic solutions ratings generated more sad than unflavored milk ($p<0.025$). Also, sour, green tea, and salty flavored milk beverages expressed more disgust than unflavored milk ($p<0.025$). Danner et al. (2014) found that disliked juice samples elicited more disgust, "sum of negative emotions" and less neutral than the liked samples. Malty, green tea, and salty flavored milk beverages elicited surprised than unflavored milk ($p<0.025$). Surprised could be attributed to the novelty and lack of awareness of the flavor addition. These flavors were used to promote disgust and panelists may have been surprised by the atypical flavor. Malty, green tea, and salty milk beverages expressed more angry than unflavored milk ($p<0.025$). The trend prevalence of angry over 10 sec was more consistent in green tea and salty. Additionally, scared was evoked in sour and salty flavored milk than in unflavored milk ($p<0.025$). Both sour and salty are considered to be off-flavors in fresh milk (Alvarez, 2009). When asked qualitatively about samples, participants often described the salty sample as sour. Moreover, green tea and salty flavored milk generated more happy than unflavored milk ($p<0.025$). With the lowest hedonic values, it is unexpected for the samples to generate happy. However in other research, investigators have also encountered the same phenomenon. The presence of happy expression could be attributed to overcompensation to mask participant's true feelings (Greimel et al., 2006; Danner et al., 2014). Using caffeine bitter solutions, happy was expressed in the high and medium bitter solutions compared to the unflavored water control (Crist et al., 2014). In a study with different juices, the disliked sample flavors generated happy (Danner et al., 2014). When prompted for a qualitative explanation, the participants mentioned they were surprised by the disgusting unfamiliar flavor and tried to overcompensate by smiling (Danner et al., 2014). Also, Greimel et al. (2006) mentioned smiling can often be response to mask distaste. Weiland, Ellgring, and Macht (2010) stated that smiling in response to a dislike stimuli is due to learned behavior in adults or a "social display rule" Additionally, De Wijk et al. (2012) found differences only in disliked foods indicating that AFEA is more sensitive to disliked samples over liked samples. Positive or neutral products generate less pronounced facial expressions in response to stimuli (De Wijk et al., 2012; Danner et al., 2013; Danner et al., 2014; Wendin et al., 2011; Zeinstra et al., 2009).

Lastly, time series analysis based on hedonic score separation may be useful to evaluate population emotional contributions of those that liked and disliked treatment samples. The population perspective may identify emotional trends with treatments and aid in identifying emotional relationships to consumer acceptability.

5. Conclusions

Consumer acceptability revealed that unflavored milk and milks flavored with vanilla syrup and coconut syrup were all positively rated. AFEA of vanilla syrup and coconut syrup flavored milk generated happy, although happy was not a prevalent emotion and did not significantly trend over 10 seconds. The lower rated samples (salty and green tea) generated disgust as the prevalent emotion in the data. Additionally, lower acceptability treatments generated less neutral than those with positive consumer acceptability, alluding to a deviation from neutral. These results suggest and support that AFEA is a better indicator of disliked samples than liked. Time series trends exist with AFEA related to disliked flavors in milk and may assist in differentiating acceptability due to predominance of disgust emotions over 10 second duration. Time series analysis has shown to be a more sensitive method to evaluate AFEA data and generated emotions. Time series analysis can identify trends and emotional changes over time and is more sensitive than ANOVA. The methodology may aid with implicit consumer acceptability responses. Future research should continue to investigate and improve time series methodology. Moreover, emotion categorization should be refined and explored for its application to food and beverages. Food experiences are generally positive, and more emotions should be included in the analysis software to reflect eating experiences beyond "happy". Lastly, it has been suggested that facial expressions can be classified beyond the six universal emotions and may even appear as “compound emotions” or the combination of two emotions in one (Du, Tao, & Martinez, 2014). The inclusion of more emotions and exploration of facial expression analysis to foods and beverages should be further developed.

Acknowledgments

This project was funded, in part, by ConAgra Foods (Omaha, NE, USA), the Virginia Agricultural Experiment Station, the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture, and the Virginia Tech Water INTERface Interdisciplinary Graduate Education Program. The funding sources had no involvement in designing the study, collection, analysis, interpretation of data, manuscript development nor selection of the journal for submission.

References

Alvarez, V.B. (2009). Fluid milk and cream products. In S. Clark, M. Costello, M. Drake, & F. Bodyfelt (Eds.), *The sensory evaluation of dairy foods,* (2nd ed). (pp. 73-133). New York, NY: Springer Publishing Co.

Alves, N. T., Fukusima S. S., & Aznar-Casanova J. A. (2008). Models of brain asymmetry in emotional processing. *Psychology & Neuroscience, 1*(1), 63-66.

Anonymous. (2015). Almond milk continues to lead dairy alternatives segment. *Beverage Industry*. *7*(106), S0I14.

Arnade, E.A. (2013). *Measuring consumer emotional response to tastes and foods through facial*

expression analysis (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA.

Blum, J. W., Jacobsen, D. J., & Donnelly, J. E. (2005). Beverage consumption patterns in elementary school aged children across a two-year period. *Journal of the American College of Nutrition, 24*, 93–98.

Bowman, S., Gortmaker S., Ebbeling, C., Pereira, M., & Ludwig, D. (2004). Effects of fast-food consumption on energy intake and diet quality among children in a national household survey. *Pediatrics, 113,* 112-118.

Costello, M., & Clark, S. (2009). Preparation of samples for instructing students and staff in dairy products evaluation. In S. Clark, M. Costello, M. Drake, & F. Bodyfelt (Eds.), *The sensory evaluation of dairy foods*, (2nd ed.). (pp. 551-560). New York, NY: Springer Publishing Co.

Crist, C. A., Arnade, E. A., Leitch, K. A., Duncan, S. E., O'Keefe, S., Dunsmore, J. & Gallagher, D. L. 2014. Application of emotional facial analysis technology to consumer acceptability using a basic tastes model. *Technical Abstracts and Proceedings of the 2014 IFT Annual Meeting, June 21 – 24, 2014, New Orleans, LA.*

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expression and autonomous nervous system responses elicited by tasting different juices. *Food Research International*, *64*, 81-90.

Danner, L., Sidorkina, L., Joechl, M., & Duerrschmid, K. (2013). Make a face! implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference, 32*(B), 167-172.

Davidson, R.J. 1995. Cerebral asymmetry, emotion, and affective style. In R.J. Davidson & K. Hughdahl (Eds.), *Brain Asymmetry* (361-387). Boston, MA: MIT Press.

Davidson, R.J., Ekman, P., Saron, C.D., Senulis, J.A., & Friesen, W.V. (1990). Approach withdrawal and cerebral asymmetry: emotional expression and brain physiology I. *Journal of Personality and Social Psychology, 58*(2), 330–341.

De Graaf, C., & Zandstra, E.H. (1999). Sweetness intensity and pleasantness in children, adolescents and adults. *Physiology & Behavior*, *67*(4), 513–520.

De Wijk, R. A., He, W., Mensink, M. G. J., Verhoeven, R. H. G., & De Graaf, C. (2014). ANS responses and facial expression differentiate between the taste of commercial breakfast drinks. *PLoS ONE*, *9*(4 e93823), 1-9.

De Wijk, R. A., Kooijman, V., Verhoeven, R. H. G., Holthuysen, N. T. E., & De Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. *Food Quality and Preference*, *26*(2), 196-203.

Demaree, H.A., Everhart, D.E., Youngstrom, E.A., & Harrison, D.W. (2005). Brain lateralization of emotional processing: historical roots and a future incorporating "dominance". *Behavioral and Cognitive Neuroscience Review, 4*, 3-20.

Desmet, P. M. A. & Schifferstein, H. N. J. (2008). Sources of positive and negative emotions in food experience. *Appetite*, *50*, 290-301.

Dijksterhuis, A. & Smith, P. K. (2005). What do we do unconsciously? and how? *Journal of Consumer Psychology*, *15*(3), 225-229.

Du, S., Tao, Y., & Martinez, A. M. (2014). Compound facial expressions of emotion. *Proceedings of the National Academy of Sciences*, *111*(15), E1454–E1462.

Ekman, P. & Friesen, W.V. (2003). Why mistakes are made in understanding facial expressions of emotion. In u*nmasking the face: a guide to recognizing emotions from facial clues* (pp. 10-20). Los Altos, CA: Malor Books

Ekman, P., Friesen, W. V., O'Sullivan, M., Chan, A., Diacoyanni-Tarlatzis, I., Heider, K., Krause, R., LeCompte, W. A., Pitcairn, T., Ricci-Bitti, P. E., Scherer, K., Tomita, M., & Tzavaras, A. (1987). Universals and cultural differences in the judgments of facial expressions of emotion. *Journal of Personality and Social Psychology*, *53*(4), 712-717.

Erickson, K. & Schulkin, J. (2003). Facial expressions of emotion: a cognitive neuroscience perspective. *Brain and Cognition, 52*(1), 52-60.

Fisher J., Mitchell, D., Smiciklas-Wright, H., & Birch, L. (2001). Maternal milk consumption predicts the tradeoff between milk and soft drinks in young girls' diets. *Journal of Nutrition*, *131*(2), 246-250.

Garcia-Burgos, D. & Zamora, M. C. (2013). Facial affective reactions to bitter-tasting foods and body mass index in adults. *Appetite, 71*(2013), 178-186.

Garcia-Burgos, D. & Zamora, M. C. (2015). Exploring the hedonic and incentive properties in preferences for bitter foods via self-reports, facial expressions and instrumental behaviours. *Food Quality and Preference, 39*(2015), 73-81.

Gibson, E.L. (2006). Emotional influences on food choice: sensory, physiological and psychological pathways. *Physiology and Behavior, 89*(1), 53–61.

Greimel, E., Macht, M., Krumhuber, E. & Ellgring, H. (2006). Facial and affective reactions to tastes and their modulation by sadness and joy. *Physiology & Behavior. 89*(2), 261-269.

Johnson, R. K., Frary, C., & Wang, M. Q. (2002). The nutritional consequences of flavored-milk consumption by school-aged children and adolescents in the united states. *Journal of the American Dietetic Association, 102,* 853–856.

Kaiser H. (2010). Measuring the impacts of generic fluid milk and dairy marketing, research bulletin 2010-01, Cornell University. *National Institute for Commodity Promotion & Research Evaluation*. Retrieved from http://dyson.cornell.edu/research/researchpdf/rb/2010/Cornell_Dyson_rb1001.pdf

Kaiser, H., & Dong, D. (2006). Measuring the impacts of generic fluid milk and dairy marketing, research bulletin 2006-05, cornell university. *National Institute for Commodity Promotion & Research Evaluation*. Retrieved from http://www.aem.cornell.edu/research/ researchpdf/rb/2006/Cornell_Dyson_ rb0605.pdf

King, S. C., & Meiselman, H. L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21*(2), 168-177.

Köster, E. P. (2003). The psychology of food choice: some often encountered fallacies. *Food Quality and Preference, 14*(5), 359–373.

Lasater, G., Piernas, C., & Popkin, B. M. (2011). Beverage patterns and trends among school-aged children in the US, 1989–2008. *Nutrition Journal, 10,* 1-9.

Leitch, K. A., Duncan, S. E., O'Keefe, S., Rudd, R., & Gallagher, D. L. (2015). Characterizing consumer emotional response to sweeteners using an emotion terminology questionnaire and facial expression analysis. *Food Research International, 76*(2015), 283-292.

Mojet, J., Dürrschmid, K., Danner, L., Jöchl, M., Heiniö, R., Holthuysen, N., & Köster, E. (2015). Are implicit emotion measurements evoked by food unrelated to liking. *Food Research International, 76*(2), 224-232.

Murphy, M.M., Douglass, J.S., Johnson, R.K., & Spence, L.A. (2008). Drinking flavored or plain milk is positively associated with nutrient intake and is not associated with adverse effects on weight status in US children and adolescents. *Journal of the American Dietetic Association, 108*, 631–639.

Noldus Information Technology (2014). *FaceReader™ 5Technical Specifications*. Wageningen, The Netherlands: Noldus Information Technology Retrieved from http://www.noldus.com/files/file_manager/downloads/whitepaper/FaceReader_Methodology.pdf

Noldus Information Technology. (2014b). FaceReader™6 Reference Manual (6th ed.). Wageningen, Netherlands: Noldus Information Technology.

Package Facts (2015). *Innovation in vegetarian protein products lead by meat alternatives and ancient grains.* Retrieved from http://www.packagedfacts.com/about/release.asp?id= 3823

Patterson, J. & Saidel, M. (2009). The removal of flavored milk in schools results in a reduction in total milk purchases in all grades, K-12. *Journal of the American Dietetic Association, 109*(9), A97.

Pelsmaeker, S. de, Schouteten, J, & Gellynck, X. (2013). The consumption of flavored milk among a children population. the influence of beliefs and the association of brands with emotions. *Appetite, 71*(2013), 279-286.

Popkin, B. M. (2010). Patterns of beverage use across the lifecycle. *Physiology and Behavior, 100*, 4–9.

Porcherot, C., Delphanque, S., Raviot-Derrien, S., Le Calve, B., Chrea, C., Gaudreau, N., & Cayeux. I. (2010). How do you feel when you smell this? optimization of a verbal measurement of odor-elicited emotions. *Food Quality and Preference, 21*(8), 938-947.

R Core Team (2014). R: *A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from URL http://www.R-project.org/

Robbins, S.P., & Judge, T.A. (2013). *Emotions and moods. essentials of organizational behavior* (pp. 258–297). Upper Saddle River, NJ: Prentice Hall.

Stanton, J. (2013). Market View: The return of truly new products: the food and beverage industry shows signs its R&D engines are revving again. *Food Processing*. Retrieved from http://www.foodprocessing.com/articles/2013/increased-new-products/

Steiner, J. (1979). Human facial expressions in response to taste and smell stimulation. In H. Reese & L. Lipsitt (Eds.), *Advances in child development and behavior*. New York, NY: Academic Press.

Steiner, J.E., Glaser, D., Hawilo, M.E., & Berridge, K.C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience and Biobehavioral Reviews, 25*(1), 53–74.

Stewart, H. Dong, D. & Carlson, A. (2012). Is generational change contributing to the decline in fluid milk consumption? Journal of Agricultural and Resource Economics, 37(3), 435-454.

Stewart, H., Dong, D., & Carlson, A. (2013). *Why are americans consuming less fluid milk? a look at generational differences in intake frequency* [ERR-149]. U.S. Department of Agriculture, Economic Research Service, May 2013.

U.S. Department of Agriculture and U.S. Department of Health and Human Services (DHHS). 2010. *Dietary Guidelines for Americans, 2010* (7th ed.). Retrieved from http://www.cnpp.usda.gov/dietaryguidelines.htm. Last accessed August 30, 2015.)

Vartanian, L. R., Schwartz, M. B., & Brownell, K. D. (2007). Effects of soft drink consumption on nutrition and health. a systematic review and meta-analysis. *American Journal of Public Health, 97*, 667–675.

Walsh, A. M., Duncan, S. E., Potts, H., & Gallagher, D. L. (2015). Comparing quality and emotional responses as related to acceptability of light-induced oxidation flavor in milk. *Food Research International. 76*, 293 – 300.

Warrenburg, S. (2005). Effects of fragrance on emotions: moods and physiology. *Chemical Senses, 30*, i248–i249

Weiland, R., Ellgring, H., & Macht, M. (2010). Gustofacial and olfactofacial responses in human adults. Chemical Senses, 35, 841-853.

Wendin, K., Allesen-Holm, B. H., & Bredie, L. P. (2011). Do facial reactions add new dimensions to measuring sensory responses to basic tastes? *Food Quality and Preference, 22*, 346-354.

Zeinstra, G. G., Koelen, M. A., Colindrews, D., Kok, F.J., & De Graaf, C. (2009). Facial expressions in school-aged children are a good indicator of “dislikes”, but not of “likes”. *Food Quality and Preference*, *20*(8), 620–624.

Table 4.1 Mean emotional response scores (5 sec) for unflavored and flavored milk using automated facial expression analysis[1] in the continuous analysis software setting.

	Emotion[1]						
Treatment[2]	Neutral	Angry	Sad	Happy	Disgusted	Surprised	Scared
Unflavored Milk	0.456± 0.233[aA]	0.200± 0.233[aB]	0.116± 0.166[aBC]	0.031± 0.064[aCD]	0.027± 0.074[aCD]	0.022± 0.039[aD]	0.003± 0.011[aD]
Vanilla Syrup	0.412± 0.216[aA]	0.153± 0.180[aBC]	0.174± 0.213[aB]	0.057± 0.112[aCD]	0.028± 0.073[aD]	0.044± 0.106[aD]	0.003± 0.008[aD]
Coconut Syrup	0.445± 0.239[aA]	0.171± 0.212[aB]	0.152± 0.166[aB]	0.030± 0.045[aC]	0.022± 0.054[aC]	0.027± 0.080[aC]	0.004± 0.012[aC]
Water	0.467± 0.282[aA]	0.191± 0.230[aB]	0.126± 0.191[aBC]	0.032± 0.074[aCD]	0.019± 0.050[aCD]	0.025± 0.052[aCD]	0.002± 0.008[aD]
Vanilla Extract	0.448± 0.226[aA]	0.168± 0.182[aB]	0.130± 0.185[aBC]	0.053± 0.120[aCD]	0.029± 0.076[aD]	0.022± 0.035[aD]	0.003± 0.013[aD]
Malty	0.430± 0.248[aA]	0.162± 0.186[aB]	0.188± 0.212[aB]	0.041± 0.117[aC]	0.028± 0.078[aC]	0.024± 0.057[aC]	0.003± 0.011[aC]
Sour	0.437± 0.212[aA]	0.168± 0.168[aB]	0.119± 0.142[aB]	0.019± 0.025[aC]	0.035± 0.079[aC]	0.020± 0.060[aC]	0.009± 0.045[aC]
Green Tea	0.400± 0.225[aA]	0.212± 0.223[aB]	0.135± 0.180[aBC]	0.025± 0.049[aD]	0.049± 0.113[aCD]	0.027± 0.059[aD]	0.005± 0.017[aD]
Salty	0.397± 0.225[aA]	0.142± 0.163[aB]	0.162± 0.208[aB]	0.035± 0.060[aC]	0.071± 0.129[aBC]	0.031± 0.059[aC]	0.007± 0.020[aC]

[a, b] Means within each column with different superscripts significantly differ ($p<0.05$).
[A, B, C, D] Means within each row with different superscripts significantly differ ($p<0.05$).
[1]AFEA translates facial muscle motion to neutral, happy, disgusted, sad, angry, surprised and scared on a scale from 0 (not expressed) to 1 (fully expressed) for each emotion. FaceReader™6, Noldus Information Technology, Wageningen, The Netherlands.
[2]Water (Drinking Water); unflavored milk (2% reduced fat milk); sour (0.02g buttermilk/ml); coconut syrup (0.02g/ml); vanilla syrup (0.02g/ml); vanilla extract (0.02g/ml); malty (Solution 1: 0.15g grape nuts /ml milk; Solution 2: 0.05g Solution1 /ml milk); salty (0.004g salt/ml); and green tea (Solution 1: Prepared as manufacturer's instructions in distilled water (0.009/ml); Solution 2: 0.11g/ml)

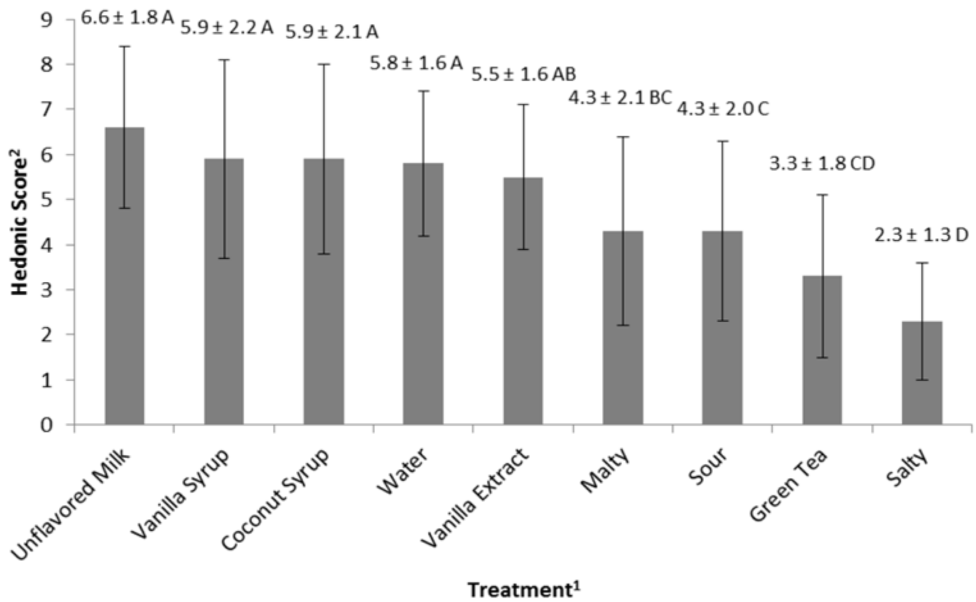


Figure 4.1 Consumer acceptability of unflavored and flavored milk treatments.

[A, B, C, D]Means with different superscripts significantly differ ($p<0.05$).
[1]Water (Drinking Water); unflavored milk (2% reduced fat milk); sour (0.02g buttermilk/ml); coconut syrup (0.02g/ml); vanilla syrup (0.02g/ml); vanilla extract (0.02g/ml); malty (Solution 1: 0.15g grape nuts /ml milk; Solution 2: 0.05g Solution1 /ml milk); salty (0.004g salt/ml); and green tea (Solution 1: Prepared as manufacturer's instructions in distilled water (0.009g/ml; Solution 2: 0.11g/ml).
[2]Hedonic scores: 1 = "dislike extremely", 9 = "like extremely"; mean +/- SD.

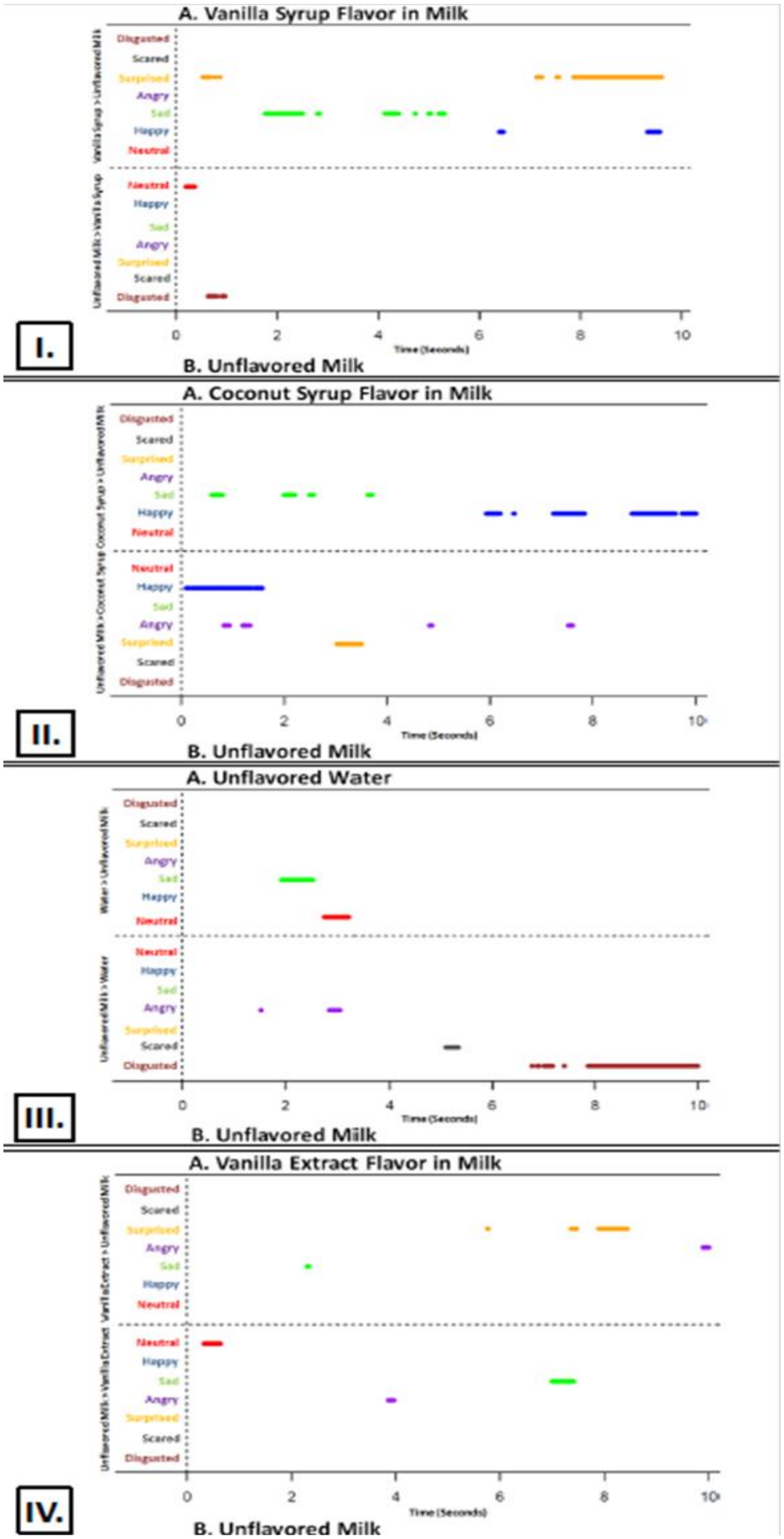


Figure 4.2 Emotional time series data over 10 sec comparing unflavored milk and high hedonic flavored milk treatments.

[1]Sequential paired nonparametric Wilcoxon tests ($p<0.05$) were performed between unflavored milk and each treatment based on the 30 Hz AFEA sampling rate. Results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2] Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).

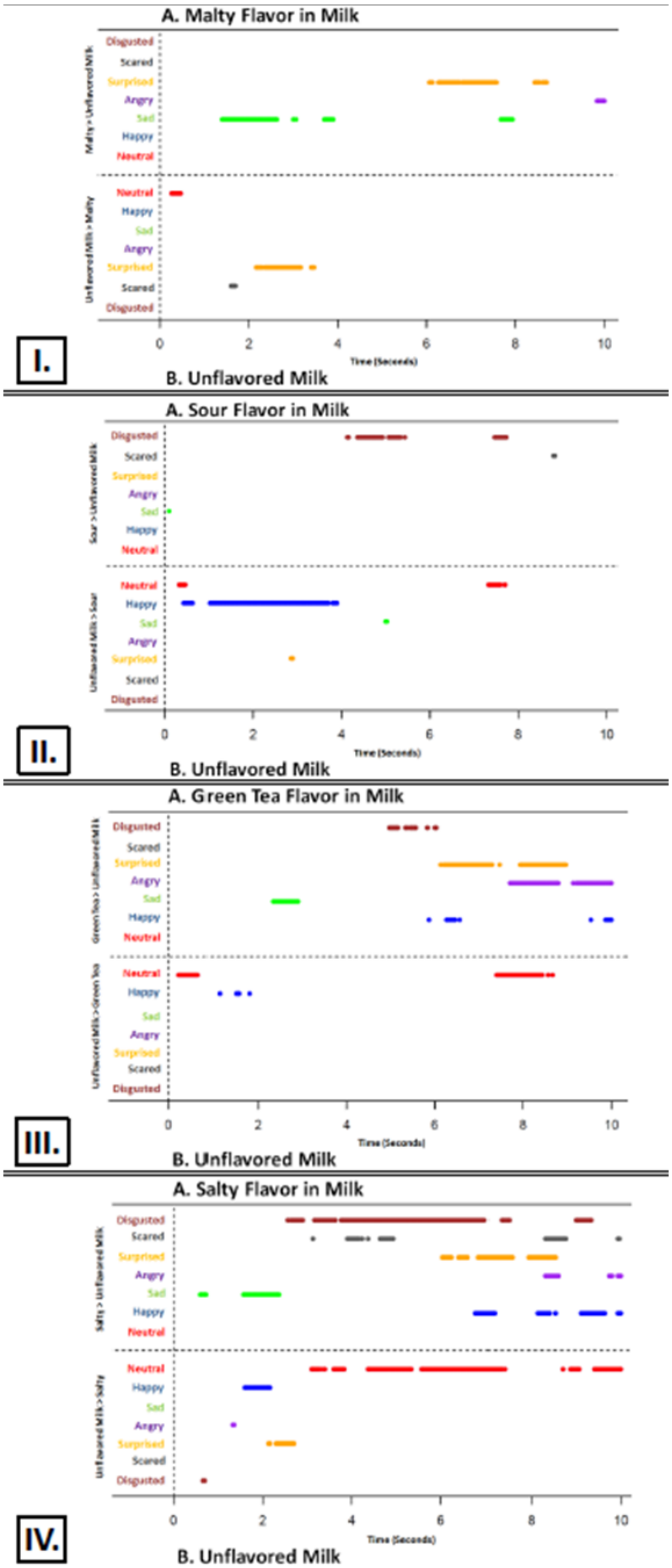


Figure 4.3 Emotional time series data over 10 sec comparing unflavored milk and low hedonic flavored milk treatments.

[1]Sequential paired nonparametric Wilcoxon tests ($p<0.05$) were performed between unflavored milk and each treatment based on the 30 Hz AFEA sampling rate. Results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2] Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).

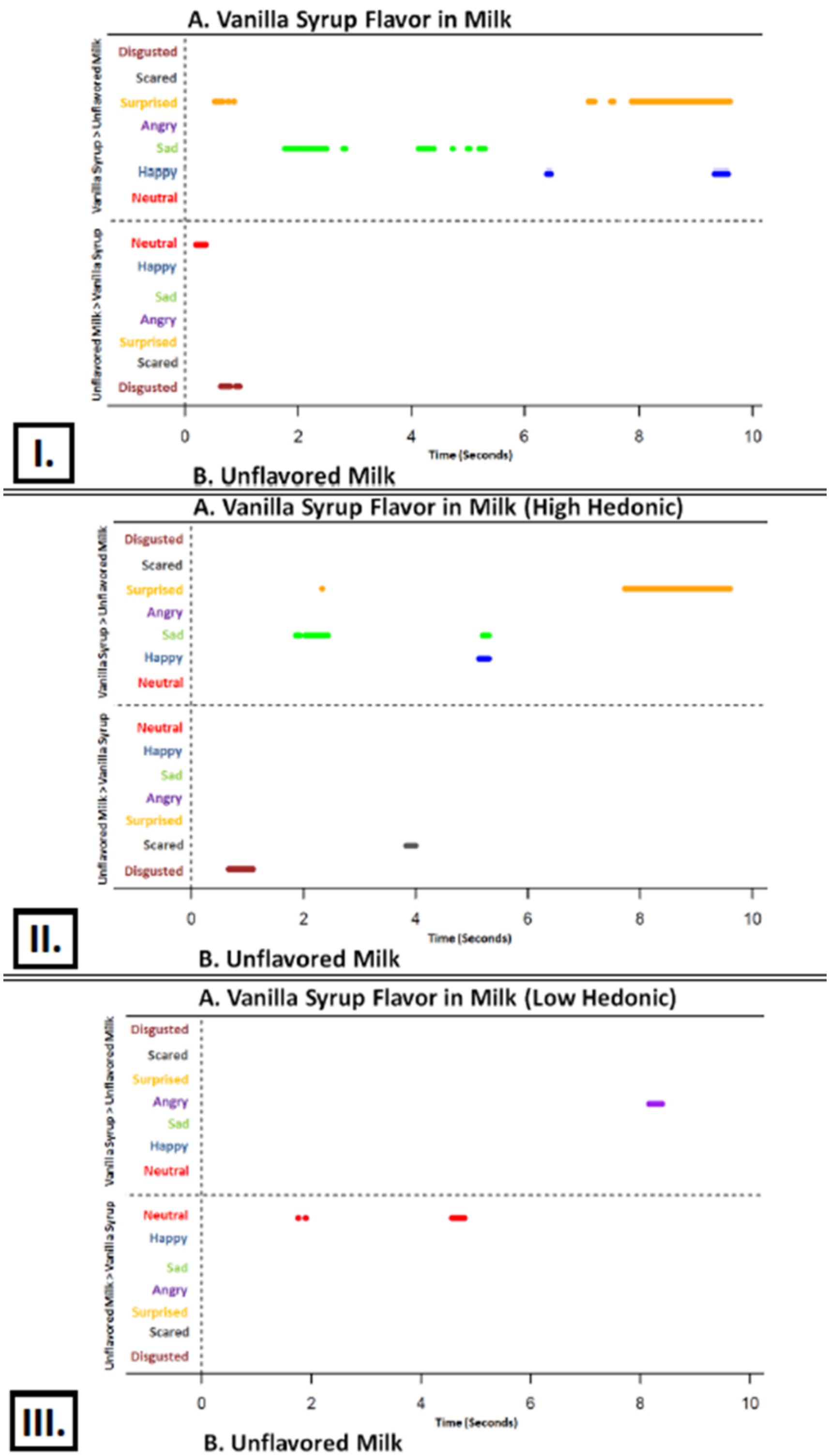


Figure 4.4 Emotional time series data over 10 sec comparing unflavored milk to high hedonic vanilla syrup (II) and unflavored milk to low hedonic vanilla syrup milk (III).

[1]Sequential paired nonparametric Wilcoxon tests ($p<0.05$) were performed between unflavored milk and each treatment based on the 30 Hz AFEA sampling rate. Results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2] Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).
[3]The treatment acceptability scores were divided by panelist hedonic rating as "liked" (consumer acceptability score=6, 7, 8, 9) and "disliked" (consumer acceptability scores = 4, 3, 2, 1).
[4]Vanilla syrup: "population" n=42 (I); "liked" n= 27 (II); "disliked" n= 12 (III).

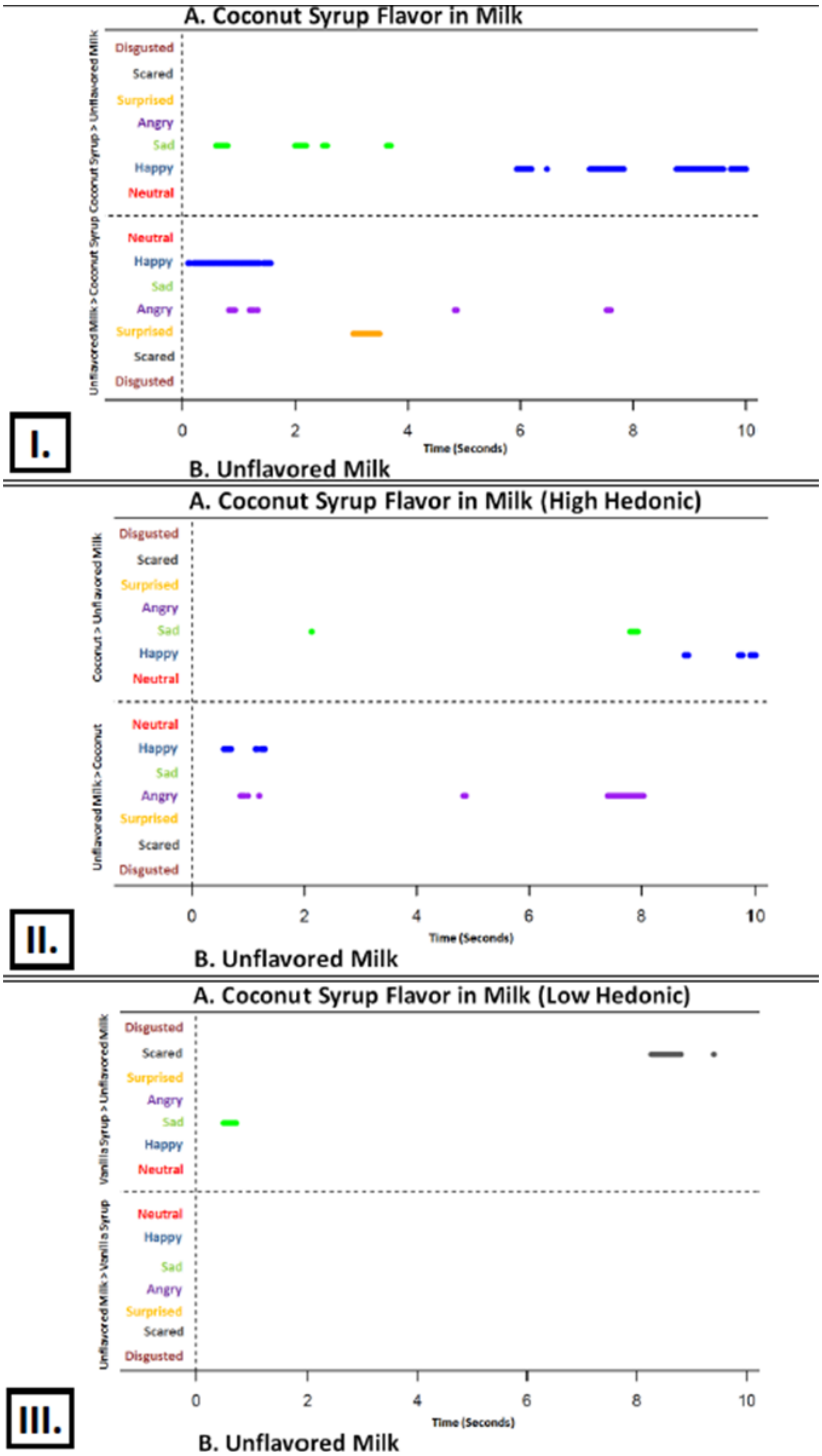


Figure 4.5 Emotional time series data over 10 sec comparing unflavored milk to high hedonic coconut syrup (II) and unflavored milk to low hedonic coconut syrup milk (III).

[1]Sequential paired nonparametric Wilcoxon tests ($p<0.05$) were performed between unflavored milk and each treatment based on the 30 Hz AFEA sampling rate. Results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2] Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).
[3]The treatment acceptability scores were divided by panelist hedonic rating as "liked" (consumer acceptability score=6, 7, 8, 9) and "disliked" (consumer acceptability scores = 4, 3, 2, 1).
[4]Coconut syrup: "population" n=42 (I); "liked" n=28 (II); "disliked" n=12 (III).

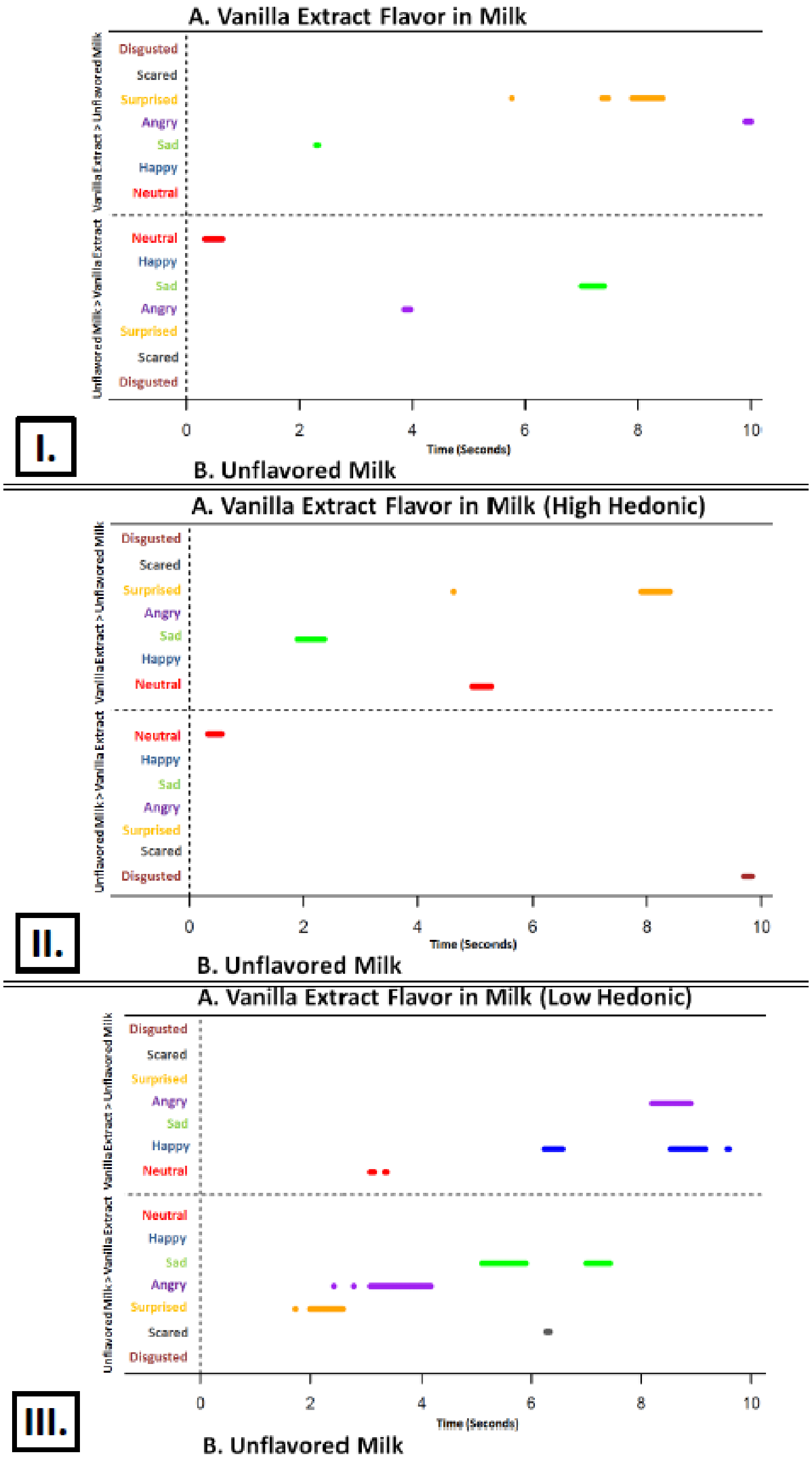


Figure 4.6 Emotional time series data over 10 sec comparing unflavored milk to high hedonic vanilla extract (II) and unflavored milk to low hedonic vanilla extract milk (III).

[1]Sequential paired nonparametric Wilcoxon tests ($p<0.05$) were performed between unflavored milk and each treatment based on the 30 Hz AFEA sampling rate. Results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2] Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).
[3]The treatment acceptability scores were divided by panelist hedonic rating as "liked" (consumer acceptability score=6, 7, 8, 9) and "disliked" (consumer acceptability scores = 4, 3, 2, 1).
[4]Vanilla extract: "population" n=42 (I); "liked" n=22 (II); "disliked" n=13 (III).

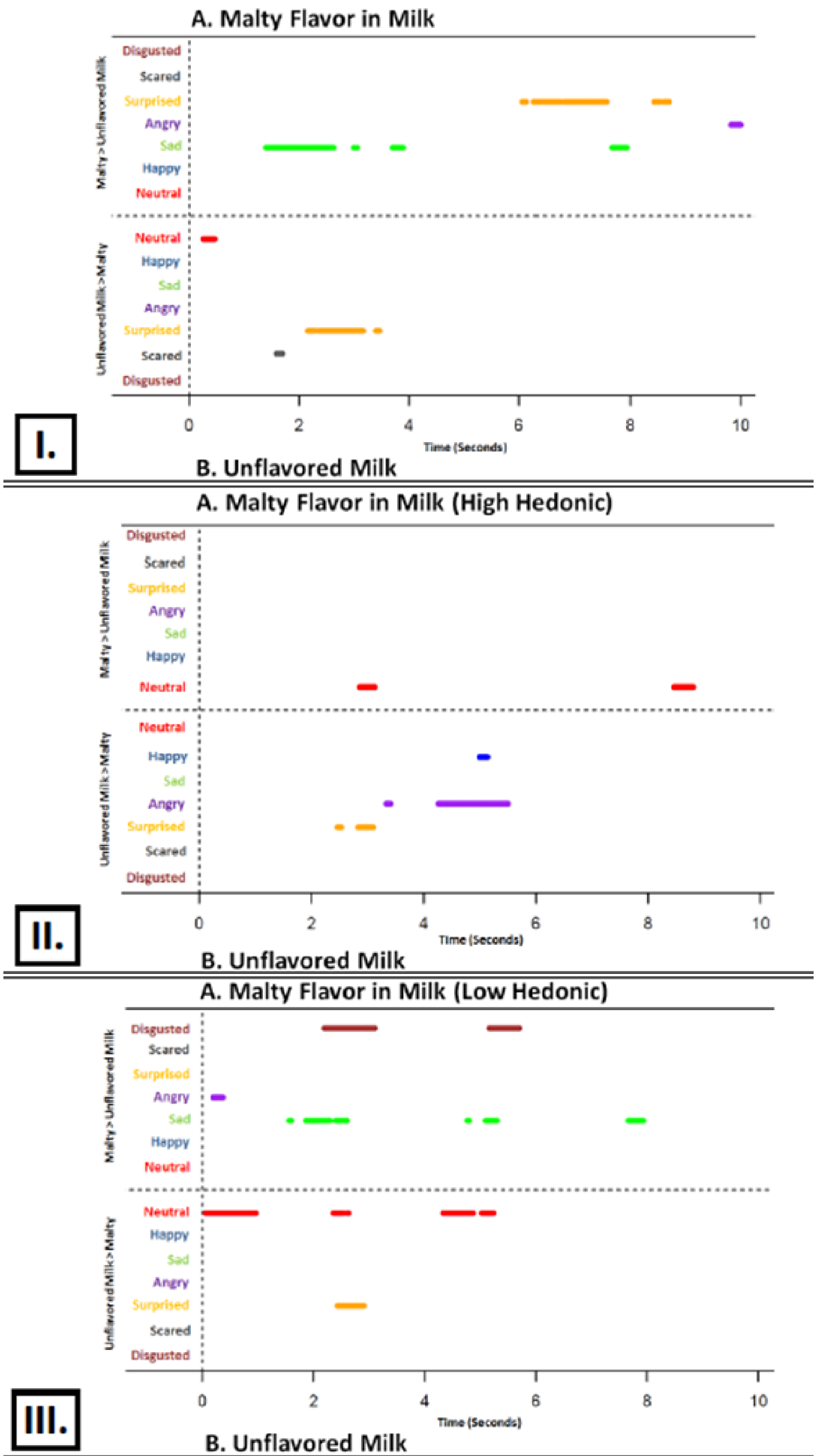


Figure 4.7 Emotional time series data over 10 sec comparing unflavored milk to high hedonic malty (II) and unflavored milk to low hedonic malty milk (III).

[1]Sequential paired nonparametric Wilcoxon tests ($p<0.05$) were performed between unflavored milk and each treatment based on the 30 Hz AFEA sampling rate. Results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2] Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).
[3]The treatment acceptability scores were divided by panelist hedonic rating as "liked" (consumer acceptability score=6, 7, 8, 9) and "disliked" (consumer acceptability scores = 4, 3, 2, 1).
[4]Malty: "population" n=42 (I); "liked" n=12 (II); "disliked" n=25 (III).

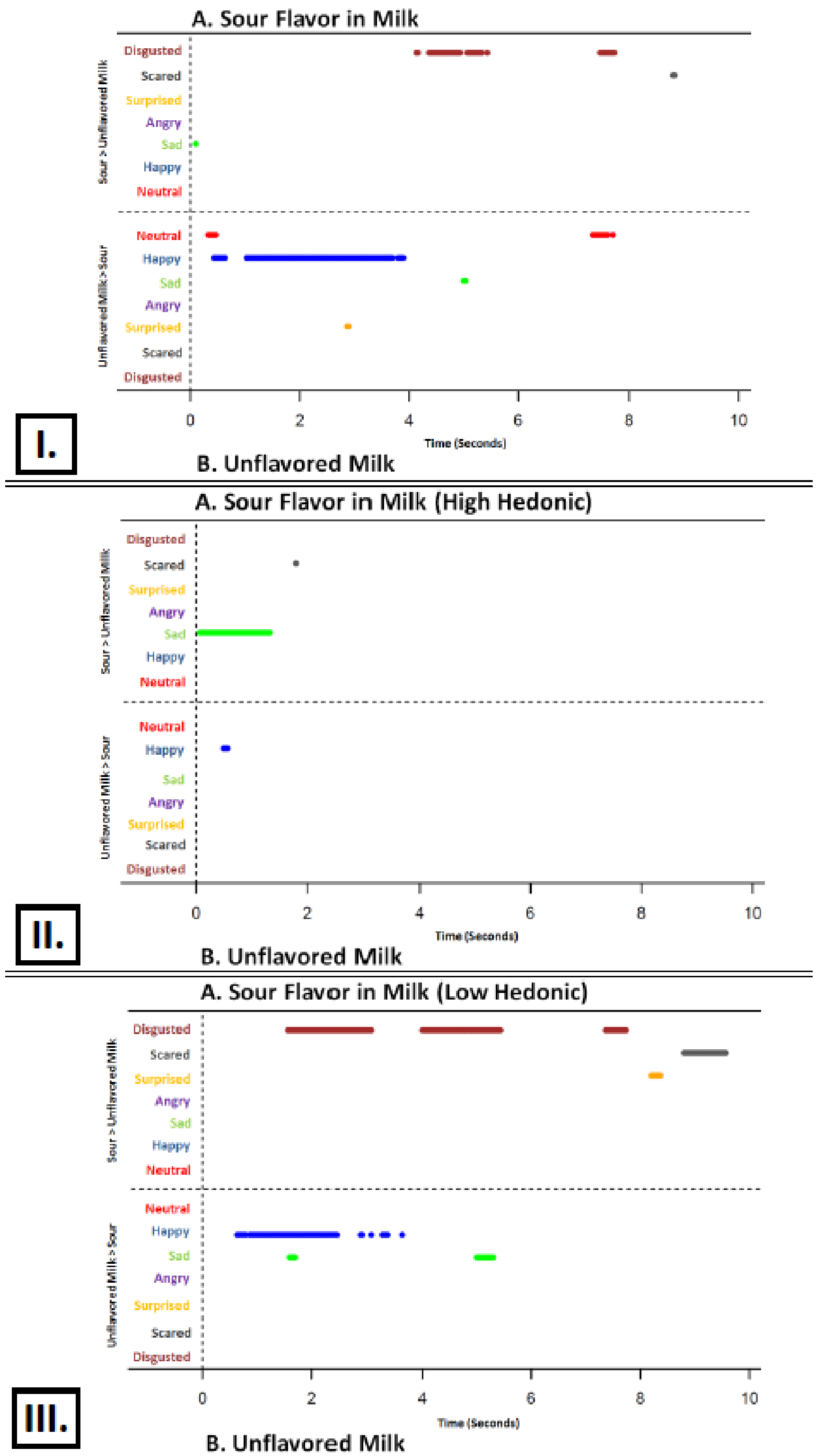


Figure 4.8 Emotional time series data over 10 sec comparing unflavored milk to high hedonic sour flavored milk (II) and unflavored milk to low hedonic sour milk (III).

[1]Sequential paired nonparametric Wilcoxon tests ($p<0.05$) were performed between unflavored milk and each treatment based on the 30 Hz AFEA sampling rate. Results are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2] Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).
[3]The treatment acceptability scores were divided by panelist hedonic rating as “liked” (consumer acceptability score=6, 7, 8, 9) and “disliked” (consumer acceptability scores = 4, 3, 2, 1).
[4]Sour: “population” n=42 (I); “liked” n=12 (II); “disliked” n=25 (III).

CHAPTER V

Application of Automated Facial Expression Analysis Technology to Acceptability Using an Aqueous Bitter Model

Abstract

Automated facial expression analysis (AFEA) is a prospective analytical dimension for consumer acceptability in the food industry. The purpose of these investigations was threefold: (1) to determine if AFEA could supplement consumer acceptability using bitter solutions ; (2) to determine optimal AFEA methodology using an aqueous bitter solution; (3) determine an appropriate statistical analysis of AFEA output. We hypothesized: (1) bitter solutions would elicit a strong disgust reaction post-consumption as measured by AFEA; (2) product acceptability would decrease as bitterness increased.

Participants (n=46) evaluated a control (distilled water) and three bitter (caffeine) solutions: low (0.05% w/v); medium (0.08% w/v); and high (0.15% w/v). Sessions were video-recorded and analyzed per participant per sample for 5 seconds post-consumption (α = 0.20) in the default and continuous analysis setting. Participants rated acceptability and taste intensity on a 9-point scale.

An inverse relationship existed between acceptability and bitter intensity (r_s= -0.90; $p<0.0001$). In continuous settings, a higher disgust response was elicited in the medium bitter treatment than for control and low bitter ($p<0.20$); but, there were no differences between treatments in default disgust ($p>0.20$). Surprised was elicited more in the control than in the high bitter ($p<0.20$) in both the default and continuous analysis.

The same frequency of significant differences ($n=42$; $p<0.05$) was observed in both continuous and default setting using ANOVA ($n=42$); however, continuous analysis had lower variability potentially justifying its methodological use. In time series analysis, disgust was a predominant emotion in the medium and high bitter solutions in both the continuous and default setting ($p<0.025$). Using time series analysis, continuous and default results were of similar patterns over 5 sec, but continuous data was more intermittent. Time series analysis is a promising tool for interpreting emotional output and is more sensitive to emotional changes than ANOVA.

1. Introduction

Consumer-brand companies are actively seeking ways to improve their connection and relationship with consumers in a saturated competitive environment. Consumer choices and behaviors are difficult to predict and may be driven by implicit (unconscious) responses to environmental cues and stimuli (Dijksterhuis & Smith, 2005). In recent years, there has been a desire to develop more relevant analysis to supplement hedonic testing, which is a common method for assessing product acceptability (Meilgaard, Civille, & Carr, 2007). Consumer bias, such as anticipation and expectation, can influence hedonic testing due to the conscious state of evaluation and failure to evaluate initial reactions and interaction with food products (De Wijk, Kooijman, Verhoeven, Holthuysen, & De Graaf, 2012). Products are often evaluated based on a directionality of expectation (Cardello, 1994; Meiselman & Schutz, 2003). Wendin, Allesen-Holm, and Bredie (2011) stated that in addition to typical sensory analysis, facial expressions provided additional information to acceptability of a stimulus using a basic taste model.

Automated facial expression analysis (AFEA) for the assessment of implicit response is an innovative application, although the literature on food applications is very limited. Several explicit and implicit methodologies have been developed to incorporate attitudes, mood, emotional, and physiological cues in measuring affective behaviors to products and environment (Koster & Mojet, 2015). Explicit methodologies rely on conscious actions for consumer evaluation related data for emotional and/or mood evaluation using check all that apply (CATA) and food emotional lexicons (King & Meiselman, 2010; Koster & Mojet, 2015). Measures of implicit responses applied to emotion include physiological measures such as facial electromyography (Hu, Player, Mcchesney, Dalistan, Tyner, & Scozzafava, 1999), skin conductance responses, heart rate, and finger temperature (De Wijk et al., 2012). Additionally, implicit evaluation using emotional analysis can be conducted using manual facial coding and AFEA. Most notably, the facial action coding system (FACS) discriminates facial movements characterized by action units (AU) on a 5-point intensity scale (Ekman & Friesen, 1978). The FACS approach requires trained reviewers, is a time intensive approach, and provides limited data analysis options. Automated facial expression analysis (AFEA) was developed to reduce the challenges of FACS and provide more rapid evaluation. There are several commercially available software systems that can generate AFEA. In our study, FaceReader™6 (Noldus Information Technology, Wageningen, The Netherlands) was used; expression analysis in this software is based on the Viola-Jones algorithm (Viola & Jones, 2001) to detect the face with eye detection used to determine the plane rotation of the face (Sung & Poggio, 1998; Noldus Information Technology, 2014a). A 3D modeling application is used based on the Active Appearance Model (AAM) that detects about 500 key points on the face associated with emotional movement (Cootes & Taylor, 2000; Noldus Information Technology, 2014a). The face reading software contains “an artificial neural network” (Bishop, 1995) developed from thousands of photos analyzed by face reading experts, which detects the universal emotions happy, sad, disgusted, surprised, angry, scared and neutral each on a scale (0=not expressed; 1=fully expressed) (Noldus Information Technology, 2014ab). Happy is categorized as the only positive emotion with sad, angry, scared and disgusted being negative, whereas surprised could be considered either negative or positive (Noldus Information

Technology, 2014b). From a psychological perspective, “approach” emotions (toward stimuli) include happy, surprised, and angry, while “withdrawal” emotions (away from aversive stimuli) are sad, scared, and disgusted (Alves, Fukusima, & Aznar-Casanova, 2008).

FaceReader™ 6 offers three analysis settings: default (no calibration), continuous calibration, and individual calibration. For the individual calibration in FaceReader™ 6, a participant’s neutral expression is used for calibration (Noldus Information Technology, 2014b). Continuous calibration consists of software actively eliminating participant expression bias (i.e. some people look sad by nature; data capture setting is not optimal) while running analysis without individual calibration images or video (Noldus Information Technology, 2014b). At present there is not a standard methodology or consistency of calibration use as evident by other research methodology (Danner, Sidorkina, Joechl, and Duerrschmid, 2013; De Wijk et al., 2012); however, it was suggested by a Noldus representative to use continuous with food product evaluation (A. Macbeth (Noldus Representative), personal communication, February 15, 2015).

We chose to evaluate the AFEA response to bitter stimulus because bitter is not a preferred taste and it has a distinct facial response (Wendin et al., 2011). Wendin et al. (2011) summarized that facial reactions to bitter include “mouth opening, lips raised, mouth angles down, brow lowering, frowning and nose wrinkle”. Many beverages, foods and medicines have a bitter note that may affect consumer acceptability of the product. Bitterness may be attributed to many different compounds including caffeine (coffee), quinine (tonic water) and tannins (wine and tea).

Literature describing the use of AFEA related to food consumption is very limited. This research area is in its infancy, providing an opportunity for establishing best methods for beverage and food applications and for data interpretation. De Wijk et al. (2012) used AFEA (FaceReader, Noldus Information Technology, Wageningen, The Netherlands) to determine the emotional response to liked and disliked food items based on first sight of the food as well as during detailed visual smell or taste assessment of the foods. In a subsequent study, De Wijk, He, Mensink, Verhoeven, and De Graaf (2014) investigated facial expression among commercial breakfast drinks. Additionally, Danner et al. (2013) used the same software to determine facial expressions to different kinds of orange juice, reporting that automated analysis was a sufficient method to differentiate among samples. Also, Danner, Haindl, Joechl, and Duerrschmid (2014) investigated the emotional response of different kinds of juices. Arnade (2013) found high variability among individual emotional response to chocolate milk and white milk. However, even with this variability, panelists elicited a happy response from samples longer than sad and disgusted (Arnade, 2013). In a separate study using high and low concentrations of compounds eliciting basic tastes, Arnade (2013) found, in both high and low concentration sessions, that the mean for sad emotion was higher than that of the angry, scared, disgusted, and happy emotions. The differences among basic tastes were not as significant as expected, thus questioning the accuracy of current methods for emotional capture or statistical analysis (Arnade, 2013). However, Leitch, Duncan, O'Keefe, Rudd, & Gallagher, (2015) found temporal trends using time series analysis of emotions.

Limitations of AFEA can include facial occlusion, which unavoidably occurs during beverage or food testing. The action of chewing or swallowing could affect the ability to accurately analyze the face. Lastly, there is no approach consensus to statistically analyze and interpret output. Development of AFEA methods for implicit emotional response to foods and beverages might contribute to improved understanding of consumer affective response. Such a tool may provide a more unique and deeper relationship with brands and its consumers. This deeper connection has the potential to improve overall consumer experience and emotional investment. Our goal was to use a simple stimulus with a known facial expression response (caffeine; bitter) to compare the analytical software setting options for improved assessment. In the assessment of bitterness solutions using AFEA, this study evaluated

A. Consumer acceptability:

   1. Consumer acceptability of aqueous bitterness solutions (caffeine) using hedonic ratings

   2. Consumer acceptability as it relates to implicit emotions as measured by AFEA

      Our hypothesis was that with increasing bitterness concentrations, the hedonic response would decrease and disgust facial expression would increase

B. AFEA calibrations and analysis settings for optimal assessment:

   1. Analysis of AFEA videos using default and continuous calibration settings to determine a recommendation for application to beverage analysis

   2. Evaluation of the sensitivity of the calibration settings appropriate for beverage analysis

Our hypothesis was that continuous calibration setting would provide higher sensitivity to subtle changes in facial expression in the context of this study

C. To explore the use of time series analysis for characterizing AFEA differences:

Our hypothesis was that time series analysis of emotion states would provide detailed emotional analysis and results that differentiate products over time

2. Materials and Methods

2.1 Sample Preparation

Aqueous bitter treatment solutions were prepared as described by the Spectrum™ Descriptive Analysis Method (Meilgaard et al., 2007) using caffeine (Sigma Aldrich, St. Louis, MO) in distilled water (The Kroger Co., Cincinnati, OH) at four levels control (distilled water); low (Spectrum™ 2; 0.05% (0.5mg caffeine/mL distilled water) solution in water); medium (Spectrum™ 5, 0.08% (0.8mg caffeine/mL distilled water); and high (Spectrum™ 10, 0.15% solution in water (1.5mg caffeine/mL distilled water). The Spectrum™ Descriptive Analysis Method Intensity Scales Values (0-15) provide a standard reference for product evaluation using scaled intensities (Meilgaard et al., 2007). Solutions were poured into 1 oz. plastic sample cups (Monogram Company, Columbia, MD) and capped with color coded lids for ease of visual identification.

2.2 Consumer Sensory Analysis

2.2.1 Participant Recruitment

Study was pre-approved by Virginia Tech IRB (IRB 13-037) prior to project initiation. Study recruitment was accomplished through email listservs to Virginia Tech faculty, staff, students and visitors. Recruited participants completed a screening survey for personal attributes and demographics. Exclusion criteria included report of facial hair, required use of glasses for vision, allergies, and age less than 18. Selected participants (n=65; 18 male; 47 female) were Virginia Tech faculty, staff, students or visitors. Before sample evaluation, participants reviewed or consented to the study parameters, including video recording, before receiving additional instructions or samples.

2.2.2 Consumer Self-reported Acceptability and Intensity Responses

Only one panelist at a time evaluated the samples to standardize the sensory booth conditions for video capture. Participants followed instructions on the touch screen monitor electronically provided by the automated sensory software (Sensory Information Management System (SIMS) 2000, Version 6, Sensory Computer Systems, Berkeley Heights, NJ). Prior to sample evaluation, specific protocols were described to the panelist by a researcher and provided visually on the monitor.

Panelists evaluated a total of four solution samples (representing each treatment), presented simultaneously, at room temperature. Panelists received treatments in increasing order of bitterness, arranged from left to right, with a colored index card, relating to the sample color code, placed on top of each sample. Participants held up the associated color card pre-consumption for sample video identification, fully consumed the sample and waited 30 seconds (enforced) facing towards the camera without additional action. Participants then entered hedonic (1=dislike extremely, 9=like extremely) and intensity responses (1= extremely weak/ no bitterness, 9=extremely bitter). Participants were instructed to rinse their palate with room temperature distilled water (Kroger Brand, Cincinnati, OH) before the first sample and in between each sample. Data capture was managed using the sensory software system (SIMS 2000, Version 6, Sensory Computer Systems, Berkeley Heights, NJ) and upon completion all data were transferred to Excel (Microsoft Corporation, Inc., Redmond, WA) for analysis.

2.2.3 Video Capture

The camera (2.0 megapixel LifeCam NX-6000, 640 x 480, Microsoft Corporation, Inc., Redmond, WA) was positioned on the lower portion of the monitor and video capture centered on the participant's face. Video capture commenced once the panelist was comfortable at the booth and video capture was optimal (before sample presentation). Video was set to record at 30 frames per second (fps; actual recording rate range: 16.9-23.8 fps; $\bar{x}$= 19.5 fps) on a laptop (Latitude Essio, Dell, Inc., Round Rock, TX) with recording software (My Movie: Windows Live Movie Maker, Microsoft Windows, Microsoft Corporation, Inc., Redmond, WA) through the entire sensory session. Recordings were saved as Windows media video (.wmv) files. White fluorescent ceiling panel lights illuminated the booth and face for video-recording with minimal additional lighting from the monitor.

2.2.4 Automated Facial Expression Analysis, Data Processing and Statistical Analysis

Participant videos were analyzed using AFEA software (FaceReader™ 6, Noldus Information Technology, Wageningen, The Netherlands). Videos were analyzed frame-by-frame under both the default and continuous calibration analysis settings in the software using batch analysis. The AFEA data output was exported as log files (.txt) for further analysis. The AFEA means data from the 0 to 5 second interval post-consumption was used for analysis. Arnade (2013) evaluated facial expression milk beverages at 5, 10, and 20 seconds post-consumption, and suggested that 5 to 10 seconds post-consumption as sufficient because 20 seconds appeared too long. Post-consumption was defined as when the sample cup no longer occluded the face at the panelist's chin. Participant videos were time stamped by sample and statistical code (R, version 3.1.1, R Core Team, 2014) isolated specified data within the software exported log files (.txt) for statistical analysis.

Twelve videos failures were not included in statistical analysis because the participant's face was not readable by the AFEA software and/or participants failed to follow protocol. Additionally, panelists who were not sufficiently sensitive to discriminate the bitterness intensity increase for each sample were not included in data analysis (n=7). Data from a total of n=46 (13 male; 33 female) panelists were used for data analysis. Tukey's multiple comparison of means (JMP, Statistical Analysis Software (SAS) Version 9.2, SAS Institute, Cary, NC) was used to determine statistical differences among acceptability and intensity responses (α=0.05). Spearman's rank correlation coefficient ($r_{s)}$ was used to determine a relationship between intensity and acceptability responses (R, version 3.1.1, R Core Team, 2014). Using R-generated means data derived from AFEA output, paired t-tests (JMP SAS, Cary, NC) were used to compare AFEA settings (default versus continuous) and Tukey's multiple comparison of means was used for emotional data analysis (R, version 3.1.1, R Core Team, 2014). The alpha value was established at α=0.20 to identify statistical differences among emotions as the bitter concentration increased. This research area is new and exploratory; we determined that identifying differences at this alpha value had importance to this and future research decisions.

2.2.5 Automated Facial Expression Analysis and Time Series Analysis

For AFEA time series analysis, sequential paired nonparametric Wilcoxon tests ($\alpha=0.05$) were performed between control (water) and treatments based on the video frame rate mode baseline of 20 Hz AFEA sampling frame. The frequency was selected to optimize comparison and reduce time point comparison overlap. Results were translated into time series graphs for 5 seconds post-consumption. Emotions with significant differences at $p<0.025$ were graphed between the control treatment and the respective treatment where treatment median is higher and of greater significance ($p<0.025$) for each emotion. Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).

3. Results

3.1 Acceptability and Intensity Response

As bitter intensity increased, the mean acceptability scores decreased ($r_s= -0.79$, $p<0.0001$, Figure 5.1). The inverse relationship supported the hypothesis that bitter increases reduced product acceptability. Differences existed among treatment acceptability ($p<0.05$). Control (distilled water) had the highest degree of liking ($\overline{x}=5.4$; neither liked nor disliked) while the high bitter sample was associated with a low rating ($\overline{x}=1.8$; dislike moderately to dislike extremely). As bitter intensity increased, the mean perceived intensity scores increased (r_s=0.77, p<0.0001, Figure 5.1) as expected, with the control receiving a low bitter intensity rating. Spearman's correlation revealed that hedonic and intensity responses had an inverse relationship (r_s= -0.90, p<0.0001).

3.2 Automated Facial Emotional Analysis

3.2.1 Default and Continuous Analysis Setting using ANOVA

3.2.1.1 Default Analysis

AFEA revealed that across increasing bitter intensity treatments, no differences existed (p>0.20) for neutral, scared, disgusted, angry, sad, and happy emotions (Table 5.1; Table 5.2). Surprised was of higher expression for control than for high bitter (p=0.139).

Comparing across emotions within each bitter treatment (Table 5.1; Table 5.2), surprised was most highly expressed (p<0.20). Additionally, neutral was more pronounced than the other emotions (disgusted, angry, sad, and happy; (p<0.20)). For all treatments, happy was less expressed than scared (p<0.20). Table 5.2 illustrates p-values among emotions within each treatment.

3.2.1.2 Continuous Analysis

There were no differences in emotion intensity across bitter intensity treatments (p>0.20) for neutral, sad, happy, scared and angry (Table 5.1). Disgusted was more expressed in medium bitter than control (p=0.133) and low bitter (p=0.154). Surprised was more expressed in control than high bitter (p=0.114). Surprised and neutral were the most expressed (p<0.20) in the continuous setting within each bitter treatment than other emotions (scared, disgusted, angry, sad, and happy (p<0.20); an exception occurred for control treatment where surprised was more expressed than neutral ($p<0.20$) (Table 5.1; Table 5.3). Additionally, scared was of a more pronounced higher expression than happy for all treatments ($p<0.20$) except for high bitter ($p>0.20$). Furthermore, in the water control, scared was more expressed than disgusted and happy ($p<0.20$). Table 5.3 illustrates p-values among emotions within each treatment.

3.2.1.3 Default and Continuous Analysis Comparison

AFEA expression intensity for the continuous analysis setting largely followed the patterns for the default analysis (Table 5.1). Surprised was more expressed in control than high bitter ($p=0.114$), same as in the default analysis setting. Similar to the default setting, surprised and neutral were the most expressed ($p<0.20$) in the continuous setting within each bitter treatment (scared, disgusted, angry, sad, and happy); an exception occurred for control treatment where surprised was more expressed than neutral ($p<0.20$).

Overall, there were not any statistically different benefits between continuous and default analysis settings (Table 5.2, Table 5.3). Generally, the same amount statistically significant differences ($n=42$; $p<0.05$) across emotions were observed in default analysis and in the continuous setting (Table 5.2, Table 5.3). However, continuous analysis had lower variability (standard deviation) for each treatment and respective emotional response. The lower variability may have a stronger benefit in emotional analysis.

Based on paired t-tests of mean emotion intensity between default and continuous settings, neutral was the only state more expressed in the continuous analysis than the default for all treatments ($p<0.0001$) (Table 5.4). The remainder of emotions (happy, sad, angry, surprised scared, and disgusted) were higher in the default analysis than the continuous analysis ($p<0.05$) (Table 5.4).

3.2.2 Default and Continuous Analysis Setting using Time Series Emotional Analysis

3.2.2.1 Default Analysis

Compared to the distilled water control, low bitter stimuli generated facial expressions identified as more neutral (3 – 4.5 sec), more angry (~4 sec), and more disgusted (~3.75 sec; ~4.25 sec) and less sad (~0 sec), less surprised (~0.25 sec; ~3.5 sec – 4.5 sec), and less scared (1.5 – 2.5 sec) ($p<0.025$) (Figure 5.2, I). Medium bitter stimuli elicited strong disgust expressions over 5 sec (0.05 – 5 sec), angry (1.5 sec; 1.75 – 2.5 sec), happy (4.25 – 4.5 sec; ~5 sec) and neutral (~4 sec) and less surprised (~0.5 – 0.75 sec, 3.5 – 4.5 sec) and less scared (~2 sec) ($p<0.025$) (Figure 5.2, II). High bitter stimuli responses were characterized as strong disgust (0.05 – 5 sec), angry (~0.5 sec), happy (1 – 5 sec), and neutral (~1 sec; 2.5 – 4.25 sec) and less surprised (0 – 1.75 sec, 2.5 sec – 5 sec) and less scared (~2 sec) ($p<0.025$) (Figure 5.2, III). For the water control, surprised increased as intensity increased, while scared was less present as intensity increased.

In general, for emotions that were strong with the bitter samples compared to water, the disgust and happy durations increased as bitter levels increased. Angry moved to earlier times as intensity increased. Neutral stayed approximately the same. For emotions that were less in the bitter samples compared to water, the timing of scared became more intermittent and surprised lasted for almost the entire test period.

3.2.2.2 Continuous Analysis

Low bitter stimuli produced more neutral (3-4 sec) and less scared (1.5 – 2.25 sec) and less surprised (~3.75 – 4.25 sec) ($p<0.025$) (Figure 5.2, IV). Medium bitter stimuli trended disgust (1 sec – 5 sec) and neutral (3.5 – 4 sec) and less scared (1.75 – 2.25 sec) and less surprised (~3.75 – 4.25 sec) ($p<0.025$) (Figure 5.2, V). High bitter stimuli evoked disgust (~2 – 3.75 sec, 4 – 4.75 sec), happy (1 – 5 sec), and neutral (2.5 – 4 sec) and less surprised (0.75 sec, 3 – 4 sec) and less scared (~2 sec) ($p<0.025$) (Figure 5.2, VI). Duration patterns were similar to the default setting, with slightly fewer differences compared to the control.

3.2.2.3 Default and Continuous Analysis Comparison

Continuous time series analysis largely followed a similar pattern of the default analysis (Figure 5.2). Time series analysis revealed surprised was a consistent emotion more evoked by the control treatment solutions than the bitter solutions ($p<0.025$) in both the default and continuous analysis (Figure 5.2). Additionally, scared was most predominant in the control when compared to the low bitter stimuli around 1.5 – 2.25 sec in both the continuous and default setting ($p<0.025$) (Figure 5.2, I and IV). Scared appears in the control when compared to the medium and high bitter around the same time in both the continuous and default setting ($p<0.025$) (Figure 5.2, II, III, V, and VI). Expressions characterized as happy was strongly generated in the high bitter solution ($p<0.025$) (Figure 5.2, III and VI) while only a slight display of happy occurred in the medium bitter in both the default and continuous analysis ($p<0.025$) (Figure 5.2, II and V). Neutral tended to appear around the 3 – 4 second time range for all treatment solutions: ~3 – 4 sec for low (Figure 5.2, I and IV); ~ 4 sec for medium (Figure 5.2, II and IV); ~2.5 – 4 sec for high in both the default and continuous setting ($p<0.025$) (Figure 5.2, III and VI). In the default and continuous setting, disgust was most predominant in medium (Figure 5.2, II and V) and high bitter solutions ($p<0.025$) (Figure 5.2, III and VI). In the default setting, low bitter solutions expressed disgust around 4 sec ($p<0.025$) (Figure 5.2, I) but did not appear in the continuous setting ($p>0.025$) (Figure

5.2, IV). For medium bitter, angry appears around 2 sec (Figure 5.2, II and V) but presence is more consistent in the default ($p<0.025$) (Figure 5.2, II). Also, angry was generated in high bitter (between 0 – 1 sec) in the default setting. Overall, the continuous analysis results were more intermittent with fewer hits than the default, potentially due to the calibration effects and reduction of variability.

4. Discussion

4.1 Acceptability and Intensity Response

Bitter is not a preferred basic taste amongst consumers and is associated with a distinct negative facial response (Wendin et al. 2011). In a basic taste study, Arnade (2013) found consumers preferred the low bitter solution to the high bitter solution. Our study illustrated this relationship as well, with increasing hedonic ratings for increasing bitter concentrations ($p<0.05$); high variability was expected for this consumer acceptability study. Wendin et al. (2011) using caffeine also found that participants were able to discern intensity differences with different concentrations (low, medium and high bitter (caffeine solutions)). The results were as expected, because bitterness is typically unpleasant unless one has adapted to appreciate bitterness (Chaudhari & Roper, 2010; Erickson & Schulkin, 2003).

4.2 Automated Facial Emotional Analysis and Emotional Response

Water is not considered a highly emotional beverage due to its neutral reaction (Steiner, 1979; Steiner, Glaser, Hawilo, & Berridge, 2001) and has served as a control baseline (Leitch et al., 2015; Garcia-Burgos & Zamora, 2015), thus allowing the interpretation of this study to focus on the consumer response to bitterness. Bitter taste is not popular in most food and individual bitter sensitivity may influence reduced intake of bitter containing products (Mattes, 1994). Due to this culinary phenomenon, we hypothesized that this would provide a good stimulus condition to evaluate the AFEA protocol.

In both the default and continuous setting, only the surprised emotion was affected by the increasing bitterness when using ANOVA as the statistical approach. The AFEA identified surprised (approach) at a higher intensity in the control than the high bitter treatment in both the continuous and default setting ($p<0.20$). The greater expression of surprised emotion was not expected as research associates bitter compounds with negative consumer responses (Drewnowski & Gomez-Carneros, 2000); however surprised emotion may be characterized as either positive or negative (Noldus Information Technology, 2014b; Desmet & Schifferstein, 2008; Ekman, 2003). However, control was the first sample served which might have influenced the decrease in surprised as bitter increased because of participant anticipation. The time series analysis appears to support this trend in the control compared to the high bitter ($p<0.025$) (Figure 5.2, III and VI). Most importantly, the time series analysis elucidates more emotional dynamic results over time than that of ANOVA, suggesting that time series analysis using paired nonparametric Wilcoxon tests allow researchers to identify trends.

Our anticipated outcome was to evoke disgust using the bitter solutions. Disgust was present in both continuous and default time series analysis of AFEA responses to medium and high bitter solutions ($p<0.025$) (Figure 5.2, II, III, V, and VI). Additionally, in the continuous setting bitter was more pronounced in the medium bitter than the control ($p<0.20$) using ANOVA. The presentation and consumption of a disliked food elicits a more pronounced facial expression response (reportedly higher scores in disgusted, sad and angry) (De Wijk et al., 2012). Positive or neutral products elicit a less pronounced facial expression response (De Wijk et al., 2012; Danner et al., 2013; Danner et al., 2014; Wendin et al., 2011; Zeinstra, Koelen, Colindrews, Kok, & De Graaf, 2009). Wendin et al. (2011) found that bitter solutions elicited strong facial reactions (using manual FACS) as concentration increased.

The human taste and response process is complex. Disgust appeared as a predominant emotion in the time series analysis in both continuous and default for medium and high bitter ($p<0.025$) (Figure 5.2, II, III, V, and VI). More unusually, high bitter generated happy when compared to control in both the continuous and default setting ($p<0.025$) (Figure 5.2, III and VI). Disgust alone has many “faces”, and disgust face components are used depending on the stimulus (Rozin, Lowery, & Ebert, 1994). Danner et al. (2014) saw that disliked juice samples had a more intense happy response post-consumption. After explicit measurements and participant inquiry, Danner et al. (2014) attributed the happy response to consumers stating they were surprised by the unexpected juice taste and potentially masked their disgust by smiling in response to disliked samples. Additionally, Greimel, Macht, Krumhuber and Ellgring (2006) discussed that smiling was oftentimes a response to bitter to mask distaste. Danner et al. (2014) was using FaceReader™ 5 for their facial analysis methodology. From our preliminary data using FaceReader™ 5 using the same bitter treatment levels as in this study, happy was more expressed in high bitter than control ($p=0.012$) and medium bitter ($p=0.14$); angry was more expressed in high bitter than control ($p=0.18$) (Crist, Arnade, Leitch, Duncan, O’Keefe, Dunsmore, & Gallagher, 2014).

AFEA software products are upgraded in each new release to increase sensitivity and improve accuracy of expression analysis. Noldus Information Technology has updated and improved their analysis program for FaceReader™ 6 compared to FaceReader™5. In a validation study, Lewinski, den Uyl and Butler (2014) used two different databases, Warsaw Set of Emotional Facial Expression Pictures (WSEFEP) and Amsterdam Dynamic Facial Expression Set (ADFES), to assess the FaceReader™ 6 identification of emotion. They reported that FaceReader™6 reached a "FACS index of agreement of 0.67 on average on both data sets." Additionally, the authors mentioned that "FaceReader is as good at recognizing emotions as humans because a human coder must reach an agreement of 0.70 with the master coder to receive a FACS certification (Lewinski et al., 2014). This research assisted in validated FaceReader™6 accuracy to manual coding; however, the stimuli was not foods or beverages. In our study, FaceReader™6 categorizes happy in response to the bitter stimuli. The phenomenon of the happy "response" to disliked products has been noted by other researchers (Danner et al., 2014; Crist et al., 2014; Weiland, Ellgring, & Macht, 2010; Ekman 1972; Greimel et al., 2006). Facial action coding (FACS) relies on action units (AUs) and groups of AUs can represent an emotion (Tong, Liao, & Ji, 2007). Happy expression may involve AU 6 (cheek raiser), AU 12 (lip corner puller), and AU 25 (lips part); surprise may involve AU 1 (inner brow raiser), AU 2 (outer brow raiser), AU 5 (upper lid raiser), AU 25 (lips part) and AU 27 (mouth stretch); and sadness may involve AU 1 (inner brow raiser), AU 4 (brow lower), AU 15 (lip corner depressor) and AU 17 (chin raiser) (Tong et al., 2007). Greimel et al. (2006) found that bitter samples (quinine and bitter-sweet soft drink) elicited AU 4 (brow lower), AU 10 (upper lip raiser), AU 12 (lip corner puller), and AU

26 (jaw drop). In another study with basic tastes, AU 12 (lip corner puller) was present among all tastes; and in bitter (6-n-propylthiouracil (PROP)), salty (NaCl), and sour (citric acid) tastes AU 1 (inner brow raiser) and AU 2 (outer brow raiser) were prevalent, which reveals a surprised expression (Weiland et al., 2010). Furthermore, participants can be surprised and suppress a grimace by smiling (Ekman, 1972) or as a coping strategy to distract themselves from the taste (Weiland et al., 2010). Smiling in response to disliked or offensive products could be due to a "social display rule" to be polite (Weiland et al., 2010). We hypothesize that the overlap of AUs in emotional determination may influence the FaceReader™6 emotional characterization, potentially misclassifying emotions in response to foods and beverages.

In response to quinine (bitter), humans and animals illustrate facial disliking by gaping (Berridge & Robinson, 2003; Rozin et al., 1994). Due to the surprised emotion being most active in the control, we hypothesize it is derived from consumer unfamiliarity to the sensory evaluation process as well as being the first sample consumed. Using manual coding and facial action units, Greimel et al. (2006) found that reactions to a bitter solution (quinine) were more complex than sweet or bitter-sweet samples pre-consumption but did not differ post-consumption. "The time to maximum bitterness can be as long as 13 seconds… and studies have placed a caffeine threshold in water at 0.5 mmol/L (0.094 mg/L)" (Drewnowski, 2001) which is in between the medium and high solutions used in this study. Greimel et al. (2006) found participants reacted the quickest upon consumption of bitter solution (quinine) and took more time to react to sweet and bitter-sweet solutions.

Interpreting responses also requires examination of the broader literature. There is evidence that there are different bitter-responsive taste cells that can aid in discrimination of bitter compounds (Chaudhari & Roper, 2010; Caicedo & Roper, 2001). Garcia-Burgos and Zamora (2013) explored the influence of bitter foods and their association to low and high body mass index (BMI) participants; high BMI participants exhibited higher disgust expression by FaceReader™4 after consuming a bitter sample.

The bitter stimulus used in our study (caffeine) is associated with many well-liked beverages in the US diet. Coca-Cola contains 46mg/12 fl oz (0.12mg/mL) which is lower in concentration than the lowest bitter treatment used in this study. (Spiller, 1997). Through adaption, caffeine may have a pleasant response among this consumer group (Smith & Tola, 1997), though generally at low doses (Warburton, 1995). Herz (1999) found that a 5mg/kg caffeine capsule dose has the ability to alter mood arousal without influencing pleasantness. Also, the addition of caffeine (2 mg/kg) to newly developed products was found to have an initial decrease in liking but over time an increase in liking over four sample trials (Temple, Ziegler, Graczyk, Bendlin, O'Leary, & Schnittker, 2012). Additionally, in an investigation where participants were given caffeine after a period of abstinence, Heatherley, Hayward, Seers, and Rogers (2005) found that caffeine increased "hedonic tone and improved 'overall mood' after an 8 h abstinence". Furthermore, Quinlan, Lane, and Aspinall (1997) determined that caffeine improved mood and hedonic tone when consumed in beverages; however this may be due to counteracting the effects of withdrawal. Caffeine has an immediate physiological response and effect after consumption (skin conductance; autonomic nervous system) (Quinlan et al., 1997).

Research on basic tastes suggests that humans adapt to tastes over time. Infants are more responsive and express more intense responses than adults to bitter. However, Steiner (1979) determined that responses to basic tastes were innate and usually do not change throughout age. Additionally, over time and repeated trials, consumers may condition themselves to like products that were previously not accepted (Ekman, 2007). Stein, Nagai, Nakagawa, and Beauchamp (2003) found that participants increased their hedonic liking of a bitter beverage with repeated exposure which suggests human conditioning may increase bitterness liking. Our study did not include caffeine or "bitter" product use among panelists, but this may be a contributor to panelist response variation noise in AFEA. Tinley, Durlach, and Yeomans (2004) investigated the effect of varying levels of caffeinated tea with habitual caffeine consumers and non- to low caffeine consumers and found those who consumed caffeine, the non-caffeinated tea was ranked less pleasant than the 1-mg caffeine dose tea which supports the idea that caffeine consumers have the ability to discriminate between doses of caffeine solutions and that this influences their responses.

Within treatments across emotions, surprised was the most intensely expressed state in the default setting ($p<0.20$) (Table 5.1). With the exception of control, surprised and neutral did not differ ($p>0.20$) in the continuous setting (Table 5.1). Reactions to pure water are typically neutral (Steiner et al., 2001). A high neutral state may be indicative of a higher approach (positive) condition when low withdrawal emotion intensity is expressed. Surprised is considered an "approach" emotion, even though it may be classified as either a positive or a negative emotion. Erickson and Schulkin (2003) stated "a change in regulatory state results in a change in approach behavior and facial display suggesting enjoyment or disgust, depending on the valence of the situation." Danner et al. (2013) found that happy and disgusted correlated with hedonic liking and disliking of different orange juice samples. As previously mentioned, De Wijk et al. (2012) found differences only in disliked foods with the first visual and tasting experience.

4.3 Comparison of Default and Continuous Analysis

The AFEA software manual states that individual calibration will give a better result than continuous calibration yet continuous is optimal analysis if there are "person-specific or setup specific biases" (Noldus Information Technology, 2014b). As mentioned previously, default does not have any calibration included in the analysis. In regards to food consumption, it was recommended to use continuous analysis (A. Macbeth (Noldus Representative), personal communication, February 15, 2015). Regardless, there is no standardized approach for collecting individual calibration expressions at the intensities associated with food intake; this approach may not be efficient when using a large consumer population. It is not known which setting is appropriate for food and beverage analysis and published literature does not always explicitly state the analysis conditions. Danner et al. (2013) utilized the individual calibration. De Wijk et al. (2012) "automatically analyzed" their data. Our research is does not identify as to whether default or continuous is the optimal analysis setting for foods and beverages. Arnade (2013) compared 5, 10 and 20 seconds post-consumption under default analysis.

Additionally, there is no agreed upon optimal time frame standard for analysis. Garcia-Burgos and Zamora (2015) and Garcia-Burgos and Zamora (2013) standardized by subtracting 10 seconds pre-consumption from 10 seconds post-consumption to determine average emotional intensity. Arnade (2013) evaluated facial expression to flavored and unflavored milk at 5, 10, and 20 seconds post-consumption. She reported only minor differences across time and suggested that 5 or 10 seconds post-consumption was sufficient (Arnade, 2013). This may not be true for products that have an unexpected flavor or texture event at a later post-consumption moment.

Time series analysis provided increased sensitivity to emotional changes over time and should continue to evolve as the applications of AFEA to foods and beverages continue. As evident in our time series analysis, time series provided insight and elucidated trends that single time point analysis (ANOVA) did not provide. Time series analysis using paired nonparametric Wilcoxon tests was useful to assess emotional trends in beverage analysis. With a few minor differences, the default and continuous analysis settings appear to follow the same emotional significances suggesting that the FaceReader™6 analysis setting is not critical to emotional analysis and sensitivity; however, variability (standard deviation) was lower in the continuous setting using analysis of variance.

5. Conclusions

The use of increasing concentrations of bitter (caffeine) stimuli to evoke a decrease in acceptability with increased expression of disgust was successful. While analysis of variance (ANOVA) did not reveal many emotional differences for the bitter stimuli, a time series analysis provided insight to useful emotional trends over time. While disgust was expressed for medium and high bitter solutions post-consumption, surprisingly for the high bitter solutions in both the continuous and default settings, happy was also expressed. The happy expression elicited in high bitter solution post-consumption could indicate that further algorithm development needs to occur to improve participant sensitivity, especially when consuming beverages. Microemotions and Facial Action Coding System (FACS) could be supplemented to determine the sensitivity of AFEA to beverages and food. Some expressions may not specifically match explicit language or affective (hedonic) scores; however, there is a need to understand the complexity of expressed emotions and intensity to fully comprehend the relationship to affective consumer responses. Research should continue to evaluate the accuracy and efficiency of AFEA for applications with food and in relation to explicit product acceptability hedonic responses. The continuous analysis setting in the software program reduces participant variation (standard deviation) and we suggest the use of continuous analysis due to the variation reduction. Additional research could explore use of individual calibration as a baseline and/or a way to reduce individual bias, and possibly variability among panelists. The optimal time frame post-consumption has been explored and a 5 second time frame seems appropriate, but may differ depending on the stimulus. Lastly, time series analysis provided a more holistic picture of the emotional changes and presence over time, and can provide a view of the profile elicited by products.

Acknowledgments

This project was funded, in part, by ConAgra Foods (Omaha, NE, USA), the Virginia Agricultural Experiment Station, the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture, and the Virginia Tech Water INTERface Interdisciplinary Graduate Education Program. The authors acknowledge Dr. Julie Dunsmore (Department of Psychology, Virginia Tech) for her guidance.

References

Alves, N. T., Fukusima, S. S. & Aznar-Casanova, J. A. (2008). Models of brain asymmetry in emotional processing. *Psychology & Neuroscience, 1*(1), 63-66.

Arnade, E. A. (2013). *Measuring consumer emotional response to tastes and foods through facial expression analysis* (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA.

Berridge, K. C. & Robinson, T. E. (2003). Parsing reward. *TRENDS in Neurosciences*. *26*(9), 507-513.

Bishop, C. M. (1995). *Neural networks for pattern recognition*. New York, NY: Oxford University Press.

Caicedo, A. & Roper, S. D. (2001). Taste receptor cells that discriminate between bitter stimuli. *Science*, *291*(5508), 1557-1560.

Cardello, A. V. (1994). Consumer expectation and their role in food acceptance. In H. J. MacFie & D. M. H. Thomson (Eds.), *Measurement of food preferences* (pp. 253-297). London, UK: Chapman and Hall.

Chaudhari, N. & Roper, S. D. (2010). The cell biology of taste. *Journal of Cell Biology, 190*(3), 285-296.

Cootes, T. & Taylor, C. (2000). *Statistical models of appearance for computer vision*. In FaceReader methodology white paper. University of Manchester, UK: Wolfson Image Analysis Unit, Imaging Science and Biomedical Engineering. Retrieved from http://www.noldus.com/human-behavior-research/products/facereader

Crist, C. A., Arnade, E. A., Leitch, K. A., Duncan, S. E., O'Keefe, S., Dunsmore, J. & Gallagher, D. L. (2014). Application of emotional facial analysis technology to consumer acceptability using a basic tastes model. *Technical Abstracts and Proceedings of the 2014 Institute of Food Technologists Annual Meeting, 2014 June 21 – 24, New Orleans, LA.*

Danner, L., Haindl, S., Joechl, M., & Duerrschmid, K. (2014). Facial expression and autonomous nervous system responses elicited by tasting different juices. *Food Research International, 64,* 81-90.

Danner, L., Sidorkina, L., Joechl, M., & Duerrschmid, K. (2013). Make a face! implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference, 32*(B), 167-172.

De Wijk, R. A., He, W., Mensink, M. G. J., Verhoeven, R. H. G., & de Graaf, C. (2014). ANS responses and facial expression differentiate between the taste of commercial breakfast drinks. *PLoS ONE, 9*(4 e93823), 1-9.

De Wijk, R. A., Kooijman, V., Verhoeven, R. H. G., Holthuysen, N. T. E., & De Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. *Food Quality and Preference*, *26*(2), 196-203.

Desmet, P. M. A. & Schifferstein, H. N. J. (2008). Sources of positive and negative emotions in food experience. *Appetite*, *50*, 290-301.

Dijksterhuis, A. & Smith, P. K. (2005). What do we do unconsciously? and how? *Journal of Consumer Psychology*, *15*(3), 225-229.

Drewnowski, A. (2001). The science and complexity of bitter taste. *Nutrition Reviews*, 59(6), 163-169.

Drewnowski, A. & Gomez-Carneros, C. (2000). Bitter taste, phytonutrients, and the consumer: a review. *American Journal of Clinical Nutrition*, *72*, 1424-35.

Ekman, P. (1972). Universal and cultural differences in facial expressions of emotion. In Cole, J, (Ed.), *Nebraska symposium on motivation 1971* (pp. 207-283). Lincoln, NE: University of Nebraska Press.

Ekman, P. (2003). Emotions revealed. Recognizing faces and feelings to improve communication and emotional life. New York: Owl Books.

Ekman, P. (2007). Emotions revealed: Recognizing faces and feelings to improve communication and emotional life. New York, NY: Henry Holt & Co.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: a technique for the measurement of facial movement.* Palo Alto, CA: Consulting Psychologists Press.

Erickson, K. & Schulkin, J. (2003). Facial expressions of emotion: a cognitive neuroscience perspective. *Brain and Cognition*, *52*(1), 52-60.

Fuller, G. W. (2011). Going to market: success or failure. *In New food product development: from concept to marketplace* (3rd ed.) (pp. 275-300). Boca Raton, FL: CRC Press.

Garcia-Burgos, D. & Zamora, M. C. (2015). Exploring the hedonic and incentive properties in preferences for bitter foods via self-reports, facial expressions and instrumental behaviours. *Food Quality and Preference*, *39*, 73-81.

Garcia-Burgos, D. & Zamora, M. C. (2013). Facial affective reactions to bitter-tasting foods and body mass index in adults. *Appetite, 71*, 178-186.

Greimel, E., Macht, M., Krumhuber, E. & Ellgring, H. (2006). Facial and affective reactions to tastes and their modulation by sadness and joy. *Physiology & Behavior*, *89*(2), 261-269.

Heatherley, S. V., Hayward, R. C., Seers, H. E. & Rogers, P. J. (2005). Cognitive and psychomotor performance, mood, and pressor effects of caffeine after 4, 6 and 8 h caffeine abstinence. *Psychopharmacology*, *178*, 461-470.

Herz, R. S. (1999). Caffeine effects on mood and memory. *Behaviour Research and Therapy*, *37*(9), 869-879.

Hu, S., Player, K. A., Mcchesney, K. A., Dalistan, M. D., Tyner, C. A. & Scozzafava, J. E. (1999). Facial EMG as an indicator of palatability in humans. *Physiology and Behavior*, *68*(1-2), 31-35.

King, S. C. & Meiselman, H. L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference*, *21*, 168-177.

Koster, E. P. & Mojet, J. (2015). From mood to food and from food to mood: a psychological perspective on the measurement of food-related emotions in consume research. *Food Research International*, *76*, 180-191.

Leitch, K. A., Duncan, S. E., O'Keefe, S., Rudd, R., & Gallagher, D. L. (2015). Characterizing consumer emotional response to sweeteners using an emotion terminology questionnaire and facial expression analysis. *Food Research International*, *76*, 283-292.

Lewinski, P., den Uyl, T. M. & Butler, C. (2014). Automated facial coding: validation of basic emotions and FACS AUs in FaceReader. *Journal of Neuroscience, Psychology, and Economics*, *7*(4), 227-236.

Lord, J. B. (2000). New product failure and success. In A. L. Brody, & J. B. Lord (Eds.), *Developing new products for a changing market place* (pp. 55-86). Boca Raton, FL: CRC Press.

Mattes, R. S. (1994). Influences on acceptance of bitter foods and beverages. *Physiology and Behavior, 56*(6), 1229-1236.

Meilgaard, M. C., Civille, G. V., & Carr, B. T. (2007). *Sensory evaluation techniques* (4th ed.). Boca Raton, FL: CRC Press.

Meiselman, H. L. & Schutz, H. G. (2003). History of food acceptance research in the US army. *Appetite,* 40, 199-216.

Noldus Information Technology (2014a). *FaceReader™5Technical Specifications*. Wageningen, Netherlands: Noldus Information Technology. Retrieved from http://www.noldus.com/files/file_manager/downloads/whitepaper/FaceReader_Methodology.pdf

Noldus Information Technology. (2014b). *FaceReader™6 Reference Manual* (6th ed.). Wageningen, Netherlands: Noldus Information Technology.

Quinlan, P., Lane, J. & Aspinall, L. (1997). Effects of hot tea, coffee and water ingestion on physiological responses and mood: the role of caffeine, water and beverage type. *Psychopharmacology*, *134*, 164-173.

R Core Team (2014). R: *A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from http://www.R-project.org/

Rozin, P., Lowery, L., & Ebert, R. (1994). Varieties of disgust faces and the structure of disgust. *Journal of Personality and Social Psychology, 66*(5), 870-881.

Smith, B. D. & Tola, K. (1997). Caffeine: Effects on psychological functioning and performance. In G. A. Spiller (Ed.), *Caffeine*, (pp 251- 299). Boca Raton, FL: CRC Press.

Spiller, G. A. (1997). Caffeine content of some cola beverages. In G. A. Spiller (Ed.), *Caffeine*, (pp 363). Boca Raton, FL: CRC Press.

Stein, L. J., Nagai, H., Nakagawa, M., & Beauchamp, G. K. (2003). Effects of repeated exposure and health-related information on hedonic evaluation and acceptance of a bitter beverage. *Appetite*, *40*, 119-129.

Steiner, J. (1979). Human facial expressions in response to taste and smell stimulation. In H. Reese & L. Lipsitt (Eds.), *Advances in child development and behavior*. New York, NY: Academic Press.

Steiner, J., Glaser, D., Hawilo, M. E., & Berridge, K. C. (2001). Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates. *Neuroscience and Biobehavioral Reviews*, *25*, 53-74.

Sung, K. K., & Poggio, T. (1998). Example-based learning for view-based human face detection. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *20*(1), 39-51.

Temple, J. L., Ziegler, A. M., Graczyk, A., Bendlin, A., O'Leary, S., & Schnittker, Y. S. (2012). Influence of caffeine on the liking of novel-flavored soda in adolescents. *Psychopharmacology*, *223*, 37-45.

Tinley, E. M., Durlach, P. J. & Yeomans. (2004). How habitual caffeine consumption and dose influence flavour preference conditioning with caffeine. *Physiology and Behavior*, *82*, 317-324.

Tong, Y., Liao, W., & Ji, Q. (2007). Facial action unit recognition by exploiting their dynamic and semantic relationships. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, *29*(10), 1-17.

Viola, P., & Jones, M. (2001). Rapid object detection using a boosted cascade of simple features. In *FaceReader methodology white pater*. Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition. Kauai, HI. Retrieved from http://www.noldus.com/human-behavior-research/products/facereader

Warburton, D. M. (1995). Effects of caffeine on cognition and mood without caffeine abstinence. *Psychopharmacology*, *119*(1), 66-70.

Weiland, R., Ellgring, H., & Macht, M. (2010). Gustofacial and olfactofacial responses in human adults. *Chemical Senses*, *35*, 841-853.

Wendin, K., Allesen-Holm, B. H., & Bredie, L. P. (2011). Do facial reactions add new dimensions to measuring sensory responses to basic tastes? *Food Quality and Preference*, *22*, 346-354.

Zeinstra, G. G., Koelen, M. A., Colindrews, D., Kok, F. J., & De Graaf, C. (2009). Facial expressions in school-aged children are a good indicator of “dislikes”, but not of “likes”. *Food Quality and Preference*, *20*(8), 620–624.

Table 5.1 Mean emotional response scores for bitter stimuli (increasing concentrations of (caffeine) in water using automated facial expression analysis[1] in the default and the continuous analysis software setting.

Default Analysis Setting

Treatment[2]	**Surprised**	**Neutral**	**Scared**	**Disgusted**	**Angry**	**Sad**	**Happy**
Control (0)	0.563± 0.312 ^{aA}	0.157±0.126^{aB}	0.169±0.234^{aB}	0.040±0.078^{aC}	0.061±0.116^{aC}	0.066±0.116^{aC}	0.014±0.035^{aC}
Low	0.510± 0.304^{abA}	0.181±0.135^{aB}	0.147±0.210^{aBC}	0.041±0.062^{aD}	0.094±0.160^{aCD}	0.043±0.090^{aD}	0.023±0.073^{aD}
Medium	0.505± 0.310^{abA}	0.171±0.113^{aB}	0.144±0.221^{aBC}	0.083±0.145^{aCD}	0.068±0.123^{aCD}	0.059±0.110^{aCD}	0.020±0.047^{aD}
High	0.425± 0.281^{bA}	0.202±0.120^{aB}	0.137±0.199^{aBC}	0.065±0.120^{aCD}	0.065±0.093^{aCD}	0.060±0.094^{aCD}	0.037±0.084^{aD}

Continuous Analysis Setting

Treatment[2]	**Surprised**	**Neutral**	**Scared**	**Disgusted**	**Angry**	**Sad**	**Happy**
Control (0)	0.344±0.258^{aA}	0.247±0.113^{aB}	0.114±0.195^{aC}	0.026±0.055^{aD}	0.047± .098^{aCD}	0.049±0.091^{aCD}	0.010±0.030^{aD}
Low	0.300±0.247^{abA}	0.272±0.122^{aA}	0.088±0.151^{aB}	0.027±0.043^{aBC}	0.070±0.129^{aBC}	0.031±0.076^{aBC}	0.020±0.070^{aC}
Medium	0.299±0.247^{abA}	0.263±0.107^{aA}	0.093±0.184^{aB}	0.067±0.127^{bBC}	0.048±0.105^{aBC}	0.045±0.089^{aBC}	0.016±0.040^{aC}
High	0.229±0.217^{bA}	0.287±0.115^{aA}	0.085±0.160^{aB}	0.052± 0.112^{abB}	0.045±0.076^{aB}	0.047±0.073^{aB}	0.031±0.078^{aB}

[a, b]Means within each column with different superscripts significantly differ ($p<0.20$).

[A, B, C, D, E]Means within each row with different superscripts significantly differ ($p<0.20$).

[1]FaceReader ™ 6, Noldus Information Technology, Wageningen, The Netherlands

[2]C=Control (distilled water); Low: Spectrum™ 2=0.05% solution; Medium: Spectrum™ 5=0.08% solution; High: Spectrum™ 10=0.15% solution (Meilgaard et al., 2007).

[3] Mean ± SD

Table 5.2 P-value table of automated facial expression analysis in the *default analysis setting* within each treatment using ANOVA.

Control (0)[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		**	*	o	***		*
Happy	**				***	***	
Sad	*				***	o	
Angry	o				***	*	
Surprised	***	***	***	***		***	***
Scared		***	o	*	***		**
Disgusted	*				***	**	
Low[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		***	**	o	***		**
Happy	***				***	**	
Sad	**				***	o	
Angry	o				***		
Surprised	***	***	***	***		***	***
Scared		**	o		***		*
Disgusted	**				***	*	
Medium[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		***	*	o	***		o
Happy	***				***	*	
Sad	*				***		
Angry	o				***		
Surprised	***	***	***	***		***	***
Scared		*			***		
Disgusted	o				***		
High[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		***	***	***	***		***
Happy	***				***	*	
Sad	***				***		
Angry	***				***		
Surprised	***	***	***	***		***	***
Scared		*			***		
Disgusted	***				***		

[1]C=Control (distilled water); Low: Spectrum™ 2=0.05% solution; Medium: Spectrum™ 5=0.08% solution; High: Spectrum™ 10=0.15% solution (Meilgaard et al., 2007).

Empty	p>0.20
o	p=0.05-0.20
*	p<0.05
**	p<0.01
***	p<0.001

Table 5.3 P-value table of automated facial expression analysis in the *continuous analysis setting* within each treatment using ANOVA

Control (0)[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		***	***	***	*	***	***
Happy	***				***	*	
Sad	***				***		
Angry	***				***		
Surprised	*	***	***	***		***	***
Scared	***	*			***		o
Disgusted	***				***	o	
Low[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		***	***	***		***	***
Happy	***				***	o	
Sad	***				***		
Angry	***				***		
Surprised		***	***	***		***	***
Scared	***	o			***		
Disgusted	***				***		
Medium[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		***	***	***		***	***
Happy	***				***	o	
Sad	***				***		
Angry	***				***		
Surprised		***	***	***		***	***
Scared	***	o			***		
Disgusted	***				***		
High[1]							
	Neutral	Happy	Sad	Angry	Surprised	Scared	Disgusted
Neutral		***	***	***		***	***
Happy	***				***		
Sad	***				***		
Angry	***				***		
Surprised		***	***	***		***	***
Scared	***				***		
Disgusted	***				***		

[1]C=Control (distilled water); Low: Spectrum™ 2=0.05% solution; Medium: Spectrum™ 5=0.08% solution; High: Spectrum™ 10=0.15% solution (Meilgaard et al., 2007).

Empty	p>0.20
o	p=0.05-0.20
*	p<0.05
**	p<0.01
***	p<0.001

Table 5.4 Comparison of mean intensity[1] for emotions based on automated facial expression analysis through default and continuous analysis software settings and p-value based on paired t-tests[2].

Treatment[3]	**Control (0)**	**Low**	**Medium**	**High**
Emotion				
Neutral (Default)	0.157	0.181	0.171	0.202
Neutral (Continuous)	**0.247**	**0.272**	**0.263**	**0.287**
p-value	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
Happy (Default)	**0.014**	**0.023**	**0.020**	**0.037**
Happy (Continuous)	0.010	0.020	0.016	0.031
p-value	*0.0343*	*0.0257*	*0.0057*	*0.0098*
Sad (Default)	**0.066**	**0.043**	**0.059**	**0.060**
Sad (Continuous)	0.049	0.031	0.045	0.047
p-value	*0.0019*	*0.0014*	*0.0005*	*0.0017*
Angry (Default)	**0.061**	**0.094**	**0.068**	**0.065**
Angry (Continuous)	0.047	0.070	0.048	0.045
p-value	*0.0004*	*0.0007*	*0.0008*	*0.0005*
Surprised (Default)	**0.563**	**0.510**	**0.505**	**0.425**
Surprised (Continuous)	0.344	0.300	0.299	0.229
p-value	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
Scared (Default)	**0.169**	**0.147**	**0.144**	**0.137**
Scared (Continuous)	0.114	0.088	0.093	0.085
p-value	*<0.0001*	*<0.0001*	*<0.0001*	*<0.0001*
Disgusted (Default)	**0.040**	**0.041**	**0.083**	**0.065**
Disgusted (Continuous)	0.026	0.027	0.067	0.052
p-value	*0.0027*	*0.0003*	*0.0003*	*<0.0001*

[1]Intensity: 0=not expressed; 1=fully expressed
[2]Matched pairs t-test, 2-sided p-value (p<0.20)
Bold=higher mean value; *Italics*=p<0.20
[3]C=Control (distilled water); Low: Spectrum™ 2=0.05% solution; Medium: Spectrum™ 5=0.08% solution; High: Spectrum™ 10=0.15% solution (Meilgaard et al., 2007).

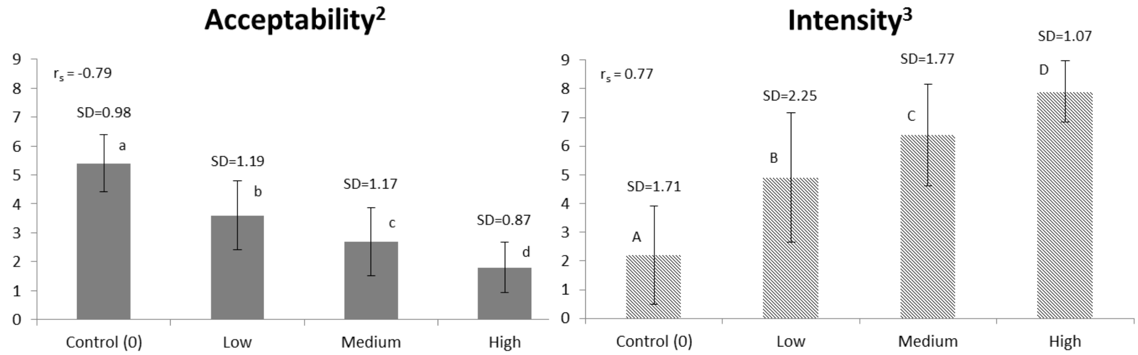


Figure 5.1 Mean acceptability and intensity scores of increasing concentrations of caffeine (bitter) in water.

[a, b, c, d]Means within acceptability with different superscripts significantly differ in acceptability ($p<0.05$).
[A, B, C, D]Means within intensity with different superscripts significantly differ in intensity ($p<0.05$).
[1]C=Control (distilled water); Low: Spectrum™ 2=0.05% solution; Medium: Spectrum™ 5=0.08% solution; High: Spectrum™ 10=0.15% solution (Meilgaard et al., 2007).
[2]Hedonic acceptability scale was based on a 9-point scale (1=dislike extremely, 5=neither like nor dislike, 9=like extremely).
[3]Intensity scale was based on a 9-point scale (1=extremely weak bitter taste/no bitter taste, 5=neither strong nor weak, 9=extremely strong bitter taste).
[4] r_s = Spearman's rank correlation coefficient

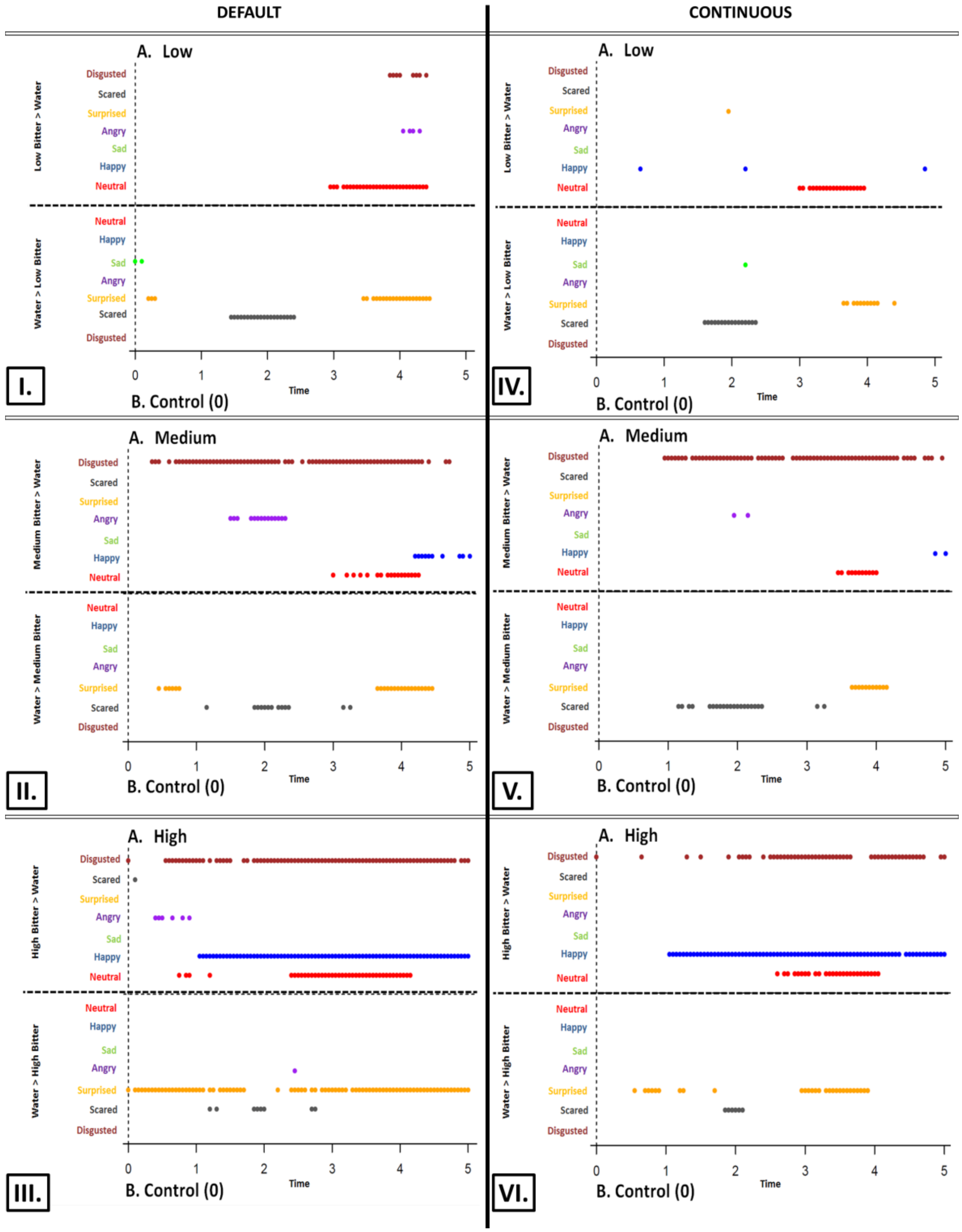


Figure 5.2 Time series graphs of classified emotions on automated facial expression analysis data over 5 seconds under the default (I, II, III) and continuous (IV, V, VI) setting comparing the (b) control (0) (water) to (a) low, (a) medium, and (a) high bitter solutions.

[1]Emotional results of sequential paired nonparametric Wilcoxon tests between control (0) (water) and respective bitter solution are plotted on the respective treatment graph if the treatment median is higher and of greater significance ($p<0.025$) for each emotion.
[2]Presence of a line indicates a significant difference ($p<0.025$) at the specific time point where the median is higher, while absence of a line indicates no difference at a specific time point ($p>0.025$).

CHAPTER VI

Application of the Theory of Planned Behavior to Elucidate Student Reusable Water Bottle Use on a College Campus

Abstract

Installment of water filling stations on college campuses is increasing as students carry reusable water bottles and campuses promote reusable water bottle use. Consumer acceptability of tap water is based largely on aesthetic qualities. Consumers associate off-flavors or off-odors with negative quality properties and safety concerns of tap water, such as contamination or health risks. The purpose of this study was to explore reusable water bottle usage on campus and to understand the phenomenon surrounding this behavior as it relates to water consumption and source selection. This investigation will aid in understanding water consumption, preferences, perceptions and opinions on college campuses.

The targeted population was undergraduate students who use a reusable water bottle. After an initial survey, five focus groups with 23 undergraduate students were conducted using a script rooted in the Theory of Planned Behavior (TPB). The scripted rooted in TPB assisted to identify attitudes, subjective norms, intentions and perceived behavioral control related to reusable water bottle use behavior. All focus groups were audiotaped and conversation transcribed verbatim. Two researchers coded the scripts individually and discussed codes until consensus was met. After consensus, the researchers categorized the codes by the major themes as well as identified sub-themes.

Themes emerged within attitudes, subjective norms, intentions, and perceived behavioral control (11 categories (attitudes n=6 categories; subjective norms n=2; perceived behavioral control n=2; intentions n=1)). Themes within attitude associated with reusable water bottles included: convenience and ability to assist with staying hydrated due to routine/schedule; health and physiological benefits; and cost (financial and environmental). Normative beliefs, including the influence of peers, coaches, and parents contribute to reusable water bottle use. Themes for perceived behavior control included: reusable water bottle qualities (eco-friendly, carrying ability, cost) and assistance to drink water each day (help with healthy behavior, reduce thirst, and convenience). Lastly, many participants carried reusable water bottles with the intention of consuming water to meet a daily need to assist with health and hydration goals.

In conclusion, participants find reusable water bottles to be convenient and an easy way to increase water consumption for health each day while reducing the environmental burden. Water consumption is essential for health and hydration. The themes that emerged regarding reusable water bottle habits can assist and provide insight for marketing and educational materials regarding water consumption habits through reusable water bottles to improve hydration status. Through the research findings to understand and identify components of consumer reusable water bottle behavior, effective educational materials can be developed to encourage water consumption as well as assist to reduce barriers preventing water consumption.

1. Introduction

The U.S. has one of the safest tap water systems in the world, yet the U.S. is the largest market for bottled water at 9.7B gallons in 2012 (Beverage Market Corporation, 2013; Fishman, 2012). The concept of bottled water gained momentum in the 1990s and consumption of bottled water has increased significantly over time. Even though bottled water consumption continues to increase, “Ban on the Bottle” movements have picked up speed in recent years. The National Park Service (2011) implemented a sustainability plan (“Green Parks Plan”) in which they aim to reduce their carbon footprint, including the disposable water bottle (United States Department of the Interior, 2011). The process and recycling of bottling water is deemed environmentally costly as resources could be used to fuel other industrial segments. Colleges and Universities are also banning the bottle due to cost and sustainability. Portland State University in Oregon (over 25,000 students) reported that in fiscal year 2011 the university sold approximately 54,540 bottles of water through retail, vending, dining and vending (Portland State University, 2012). Loyola University in Chicago is encouraging students to drink tap water by giving all freshmen reusable bottles and installing more water refill stations around campus in addition to stopping the sale of bottled water on campus (Cohen, 2012; Fishman, 2012). Many other universities are following (University of Vermont, Washington University, DePauw University, Harvard School of Public Health and Pennsylvania State University). Penn State annually recycles over 200 tons of plastic water bottles (approximately 7.6 million water bottles) (Penn State Sustainability, n.d.). Entities are taking strides to reduce plastic waste on campus due to the environmental concern, waste costs and the low recycling rate of plastics.

The most commonly consumed beverages among college students are water (72%), juice (72%), and sugar-sweetened soda (68%) (Block, Gillman, Linakis, & Goldman, 2013). The Institute of Medicine recommended daily intake (RDI) for water is about 3 liters a day (2.7 for women and 3.7 for men) (Institute of Medicine of the National Academies, 2004). Many benefits are associated with increased water consumption and or SSB substitution. Studies in children and adults have found that SSB substitution with water can lead to better weight control among the overweight (Ebbeling, Feldman, Osganian, Chomitz, Ellenbogen, & Ludwig, 2006; Tate, Turner-McGrievy, Lyons, Stevens, Erickson, Polzien, Diamond, Wang, & Popkin, 2012). In a study, surveying student beverage intake, students reported drinking more than one sugar-sweetened beverage a day, although a majority (70%) reported that they had begun to reduce their consumption (Huffman & West, 2007). This beverage shift indicates a potential avenue for educational opportunities for a healthier lifestyle in college through water consumption. Twenty-one million adults in the United States are enrolled in college (Snyder & Dillow, 2011). Alarmingly, 35% are already overweight or obese based on height and weight (Lowry, Galuska, Fulton, Wechsler, Kann, & Collins, 2000). College is the first opportunity many young adults explore independent decision making and experiences that influence their lifetime choice and behavior patterns (Arnett, 2000). It is during this experimental decision making stage that the college environment is an attractive location to change habits and educate students about healthy lifestyle especially since the greatest rise in obesity over in the 1990s was in young adults (Mokad, Serdula, Dietz, Bowman, Marks, & Koplan, 1999).

The Theory of Planned Behavior (TPB) has been used to explain a variety of social phenomena and to explain social behavior and decision making processes in regards to food and beverage consumption. Using this theory, many studies have evaluated the connection between behavior and consumption especially involving alcohol (Todd & Mullan, 2011; Huchting, Lac, & LaBrie, 2008), safe food handling (Mullan, Wong, & Kothe, 2013), vitamins (Conner, Kirk, Cade., & Barrett, 2001), diets/food intake (Sainsbury & Mullan, 2011; De Bruijn, 2010; Bogers, Brug, van Assema, & Dagnelie, 2004), eating disorders (Pickett, Ginsburg, Mendez, Lim, Blankenship, Foster, Lewis, Ramon, Saltis, & Sheffield, 2012) and sugar sweetened beverages (SSB) (Zoellner, Estabrooks, Davy, Chun, & You, 2012; Zoellner, Krzeski, Harden, Cook, Allen, & Estabrooks, 2012b; Krzeski, 2011). Little work has been done involving water consumption and reusable water bottle use, attitudes on college campuses and motivations to use reusable water bottles. College campuses typically have many sources for water including fountains, tap, refilling stations, and bottles from vending. TPB is deemed an extension of the theory of reasoned action (Ajzen, 1991). The main focus of the TPB is an individual's intention to perform a behavior. Ajzen defines the TPB as having three main independent components: specific attitudes, subjective norms, and perceived behavioral control (Figure 2.1). Attitude refers to the unfavorable or favorable position of behavior being investigated (Ajzen, 1991). Subjective norm is reference to perceived social pressure to act or not act the behavior in question (Ajzen, 1991). Lastly, perceived behavioral control is defined by the perceived ease or difficulty to perform the behavior (Ajzen, 1991).

TPB has the potential to be extended to other areas of research in food and beverages to understand the meaning behind actions and decision making processes. Within the reusable water bottle niche, consumers have selected water containers for a variety of reasons. As environmental concerns have increased, consumers have begun to use multi-use water containers to reduce their footprint. Typically food and beverage packaging is used for content containment, communication, protection, and convenience (Robertson, 2006). The importance and value of green practices is paramount to current and incoming students as found by the Princeton Review, which suggested that that nearly two-thirds of all incoming freshmen include sustainability as a factor when making a decision to attend a specific institution (Norman, 2013). Research emphasis is not placed on those who currently use containers. Information can be gained from those currently using a reusable water bottle and applied in an effort to improve interventions as it relates to increasing water consumption, improving health and drinking water perceptions. Focus groups with current students who use reusable water bottles can elucidate a potential pathway for improving the health and hydration status of students. Additionally, a study of reusable water bottle use and a focus on water consumption and availability could elucidate methods to promote water consumption and reduce sugar sweetened beverage intake in young adults. New opportunities for water delivery in institutions could lessen the burden on landfill waste, increase aesthetics surrounding water, improve brand image, create a better product to consumer experience, and promote health and sustainability. This research aims to determine the attitudes, subjective norms, perceived behavioral control and intention to explain behavior associated with reusable water bottle use and water consumption among undergraduates using a focus group script rooted in The Theory of Planned Behavior.

2. Materials and Methods

2.1 Qualitative Application of the Theory of Planned Behavior and Emotional Ballot

2.1.1 Participant Recruitment and Screen Survey

Study was pre-approved by Virginia Tech IRB (IRB #15-031) prior to project initiation. Study recruitment was accomplished through email listservs to Virginia Tech faculty, staff, and students; however, the target demographic population was undergraduates who use reusable water bottles. Prospective participants completed a pre-screening survey for reusable water bottle usage, water bottle attributes, and demographics. Exclusion criteria included status other than an undergraduate and lack of reusable water bottle usage, and age less than 18.

2.1.2. Focus Groups

Five focus groups were conducted and lasted about an hour (n=23 participants; Range 3 – 6 participants per focus group). Selected participants from the pre-screening survey (n=23; Male=4 (Male Mean age=20); Female=19 (Female Mean age=20.2); Mean age=20.2; Age Range=18-22; Commuter=12; Resident=11; Freshman=4; Sophomore=3; Junior=11; Senior=5; Majors: Human Foods, Nutrition, and Exercise=6; Food Science and Technology=10; Agricultural Science=1; Biological Sciences=1; Interior Design=2; Biochemistry=1; Architecture=1; Mechanical Engineering=1) were Virginia Tech undergraduates who use reusable water bottles. A moderator and co-moderator were present to provide structure, questions and moderate. Before focus group initiation, the consent forms were verbally read to participants by the researchers and participants had the opportunity to review study parameters and consent forms. The focus group did not begin until consent forms were signed and participants collectively approved of audio recording, before receiving additional instructions. Focus group sessions were audio recorded (Olympus WS-110 Digital Voice Recorder, Olympus America, Inc., Center Valley, PA), for an accurate and complete documentation of participant responses. The recorded portions of the session started with an introduction, instructions completing the demographic page, and instructions for completing the emotional ballot (Modified EsSense Profile). After participant completion of the emotional ballot (Modified EsSense Profile), questions related to the emotional ballot photographs and The Theory of Planned Behavior focus group questions were asked.

2.1.2.1. Emotional Ballot Check-All-That Apply (CATA) (Modified EsSense Profile) and Analysis

The EsSense Profile (King, Meiselman & Carr, 2010; King & Meiselman, 2010) is a check all that apply (CATA) ballot. The ballot was modified to incorporate more holistic emotional and acceptability terms for assessing user experiences prompted by the photographs. The modified terms originated from the list from which The EsSense Profile was developed (King & Meiselman, 2010). Eight terms from The EsSense Profile (wild, understanding, whole, warm, merry, loving, joyful, and tame) were replaced with 8 terms from the original list (angry, annoyed, discouraged, irritated, nervous, sad, scared, and surprised). The modified emotional CATA ballot used in this study consisted of 39 terms and included the following guided distinctions (King & Meiselman, 2010) but modified for the purpose of this study: “positive” terms (n=20) (active, adventurous, affectionate, calm, energetic, enthusiastic, free, friendly, glad, good, good-natured, happy, interested, nostalgic, peaceful, pleasant, pleased, satisfied, secure, and tender); “negative” terms (n=10) (angry, annoyed, bored, discouraged, disgusted, irritated, sad, scared, nervous, and worried); and “no clear classification” terms (n=9) (aggressive, daring, eager, guilty, mild, polite, quiet, steady, and surprised).

The emotional ballot (modified EsSense Profile) was used to assess the emotional attributes and acceptability of water source graphics ((filling station, water fountain, reusable water bottle, disposable water bottle, and tap with tap water) (Appendix C.6)). The pictures were used as a prompt and participants were instructed to evaluate the pictures based on their overall experience and perception of the sources, not necessarily the pictures themselves. The color photos were randomized for each participant and presented in a notebook. The students completed an emotional ballot (modified EsSense Profile) (King, Meiselman & Carr, 2010; King & Meiselman, 2010), as modified, to determine an emotional profile associated with reusable water bottles (Appendix C.5). Count frequencies for each emotion term (39 total) were calculated for all photographs (filling station, water fountain, reusable water bottle, disposable water bottle, and tap with tap water). Terms that were selected with at least 20% frequency (count frequency = 5 (5/23 =21.7%); maximum possible count = 23 per emotional term) for at least one situational photograph were “frequently selected” (Arnade, 2013; Leitch, 2015). For the purpose of this study, only information regarding reusable water bottles and disposable water bottles were used in analysis.

2.1.2.2. Focus Group Procedure, Script and Analysis

Focus groups were conducted according to the guidelines and procedures of Krueger & Casey (2000). A semi-scripted open-ended question focus group rooted in The Theory of Planned Behavior (Ajzen, 1991) was modified from Zoellner et al. (2012a), Zoellner et al. (2012b), and Krzeski (2011) to determine the attitudes, subjective norms, perceived behavioral control, and intention to explain behavior associated with water consumption, reusable water bottle use, and water delivery sources on campus (Appendix C.7). Focus group questions were related to the emotional ballot (modified EsSense Profile), water availability on campus, routines, water consumption barriers, health, hydration and purpose of reusable water bottle usage.

Data saturation was met after five focus groups and, upon completion, focus group sessions were transcribed verbatim. The transcriptions were qualitatively analyzed using the comparative method with joint coding and analysis (Denzin & Lincoln, 2005; Rossman & Rallis, 2012; Schroeder, 2016; Krueger & Casey, 2000). Transcripts were evaluated by two coders individually. Coders agreed on codes before categorizing. Transcripts were categorized to determine themes under the constructs of The Theory of Planned Behavior (attitudes, subjective norms, perceived behavioral control, and intentions). Themes are considered similar phrases, words or feelings amongst the focus group.

3. Results

3.1 Emotional Ballot Check-All-That Apply (CATA) (Modified EsSense Profile)

The profile (n= 16 frequently selected emotional terms) associated with the reusable water bottle included the positive terms, active (82.6%), adventurous (60.9%), good (56.5%), satisfied (56.5%), happy (52.2%), energetic (47.8%), pleasant (47.8%), friendly (43.5%), good-natured (43.5%), peaceful (43.5%), secure (34.8%), enthusiastic (30.4%), pleased (30.4%), calm (21.7%), and free (21.7%). Eager (21.7%) with "no clear classification" was also selected (Figure 6.1).

The profile (n= 7 emotional terms) of the disposable water bottle included positive terms active (43.5%), calm (21.7%); and negative terms guilty (43.5%), discouraged (30.4%), annoyed (26.1%), irritated (26.1%), and worried (26.1%) (Figure 6.1).

3.2 Focus Groups

The focus group analysis of student's opinion, perception, and use regarding reusable water bottles and disposable water bottles were organized into 11 categories (attitudes n=6 categories; subjective norms n=2; perceived behavioral control n=2 ; intentions n=1). The results are summarized in Table 6.1.

3.2.1 Attitudes

(1) Associated qualities of RWB that fit preference and lifestyle

Participants felt that RWB fit their active lifestyles and provide a convenient source of water that they prefer to use. RWB are financially cheaper and easier to use than DWB. RWB provide an easy way to carry water and be "eco-friendly". RWB are sustainable and offer a waste reduction benefit quality, which makes RWB appealing to students. On a side note, RWB serve as entertainment and distraction during periods of boredom. Certain RWB qualities make RWB more appealing for everyday use: straw options (bacteria); transport ease and leak prevention and reduction; opportunities for accessories (sticker, flag, sorority); hot and cold liquid capabilities; amount of water volume; eco-friendly quality; warranty, price, filtering capabilities; cleanliness and ease of maintenance); and 'shakability' for dry powder beverage mixes.

(2) RWB usage depends on daily schedule and circumstances

Frequency of RWB use depends on daily routine and schedule, which influences a refilling routine and water consumption routine. RWB are useful due to the on-the-go feature and nature of user schedule. RWB can be carried mostly everywhere. Most participants use RWB throughout the day and week; however, RWB use is dependent on the beverage. Students will switch to different containers or glasses for other beverages. Typically, RWB are used solely for water. Additionally, participants will switch to glasses for water depending on the location and circumstances (eating at a dining room table, eating in general, or different activity).

(3) Physiological/Psychological influences of RWB use

Participants stated that RWB make it easier to accomplish drinking water each day. RWB allow for hydration opportunities as well as reduce thirst and thirst cravings. RWB are used to mitigate several perceived physiological and psychological occurrences each day. Generally, RWB are used to quench thirst, stay hydrated, and reduce the burden of finding water when thirsty. Water helps participants stay focused and alert in class. Also, the action of drinking water from RWB helps reduce stress and nerves in certain situations (i.e. presentations, tests). RWB assist in staying hydrated for sports or exercise performance. RWB themselves serve as a reminder to drink water and perhaps drive thirst due to constant presence with users. Participants mentioned that without a RWB they notice and/or feel they are thirstier during the day.

(4) Experiences with RWB that contribute to sentimental value

The emotional connection of user and RWB varied across participants. If an emotional connection was present it is because of experiences with the RWB. Participants stated that certain RWB have a nostalgic remembrance of the past including trips or athletic events. Additionally, if the RWB was given to the participant as a gift (parents, friends, sorority, etc.) it holds more sentimental value than a purchased generic RWB. If a RWB is personalized with stickers is lost or broken, there is a potential greater sense of loss and sadness. With some participants there is a deeper connection with RWB due to experiences with the RWB. The RWB can be a source of companionship, dependability, sentimentality and being a part of the participant's history or journey.

(5) RWB does not elicit deep emotional response: inconvenient if lost but replaceable

Some participants were only tied to their RWB superficially. If they lost their RWB, the emotional loss would be minimal. The emotional loss would be tied to anger, annoyance and frustration of losing the RWB. Replacing the RWB is an inconvenience of going to the store as well as a financial inconvenience of having to purchase another RWB. RWB characteristics (color, design) might influence the reaction to the loss; however, participants with this perception said they could easily move on. Some students buy cheap and easily replaceable bottles due to their ability to lose RWB easily. Generally, it is easy for students to move on to a replacement RWB. RWB are treated more as a non-emotional investment than an emotional companionship.

(6) Cost (financial and environmental) and quality lead to opinions about DWB but use can be situationally dependent

Participants expressed that DWB are wasteful, and expensive; however, they do serve a purpose in certain circumstances or when water is unacceptable to drink due to aesthetics or safety concerns. Some participants used to like DWB because they felt the water is safer. DWB are not considered eco-friendly and DWB usage is not environmentally conscious. Participants stated that DWB are financially wasteful and they felt that people could spend money on other items. The lack of recycling options, seeing DWB in garbage, and seeing plastic bottles everywhere influenced the anti-use of DWB and the use of RWB. Participants did not wish to purchase DWB but will use them if handed out for free.

Aesthetically, DWB can have an off-flavor and participants feel that they are drinking sweet melted plastic and some brands taste “gross”. Also, warm temperature affects the flavor of DWB negatively. DWB are burdensome to carry if wanting to stay hydrated due to the volume needed and amount of bottles to carry to meet hydration needs. DWB are not sustainable because participants drink a large amount of water per day. The amount of DWB to sustain hydration needs is wasteful financially and environmentally. Participated stated an annoyance with others who used excessive amounts of DWB when they own RWB, as participants felt that this behavior is wasteful. While participants voiced their disdain for DWB, ultimately hydration is the most important and they are pleased to see people drinking water regardless of the source. On campus, they expressed that there are reasonably enough locations to recycle used DWB.

3.2.2 Subjective Norms

(1) Bottles saved and filter status influence filling station use and RWB filling

Filling station qualities such as the “bottles saved” indicator and the water filter status light indicator influence RWB location filling. Participants mentioned that the water filter status light indicator makes them feel that the water is safer and of higher quality for consumption. Also, the “bottles saved” marker makes students feel they are being eco-friendly because they are reducing the impact of disposable water bottles by using RWB and filling at the station.

(2) External Motivators that contribute to choices of hydration source RWB

Reusable water bottle use and hydration habits were influenced by a variety of sources. Participants stated that RWB use started as early as middle school, mainly in high school, and some began using RWB in college due to trends. In high school, staying hydrated for athletic performance drove participant’s RWB use and water consumption. Additionally, high school athletic coaches recommended that participants stay hydrated by using a RWB thus contributing to habitual use of RWB. The high school trends and coach influences of RWB use has carried over into college. Similarly to athletic coaches, in college the Air Force tells cadets to buy and use RWB because they are more likely to drink and stay hydrated. Additionally, participant’s personal forced habit makes it easy to consume water, however, weekly, schedule (i.e. work) may impact water consumption and RWB use.

Secondly, parents influence participant’s RWB because they are environmentally conscious and promoted the use of RWB. Additionally, participant’s parents did not purchase disposable water bottles due to the desire to reduce waste, be more environmentally friendly, and be more cost efficient. Also, parents encourage participants to be accountable for RWB due to the financial replacement cost. Some parents' careers influence their discouraging opinion on DWB and encouraging RWB use (i.e. water engineer and environmental teacher) that has influenced participant's RWB usage.

Participants expressed that peers can influence and encourage RWB use. Participants stated that there is peer pressure to use a RWB on campus because 'everyone' uses one and the campus environment promotes the usage of RWB. Friends, roommates, and significant others can influence RWB use especially through giving RWB as gifts or handouts. Some participants experienced significant others and friends nagging them to use RWB instead of DWB. Lastly, the inability to leave during class for water encourages RWB use to stay hydrated.

Participants stated that RWB companies or RWB giveaways may influence RWB use. Students voiced that they have gotten RWB for free via campus giveaways or promotions. Additionally, RWB companies may ask users to sample a bottle which would influence brand promotion and continued usage. RWB companies may have a value-added product with a filter, which appeals to continued usage due to the ability to filter water anywhere. In media, phone apps may also influence general water consumption habits through tracking and notification encouragement. Students have been exposed to statements or advertisements saying it is important to drink 2 – 3 bottles of water if exercising and it is important to drink more water to give blood.

For disposable water bottles, some participants' parents prefer to use DWB. Some participants were accustomed to their use and felt indifferent about the source. Participants will deviate from RWB in certain circumstances including when DWB are handed out for free at events/meetings, during travel, or if someone else purchases the DWB for use. However, there is social pressure not to use DWB due to the environmental effect and burden. Participants voiced concern about a health hazard regarding disposable water bottles due to the plastic and the potential danger from reusing a DWB. Many use RWB due to the plastic concern of DWB. Furthermore, recycling availability influences RWB or DWB use. If recycling is not available, RWB use is important to reduce the environmental impact of DWB.

3.2.3 Perceived Behavioral Control

(1) Perceived Behavioral Justification for RWB Use

Participants revealed that carrying a RWB is habitual and provides a sense of comfort. Additionally, the RWB serves as reminder for them to drink water and it is a readily available source for water. Participants carry their RWB frequently, if not everywhere. Participant justification for using a RWB includes hydration benefits, improving alertness, calming nerves, reducing dehydration due to exercise and performance related superstition. Students feel that if they carry their RWB it will help with mitigating these effects or experiences. Water access and time uncertainty drives participants to use RWB on campus.

In addition, participants expressed that RWB eliminates waste and is cheaper. By using RWB, they are not contributing to waste and they are reducing the burden on the environment. They stressed that RWB are typically a one-time cost (or free) and water is free to refill. Some students expressed that they will not go out of their way to use DWB due to environmental and financial cost.

Participants stated that some RWB have extra value-added qualities they prefer. A RWB with a Brita filter is great because you can filter anywhere and have more consistent flavored and safe water. The ability to close the spout is important to reduce germ contamination and having a straw is beneficial due to clumsiness.

(2) Accessibility and Convenience Provide Preferential Source Factors for Students

Participants placed an importance on convenience (schedule), ease of use (automation, sensor) and aesthetic qualities (temperature, ice, cleanliness) in choosing where to refill. Many students stated that they choose sources where they don't feel cheated when they refill (tilting bottle, ability to refill entirely, ability to "fit" underneath the water stream).

Students typically carry RWB everywhere on campus and use it throughout the day. Participants feel that water is available and accessible. They stated they can typically fill their RWB multiple times per day because filling stations and water fountains are on campus. Many carry RWB around because drinking from water fountain to water fountain is unrealistic, even though water is readily available on campus.

While most participants have a location preference for water, water fountains are unavoidable because it is hard to find filling stations to refill RWB. Most participants try to use filling stations or dining hall beverage fountain stations (dining halls) to refill from because it is easier to refill RWB. While many look for filling stations or use the dining hall, filling stations are often hard to find and most students will refill their RWB out of convenience using whatever is nearby depending on their schedule. A majority of participants had a strong resistance to using a bathroom sink due to perception of bathroom circumstances/unknown behavior.

3.2.4 Intentions

(1) Intentions of Reusable Water Bottle Use

Students carry a RWB to allow for more water consumption throughout the day and to attain hydration goals. RWB can be used as a measure for consumption when there is a water consumption goal (i.e. gallon challenge, measuring number of refills, intention of finishing the RWB by the end of the day, or to track the amount of ounces consumed, etc.). Participants intentionally carry their RWB due to routine especially when exercising or during the school week. Participants use a RWB to assist in attaining a healthier lifestyle and increase physical or physiological performance. Many carry to reduce thirst, improve hydration status, and to have better physical performance during a workout. Additionally, many students drink water for health and improved skin health. Participants carry a RWB to reduce the inconvenience of being thirsty and having to find a source of water and/or disrupting class. Also, students bring RWB to tests to because drinking water calms nerves and can serve as a lucky charm. Lastly, participants expressed that they carry a RWB to be environmentally friendly and financially conscious.

4. Discussion

The Theory of Planned Behavior has been used to understand consumers and explain behavior. Scholderer and Trondsen (2008), who applied the TPB to fish consumption for their research questions, determined that fish consumption could be related to "three of these barriers (quality, taste, and smell) as outcome beliefs, one as a normative belief (family preferences), three as control beliefs (price, variety and availability), and two as expressions of self-efficacy (meal preparation skills and convenience).” Pickett et al. (2012) found that the TPB has the ability to explain and predict behaviors associated with diet and health as it relates to eating disorders. Additionally in a study with fruits and vegetables, participants’ attitude and perceived behavioral control were valuable in predicting the intentions and behavior related to consumption (Blanchard, Kupperman, Sparling, Nehl, Rhodes, Courneya, & Baker, 2009).

Participants selected only positive emotional terms for the reusable water bottle. While true trends cannot be established due to the limited participant size, the major reusable water bottle (RWB) terms were active (82.6%), adventurous (60.9%), good (56.5%), happy (52.2%), and satisfied (56.5%). Surprisingly, not many students had a deep emotional connection with their RWB in both the emotional ballot and focus groups. Fenko, Schifferstein, and Hekkert, (2009) found when consumers have a relationship with their products over time emotional experiences in relation to the product become significant. Conversely, other users may not be able to commit to such self-expression and simply leave the product in its original state (Mugge, Schifferstein, & Schoormans, 2009).

The lifestyle of participants supports RWB use as many students are on the go and RWB serve as a source of water without purchasing a disposable water bottle (DWB). RWB provide a consistent, portable, financially conscious, sustainable and eco-friendly source of water for hydration. Students carry a RWB to allow for more water consumption throughout the day to attain hydration goals and to reduce the inconvenience of thirst. In a study of college beverage selection, students claimed that water is primarily consumed for hydration (Block et al., 2013). The RWB serves as a reminder to drink water. In a study with increasing fruit consumption through lunchroom services, researchers implemented the CAN (convenient, attractive, and normative) approach and placed fruit in an accessible and attractive serving dish and student intake of fruit increased (Wansink, 2013). This finding could explain the use of RWB due to their convenience and continual presence.

RWB provide water to assist in attaining a healthier lifestyle and increase physical or physiological performance. Contradicting evidence exists regarding increasing water consumption through reusable water bottle intervention studies in elementary and middle schools. In a German elementary school setting, reusable water bottles were effective in increasing student water consumption (Muckelbauer, Libuda, Clausen, Toschke, Reinehr, & Kersting, 2009); however, in an American and United States study, the intervention was not as effective in increasing water consumption through reusable water bottles (Loughridge & Barratt, 2005; Patel, Bogart, Elliott, Lamb, Uyeda, Hawes-Dawson, Klein, & Schuster, 2011). In a qualitative study with college students, students wanted and expected to drink water out of their individual reusable water bottles and not vending disposable water bottles (Kaplan, 2011).

Participants felt that water, and by association RWB, help them stay alert, focused, and assist in reducing stress while, without a RWB, students will notice a difference in their day. Water consumption benefits have been linked to improving health (Ebbeling et al., 2006; Tate et al., 2012), weight loss (Popkin et al., 2005; Dennis et al., 2010; Akers et al., 2012) and cognition (Fadda, Rapinett, Grathwohl, Parisi, Fanari ,Calo, & Schmitt, 2012; Benton & Burgess, 2009; Bar-David, Urkin, and Kozminsky, 2005). Dehydration or poor hydration has been linked to diminished attention, memory and arithmetic ability (Gopinathan, Pichan, & Sharma, 1988; Suhr, Hall, Patterson, & Niinisto, 2004).

Certain influences or experiences can enhance and promote RWB use. Water filling stations are on campus and the “filter status” and “bottles saved” feature features on the filling stations can make RWB refilling more inviting and reinforcing. Of importance, RWB use started before college and was often influenced by athletic coaches, parents, peers and college trends. Reinforced behavior can contribute to continued sustainable reusable water bottle use (Redman, 2013). Moreover, many, including the Air Force, have told participants that if you are carrying a RWB you are more inclined to consume more water. Parents influence participants RWB use by emphasizing the financial and environmental burden. Media and advertisements can also influence use and even campus flyers or the installment of filling stations can encourage RWB use. In a study with barriers to healthy eating and physical activity in students, students, parents and community stakeholders were dissatisfied with water fountains (dirty) and thought DWB were expensive (Goh, Bogart, Sipple-Asher, Uyeda, Hawes-Dawson, Olarita-Dhungana, Ryan, & Schuster, 2009). Water filling stations and RWB are a solution to these barriers and can perhaps explain their usage and promote water consumption.

The disposable water bottled generated more negative emotional terms than positive terms but none were in the majority. Students articulated that DWB are expensive and wasteful; but do serve as a convenient substitute in certain circumstances (travel, trips, events of unsafe water). The circumstantial DWB behavior is supported by researchers in Family and Consumer Sciences because clean and accessible water is important for health if tap water is not suitable (Dozier & Ferry, 2015). Health concerns are a primary reason for purchasing bottle water instead of using tap water sources (Office of Groundwater and Drinking Water, The United States Environmental Protections Agency, 2003). Students in secondary school cafeterias stated that oftentimes school water provisions are unappealing yet the alternative source for palatable water is DWB, which is financially burdensome (Loughridge & Barratt, 2005). In a study assessing college students' beverage habits, students did not purchase bottled water because they can get it for free; however, taste and appearance of tap water might influence purchase of DWB or another beverage instead of using tap water (Block et al., 2013). Most importantly, many would not purchase DWB, but if they were provided for free – they would be more willing to use DWB. There is a movement to ban DWB on college campuses and, in a recent college study, most participants would support the ban if adequate tap water sources were provided (filtered water and filling stations) (Kanda, Brar, Ho, & Yeh, 2010). However, banning the water bottle has shown increases in sugar sweetened beverages instead of reusable water bottle usage (Berman & Johnson, 2015). Also, participants mentioned that occasionally they are bothered by others, who use DWB extensively, but ultimately it is about "hydration" and they were happy others were drinking water. Regardless, using DWB as the only source of water is wasteful and unfeasible due to the amount needed to stay hydrated. The cost of water on campus is around $1.00/20 fluid ounces (fl oz). Zoellner et al. (2012) and Krzeski (2012) stated that health professionals recommend 5 cups (40 fl oz) – 8 cups (64 fl oz) of water per day. To rely solely on DWB to meet this recommendation, students would spend $2.00 - $3.20/day. The bottled water industry is taking strides to reduce the use of plastic with new designs due to the green movement in hopes to reduce consumer guilt (Noble, Paul, McMinimee, Mallett, & Singh, 2009). Also aesthetically DWB can be displeasing due to off-flavors. DWB off-flavors can be attributed to acetaldehyde migration from the poly(ethylene terephthalate) (PETE) packaging to the water (van Aardt, 2000; Poretta & Minuti, 1995). In a study with bottled water, participants were able to detect differences between bottled water brands due to a “plastic” taste (Whelton, Dietrich, Burlingame, Schechs & Duncan, 2007). Parents, media, and peers can also discourage DWB use due to recycling capabilities and environmental burden.

5. Conclusions

The Theory of Planned Behavior was useful in identifying the construct contributions to the reusable water bottle behavior and preferences. There is an interesting battle playing between RWB and DWB for convenience and health to suit hydration needs, especially on college campuses. With college students, it appears the environmental and financial importance weigh more heavily in choosing a hydration vessel for water needs. Students appear conscious of their environmental impact and prefer to use RWB. Moreover, RWB assists in both physiological and psychological benefits for the user.

In conclusion, participants find reusable water bottles to be convenient and an easy way to increase water consumption for health each day while reducing the environmental burden. The themes that emerged regarding reusable water bottle habits can assist and provide insight for marketing and educational materials regarding water consumption habits through reusable water bottle use to improve hydration status. Through the research findings to understand and identify components of consumer reusable water bottle behavior, effective educational materials can be developed to encourage water consumption as well as assist to reduce barriers preventing water consumption. The information gained through this study can contribute to health promotion techniques and strategies to improve health and hydration status with an environmentally friendly reusable water bottle behavior.

Acknowledgements

This project was funded, in part, by the Virginia Tech Graduate Student Assembly Graduate Research Development Fund, the Virginia Agricultural Experiment Station, the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture, and the Virginia Tech Water INTERface Interdisciplinary Graduate Education Program. The authors would like to thank Diana Woodrum and Taylor Duncan for their assistance.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior Human Decision Processes*. *50*, 179-211.

Arnade, E.A. (2013). *Measuring consumer emotional response to tastes and foods through facial expression analysis* (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA.

Arnett, J. J. (2000). Emerging adulthood: a theory of development from the late teens through the twenties. *American Psychologist, 55*(5), 469 – 480.

Bar-David, Y., Urkin, J., & Kozminsky, E. (2005). The effect of voluntary dehydration on cognitive functions of elementary school children. *Acta Paediatrica, 94*(11), 1667–1673.

Benton, D. & Burgess, N. (2009). The effect of the consumption of water on the memory and attention of children. *Appetite, 53*(1) 143–146.

Berman E. R. & Johnson, R. K. (2015). The unintended consequences of changes in beverage options and the removal of bottled water on a university campus. *American Journal of Public Health, 105*(7), 1404-1408.

Beverage Market Corporation. (2013). Bottled water shows strength yet again, new report from BMC shows. *Beverage Market Corporation press release*. Retrieved from http://beveragemarketing.com/news-detail.asp?id=260

Blanchard, C. M., Kupperman, J., Sparling, P. B., Nehl, E., Rhodes, R. E., Courneya, K. S., & Baker, F. (2009). Do ethnicity and gender matter when using the theory of planned behavior to understand fruit and vegetable consumption? *Appetite, 52*(1), 15-20.

Block, J. P., Gillman, M. W., Linakis, S. K. & Goldman, R. E. (2013). “If it tastes food, I’m drinking it”: qualitative study of beverage consumption among college students. *Journal of Adolescent Health, 52*(6), 702-706.

Bogers, R. P., Brug, J., van Assema, P., & Dagnelie, P. C. (2004). Explaining fruit and vegetable consumption: the theory of planned behavior and misconception of personal intake levels. *Appetite, 42*(2), 157-166.

Cohen, J. S. (2012). Loyola to ban sale of bottled water on campus. *Chicago Tribune News*. Retrieved from http://articles.chicagotribune.com/2012-05-08/news/ct-met-loyola-bottled-water-ban-20120508_1_illinois-beverage-association-bottled-water-tim-bramlet

Conner, M., Kirk, S. F .L., Cade., J. E., & Barrett, J. H. (2001). Why do women use dietary supplements? the use of the theory of planned behavior to explore beliefs about their use. *Social Sciences & Medicine, 52*(4), 621-633.

De Bruijn, G. J. (2010). Understanding college students' fruit consumption. integrating habit strength in the theory of planned behavior. *Appetite*. *54*(1), 16-22.

Denzin, N., & Lincoln, Y. (2005). *The sage handbook of qualitative research* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Dozier, C. & Ferry, A. (2015). Factors determining water preferences on university campuses: insights for FCS. *Journal of Family and Consumer Sciences, 107*(1), 35-44.

Ebbeling, C. B., Feldman, H. A., Osganian, S. K., Chomitz, V. R., Ellenbogen, S. J. & Ludwig, D. S. (2006). Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. *Pediatrics. 117*, 673-680.

Fadda, R., Rapinett, G., Grathwohl, D., Parisi, M., Fanari ,R., Calo, C.M., & Schmitt, J. (2012). Effects of drinking supplementary water at school on cognitive performance in children. *Appetite, 59* (3), 730–737

Fenko, A., Schifferstein, H. N. J., & Hekkert, P. (2009). Shifts in sensory dominance between various states of user-product interactions. *Applied Ergonomics, 41*, 34-40.

Fishman, C. (2012). U.S. bottled water sales are booming (again) despite opposition. *National Geographic*. Retrieved from http://newswatch.nationalgeographic.com /2012/05/17/u-s-bottled-water-sales-are-booming-again-despite-opposition/

Goh, Y., Bogart, L. M., Sipple-Asher, B. K., Uyeda, K., Hawes-Dawson, J., Olarita-Dhungana, J., Ryan, G. W., & Schuster, M. A. (2009). Using community-based participatory research to identify potential interventions to overcome barriers to adolescents' healthy eating and physical activity. *Journal of Behavioral Medicine, 32*(5), 491–502.

Gopinathan, P. M., Pichan, G., & Sharma, V. M. (1988). Role of dehydration in heat stress-induced variations in mental performance. *Archives of Environmental Health, 43*, 15–17

Huffman, L. & West, D. S. (2007). Readiness to change sugar sweetened beverage intake among college students. *Eating Behaviors, 8*, 10-14.

Huchting, K., Lac, A., & LaBrie, J. W. (2008). An application of the theory of planned behavior to sorority alcohol consumption. *Addictive Behaviors, 33*, 538-551.

Institute of Medicine of the National Academies. (2004). *Dietary reference intakes: water, potassium, sodium, chloride, and sulfate*. Retrieved from http://www.iom.edu/Reports /2004/Dietary-Reference-Intakes-Water-Potassium-Sodium-Chloride-and-Sulfate.aspx

Kanda, K., Brar, T., Ho, R., & Yeh, N. (2010). An investigation into sustainable water consumption university of british columbia (APSC261). *The University of British Columbia Social Ecological Economic Development Studies (SEEDS) Student Report*, 1-19.

Kaplan, M. (2011). Lonely drinking fountains and comforting coolers: paradoxes of water value and ironies of water use. *Cultural Anthropology, 26*(4), 514–541.

King, S. C, & Meiselman, H. L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21*, 168 – 177.

King, S. C, Meiselman, H. L., & Carr, B.T. (2010). Measuring emotions associated with foods in consumer testing. *Food Quality and Preference, 21*, 114-116.

Krueger, R. A. & Casey, M. A. (2000). *Focus groups: a practical guide for applied research*. Thousand Oaks, CA: Sage Publications, Inc.

Krzeski, E. (2011). Using the theory of planned behavior to understand drink choices in southwest virginians (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Leitch, K.A. (2015). Evaluating consumer emotional response to beverage sweeteners through facial expression analysis (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Lowry, R., Galuska, D. A., Fulton, J., Wechsler, H., Kann, L., & Collins, J. (2000). Physical activity, food choice, and weight management goals and practices among U.S. college students. *American Journal of Preventive Medicine, 18*, 18-27.

Loughridge, J. L. & Barratt, J. (2005). Does the provision of cooled filtered water in secondary school cafeterias increase water drinking and decrease the purchase of soft drinks? *Journal of Human Nutrition and Dietetics, 18*(4), 281-286.

Mokad, A. H., Serdula, M. K., Dietz, W. H., Bowman, B. A., Marks, J. S., & Koplan, J. P. (1999). The spread of the obesity epidemic in the united states, 1991-1998. *Journal of the American Medical Association, 282*, 1519-1522.

Muckelbauer, R., Libuda, L., Clausen, K., Toschke, A. M., Reinehr, T., & Kersting, M. (2009). Promotion and provision of drinking water in schools for overweight prevention: randomized, controlled cluster trial. *Pediatrics, 123*(4), e661-e667.

Mugge, R., Schifferstein, H. N .J., & Schoormans, J. P. I. (2009). Incorporating consumers in the design of their own products. the dimensions of product personalization. *CoDesign: International Journal of CoCreation in Design and the Arts, 5*(2), 79-97.

Mullan, B. A., Wong, C. & Kothe, E .J. (2013). Predicting adolescents' safe food handling using extended theory of planned behavior. *Food Control, 31*(2), 454-460.

Noble, N., Paul, L., McMinimee, C., Mallett, M., & Singh, J. (2009) Packaging trends for bottled water. *Journal of Applied Packaging Research, 3*(3), 123-136.

Norman, C. R. (2013). *For fourth consecutive year, virginia tech ranked among the 'greenest colleges' in nation*. Retrieved from http://www.vtnews.vt.edu/articles /2013/05/050613-vpa-princetongreenaward.html

Office of Groundwater and Drinking Water, The U.S. Environmental Protection Agency (2003). *Analysis and findings of the gallup organization's drinking water customer satisfaction survey*. Retrieved from http://nepis.epa.gov/Exe /ZyNET.exe/901U0L00.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2000+Thru+2005&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C00thru05%5CTxt%5C00000011%5C901U0L00.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=p%7Cf&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL

Patel, A. I., Bogart, L .M., Elliott M. N., Lamb, S., Uyeda, K. E., Hawes-Dawson, J., Klein, D. J., & Schuster, M. A. (2011). Increasing the availability and consumption of drinking water in middle schools: A pilot study. *Preventing Chronic Disease, 8*(3), 1-9.

Penn State Sustainability Office (n.d.). *Bottle refilling stations*. Retrieved from http://sustainability .psu.edu/live/what-penn-state-can-do/recycling-and-waste-management/bottle-refilling-stations

Pickett, L. L., Ginsburg, H .J., Mendez, R. V., Lim, D. E., Blankenship, K. R., Foster, L. E., Lewis, D. H, Ramon, S. W., Saltis, B. M., & Sheffield, S. B. (2012). Ajzen's theory of planned behavior as it relates to eating disorders and body satisfaction. *North American Journal of Psychology, 14*(2), 339-354.

Poretta, S. and Minuti, E. (1995). Acetaldehyde in PETE-packaged commercial mineral waters and soft drinks: determination of its content and evaluation of its taste threshold. *Industria Conserve, 70*, 266-274.

Portland State University. (2012). *Report of the PSU sustainable drinking water task force*. Retrieved from: http://www.pdx.edu/planningsustainability/sites/www.pdx.edu.planning-sustainability/files/SDW%20Task%20Force%20Report%20-%201.24.12.pdf

Redman, E. (2013). Advancing educational pedagogy for sustainability: developing and implementing programs to transform behaviors. *International Journal of Environmental & Science Education, 8*(1), 1-34.

Robertson, G.L. (2006). *Food packaging: principles and practice* (2nd ed.) (p. 550). Boca Raton, FL: CRC Press.

Rossman, G., & Rallis, S. (2012). *Learning in the field: an introduction to qualitative research* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Sainsbury, K. & Mullan, B. (2011). Measuring beliefs about gluten free diet adherence in adult coeliac disease using the theory of planned behavior. *Appetite, 56*(2), 476-483.

Schroeder, M., Galagarza, O., Eifert, J., Boyer, R., Chase. M., & Nieto-Montenegro, S. (2016). Employee perceptions of food safety pictograms at meat and poultry processing plants leads to new hand washing pictogram. *Food Protection Trends, 36*(3), 195-207.

Scholderer, J. & Trondsen, T. (2008). The dynamics of consumer behavior: on habit, discontent, and other fish to fry, *Appetite, 51*(3), 576-591.

Snyder T. D. & Dillow S. A. (2012). *Digest of education statistics 2011* (NCES Publication 2012-001) (pp. 309-538). Washington DC: National Center for Education Statistics, Institute of Education Sciences, United States Department of Education

Suhr, J. A., Hall, J., Patterson, S. M., Niinisto, R. T. (2004). The relation of hydration status to cognitive performance in healthy older adults. *International Journal of Psychophysiology, 53*(2), 121–125.

Tate, D. F., Turner-McGrievy, G., Lyons, E., Stevens, J., Erickson, K., Polzien, K., Diamond, M., Wang, X., & Popkin, B. (2012). Replacing caloric beverages with water or diet beverages for weight loss in adults: main results of the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. *American Journal of Clinical Nutrition, 95*(3), 555-563.

Todd, J. & Mullan, B. (2011). Using the theory of planned behaviour and prototype willingness model to target binge drinking in female undergraduate university students. *Additive Behaviors, 36*, 980-986.

National Park Service, United States Department of the Interior. (2011). *Disposable plastic water bottle recycling and reduction*. Retrieved from http://www.nps.gov/policy/ plastic.pdf

van Aardt, M. (2000). Effect of shelf-life and light exposure on acetaldehyde concentration in milk packaged in HDPE and PETE bottles (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA.

Wansink, B. (2013). Convenient, Attractive, and Normative: The CAN approach to making children slim by design. *Childhood Obesity, 9*(4), 277-278.

Whelton, A. J., Dietrich, A. M., Burlingame, G. A., Schechs, M. & Duncan, S. E. (2007). Minerals in drinking water: impacts on taste and importance to consumer health. *Water Science & Technology, 55*(5), 283 – 291.

Zoellner, J., Estabrooks, P. A., Davy, B. M., Chun, Y., & You, W. (2012a). Exploring the theory of planned behavior to explain sugar-sweetened beverage consumption. *Journal of Nutrition Education and Behavior, 44,* 172-177.

Zoellner, J., Krzeski, E., Harden, S., Cook, E., Allen, K., & Estabrooks, P. A. (2012b). Qualitative application of the theory of planned behavior to understand beverage consumption behaviors among adults. *Journal of the Academy of Nutrition and Dietetics, 112* (11), 1774-1784.

Table 6.1 Summary of focus group discussions on opinions, perspectives, and perceptions of reusable water bottles and disposable water bottles.

Category	Quotes
Attitudes	
(1) **Associated qualities of RWB that fit preference and lifestyle**	"I bought a [RWB] off of Amazon because of the fact that you can put in it your [ID Card] and your keys. It's really nice to take it to the gym, so that way I don't have to bring my wallet or anything… I use it everywhere. I take it to classes. I take it with me when I go to the library, when I go to bed actually. I keep it next to me in case I need to drink water when I get thirsty or something." - "I think I looked for the word convenient on the [emotional ballot]… I just think it's convenient. To look at the water bottle kind of reminded me why I chose a Contigo water bottle. Because I think $10-$20 for a water bottle is kind of expensive... I don't really care about water bottles. I don't really care how much it costs. I just kind of have a water bottle because I tried it once and it was kind of cool, so I got myself one." - "I think it's kind of a tradeoff too because yea the [RWB] and people think they're really expensive, but how much money you're going to save from buying those big huge cases of bottles at the store."
(2) RWB usage depends on daily schedule and circumstances	"I kind of always just use [RWB] because usually, especially the past two weeks I've been studying a lot so I'm home for a few seconds then I go to the Empo or the library. Then for coffee I have a reusable coffee to-go thing. So I just kind of use those and not really glasses. And also because I don't have to clean them." - "I think it's just become a habit [using RWB]. I feel weird when I don't have my water bottle with me. I don't know. It's almost like incomplete because if I want water and I don't have it then I notice it so much more than if I have my water bottle with me and I don't need it." - "But I use water bottles all the time. I typically use them for, well I carry them around campus, but I use them for working out mainly and I clean it every day because I normally put my pre-workout or post-workout in it... I prefer reusable water bottles over bottled waters because of the waste

	factor and I don't think bottled water tastes as good as it does from a fountain."
(3) Physiological/ Psychological influences of RWB use	"Anytime I know I have a long class or a test in a class or an assessment, people like to tap pencils, I like to drink water when I get nervous. I literally just drink my water bottle. So anytime I have a big test or something I make sure I have at least a bottle of water with me." - "I guess I notice that I'm thirsty more when I don't have [RWB] with me." - "If I don't have a [reusable] water bottle with me I don't think I get 64 ounces because I won't drink, I wouldn't sit there and drink a full cup of water at the water fountain 8 times a day." - "Mine's thirst too. I don't know if it's because I'm studying or what it is, but when I study I just drink so much water." - "My friends will make fun of me because I always have to get my [reusable] water bottle before I leave the dorm. Because it just like… I get thirsty. I feel like now that I've started using a [RWB] I become more thirsty so I crave water all the time now."
(4) Experiences with RWB that contribute to sentimental value	"But if I did lose [my RWB], I'd be pretty sad. Especially when it has stickers on it or something because people give me stickers from places they've been and I collect stickers if it's a cool place or store or something. - "I liked the term "adventurous" on [the emotional ballot] because it reminded me of whenever I go hiking or go to the river or go to concerts or festivals and stuff I always have my water bottle with me and so it's associated with adventure for me." - "I was very upset [about losing a RWB] also. I felt like I lost a part of me because it had been with me through so much." -

	‘It’s mostly memories. I mean [the RWB has] been in like several countries. It’s been in my backpack for… it’s always been there. It’s always been there for me.”
(5) RWB does not elicit deep emotional response: inconvenient if lost but replaceable	Emotional attachment, like it’s kinda, I mean [a RWB is] not that expensive, but I’d be kind of mad if I had to buy another one again. Because last time I had to it was kind of a pain. It was like a waste of $20 or whatever it was. - “I lose [RWBs] all the time. I lose it everywhere I go. I get so annoyed with myself. I’ve had to buy so many water bottles, it’s ridiculous. What was the process? I get super annoyed when I end up buying another one and find it the next day. So I just have a collection now.”
(6) Cost (financial and environmental) and quality lead to opinions about DWB but use can be situationally dependent	“I’ve got nothing against bottled water. It’s just price. It’s really expensive and I don’t like paying that much for something I usually get free.” - “I feel kind of guilty like I know this is going in a land fill. I know this is probably going to kill some animals. So it makes me happy to know I’m not contributing to that.” - “I feel like they’re just a waste of money and they accumulate if you drink them. They take up space.” - “I feel bad having to go buy the [disposable campus water bottle] because I don’t want to have to pay $1 for this and I’m going to have to throw it away at the end of the day. Just the wasteful aspect and the environmental friendliness.”
Subjective Norms	
(1) Bottles saved and filter status	“I like that it says how many bottles it says it saves. I know it’s really small and I’m like “Yea! I’ve added one of those!” - I feel like [water filling stations], I don’t know if this is true, but I just feel

influence filling **station use and** **RWB filling**	like the water's cleaner, more filtered or purified or something. And it tells you how many gallons of water you've used." - I don't like the filter lights on "filling stations" because when it says it's red filter I'm like… it's not bad water. It's still clean water, but for some reason when that red filter light pops on I'm like "eww."
(2) External Motivators that contribute to choices of hydration source RWB	"My coach would tell me to get a water bottle and to force myself to drink water. And then I started to improve and I just carried that out of it." - "[Usage has] kind of shifted over the past year. I had been playing a 3 season varsity sport so I'd have water with me at all times for a hydration thing before practice, during practice, recovery after and everything. And then since then it's just such a habit of having it that I've kept up with it. It's just… I don't know. My backpack feels kind of weird when it doesn't have weight on one side…" - "I used to play soccer and my coach was like make sure you stay hydrated throughout the day. So I just kind of started, you know, on and off in high school, but once I got to college it became a habit." - "I mean I do [drink water] for health and exercise too. Plus influences from family and friends who drink a lot of water and they influence me to drink it. Plus like she said, if I don't have a water bottle with me, I won't be drinking water throughout the day.... My sister, she is kind of obsessed with drinking water and one of my friends from back home literally that's all she would drink is just water. And they would go through water bottle after water bottle and that made me want to drink more water just to get where they are kind of thing." - "…[The campus is] really healthy here and I've kind of like adapted to other people's lifestyles if that makes sense. And I've gotten healthy as I've been here and my water bottle has been a big part of that." -

	"My mom made me get [a RWB] in middle school so then it just became habit.... she [Mom] was like "I want to be green." She was like "I'm not buying water bottle cases anymore. I will not buy another one." And I was just like "Okay. I guess I'll have to use that." And now it's a habit and I don't like it when I don't have it with me." - "I mean I guess it's readily available and very much encouraged by everything. Everywhere you go there are signs. "Get a reusable water bottle. Do this. Do that."" - "They teach us in Air Force that if you carry something with you, you'll be more likely to drink and you'll stay better hydrated throughout the day. I kind of notice that if I don't want to carry the jug around all day I'm less hydrated than if I do carry it."
Perceived Behavioral Control	
(1) Perceived Behavioral Justification for RWB Use	"I guess because I have it with me all the time that it feels weird not to have it with me. Also I think that in general, water is pretty cold and I think that kind of calms the nerves a little." - "I think it's just because you have it in front of you or in your backpack or something. It's a constant reminder to drink it." - "I think it was when I moved away from home. So when I came to college that's when I transitioned to a reusable water bottle that I used every day. Because you don't have dishes and it's become the easier thing to do." - "I'm really really bad at remembering to drink water and if I don't carry a water bottle with me I'll drink water at meals, maybe, and that's it." - "[by using a RWB and not DWB] Mainly I just feel good knowing that I would probably be throwing four water bottles away a day. That's really eliminating waste."
(2) Accessibility	"I'm not going to just go walk around from water fountain to water

and Convenience Provide Preferential Source Factors for Students	fountain drinking.” - “I look for the automatic fillers if I can find one, but sometimes I’ll just fill it up to there with the water fountains because you have to tilt it.” - “I make sure it’s rust free because I’m like that. And if it’s a water fountain, I make sure it can actually go high enough that it can reach into the bottle. Things like that. And if the filter needs changed. I try to look at the real small things that might impact the water.”
Intentions	
(1) Intentions of Reusable Water Bottle Use	“If I want to run, like at the gym or something, and I don’t drink water, it doesn’t really work out and I get really bad cramps so I’ll have to stop. So if I know that later I’m going to run then I have to make sure that I have my water bottle with me so I can be hydrated for when I want to run and stuff.” - “I notice a really big difference when I don’t have a lot of water. I just feel more tired when I’m trying to work out.” - “[Use RWB] Every day. The beginning [RWB use] of mine was just eco-friendly for me.”

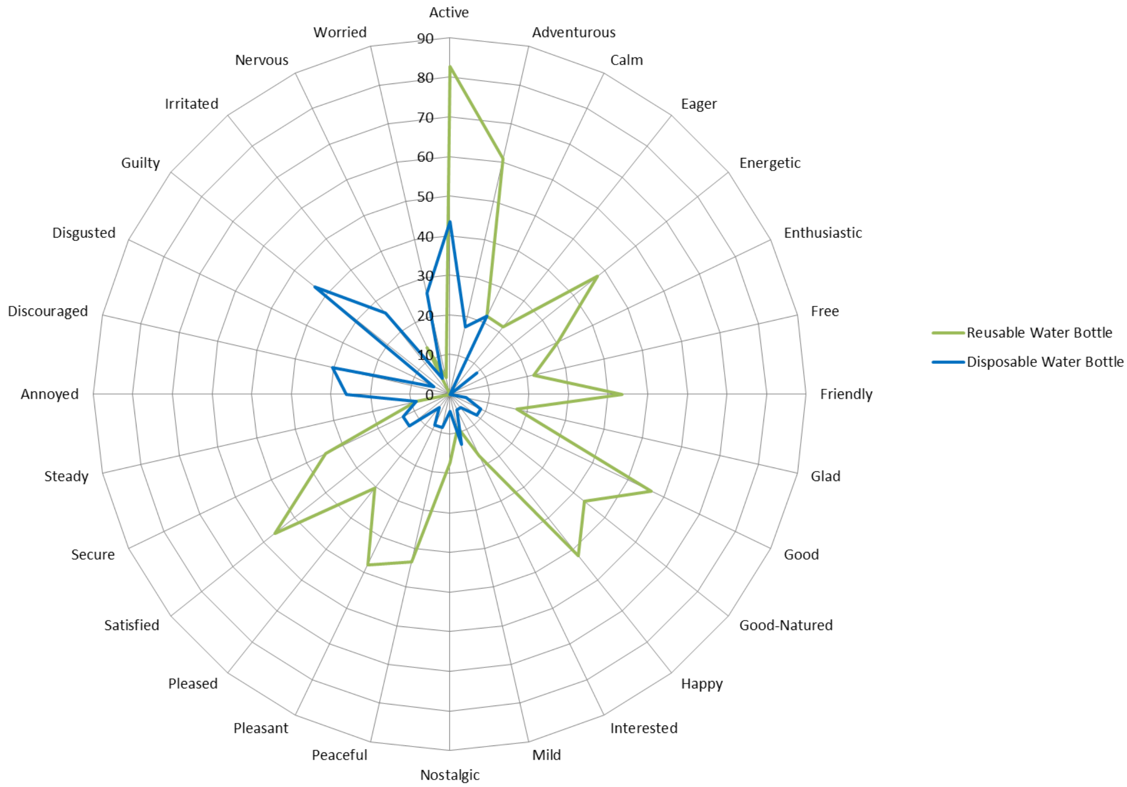


Figure 6.1 Summary of frequently selected emotion terms for a reusable water bottle and disposable water bottle. The displayed emotion terms (5/23 or ~21% of participants) were selected based on a 20% or greater selection frequency.

CHAPTER VII

Assessment of Drinking Water Quality and User Perceptions between Filling Stations and Water Fountains on a College Campus: A Mixed Methods Approach

Abstract

Installation and use of water filling stations for reusable bottles on college campuses are increasing, yet stations have not been investigated for hygiene, microbial levels, chemical water quality, consumer use and perception. Reusable water bottles are unique as the user dictates the cleaning regimen but can refill anywhere. Filling station conditions and reusable water bottle use may impact public health and safety due to increased access to water but also risk of cross-contamination. The purpose of this study was to enumerate microbial populations on public water fountains and filling stations to determine the influence of reusable water bottles on public water structures and to assess influence of these delivery sources on consumer acceptability opinion using focus groups. For qualitative research, five focus groups, using an open-ended script, focused on participant experiences with water fountains, filling stations, and tap water, were conducted (n=23 participants; Range 3 – 6 participants per focus group; 1 h). Focus groups were transcribed verbatim and 8 categories emerged regarding participant opinion and usage of these water sources. For the quantitative approach, buildings (n=4), with near-proximity water fountain and filling stations, were assessed and sampled three times over three months. Swabs were used to sample the spouts and a drain surface ($10cm^2$) on the water fountain and filling station surface. Water samples were taken at each location for chemical (pH, chlorine, and metals) and microbial evaluation (aerobic plate count

(APC) and *E.coli*/coliforms). Two reviewers assessed water source hygiene using a rubric. T-tests were used to determine statistical differences between the fountains and filling stations ($\alpha=0.05$). Filling stations had higher APC (10.4×10^3 CFU/cm^2) than fountains (8.8 CFU/cm^2) ($p<0.05$) in the drain surface (10cm^2) but not on the spouts. Water chemistry and water microbial levels (<1 CFU/ml) were not different ($p>0.05$). Coliforms were present at three of four filling station sites in the drain surface (10cm^2) while coliforms were not found at fountain sites. Reviewers evaluated the filling stations to be less clean than water fountains ($p<0.05$). Qualitative data contradicts quantitative results, as participants disliked using water fountains due to unsanitary perceptions and felt filling stations were cleaner as well as more user friendly. The poor sanitation of filling stations and frequent reusable water bottle use may provide cross-contamination opportunities at filling stations and foodservice establishments, thus impacting public health and safety.

1. Introduction

Consumers are increasingly aware and curious about the source of their food and beverages and distribution path the product takes from the original source to their hands. Consumer perception and consumption behavior of water may be influenced by preference, appearance, regulation, conservation, and quality. On college campuses there are several options available for obtaining water such as water fountains, bottled water, and water filling stations. Water, even in its most basic delivery infrastructure, should be of a quality to invite and encourage increased consumption behavior. However, perceptions of exterior conditions for the water delivery source could negatively influence and deter students from drinking water, as seen in elementary school students (Patel, Bogart, Schuster, Uyeda & Rabin, 2010). Water consumption benefits have been linked to improving health (Ebbeling, Feldman, Osganian, Chomitz, Ellenbogen, & Ludwig, 2006; Tate, Turner-McGrievy, Lyons, Stevens, Erickson, Polzien, Diamond, Wang, & Popkin, 2012). If increasing water consumption for health using tap water, we must provide a suitable infrastructure with perceived health, safety and quality.

Consumer satisfaction or dissatisfaction with water flavor and source knowledge are determining factors in consumer behavior (Levallois, Grondin, & Gingras, 1999). Current American college students are no stranger to water fountains, as drinking water fountains are the primary source of tap water in schools in the United States (Patel & Hampton, 2011). Even when tap water is safe, the water still may not appeal to consumers due to water quality concerns (e.g. taste, appearance, temperature) (Patel et al., 2010). Water is deemed “tasteless” and “odorless”; however different mineral content and composition of water can alter the flavor and influence acceptability and palatability.

Also, chlorine is vital to the safety of water; however it negatively influences the acceptability of tap water (Puget, Beno, Chabanet, Guichard, & Thomas-Danguin, 2010).

Many studies have elucidated that a barrier to water consumption in schools is related to the water fountain. For example, a California study reported that students will avoid water fountains when they are in disrepair, dirty and produce unpalatable water (Northcoast Nutrition and Fitness Collaborative, n.d.). Poor maintenance of drinking water fountains discourages students from using school fountains (Northcoast Nutrition and Fitness Collaborative, n.d.; Patel et al., 2010). In an assessment of drinking water habits in elementary, middle and high schools across California, Patel et al. (2012) suggested that more appealing water delivery systems may be necessary to increase water consumption at mealtime. College campuses have implemented water filling stations which are sleeker, convenient and more eco-friendly. The installment of water filling stations on college campuses are increasing as students carry reusable water bottles and campuses promote reusable water bottle use.

Research comparing the water quality and hygienic aspects of water fountains and filling stations may assist with studying the perception of barriers, safety, and consumption of water on college campuses. Additionally, water delivery sources have not been thoroughly investigated for hygiene or cleaning standard operating procedures. The microbial populations and levels present in or around water filling stations and water fountains have not been fully explored, especially with the rise of reusable water bottles and their influence on microbial contributions to these stations.

Our goal was to identify aesthetic barriers, water quality and infrastructure hygiene differences relating to publicly available water delivery sources. Achieving this goal will assist in informing health promotion techniques and recommendations for cleaning and hygiene procedures to encourage increased water consumption and continued safe water delivery. This research will provide insight to the public water infrastructure to improve water consumption and positive perception of these delivery sources. We approached this goal with the specific objectives of 1) characterizing differences in water chemistry and microbial quality of water fountains and filling stations in 4 buildings on the Virginia Tech campus; 2) assessing hygiene and water flavor using a rubric; and 3) identifying student user perceptions of tap water delivery infrastructure (water fountains, filling stations, and tap water faucets).

2. Materials and Methods

2.1 Quantitative Assessments of Water Quality on Campus

2.1.1 Sampling Site Information

Sampling sites on the Virginia Tech campus were determined using the following criteria: (1) Elkay EZH20 filling station models; (2) filling stations located next to a water fountain; (3) "bottles saved" measurement included in the filling station model; and (4) undergraduate access to filling station and fountain. Four sampling sites were chosen including three academic buildings (Patton Hall, Davidson Hall, Surge Space Building) and an undergraduate general health/athletic gymnasium facility (McComas Hall). Sampling occurred three times over the semester at the four chosen locations, always in the afternoon (September 30, 2015 (23.9°C); October 27, 2015 (9.4°C); and December 1, 2015 (10°C)). The afternoon sampling was to reduce the influence due to low use periods (stagnant water) on samples. Inquiries to university facilities office about filter types and systems determined the degree of filtration and types of filters employed. Likewise, sanitation standard operating procedures were also determined through university cleaning services.

2.2.2 Sampling Procedure Overview

Upon sampling, time of sampling and filling station "bottles saved" was recorded. The hygiene assessment portion of the rubric was performed (Appendix C.8), followed by the swabbing of the spout (20 sec swabbing contact) and the drain surface ($10cm^2$) on the filling station and fountain using aseptic techniques. After microbial swabbing, the filling station and fountain were flushed for five minutes (Virginia Cooperative Extension, 2016) in order to reduce water variability and improve more accurate comparison between the filling station and water fountain content. The water aesthetic and taste evaluation portion of the survey was completed with two reviewers on-site using clear drinking cups. Water samples were then taken for subsequent evaluation in the following order (3 total water samples): 1) microbial water analysis using sterile 15 mL tubes (Falcon™ 15mL Conical Centrifuge Tubes, Fisher Scientific, Pittsburgh, PA); 2) pH and temperature analysis using 50 mL sterile tubes (Falcon™ 50mL Conical Centrifuge Tubes, Fisher Scientific, Pittsburgh, PA); 3) water chemistry analysis using 100mL glass bottles (chlorine analysis and inductively coupled plasma mass spectrometry (ICPMS) analysis (Figure 7.1).

2.2.2.1 Hygiene and Water Acceptability Assessment Rubric

Two reviewers independently assessed the hygiene and water aesthetics of the water fountain and filling station at each location on each date on-site. The two reviewers discussed the rubric before sampling initiation to understand assessment expectations; however, true standardization of evaluation did not occur as the reviewers evaluated the water fountains and filling stations as users. Assessments were completed using the rubric (Appendix C.8), including: visible debris, cleanliness, water turbidity, water odor, water color, water flavor, and overall water quality.

2.2.2.2 Swabbing and Microbial Analysis (Aerobic Plate Count and E.coli/Coliform Counts)

Sample collection and swabbing protocol was done according to guidelines in the Compendium or Methods for the Microbiological Examination of Foods (Evancho, Sveum, Moberg, &Frank, 2001). Each water fountain and filling station spout and drain surface ($10cm^2$) was sampled by swabbing. For the spout sampling, a sterile cotton swab (Sterile Cotton Swabs, Fisher Scientific, Pittsburgh, PA) was dipped into 10mL sterilized neutralizing buffer in a glass tube (Difco™ Neutralizing Buffer, Becton, Dickinson and Company, Sparks, MD) and swabbed around the spout for 20 sec. After swabbing, the swab head was returned and broken off into 10mL sterilized neutralizing buffer glass tube with a screw cap. A standard site on the surface of each water delivery infrastructure source was selected for swabbing (“drain surface”). The filing station designated area (“drain surface”) was the base where bottles are placed. The water fountain designated area (“drain surface”) was a space directly behind the spout but in between the spout and drain. For the drain surface sampling, a sterile template ($10cm^2$) was placed on the drain surface area. The swab was dipped into 10mL sterilized neutralizing buffer in a glass tube with a screw cap (Difco™ Neutralizing Buffer, Becton, Dickinson and Company, Sparks, MD) and completely swabbed the surface in three directions within the designated drain surface area ($10cm^2$). After swabbing, the swab head was broken off into 10mL sterilized neutralizing buffer glass tube with a screw cap. The microbiological sampling tubes were kept at or below room temperature until returning to the lab (< 2h), where they were placed in refrigeration until analysis.

Swab tubes were vortexed for 20 sec. From the neutralizing buffer, serial dilutions were prepared using 0.1% peptone diluent (9 mL; Peptone, Fisher Scientific, Pittsburgh, PA). Dilutions were plated to Petrifilm™ Aerobic Count Plates (APC) (Petrifilm™ Aerobic Count Plates, 3M™, St. Paul, MN) and incubated 48h ± 3h at 35°C ± 1°C before evaluation. Additionally, samples were plated to Petrifilm™ *E. coli/*Coliform Count (Petrifilm™ *E. coli/*Coliform Count , 3M™, St. Paul, MN) and incubated at 24h ± 2h at 35ºC ± 1ºC. After required time, plates were evaluated and calculated as colony forming units (CFU/cm^2).

2.2.2.3 Water Microbial Analysis

After flushing, water samples were aseptically collected from each source at each location using sterile 15 mL tubes with a cap (Falcon™ 15mL Concial Centrifuge Tubes, Fisher Scientific, Pittsburgh, PA). The microbiological sampling tubes were kept at or below room temperature until returning to the lab (9°C – 25°C; < 2h), where they were placed in refrigeration until analysis.

Water samples were vortexed for 20 sec. Water was directly plated to Petrifilm™ Aerobic Count Plates (APC) (Petrifilm™ Aerobic Count Plates, 3M™, St. Paul, MN) and incubated at 48h ± 3h at 35°C ± 1°C before evaluation. Additionally, samples were plated to Petrifilm™ *E. coli/*Coliform Count Petrifilm (Petrifilm™ *E. coli/*Coliform Count , 3M™, St. Paul, MN) and incubated at 24h ± 2h at 35ºC ± 1ºC. After required time, plates were evaluated and calculated as colony forming units (CFU/mL).

2.2.2.4 Temperature and pH Analysis

pH and temperature analysis using 50 mL sterile tubes with a cap were collected after flushing (Falcon™ 50mL Conical Centrifuge Tubes, Fisher Scientific, Pittsburgh, PA). Water temperature was measured on-site (Fisher Scientific, Accumet ®, Singapore). Also, pH was measured using a pH meter (Fisher Scientific Waterproof Meter, Accumet ®, Singapore) immediately upon return to the lab.

2.2.2.5 Chlorine Analysis

Free and total chlorine were analyzed according to the instrument manual guidelines (Free Chlorine: Method 8021 and Total Chlorine: Method 8167; DR/2400 Spectrophotometer, HACH, Loveland, Colorado) using respective powder pillows (DPD Free Chlorine Reagent and DPD Total Chlorine Reagent, HACH Permachem® Reagents, Loveland, Colorado). Sample (10mL) was taken from the 100mL glass bottle sample and was mixed with the respective chlorine powder pillow for analysis. The chlorine measurement range for both free and total was 0.02 to 2.00 mg/L Cl_2. If sample exceeded spectrophotometer range, samples were diluted with distilled water so as to fall within the detectable range and then the concentration was calculated based on the dilution.

2.2.2.6 Metals Analysis using Inductively Coupled Plasma Mass Spectrophotometry

Samples were analyzed for metals (sodium, magnesium, aluminum, silicon, phosphorus, sulfur, chloride, potassium, calcium, titanium, vanadium, chromium, iron, manganese, cobalt, nickel, copper, zinc, arsenic, selenium, strontium, molybdenum, silver, cadmium, tin, barium, lead, and uranium) concentrations using a Thermo Electron X-Series inductively coupled plasma mass spectrometer (ICP-MS) (Thermo Electronic

Corporation, X-Series ICP-MS, Waltham, MA) per Standard Method 3125-B (American Public Health Association (1998); American Water Works Association (1998); and Water Environment Federation (1998)). Samples (10mL) Sample (10mL) was taken from the 100mL glass bottle sample and calibration standards were prepared in a matrix of 2% nitric acid by volume.

2.2.2.7 Data Analysis

Observations and results from the 4 sampling sites were combined to represent filling stations (n=4 sites; n=12 observations) and water fountains (n=4 sites; n=12 observations). T-tests were used to assess the statistical significance between filling stations and water fountains ($\alpha=0.05$) (JMP, Statistical Analysis Software (SAS) Version 11, SAS Institute, Cary, NC).

2.2 Qualitative Analysis Using Focus Groups and Emotional Ballot

2.2.1 Participant Recruitment and Screen Survey

Study was pre-approved by Virginia Tech IRB (IRB #15-031) prior to project initiation. Study recruitment, pre-screening survey and exclusion criteria were the same as Chapter 6, *Section 2.1.1 Participant Recruitment and Screen Survey*.

2.2.2. Focus Groups

The focus groups were conducted using the same methodology and participants as in Chapter 6, *Section 2.1.2. Focus Groups* (Appendix C.7).However, for the purpose of this investigation information regarding tap water faucets, water fountains and water filling stations were used in qualitative analysis and emotional ballot analysis (Modified EsSense Profile) (Appendix C.5).

2.2.2.1.Emotional Ballot Check-All-That Apply (CATA) (Modified EsSense Profile) and Analysis

The emotional ballot procedure and analysis were conducted as described in Chapter 6, Section *2.1.2.1. Emotional Ballot Check-All-That Apply (CATA) (Modified EsSense Profile) and Analysis*. For the purpose of this study, only information regarding water fountains, filling stations, and tap water faucets were included (Appendix C.6).

2.2.2.2. Focus Group Procedure, Script and Analysis

Focus groups were conducted and analyzed according to the procedure in Chapter 6, *Section 2.1.2.2. Focus Group Procedure, Script and Analysis*. For the purpose of this study, only information regarding water fountains, filling stations, and tap water faucets were included.

3. Results

3.1 Sampling Site Information

3.1.1 Site Information and Filters

The average “bottles saved” monthly use for each building were Patton = 784 bottles; Davidson = 2,545; Surge = 3,682; and McComas = 20,172. Three of the four sites had a filter status on the filling station (the exception was Patton Hall). According to the water filling station filter manufacturer website, “The Elkay® WaterSentry® Plus EWF3000 filter used in the EZH2O® bottle filling stations reduces aesthetic chlorine, taste and odor, Particulate Class I, and lead” (Elkay, 2016). The Elkay filter “bottles saved” is measured by “20 oz. bottles” (Elkay, 2016). All sampling sites were near a restroom. Additionally, the building cleaning services does not have a thorough standard cleaning protocol or enforced daily cleaning frequency of the filling stations or water fountains, as verified through personal communication – the filling stations are instructed to be “wiped down” with a disinfectant cleaner and deodorant (Virex ®II 256, Diversey, Racine, Wisconsin) (A. Meadows, personal communication, July 15, 2015; March 11, 2016).

3.1.2 Building Information

Buildings where sampling occurred represented a broad spectrum of aging and renovation, characteristic of a college campus. Patton Hall was completed in 1926, and three additional floors were added in 1929 (Virginia Tech, Patton Hall, 2016). The original portions of Davidson Hall were completed in 1928 with other sections added in 1933 and 1938; the building was renovated in 1964, 1965 and 2014 (Virginia Tech, Davidson Hall, 2016). McComas Hall was completed in 1998 and an addition was completed in 2010 (Virginia Tech, McComas Hall, 2016). Surge Space Building construction was finished in 2007 (Virginia Tech, Surge Space Building, 2016). Information about the water pipe infrastructure in Patton, McComas, Surge, or Davidson was not accessible to the researchers.

3.2. Quantitative Analysis

3.2.1 Hygiene and Water Quality Assessment

The cleanliness of the filling stations were rated lower than that of the water fountains ($p<0.05$) (Table 7.1). “Cleanliness” is evaluated by the overall appearance and delivery source appeal. Reviewers (n=2) rated the cleanliness as fair ($\bar{x}$ = 2.3) while water fountains were rated as good ($\bar{x}$ =3.5). Reviewer comments of cleanliness of the filling station mentioned grime, mold, mildew, and calcium deposits on the filling stations that were unappealing. Statistical differences did not exist between the filling station and water fountain among the other assessment attributes of the rubric: visible debris; water turbidity; water odor; water color; water flavor; and overall quality of water ($p>0.05$) (Table 7.1).

3.2.2 Microbial Analysis

No microbial difference (APC) was found between the filling station spouts ($\bar{x}$ = 3.1 x 10^2 CFU/spout) and water fountain spouts ($\bar{x}$ =5.5 x10^2 CFU/spout) ($p>0.05$) (Table 7.2). Additionally, water sample microbial (APC) evaluation of both the filling station and water fountain showed non-detectable microbial levels (<1 CFU/ml est.).

Unlike the spout and water, the drain surface of the filling station ($\bar{x}$ =1.0 x10^4 CFU/cm^2) had significantly higher microbial counts (APC) than that of the water fountain ($\bar{x}$ = 8.8 CFU/cm^2) ($p<0.05$). Coliforms were present at three of the four filling station sites on the drain surface area but coliform presence was sporadic and not found consistently across all replications at the filling stations sites. Coliforms were not found at water fountain sites (<1 CFU/cm^2) or in the water samples derived from the filling stations and water fountains (<1 CFU/ml est.).

3.2.3 Temperature and pH

Water temperatures and pH from the filling stations ($\bar{x}$ =16.6°C (61.8°F); pH = 6.7) and water fountains ($\bar{x}$ = 15.6°C (60.0°F); pH = 6.7) were not significantly different ($p>0.05$) (Table 7.3).

3.2.4 Chlorine Analysis

Free chlorine and total chlorine in the water from the filling stations ($\bar{x}$ =0.08 mg/L Cl_2; 1.4 mg/L Cl_2, respectively) and water fountains ($\bar{x}$ =0.12 mg/L Cl_2; 2.1 mg/L Cl_2, respectively) were not significantly different ($p>0.05$) between the two sources (Table 7.4).

3.2.5 Metals Analysis

A full metals analysis was performed with samples from filling stations and water fountains and differences were not found for each of the metals between the filling stations and water fountains ($p>0.05$) (Table 7.5). The lack of differences supports that there is little water variability on the Virginia Tech campus between the water delivery methods. The filling stations and water fountains generally provide the same water. Additionally, the content of the metals fell within general expectations and/or safety allowances. Sodium is typically less than 50 mg/L for most drinking water (Whelton, Dietrich, Burlingame, Schechs,& Duncan, 2007; Renfrew 1990; World Health Organization (WHO), 2004; United States Environmental Protection Agency (USEPA), 2003; Burlingame, Dietrich, & Whelton, 2007), the filling station and water fountain fell below that level ($\bar{x}$ = 9.8 mg/L; $\bar{x}$ = 9.9 mg/L respectively). Magnesium was below 20 mg/L as expected for most tap water (filling station: $\bar{x}$ = 4.6 mg/L; water fountain: $\bar{x}$ = 4.6 mg/L) (Whelton et al., 2007; Burlingame et al., 2007; Lockhart, Tucker, and Merritt, 1955; Renfrew,1990; Westcott, 2013 ; Smith and Margolskee, 2001). Chloride was well below the threshold detection level (200 – 300 mg/L) (filling station: $\bar{x}$ = 19.4 mg/L; water fountain: $\bar{x}$ = 20.6 mg/L) (Whelton et al., 2007; WHO, 2004; Westcott, 2013) for both the filling station and water fountain. Potassium was within the typical tap water range (<5 mg/L) (filling station: $\bar{x}$ = 2.0 mg/L; water fountain: $\bar{x}$ = 2.0 mg/L) (Whelton et al., 2007; Renfrew, 1990). Calcium is typically between 100 – 300 mg/L (Whelton et al., 2007; WHO, 2004; Burlingame et al., 2007; Smith & Margolskee, 2001). The samples collected were low in calcium (filling station: $\bar{x}$ = 10.9 mg/L; water fountain: $\bar{x}$ = 10.9 mg/L).

3.3 Qualitative Analysis

3.3.1 Emotional Ballot (Modified EsSense Profile)

The emotional term profiles, as selected by focus group participants while viewing representative picture images of the different water source infrastructures, illustrated different perspectives for each (filling station, fountain, and tap water faucet). Emotional terms selected for the water filling station (n=15) included the positive terms good (73.9%), satisfied (69.6%), pleasant (56.5%), happy (47.8%), active (43.5%), pleased (43.5%), enthusiastic (39.1%), friendly (39.1%), good-natured (39.1%), energetic (34.8%), interested (34.8%), free (30.4%), glad (30.4%), and secure (26.1%) (Figure 7.2). Also, the frequently chosen emotional term eager (26.1%) has no clear classification/neutral.

Profile (n=11 terms) for the water fountain included negative terms annoyed (52.2%), disgusted (47.8%), irritated (31.1%), nervous (26.1%), discouraged (21.7%), worried (21.7%), neutral/unclassified in emotional direction mild (24.8%), and positive terms, good (26.1%), good-natured (21.7%), free (21.7%), nostalgic (21.7%) (Figure 7.2).

The profile (n= 10 emotional terms) of the tap water faucet was mostly positive, including calm (47.8%), good (39.1%), pleasant (39.1%), peaceful (34.8%), secure (34.8%), pleased (30.4%), and satisfied (30.4%). The frequently chosen emotional term steady (30.4%) has no clear classification/neutral. Two negative terms, disgusted (26.1%) and worried (21.7%), also were selected with sufficient frequency to be noted (Figure 7.2).

3.3.2 Focus Groups

Students' opinions, perceptions, and use regarding water fountains, filling stations and tap water were organized into 8 categories (Table 7.6).

(1) Filling station attributes and experiences influence positive attitude and continued use

Students strongly stated their excitement, admiration and love for filling stations. Filling stations are modern, convenient, and 'new age'. The newness of filling stations on campus makes them appealing to use. Filling stations give participants the impression, through refilling use, that they are saving the environment by limiting disposable water bottles entering landfills and reducing the plastic waste environmental burden. The sustainability and waste reduction makes participants feel good about using reusable water bottles and filling stations. The filter status makes users feel that the filling stations water is safer and the 'best water' they can acquire on campus. Participants prefer filling stations when active on campus as filling stations are convenient to refill their reusable water bottles due to filling pace and filling efficiency. Participants appreciate that filling stations can give a full refill (no tilting or maneuvering of reusable water bottles under the water stream) so they do not feel cheated of water. Also, aesthetically, participants stated that they thought the filling stations water temperature is colder. Participants liked that some campus filling stations can be hands free due to a sensor that triggers a water stream. Lastly, participants voiced their strong desire to see more filling stations in more buildings on campus.

(2) Barriers to using filling stations on campus

Participants stated that they wished more filling stations were on campus. Filling stations are hard to find on campus and aren't prevalent in buildings. Some participants will wait to refill until they find a filling station or until they return home to fill with tap water. Filter light status on filling stations can be concerning for water quality and safety. While filling stations are appealing they still must look clean and safe to get water from. They must look clean and be free from rust and mold. Temperature inconsistency drives annoyance of filling stations.

(3) Inconsistent physical attributes of water fountains discourages use

Participants do not enjoy their experience at water fountains, regardless if drinking or refilling reusable water bottles. Reusable water bottles are hard to fill at water fountains due to the water pressure or stream height. Participants want to be able to fill their reusable water bottles completely with ease without significant effort. Participants stated that water fountains look unsanitary. Participants would use water fountains more if they were cleaner. The flavor quality of water fountains is highly variable but oftentimes the flavor is displeasing and unacceptable. Participants are frustrated that water fountains have inconsistent water temperatures and unappealing flavors ("off-flavors"; metallic). Moreover, participants find the water fountain buttons are annoying and often do not work properly. Participants stated that water fountains are outdated, disgusting and they need to be cleaned more often. Participants feel that water fountains are not maintained well, look dirty and damaged which reduces their desire to use water fountains.

(4) Situations contributing to perception of cleanliness of fountains

Participants stated that water fountains do generate feeling of nostalgia from elementary school. However, water fountains are disgusting, nasty and usually need to be cleaned. Some water fountains have unidentifiable substances in the basin as well as gum and/or tobacco. Students are intimidated to use water fountains as they are associated with germs with the potential to get sick. Participants are hesitant to use fountains due to the proximity to bathrooms and the flushing effect on the water pressure as it affects the perception of water quality. Drinking directly from fountains adds an extra level of closeness because their face is close to the spout and thereby, negatively impacts the perception of using fountains. Also, participants dislike holding down and touching a button to operate fountains. The intimacy of drinking and touching a button adds a "yuck" factor due to germs. Also, several participants expressed that people do not know how to use a water fountain and there is a perception that people put their mouths all over it. Additionally, participants stated that others use them for spitting and pouring other beverages down them. Collectively, these experiences contribute to the participant's distrust of water fountains as a source for drinking and refilling.

(5) Student perception of tap water quality/characteristics determines usage

While not all participants filter water or have concerns about tap water, some participants feel filtering water adds some safety and aesthetic benefits. Participants expressed that filtered water tastes better than tap water. Tap water has chlorinated off-flavor that is unappealing to consumers. Filtering tap water adds a level of protection and some feel it makes a difference to have filtered water.

On the other hand, some feel filtering is unnecessary but can potentially make water safer. Some students did not have a preference and did not notice any major differences between filtered and unfiltered water. Participants expressed that filters do not filter out much. Participants recognized that the source of water is the same on campus. However, tap water can vary by locale and type (city vs. well) in terms of taste and preference acceptability. Most students would assess filtering based on location and water quality.

(6) External Motivators that Contribute to Tap Water Usage

Some of the participants had restrictions of tap water usage and only use tap water for cooking and cleaning, not drinking; however, a majority of participants felt tap water was acceptable for drinking. Roommates may use filtering devices that can influence filtration habits, which can give an extra sense of cleanliness to drinking tap water. Also, experiences with different sources of water (well vs. city) can influence water preferences and habits. Professors influence source opinions by diminishing the water source variation. Professors emphasize that it is the same water (at least on campus).

Participants had a range of tap water growing up. Many had built in refrigerator filters or external filters (reduce particulate/substance formation), some had well water, and some parents use disposable water bottles. One student lived overseas, so the student felt a major barrier to drinking tap water upon return to the US. Some students have heard and seen that tap water pipes are moldy on the inside, which is one of the reasons they filter water.

(7) External motivators that contribute to water preference and selection

With public sources students assess sources to refill based on source infrastructure design features and how much others have used or interacted with the source. Filling stations have appealing qualities as user interaction is minimal (automated sensor refill, one finger usage, cleanliness) compared to a water fountain where the drinking experience is more intimate and others might have put their mouth on the fountain spout. Participants stated there is a strong worry that they will get sick from using a public water fountain. Participants expressed a strong association of sickness and using a water fountain. Additionally, participants voiced that experiences with water fountains in elementary, middle, and high schools negatively influenced their use in college and their reluctance to use for drinking or reusable water bottles refilling. Participants said that high school fountains were unsanitary, were used for spitting, frequently had gum in them, and students put their mouth on them. There is a stigma that fountains are unsanitary and not clean. Moreover, fountains also put participants under social pressure because of the slow pace and water deliver functionality. Participants expressed that they cannot fully hydrate using fountains and they do not feel refreshed due to the pressure to quickly drink to avoid being inconsiderate to those waiting behind them in line. Water fountains are less appealing to use for drinking and refilling.

Media (TV shows, advertisements, etc.) can influence participants to prefer specific water delivery sources. A popular TV show demonstrates that users put their mouth all over the fountain spout when drinking. This media demonstration adds to the “yuck” factor when participants use water fountains. Additionally, participants have seen advertisements comparting bottle water and tap water discussing differences in aesthetic and safety qualities.

(8) Experiences and Perceptions of Safety Drive Source Preference

Participants stated that fountains and filling stations must look nice and new in order for them to drink or refill. Participants have a negative perception associated with amount of people touching and drinking from water fountains. Participants expressed that appearance of cleanliness of water fountains and filling stations dictates their usage. Participants will assess the risk before using the water delivery source (i.e. rust presence, filter status, water pressure, etc.). Overall, the negative perceptions and experiences with water fountains make them less appealing to use. Filling stations are preferred for reusable water bottle filling because there is less direct human interaction with source as compared to water fountains. Some students will not use water fountains because of the perception that people have put their mouth on the water fountain spout. Also, participants stated that the avoidance of water fountains eliminates the chance for poor water. Although regardless of the source, some participants will let water run for a few seconds before filling to get optimal water.

Participants emphasized that they will only drink water that is perceived as safe. Some participants preferred filtered water for protection and will use filter at home to avoid drinking directly from the tap. When looking for sources to refill their reusable water bottles, participants look for clean water delivery sources and sources that provide quality water. Participants prefer reusable water bottle filling stations, especially stations outfitted with automated sensor streams. The number of filling stations is low on campus. Participants expressed that they prefer and have the intention to use filling stations to refill their reusable water bottles but the stations are hard to find. Most participants did not prefer and would avoid using water fountains because of past experiences. Moreover, some participants will intentionally avoid tap water faucets due to specific concerns, including moldy pipes. Regardless of source, participants expressed that they evaluate each water delivery source before drinking or refilling. Lastly, students expressed that they would not purchase disposable water bottles due to price and would intentionally seek free sources of water to drink or refill from.

4. Discussion

Sampling was completed over 3 months to assess site cleaning practices and if there were any differences over time. Moreover, it was important to sample water over 3 months to determine if water was consistent or varied depending on month or weather. Water quality analysis did not reveal any significant differences between water from water fountains and filling stations. The temperature and the pH between filling stations and water fountains were not significantly different (filling stations: $\bar{x}$ =16.6°C (61.8°F); $\bar{x}$ =6.7 pH); water fountains: $\bar{x}$ =15.6°C (60.0°F); $\bar{x}$ =6.7 pH). In the qualitative portion, participants are frustrated that water fountains have inconsistent water temperatures and unappealing flavors ("off-flavors"; metallic). This perception could be shaped from previous college experience and during college. Participants did not mention often temperature differences between water fountains and filling stations. However, the quantitative temperature results contradict consumers feeling that there are inconsistent water temperatures between water fountains and filling stations; however, only a limited number of campus units were assessed.

Total dissolved solids (TDS) and temperature have a large influence on water flavor. The flavor of water is largely dependent on the state and mineral content of water. Tap water is generally served between 4°C (39°F) and 30°C (86°F) but Americans generally prefer it cold (Gallagher and Dietrich, 2010). The filling stations and water fountains fall into the middle of this temperature range which may contribute to flavor sensitivity and/or user preferences. In the qualitative analysis, participants mentioned they prefer colder water. Chilled water appears to lower the threshold for mineral taste detection. For example, consumers who drank high TDS water (750-1000 mg/L) when chilled detected the mineral taste less (Gallagher & Dietrich, 2010). Good tasting and acceptable tap water has a balance of minerals, chilled water temperature, and near-neutral pH (Burlingame et al., 2007). Typically, water fountains dispense chilled water but we observed similar temperatures across the water fountains and filling stations of the sources tested. Typically, water filling stations are not chilled unless temperature exceeds 18.3°C (65°F) (Penn State, 2012). Water fountains are chilled as consumption is immediate. Consumers who use filling stations often carry around a reusable bottle over a period of time in which the water reaches room temperature. Oftentimes, filling stations can save energy and associated costs by not chilling water for reusable containers. The average cost of a refrigerated drinking fountain is $35-$48 per year (North Carolina Energy Office, 2010).

On a cellular level, anions and cations are responsible for the taste sensations on the taste buds and are influenced by concentration, pH and temperature (Burlingame et al., 2007). The pH of most raw water is within 6.5 – 8.5 (American Public Health Association, 1989). Near neutral pH is preferred as high or low pH could promote carbonate and carbonic acid (Whelton et al., 2007; Burlingame et al., 2007). The metals analysis revealed little to no differences between water from water fountains and filling stations. Generally, the water is the same on campus whether derived from water fountains or filling stations. For sensory descriptive purposes, water is virtually hard to evaluate by untrained panelists as it is considered “tasteless”. However different mineral content has been associated with giving water various flavors and sensory descriptors as well as influencing consumer preference and acceptability. In a study using different bottled waters with varying mineral content and tap water, results suggested that the taste of water and total mineralization is associated with three major tastes/descriptors: bitter and metallic for low mineral content; neutral and fresh for medium mineral content, and more salty for high mineral content (Teillet, Schlich, Urbano, Cordelle, & Guichard , 2010). Minerals are the largest determinant of water flavor. Common cations in TDS are calcium, magnesium, potassium, and sodium in addition to anions such as carbonate, bicarbonate, chloride, nitrate, sulfate, and silicates (Gallagher & Dietrich, 2010). The US Environmental Protection Agency sets a secondary maximum contaminant levels (SMCL) for TDS concentration at 500 mg/L (United States Environmental Protection Agency (USEPA), 2005; United States Environmental Protection Agency (USEPA), 2016; Gallagher & Dietrich, 2010). To avoid a mineral taste, it is recommended that tap water has TDS less than 250 mg/L (Gallagher & Dietrich, 2010). In the right proportion and balance, potassium, magnesium, calcium and sodium with bicarbonates would provide good tasting water (Burlingame et al., 2007).

While not statistically different, the water fountains were numerically higher in free and total chlorine compared to the filling stations. The difference numerically could be due to the filter within the filling stations. The filling station filters aid in reducing aesthetic chlorine content (Elkay, 2016). Chlorine and chloramine are most commonly used as a disinfectant to treat municipal drinking water. After initial water disinfection using chlorine, the free residual chlorine in treated water acts as a disinfectant needed in water pipeline distribution. Chlorine is an effective disinfectant; however, it can often leave a residual chlorinated off-flavor. Unfortunately, the limit of detection or threshold can be low for chlorine, thus negatively influencing treated water acceptability. Participants in the focus group expressed that they prefer filtered water for aesthetic benefits because filtered tastes better than plain tap water. Tap water has chlorinated off-flavor that is unappealing to consumers. However, most participants feel tap water is acceptable to drink on campus. Focus group participants did not mention issues with chlorine taste on campus or differences between water fountains and filling stations. Humans can be much more sensitive than laboratory equipment in regard to taste- and odor-generating compounds (Whelton et al., 2007). Krasner and Barrett (1984) determined free residual chlorine taste threshold in water to be 0.24mg/l. The results did not approach this taste threshold level. Water flavor and risk perception moderately explains tap water consumption as well as bottled water consumption (Doria, Pidgeon, & Hunter, 2009). Chlorine (or chloramine) is vital to the safety of water; however it negatively influences the acceptability of tap water (Puget et al., 2010). Providing tap water for consumption is subtle balance between sensitivity, actual chlorine content of tap water, and tap water representation with the last two parameters under the control of the water authorities (Puget et al., 2010).

Filling stations had higher APC ($10.4x10^3$ CFU/cm^2) than fountains (8.8 CFU/cm^2) ($p<0.05$) in the drain surface (10cm^2). Water fountain and filling station spouts and water were not different ($p>0.05$). Of importance, the water itself did not exhibit any countable microbial levels; however, the water was flushed before microbial water sampling, which might influence lower levels. The lack of microbial presence in the water samples from the filling station and fountain could be due to the sampling time after the 5 minute flush. Loving, Burden, and Loving, (1998) found that flush times influenced water microbial load from water fountains, usually decreasing counts. While the enumerated bacteria from the spouts were not different, the microbial counts are high for a generally sanitized location. In the food processing environment, "cleaned and sanitized foodservice equipment should not exceed 100 colonies per utensil or surface area sampled" (Evancho et al., 2001; United States. Public Health Service, 1967).

Coliforms were present at three of the four filling station sites in the designated space; albeit the coliform presence was not found consistently across all the replications at the filling stations sites. Coliforms were not found at water fountain sites (<1 CFU/cm^2) or in the water samples derived from the filling stations and water fountains (<1 CFU/ml est.). In water, the limit for coliforms is <1 coliform/100mL (Virginia Cooperative Extension, 2009). The presence of coliforms is an indicator of general sanitary conditions. Their presence at the filling stations could be due to the reusable water bottle use and cross-contamination of use. In a study with elementary students' reusable water bottles, water samples from some bottles carried heterotrophic and coliform bacteria (Oliphant, Ryan, & Chu, 2002).

To our knowledge, microbiological research regarding filling stations has not been thoroughly investigated. However, water fountains have been assessed for bacteria. Surprisingly, in our study, filling stations had a higher microbial count than the water fountains. Speculatively, this could be due to the “hands free” nature of the filling station and the ability to place the reusable water bottle on the filling device itself. The microbial findings coincide with the “cleanliness” hygiene assessment as the reviewers found the filling stations to be in “fair” cleanliness condition as well as reported noticeable grime. Walters and Cram (2002) found that water fountain spout swab results had high microbial colony counts above recommended sanitary levels, although data of a numerical nature was not present in the article. Additionally, microbial levels in their study correlated to hygiene assessment (Walters & Cram, 2002) which is similar to the present study findings.

Contrary to the microbial findings, the focus group participants stated that water fountains were more unsanitary than filling stations in both the focus group analysis and the emotional terminology results. The emotional ballot results revealed that participants selected majority positive terms with 1 term have “no clear classification” (eager) for the water filing station. While true trends cannot be established due to the limited participant size, emotional terms of majority for the filling station were good (73.9%) and satisfied (69.6%) (Figure 7.2). The water fountain received the most negative term association of the photograph experience prompts. Of majority, participants associated water fountains with the emotional terms annoyed (52.2%) closely followed by disgusted (47.8%) (Figure 7.2).

The focus group participants stated their admiration for filling stations while calling them modern and convenient, indicating that the water source delivery qualities (style, modernization, and functions) are important to users. The filling stations typically have a “filter status” and “bottles saved” counter (environmental impact and waste reduction). These qualities are valuable and appealing to users. Participants do not enjoy their experience at water fountains, regardless if drinking or refilling reusable water bottles. Participants stated that water fountains look unsanitary, outdated, and disgusting and they need to be cleaned more often. Participants feel that water fountains are not maintained well, look dirty and appear damaged, which reduces their desire to use water fountains. Most importantly, there is a perception that others put their mouth all over the water fountain spout and there are germs present on water fountains. In a study surveying various stakeholders in California schools, most stakeholders expressed concerns about the appeal, taste, appearance, and safety of fountain water (Patel et al., 2010). Poor maintenance of drinking water fountains discourages students from using school fountains (Northcoast Nutrition and Fitness Collaborative, n.d.; Patel et al., 2010). Interviews revealed that 70% of students thought water fountains looked “disgusting” and dispensed water that tasted “gross” (Northcoast Nutrition and Fitness Collaborative, n.d.). In our study, the filling stations appeared less “clean” than the water fountains ($p<0.05$), suggesting that the filling stations are not well maintained. If the lack of upkeep continues, students may express concern similar to the findings of Patel et al., (2010) who found that students have concern about the appeal and safety of school drinking water from plumbing. Researcher observations while sampling included students using the water refill stations for other purposes than just water filling such as rinsing bottles or coffee pots, dumping old water to get new water, and mixing beverage mixes. These actions may influence the negative appearance of the filling stations. While safe drinking water is monitored through intensive parameters, aesthetic parameters such as color, flavor and aroma are difficult to monitor and standardize. However, on campus there were few, small differences noted between the water from the filling stations and water fountains in regards to flavor and aroma.

Participants expressed that appearance of cleanliness of water fountains and filling stations dictates their usage. Participants will assess the risk before using the water delivery source (i.e. rust presence, filter status, water pressure, etc.). With public sources students assess sources to refill based on features and how much others have used or interacted with the source. Filling stations have appealing qualities as user interaction is minimal (automated sensor refill, one finger usage, cleanliness) compared to a water fountain where the drinking experience is more intimate and others might have put their mouth on the fountain spout.

The emotional ballot results revealed that participants selected more positive than negative terms, however, none of the terms were in the majority for tap water faucet. Consumer acceptability of tap water is based largely on aesthetic qualities. Typically, aesthetics can influence consumer safety perception of their tap water resulting in habit change towards other sources of water. Consumers associate off-flavors or off-odors with negative quality properties of tap water, such as contamination or health risks. The correlation between compounds and microorganisms of concern with negative sensory characteristics in water is not strong but should not be disregarded (Jardine, Gibson, & Hrudey, 1999). Moreover, when tap water is safe, the water still may not appeal to consumers due to water quality concerns (e.g. taste, appearance, temperature) (Patel et al., 2010). The filter status on filling stations makes users feel that the filling stations water is safer and the 'best water' they can acquire on campus. Regardless of external qualities and filtering capabilities, water fountains and filling stations should deliver safe and acceptable water in a sanitary environment.

5. Conclusions

Overall, results infer that there was little to no water quality variability between the sampled filling stations and water fountains. The lack of variability means that both the filling stations and water fountain deliver similar water that should not influence the preference of one source over another. Water source delivery infrastructure qualities (style, modernization, and functions) are important. Qualities including information monitors such as "filter status" and "bottles saved" (environmental impact and waste reduction) are valuable and appealing to users. Surprising, only the "cleanliness" from the hygiene assessment and the designated microbial sampling space on the filling station were significant. The filling stations appeared visually less clean that the fountains and the environmental microbial sampling of the designated space supported that filling stations were dirtier than water fountains. The negative perceptions of water fountains make filling stations preferred to refill their reusable water bottles as there is less direct human interaction with source. Participants emphasized that they will only drink water that is perceived as safe. Most participants did not prefer and would avoid using water fountains because of past experiences.

Our results contradict the perception that water fountains are dirtier than filling stations and potentially deliver less than quality water. While participants voiced their strong desire to see more filling stations in more buildings on campus, more research about filling stations on campus should be explored or cleaning standard operating procedures should be updated and/or given more frequent cleaning. These results infer that further investigation is required to assess the safety and standard cleaning protocol of the water filling stations. If increasing water consumption for health using tap water, we must provide a suitable infrastructure with perceived health, safety and quality.

Acknowledgements

This project was funded, in part, by the Virginia Tech Graduate Student Assembly Graduate Research Development Fund, the Virginia Agricultural Experiment Station, the Hatch Program of the National Institute of Food and Agriculture, U.S. Department of Agriculture, and the Virginia Tech Water INTERface Interdisciplinary Graduate Education Program. The author would like to thank Diana Woodrum for her assistance on sampling days, Taylor Duncan for her assistance with transcriptions, and Dr. Jeffrey Parks for his assistance with ICPMS samples.

References

American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF). (1998). *Standard methods for examination of water and wastewater* (20th ed.). Washington, D C: APHA.

American Public Health Association. (APHA) (1989). *Standard methods for the examination of water and wastewater*, (17th ed.). Washington, DC: APHA.

Burlingame, G. A., Dietrich, A .M., & Whelton, A .J. (2007). Understanding the basics of tap water taste. *Journal American Water Works Association, 99*(5), 100-111.

Doria, M. F., Pidgeon, N., & Hunter, P. R. (2009). Perceptions of drinking water quality and risk and its effect on behavior: a cross national study. *Science of the Total Environment, 407*, 5455-5464.

Ebbeling, C. B., Feldman, H. A., Osganian, S. K., Chomitz, V. R., Ellenbogen, S .J., & Ludwig, D. S. (2006). Effects of decreasing sugar-sweetened beverage consumption on body weight in adolescents: a randomized, controlled pilot study. *Pediatrics, 117*, 673-80.

Elkay. (2016) *Bottle filling stations FAQ*. Retrieved from http://www.elkay.com/bottle-filling-stations-faq

Evancho, G. M., Sveum, W. H., Moberg, L. J., & Frank, J. F. (2001). Microbiological monitoring of the food processing environment. In F. P. Downes & K. Ito (Eds.), *Compendium or methods for the microbiological examination of foods* (4th ed.) (pp. 25-36). Washington, DC: American Public Health Association.

Gallagher, C. D. & Dietrich, A. M. (2010). TDS and temperature affect consumer taste preferences. *Opflow, 36*(12), 20-22.

Jardine, C. G., Gibson, N., & Hrudey, S. E. (1999). Detection of odor and health risk perception of drinking water. *Water Science Technology, 40*(6), 91-98.

Krasner, S. W. & Barrett, S. E. (1984). Proceedings of the American Water Works Association: *Aroma and flavor characteristics of free chlorine and chloramine.* Denver, CO: Water Quality Technical Conference (WQTC).

Levallois, P., Grondin, J., & Gingras, S. (1999). Evaluation of consumer attitudes on taste and tap water alternatives in quebec. *Water Science and Technology, 40*(6), 135-139.

Lockhart, E. E., Tucker, C. L., & Merritt, C. (1955). The effect of water impurities on the flavor of brewed coffee. *Journal of Food Science, 20*(6), 598-605.

Loving, V. A., Burden, R. W., & Loving, A. L. (1998). An investigation of public drinking fountains and the changes in bacterial colony counts when tap water is allowed to flow. *Water Quality Resource Journal Canada, 33*(3), 363 – 376.

North Carolina Energy Office. (2010). *Drinking fountains & water coolers: energy saving fact sheet*. Retrieved from https://ncdenr.s3.amazonaws.com/s3fs-public/Environmental%20Assistance %20and%20Customer%20Service/IAS%20Energy%20Efficiency/Opportunities/ Drinking%20Fountains.pdf

Northcoast Nutrition and Fitness Collaborative (n.d.). *Water woes*. Retrieved from http://www.northcoastnutrition.org/rethink-your-drink-information-and-resources

Oliphant, J. A., Ryan, M .C., & Chu, A. (2002). Bacterial water quality in personal water bottles of elementary students. *Canadian Journal of Public Health, 93*(5), 366 – 367.

Patel, A. I., Bogart, L. M., Schuster, M. A. Uyeda, K. E. & Rabin, A. (2010). Perceptions about availability and adequacy of drinking water in large California school district. *Prevention Chronic Disease: Public Health Research, Practice and Policy, 7* (2), 1-10.

Patel, A. I., Chandran, K., Hampton, K. E., Hecht, K., Grumbach, J. M., Kimura, A. T., Braff-Guajardo, E., & Brindis, C. D. (2012). Observations of drinking water access in school food service areas before implementation of federal and state school water policy, California, 2011. *Prevention Chronic Disease: Public Health Research, Practice and Policy, 9,* e121.

Patel, A. I. & Hampton, K. E. (2011). Encouraging consumption of water in school and child care settings: access, challenges, and strategies for improvement. *American Journal of Public Health, 101*(8): 1370-1379.

Penn State Campus Sustainability Office. (2012). *Water bottle filling stations at penn state university*. Retrieved from http://sustainability.psu.edu/sites/default/files/documents/ HydrationStat Business PlanFinal.pdf

Puget, S., Beno, N., Chabanet, C., Guichard, E., & Thomas-Danguin, T. (2010). Tap water consumers differ from non-consumers in chlorine flavor acceptability but not sensitivity. *Water Research, 44*, 956-964.

Renfrew, M. M. (1990). *The water encyclopedia* (2nd ed.). van der Lesden, F. Troise, F. L. & Todd, D. K. (Eds.). Chelsea, MI: Lewis Publishers Inc.

Smith, D. V. & Margolskee, R. F. (2001). Making sense of taste. *Scientific American, 284*(3), 32.

Tate, D. F., Turner-McGrievy, G. Lyons, E., Stevens, J., Erickson, K., Polzien, K., Diamond, M., Wang, W., & Popkin, B. (2012). Replacing caloric beverages with water or diet beverages for weight loss in adults: main results of the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial. *American Journal of Clinical Nutrition, 95*, 555-563.

Teillet, E. Schlich, P., Urbano, C., Cordelle, S., & Guichard. (2010). Sensory methodologies and the taste of water. *Food Quality and Preference, 21*, 967-976.

United States Environmental Protection Agency (USEPA). (2003). *Drinking water advisory: consumer acceptability advice and health effects analysis on sodium* (EPA Publication No. EPA822-R-03-006). Washington, DC: U. S. Government Printing Office.

United States Environmental Protection Agency (USEPA). (2005). *Lead and copper rule: a quick reference guide for schools and child care facilities that are regulated under the safe drinking water act.* Retrieved from http://www. epa.gov/ogwdw/schools/pdfs/lead/qrg_ lcr_schools.pdf

United States Environmental Protection Agency (USEPA). (2016). *Secondary drinking water standards: guidance for nuisance chemicals*. Retrieved from http://www.epa.gov/dw standards regulations/ secondary-drinking-water-standards-guidance-nuisance-chemicals

United States Public Health Service. (1967). *Procedure for the bacteriological examination of food utensils and/or food equipment surfaces* (Public Health Service Publication No. 1631, Tech Information Bulletin No. 1). Washington DC: U. S. Government Printing Office.

University of California –Berkeley, University Health Services Department. (n.d.). Water Fountain Assessment. Retrieved from https://uhs.berkeley.edu/facstaff/ healthmatters/watercoolerconversion/WaterFountainAssessment.pdf

Virginia Cooperative Extension. (2009). *Interpreting your water test report*. Retrieved from http://pubs.ext.vt.edu/356/356-489/356-489.html

Virginia Cooperative Extension (2016). *Virginia household water quality program.* Retrieved from http://www.wellwater.bse.vt.edu/clinics.php

Virginia Tech. (2016). *Davidson hall*. Retrieved from https://www.vt.edu/about/buildings/ davidson-hall.html

Virginia Tech (2016). *McComas hall.* Retrieved from https://www.vt.edu/about/buildings /mccomas-hall.html

Virginia Tech. (2016). *Patton hall*. Retrieved from https://www.vt.edu/about/buildings/patton-hall.html

Virginia Tech. (2016). *Surge space building.* Retrieved from https://www.vt.edu/about/buildings /surge_ space_ building.html

Walters, K & Cram, G. (2002). Drinking water in schools: hygiene standards at fountains. *Nutrition & Food Science, 32*(1), 9 – 12.

Westcott, K. (2013). Is there really a north-south water taste divide? *BBC News.* Retrieved from http://www.bbc.co.uk/news/magazine-22247668

Whelton, A. J., Dietrich, A. M., Burlingame, G. A., Schechs, M., & Duncan, S. E. (2007). Minerals in drinking water: impact on taste and importance to consumer health. *Water Science and Technology, 55*(5), 283-291.

World Health Organization (WHO) (2004). *Guidelines for drinking-water quality vol. 1* (3rd ed.). Genvea, Switzerland: WHO.

Table 7.1 Mean hygiene and sensory water quality assessment scores of filling stations and water fountains on selected on campus.

Location Type[1]	Hygiene and Sensory Water Quality Assessment Analysis						
	Visible Debris	Cleanliness	Water Turbidity	Water Odor	Water Color	Water Flavor	Overall Quality of Water
Filling Station	3.6 ± 0.7[a]	2.3 ± 1.2[a]	4.0 ± 0.2[a]	4.0 ± 0.0[a]	4.0 ± 0.0[a]	3.5 ± 0.6[a]	3.8 ±0.4[a]
Water Fountain	3.6 ± 0.6[a]	3.5 ± 0.6[b]	4.0 ± 0.0[a]	3.9 ± 0.3[a]	4.0 ± 0.0[a]	3.4 ± 0.9[a]	3.8 ± 0.6[a]

[a, b]Means within each column with different superscripts significantly differ ($p<0.05$).
[1]Location type includes filling stations and water fountain analysis measurements from Davidson Hall, McComas Hall, Patton Hall, and Surge Space building for three replications
[2]Mean ± Standard Deviation
[3]Observations and results from the 4 sampling sites were combined to represent filling stations (n=4 sites; n=12 observations) and water fountains (n=4 sites; n=12 observations)
[4] Rubric Assessment Scale: 1 (poor), 2 (fair), 3 (good), 4 (excellent).

Table 7.2 Mean microbial levels on filling stations and water fountains on selected on campus.

	Microbial Analysis Aerobic Plate Count		
Location Type[1]	Spout (CFU/spout)	Drain Surface (CFU/cm²)	Water (CFU/ml)
Filling Station	$3.1 \times 10^2 \pm 4.6 \times 10^{2}$ [a]	$1.0 \times 10^4 \pm 1.3 \times 10^{4}$ [a]	<1 est.
Water Fountain	$5.5 \times 10^2 \pm 9.7 \times 10^{2}$ [a]	$8.8 \pm 1.4 \times 10^{1}$ [b]	<1 est.

[a, b]Means within each column with different superscripts significantly differ ($p<0.05$).
[1]Location type includes filling stations and water fountain analysis measurements from Davidson Hall, McComas Hall, Patton Hall, and Surge Space building for three replications
[2] CFU = Colony Forming Units
[3]Mean ± Standard Deviation
[4] est. = estimated count
[5]Observations and results from the 4 sampling sites were combined to represent filling stations (n=4 sites; n=12 observations) and water fountains (n=4 sites; n=12 observations)

Table 7.3 Mean pH and temperature of filling stations and water fountains on selected on campus.

	Temperature and pH Analysis	
Location Type[1]	Temperature (°C)	pH
Filling Station	16.6 ± 2.5[a]	6.7 ± 0.3[a]
Water Fountain	15.6 ± 3.6[a]	6.7 ± 0.3[a]

[a, b]Means within each column with different superscripts significantly differ ($p<0.05$).
[1]Location type includes filling stations and water fountain analysis measurements from Davidson Hall, McComas Hall, Patton Hall, and Surge Space building for three replications
[2]Mean ± Standard Deviation
[3]Observations and results from the 4 sampling sites were combined to represent filling stations (n=4 sites; n=12 observations) and water fountains (n=4 sites; n=12 observations)

Table 7.4 Mean free and total chlorine levels on filling stations and water fountains on selected on campus.

	Chlorine Analysis (mg/L Cl_2)	
Location Type[1]	Free	Total
Filling Station	0.08 ± 0.0[a]	1.4 ±1.3[a]
Water Fountain	0.12 ±0.1[a]	2.1 ± 1.2[a]

[a, b]Means within each column with different superscripts significantly differ ($p<0.05$).
[1]Location type includes filling stations and water fountain analysis measurements from Davidson Hall, McComas Hall, Patton Hall, and Surge Space building for three replications
[2]Mean ± Standard Deviation
[3]Observations and results from the 4 sampling sites were combined to represent filling stations (n=4 sites; n=12 observations) and water fountains (n=4 sites; n=12 observations)

Table 7.5 Mean mineral content levels for filling stations and water fountains on selected on campus

	Mineral Content (mg/L)								
Location Type[1]	Na	Mg	Al	Si	P	S	Cl	K	Ca
Filling Station	9.8 ± 0.6[a]	4.6 ± 0.3[a]	0.02 ± 0[a]	3.5 ± 0.5[a]	0.2 ± 0.01[a]	6.3 ± 0.2[a]	19.4 ± 3.6[a]	2.0 ± 0.5[a]	10.9 ± 0.7[a]
Water Fountain	9.9 ± 0.6[a]	4.6 ± 0.3[a]	0.02 ± 0[a]	3.5 ± 0.5[a]	0.2 ± 0.01[a]	6.3 ± 0.17[a]	20.6 ± 3.7[a]	2.0 ± 0.5[a]	10.9 ± 0.8[a]

	Mineral Content (mg/L)								
Location Type[1]	Ti	V	Cr	Fe	Mn	Co	Ni	Cu	Zn
Filling Station	0	0	0	0.01 ± 0.01[a]	0	0	0	0.02 ± 0.01[a]	0.05 ± 0.01[a]
Water Fountain	0	0	0	0.02 ± 0[a]	0	0	0	0.02 ± 0[a]	0.05 ± 0.01[a]

	Mineral Content (mg/L)									
Location Type[1]	As	Se	Sr	Mo	Ag	Cd	Sn	Ba	Pb	U
Filling Station	0	0	0.05 ± 0.01[a]	0	0	0	0	0.02 ± 0[a]	0	0
Water Fountain	0	0	0.05 ± 0.01[a]	0	0	0	0	0.02 ± 0[a]	0	0

[a, b]Means within each column with different superscripts significantly differ (p<0. 05).
[1]Location type includes filling stations and water fountain analysis measurements from Davidson Hall, McComas Hall, Patton Hall, and Surge Space building for three replications
[2]Mean ± Standard Deviation
[3]Observations and results from the 4 sampling sites were combined to represent filling stations (n=4 sites; n=12 observations) and water fountains (n=4 sites; n=12 observations)

Table 7.6 Summary of focus group discussions on opinions, perspectives, and perceptions of water filling stations, water fountains, and tap water.

Category	Quotes
(1) Filling station attributes and experiences influence positive attitude and continued use	"I love them so much." - "They're the best thing in the world. Because it's just so much easier. I just have to put it there and it does everything for me. I don't have to hold anything down. And you don't have to worry about anything like if someone just flushed the toilet and the water level goes up. That doesn't happen. I don't think at least." - "I prefer to use these refilling stations over any other source, I think, because it's, I think, psychological I think that it's got the like filter gauge so if it's green I'm like "oh it's good to go it's the best water I can get." I will use other sources, like I'll use water fountains or I'll use tap water, but this is what I go to if it's available." - "I feel like they're, I don't know if this is true, but I just feel like the water's cleaner, more filtered or purified or something. And it tells you how many gallons of water you've used. How many water bottles you've saved." - "I like that it says how many bottles it says it saves. I know it's really small

	and I'm like "Yea! I've added one of those!""
(2) Barriers to using filling stations on campus	"I wish they were more places." - "Oh. Filter not changed." And I'm like "So do I drink from this or do I not fill my water bottle up." And I usually still do because I want the water and I'm like "It can't be that bad right because the number's so high." But it's still kind of concerning when I see the red light and that's my only option." - "They're [filling stations at a specific campus location] really old and funky looking so I don't fill from those because… I don't know why. I know they're relatively clean, but they don't look right so I don't feel safe putting it there. So they have to be a certain way. They can't be moldy or rusty or anything like that. Yea. I just… I don't want to complain about it. It's fine because the filter's all cool and so is everything else, but the surrounding area just looks dirty so I kind of associate that with the water."
(3) Inconsistent physical attributes of water fountains discourages use	"I was super close to it [water fountain] and I saw so dirty, like residue and everything and I was right next to it and I was like "Well. Oh well." I would probably use it more if they were clean and they were colder." - "They kind of look dirty after a while if you know what I mean. They get water stains and damage. It makes you not want to use them besides the people factor. It's like they don't get maintained very well. I get less

	inclined to use it if it doesn't look quite right either." - "For the water fountains, you just don't know what you're going to get. You don't know if it's going to be warm water or cold water or if it's going to spurt an inch and you won't be able to get your water bottle in it or it's going to spurt 10 feet and hit you in the face because I've actually had that happen before. And they kind of taste weird. Sometimes they'll taste 'metally' or I don't know. They're not preferred."
(4) Situations contributing to perception of cleanliness of fountains	"I hate using the water fountain because I feel like I'm going to get sick every time I get water from it. Well everybody uses the water fountain and some people don't know how to use a fountain and they put their mouth on it. And I don't want to have their germs. I don't like it. I use a water fountain because a lot of times… I prefer the refilling stations but those aren't everywhere on campus, but these are. The water fountains are. I do use them, but I always feel like I'm dying afterwards." - "So that goes back to the thing with the water fountains. A lot of people put their hands on the button to push. People don't wash their hands usually. I have no faith in humankind basically. Like she was saying you could put gum or tobacco spit or whatever in the little drain and it just doesn't… you know? I don't want to get my water from there. So I want it to be clean. I want it to look clean. It basically has to have that stainless steel

	appearance." - "The best is when you're refilling by a bathroom and all of a sudden you'll hear a flush and the water will kinda go [insert hand motion?]. And you're like okay we're done here." - " It's like the amount of people it's in proximity to and you don't know what's going on with the drinking system or whatever so you don't want to like get the same thing. " - " …And just how many people touch it. It's just gross."
(5) Student perception of tap water quality/characteristics determines usage	"I mean I'm not really worried about water hardness or anything. But I mean I guess it [filtering] makes a difference." - "I don't drink directly from the tap water. It just tastes different to me because I'm so accustomed to the filtered water." - "I think just having it just being filtered makes it feel like it has a little bit of extra protection or something. I don't know." - "I could go either way. Like, I could just drink it from the tap water, but I like to filter it through the Brita."

	- "Yea. I don't mind it [tap water]. The city water is the only kind of water I don't like just because you can really that it's been treated some way. Like with chlorine or whatever." - "I honestly would fill up my water bottle anywhere because I used to be a life guard and we would just fill up our water like through the hose or through the sink. Because it's all exactly the same water pretty much. Like some of it might get filtered, but in reality like you're really not filtering out much. Because it already does get filtered through, to me, from what I think, it doesn't actually get that much filtered out through whatever filter that you're using. So to me if there's no water fountain around, I'll fill it up at the sink. Like I don't care."
(6) External Motivators that Contribute to Tap Water Usage	"I feel like in a lot of my classes, for HNFE, we talk about water a lot and my teachers are very passionate about it. Like people being particular about bottled water versus tap water and they don't really see the point in it. They say that all water is the same, so I don't know." - "I just don't trust it [tap water]. I don't know what's necessarily in it." - "They switch our water so frequently between our town and other towns it's this weird blend of waters they call it, but up until my dad put a filter in

	the same thing would happen. If you put the cup down it didn't ever fully settle, but you could see the particles moving. And I was like "Um no thank you.""
(7) External motivators that contribute to water preference and selection	"It's usually just the ions and the various minerals that it picks up. Because city water is usually pretty frickin', you know. Because there's a thing where Fiji ran an ad and they said "Cleaner than Cleveland's water" and then Cleveland folk got all offended and released a water report and they had less parts per million of particulate in their water than Fiji water. So it's usually just the sanitizing agent that you taste." - Does anybody watch Parks and Rec? Andy and how they all like drink from water fountains and they put their mouth over the whole thing and they're trying to… one of the things the Parks and Rec department is trying to handle is because everybody in Pawnee drinks their water like that. So they're trying to figure out how to… I don't know but I always think of that when I see these. And they are kind of gross because people put their mouths and yea. - I think it's just me thinking how many people come in contact with whatever I refill my water bottle with. With the automatic one you don't have to touch anything. The only thing you have to touch is your water bottle. When you dispense from the fountain drinks you're just using one

	finger, you're only pushing on the thing. You aren't really touching anything, whereas with the water fountains, you know, someone might have put their mouth on there or something. -
(8) Experiences and Perceptions of Safety Drive Source Preference	"At my high school, I remember one time I filled up my water bottle, like a disposable water bottle with the water from the fountain and it was kind of murky and cloudy, so ever since that happened I'm just like "I'm not going to drink from that." And I never have." - "I think just having it [tap water] just being filtered makes it feel like it has a little bit of extra protection or something. I don't know." - "I make sure it's rust free because I'm like that. And if it's a water fountain, I make sure it can actually go high enough that it can reach into the bottle. Things like that. And if the filter needs changed. I try to look at the real small things that might impact the water." - "Sometimes I let it run for a second or a couple seconds before filling it." - "My parents never let me drink from water fountains when I was little, so that prevents the big reason why I don't want to use them today. They'd always tell me it has a lot of germs on it and stuff so now it's embedded in

	me and I won't drink from them."

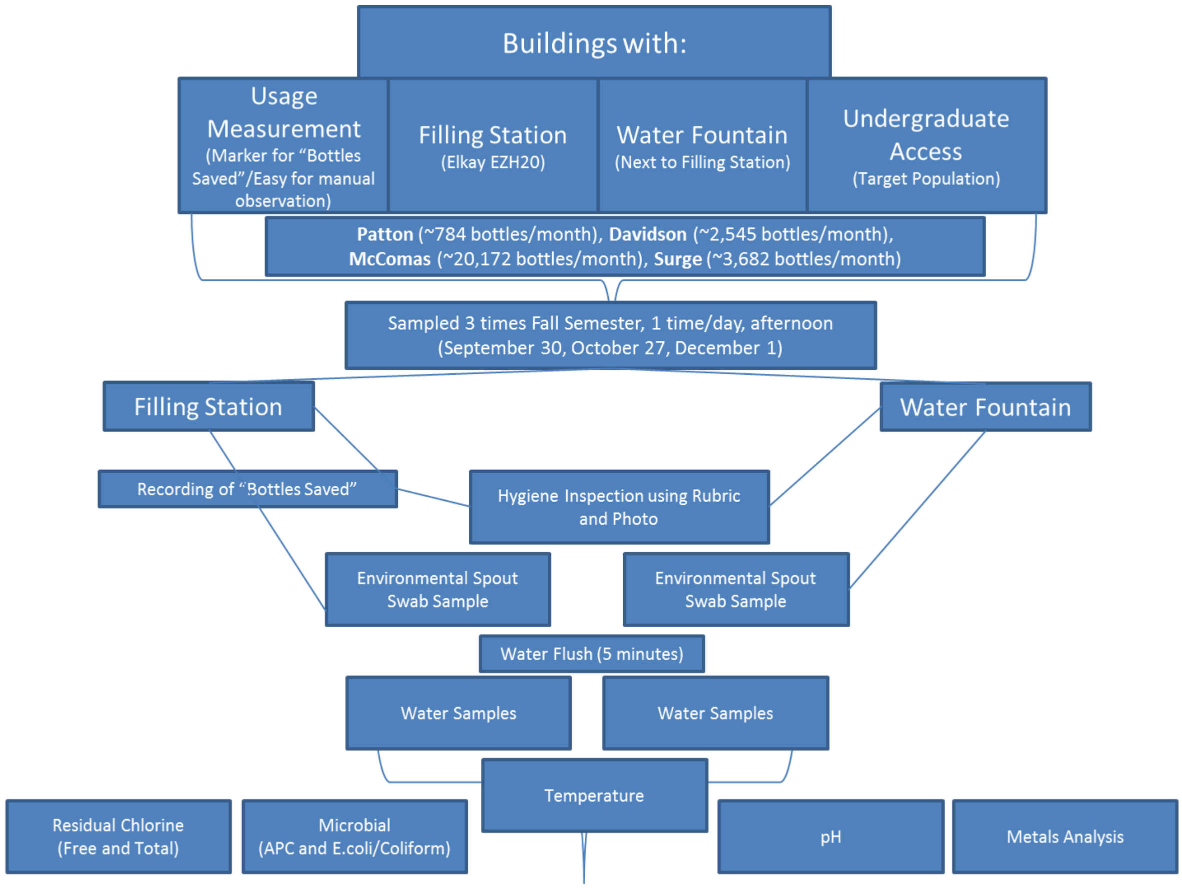


Figure 7.1 Schematic of overall sampling and research plan.

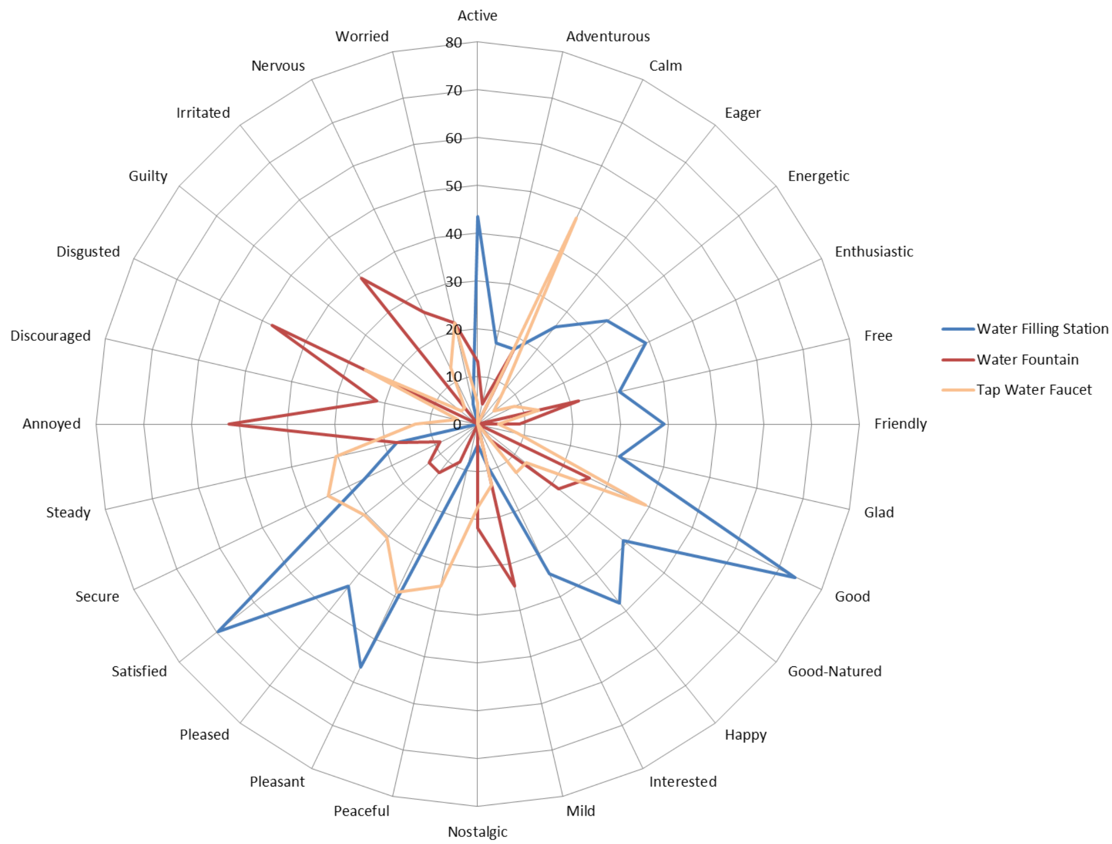


Figure 7.2 Summary of frequently selected emotion terms for water filing station, water fountain, and tap water. The displayed emotion terms (5/23 or ~21% of participants) were selected based on a 20% or greater selection frequency.

CHAPTER VIII

Conclusions

The proposed AFEA methodology and temporal analysis may aid with characterizing implicit responses, thereby providing new advances in emotional responses and behaviors of a population relating to food. AFEA software was able to identify emotions to flavored and unflavored dairy samples as well as a varying bitter intensities solutions model. Furthermore, we have demonstrated methodology to attain video capture for emotional response and data analysis methodology in an effort to create a standard methodology. The benefits of the methodology and the time series analysis can be seen in the research results. In two studies, AFEA was applied to elucidate consumers' emotional response to dairy (n=42) and water (n=46) beverages. Both of the studies aimed to test and validate the AFEA software analysis using simple flavoring models in order to determine AFEA sensitivity to beverages. For dairy, unflavored milk ($\overline{x}$=6.6±1.8) and vanilla syrup flavored milk ($\overline{x}$=5.9±2.2) ($p>0.05$) were acceptably rated (1=dislike extremely; 9=like extremely) while salty flavored milk ($\overline{x}$=2.3±1.3) was least acceptable ($p<0.05$). Vanilla syrup flavored milk generated emotions with surprised intermittently present over time (10 sec) ($p<0.025$) compared to unflavored milk. Salty flavored milk created an intense disgust response among other emotions compared to unflavored milk ($p<0.025$). Using bitter solutions in water, an inverse relationship existed with acceptability as bitter intensity increased (r_s=-0.90; $p<0.0001$). Facial expressions characterized as disgust and happy emotion increased in duration as bitter intensity increased while neutral remained similar across bitter intensities compared to the control

($p<0.025$). In both studies, results suggest and support that AFEA is a better indicator of disliked samples than liked. In the dairy study, time series trends exist with AFEA related to disliked flavors in milk and may assist in differentiating acceptability due to predominance of disgust emotions over 10 second duration.

The application of AFEA to foods and beverages is new. AFEA is able to discern negative (extremely) products from positive products, but either the algorithm for characterizing emotions or methodologies for interpretation of emotional differences, are not sensitive enough yet to discern positive or neutral products from one another. Eating is generally a positive experience and new product development would rely heavily on the ability to detect emotional differences between positive products. AFEA, at this current time, is not sensitive enough to detect changes between positive "acceptable" products based on the current software. Sensitivity and emotional categorization needs to be improved in order for application to foods and beverages. Moreover, product decisions could be improved if more options for emotional classifications were included beyond neutral and the six basic emotions (sad, angry, disgusted, scared, happy, and surprised). Additionally, emotional classification should be improved or modified as it relates to food and beverage acceptability in order to make decisions based on clearer results.

Time series analysis proved to be more sensitive that analysis of variance (ANOVA) for detecting and analyzing AFEA data over time. The inclusion of emotional analysis could be beneficial to new product development. AFEA should continue to evolve to improve emotional analysis to foods and beverages because eating is a dynamic experience. Future applications of this technique may expand into other beverage categories or soft foods. The method approach has shown success in our research, especially time series analysis. We hope the approach continues to assist in evaluating emotional response to foods and beverages and the relationship to choice and behaviors, while algorithms are developed to improve sensitivity.

Future studies should continue to eliminate barriers to data capture as well as collaborate with the AFEA software collaborators to update the software for the application to food. The collaborative updates should focus on reducing the facial obstruction and making the software more sensitive to consumption motor movements. Further validation studies could include products that are ‘positive’ and have a passionate consumer base (i.e. Pepsi and Coca-Cola) to identify and discriminate emotions of closely related positive products. Lastly, statistical analysis should continue to improve as well as look at cluster analysis and principal components analysis to identify trends within population subgroups.

In addition to AFEA analysis, qualitative and mixed methods research helped to understand consumer behaviors related to water source preferences and reusable water bottle behavior. In the mixed methods analysis to enumerate microbial populations, assess water quality, and qualitatively gain consumer insights regarding water fountains and water filling stations, results inferred that water quality differences did not exist between water fountains and water filling stations (metals, pH, chlorine, and microbial) ($p>0.05$). However, the exterior of water fountains were microbially (8.8 CFU/cm^2) and visually cleaner than filling stations (10.4×10^3 CFU/cm^2) ($p<0.05$). Qualitative data contradicts quantitative results, as participants disliked using water fountains due to unsanitary perceptions and felt filling stations were cleaner as well as more user friendly. The poor sanitation of filling stations and frequent reusable water bottle use may provide cross-contamination opportunities at filling stations and foodservice establishments, thus impacting public health and safety. Participants voiced their strong desire to see more filling stations in more buildings on campus; but more research about filling stations on campus should be explored or cleaning standard operating procedures should be updated and/or given more frequent cleaning. These results infer that further investigation is required to assess the safety and standard cleaning protocol of the water filling stations. If increasing water consumption for health using tap water, we must provide a suitable infrastructure with perceived health, safety and quality. These findings are important and have implications with anyone who uses, manages, or cleans water fountains and filling stations. Attention and consideration to updating to standard operating procedures should be undertaken as the cleanliness of the water delivery sources could impact and affect public health. Foodservice and sanitation services could use this information to improve cleaning routines and policies. Moreover, companies who design and manufacture water fountain and filling stations could improve the design to decrease contamination opportunities, reduce water stagnation, and improve consumer experience.

Lastly, The Theory of Planned Behavior was able to assist in understanding undergraduates' reusable water bottle behavior and revealed 11 categories (attitudes n=6; subjective norms n=2; perceived behavioral control n=2; intentions n=1). With college students, it appears the environmental and financial importance weigh more heavily in choosing a hydration vessel for water needs. Students appear conscious of their environmental impact and prefer to use RWB. Moreover, RWB assists in both physiological and psychological benefits for the user. Participants find reusable water bottles to be convenient and an easy way to increase water consumption for health each day while reducing the environmental burden. The themes that emerged regarding reusable water bottle habits can assist and provide insight for marketing and educational materials regarding water consumption habits through reusable water bottles to improve hydration status. Through the research findings to understand and identify components of consumer reusable water bottle behavior, effective educational materials can be developed to encourage water consumption as well as assist to reduce barriers preventing water consumption. This research could provide insight to the public water infrastructure to improve water consumption and positive perception of these delivery sources. Additionally, further research could include intervention studies related to improving health and hydration status of students using the findings of the presented studies. A variety of graphics or themes could be designed and produced to encourage positive water intake behavior, use of water filling station, and encourages the use of reusable water bottles. In other studies, college students have stated that intense graphics would catch their attention. Graphic contents have the potential to change behavior if the graphic is jarring, clever or noticeable.

Different graphics related to derived themes surrounding water intake and sustainability can be developed. Using further focus groups, graphics could be evaluated for their perception impact and potential behavior change that would influence college students to drink more water specifically via a reusable bottle. Once a graphic theme is determined, graphics could be posted near water filling stations on a college campus. To manage the success and noticeability of graphics, social media could be used. Graphics could include a QR Code (Quick Response Code) for scanning and a hashtag. Students who notice the sign will be encouraged to scan the code and/or hashtag in social media.

Statistics can be generated by social media techniques simply through tallying the scans and hashtags. Those that have used to QR code or social media (hashtag) could be prompted with a survey to determine if the graphics influenced their RWB use.

Lastly, college is the first opportunity many young adults explore independent decision making and experiences that influence their lifetime choice and behavior patterns (Arnett, 2000). It is during this experimental decision making stage that the college environment is an attractive location to change habits and educate students about healthy lifestyle especially since the greatest rise in obesity over in the 1990s was in young adults (Mokad, Serdula, Dietz, Bowman, Marks, & Koplan, 1999). The Theory of Planned Behavior (TPB) has been used to explain a variety of social phenomena and to explain social behavior and decision making processes in regards to food and beverage consumption. The Theory of Planned Behavior was useful in identifying the behavior constructs of RWB use. Future application of the Theory of Planned Behavior could extend to understanding consumer milk consumption. Fluid milk consumption has declined in the United States since the 1970s (Stewart, Dong, & Carlson, 2013; Popkin, 2010).By using a script rooted in the Theory of Planned Behavior related to milk consumption and hosting focus groups with college students, researchers can identify the constructs that contribute to milk consumption or limit milk consumption. The age of college students is a good range to understand and change behavior. The findings from the focus groups could assist in developing new milk advertising to improve consumption habits and health.

In summary, the use of AFEA and qualitative analysis provided additional insight to consumer-product interaction and acceptability. Qualitative research and more in depth emotional assessments may assist in more accurate understanding of consumers and their choices and behaviors in addition to providing insights to the influences of product acceptability and purchase decisions. However, additional research should include improving the sensitivity of AFEA to consumer product evaluation, especially in response to the consumption of foods and beverages. Also, emotional categorization should be further explored for more accurate classifications of product response. Humans are dynamic beyond a hedonic scale and the six basic emotions. Future research should continue to incorporate consumer dynamics, responses, and experiences because valuable information can be gained through implicit and qualitative research in an effort to improve the health and livelihood of consumers.

References

Arnett, J. J. (2000). Emerging adulthood: a theory of development from the late teens through the twenties. *American Psychologist, 55*(5), 469 – 480.

Mokad, A. H., Serdula, M. K., Dietz, W. H., Bowman, B. A., Marks, J. S., & Koplan, J. P. (1999). The spread of the obesity epidemic in the united states, 1991-1998. *Journal of the American Medical Association, 282*, 1519-22.

Popkin, B. M. (2010). Patterns of beverage use across the lifecycle. *Physiology and Behavior, 100*, 4–9.

Stewart, H., Dong, D., & Carlson, A. (2013). *Why are americans consuming less fluid milk? a look at generational differences in intake frequency* [ERR-149]. U.S. Department of Agriculture, Economic Research Service, May 2013.

APPENDIX A

Protocol for Data Collection and Analysis Applied to Automated Facial Expression Analysis Technology **–AND–** Temporal Analysis for Sensory Evaluation and Characterizing Implicit Emotions to Acceptable and Unacceptable Flavored Milk Beverages using Automated Facial Expression Analysis

A.1 Approval Letter

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: September 1, 2015

TO: Susan E Duncan, Courtney Alissa Crist, Kristen Leitch, Alexandra Margaret Walsh, Lester Schonberger, Hayley Potts, Taylor Duncan, Diana Opal Woodrur

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires July 29, 2020

PROTOCOL TITLE: Facial Expression Analysis of Dairy Foods

IRB NUMBER: **14-229**

Effective August 31, 2015, the Virginia Tech Institution 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:	**September 26, 2015**
Protocol Expiration Date:	**September 25, 2016**
Continuing Review Due Date*:	**September 11, 2016**

*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

Date*	OSP Number	Sponsor	Grant Comparison Conducted?
03/16/2015	14286606	Dairy Management Inc	Not required (Not federally funded)

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

A.2 Informed Consent Form

IRB Approval Date: Participant ID number:
IRB Approval Number:

Virginia Polytechnic Institute and State University

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

Title Project: Facial Expression Analysis of Dairy Foods

Investigators: Susan E. Duncan, Courtney Crist, Virginia Fernandez-Plotka, Kristen Leitch, Alexandra Walsh, Lester Schonberger, Hayley Potts, Diana Woodrum, Taylor Duncan

I. Purpose of this Research/Project
You are invited to participate in a study to identify facial response differences between different dairy based foods in order to validate facial analysis software.

You will be videotaped while you are evaluating the food 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 will perform a demo of the video capture to make sure you understand positioning and to collect video for facial analysis baseline purposes. You then will receive 1 sample as control, then 1 sample (of 8) of a dairy based product, presented one at a time. Following the guidance on the touch screen monitor, you will evaluate each sample on taste and then answer a few questions about the sample.

You will evaluate each sample serving presented by taste. 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 questions (degree of liking of sample taste) by responding on the touchscreen monitor. Once hedonic sampling is finished, you will be presented with the samples again to refresh your memory and will be asked some questions about your experience while tasting the samples.

Virginia Tech Institutional Review Board Project No. 14-229
Approved February 19, 2015 to September 25, 2015

III. Risks
There are no more than minimal risks for participating in this study. You will not be required to eat the food should you have a severe disliking to the foods. Some individuals may be uncomfortable about being videotaped or recorded. Allergy listing will be provided. If you are aware of any allergies, 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 reward card/stamp and 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.

VIII. 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.

Virginia Tech Institutional Review Board Project No. 14-229
Approved February 19, 2015 to September 25, 2015

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 ______________________________________

Virginia Tech Institutional Review Board Project No. 14-229
Approved February 19, 2015 to September 25, 2015

-----------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
Courtney Crist	cacrist@vt.edu
Virginia Fernandez-Plotka	tplotka@vt.edu
Kristen Leitch	kaleitch@gmail.com
David Moore Chair, Virginia Tech Institutional Review Board for the Protection of Human Subjects Office of Research Compliance	(540) 231-4991; moored@vt.edu

A.3. Photo Release

Virginia Polytechnic Institute and State University
Informed Consent for Participants in Research Projects Involving Human Subjects
(Sensory Evaluation)

Title Project: Facial Expression Analysis of Dairy Foods

Investigators: Susan E. Duncan, Courtney Crist, Virginia Fernandez-Plotka, Kristen Leitch, Alexandra Walsh, Lester Schonberger, Hayley Potts, Diana Woodrum, Taylor Duncan

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:

Updated Subject's Permission, Picture and Video Release

I have previously consented to the study parameters and acknowledge the conditions of the project as stated above. I have been notified that my video footage will be used in the form of a poster presentation as photos. The usage reveals my participation, identify and inclusion in this study.

I have re-read the original consent form and conditions of this project that I originally signed. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent to have my video footage and face used for research demonstration purposes as photographs, in addition to video footage.

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

Date ______________________

Subject Signature____

Subject Printed Name ____

A.4 Pre-Screening Survey

Facial Expression Analysis of Dairy Foods: 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: XXXX.

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 research study in the Food Science and Technology (FST) Sensory Laboratory. This study is to assess potential candidates for invitation to a study of dairy foods. The questions in this survey are grouped based on identifying

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

Panelists will be rewarded for their participation with reward stamp towards a gift card (Kroger, Panera, or other local store), snacks, as well as canned foods (total value about $5). Panelists can keep the reward 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 Sensory laboratory located in HABB1 on campus at the corner of Duckpond Dr. and Washington St.

Interest In and Availability for Participating in Preliminary Study

Availability: During the fall semester, are you routinely available for at least 20-30 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, 1:00 pm-5:00 pm
- Monday, 5:00 pm-8:00 pm
- Tuesday, 9:00 am-12:00 pm
- Tuesday, 3:00 pm-5:00 pm
- Tuesday, 5:00 pm-8:00pm
- Wednesday, 9:00 am-12:00 pm
- Wednesday, 2:00pm-5:00pm
- Wednesday, 5:00pm-8:00pm
- Thursday 2:00 pm-5:00 pm
- Thursday 5:00 pm-8:00 pm
- Friday, 9:00 am-12:00 pm
- Friday, 1:00 pm-5:00 pm
- Weekends
- Other:

Study information: This is a study requiring approximately 20-30 minutes of time. Participants will evaluate and taste 8 dairy based samples and respond about the liking of samples. During the 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

Please list dairy foods you like:

Please list dairy foods you dislike:

- Do you have dairy allergies?
    - 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
    - If yes, unfortunately due to software limitations we cannot include your participation in this sensory study.
- No

Thank you for your participation!

A.5 Sensory Ballot and Hedonic Scorecard

Instructions [Instructions and Evaluation will be on the touch screen monitor]: You will be provided a total of 9 samples to evaluate. For each sample, you are to determine a rating and evaluate how well you like each sample based on taste. Take the full sample into your mouth and then swallow.

It is important that you follow specific protocols while evaluating the sample in order for the response to be collected.

- **Focus your attention on the monitor in front of you. Refrain from looking to your left/right or looking up/down.**
- **Do not lean your head; keep your posture comfortable but alert.**
- **Immediately after evaluating/taking in the sample from the cup/spoon/fork, drop your hand/cup below your chin as quickly as possible.**
- **Refrain from touching your face after sample consumption.**
- **Face the monitor while you are evaluating the sample.**

Samples 1-9:

Sample ___________

Please evaluate based on taste the sample in front of you. Take the full sample into your mouth and then swallow.

[20-30 second timer will display]

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

Like extremely	______
Like very much	______
Like moderately	______
Like slightly	______
Neither like nor dislike	______
Dislike slightly	______
Dislike moderately	______
Dislike very much	______
Dislike extremely	______

Please rinse your palate with the water provided and hold up associated sample card.

When you are finished, hit "Next". Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

You are done tasting all the samples. Please click next for part 2 of the study and indicate you are ready for part 2.

We would like to know more about your thought processes before selecting how you rated the samples.

You have been presented again with the samples to be reacquainted with them. If needed, please feel free to sample for your memory.

How did you feel when evaluating?
Did you know the flavors?
Did you like the flavors?
What thought processes occurred while evaluating?
Did your opinion of the sample change over time?
Was your evaluation response based on when you first tasted the sample?

Thank you for your participation. Please exit the lab and go to the incentives table to sign for and collect your reward card/stamp and other incentives as compensation for your participation.

A.6 Beverage Questionnaire

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."

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.

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. Count cow's milk used in food and cooking in a separate category (such as milk in cereal).

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

Participant ID ______________

Date ______________

	How Often (Mark One)							**How Much Each Time (Mark One)**				
Type of Beverage	**Never or less than 1 time per week (go to next beverage)**	**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)**
Whole Milk	o	o	o	o	o	o	o	o	o	o	o	o
Reduced Fat Milk (2%)	o	o	o	o	o	o	o	o	o	o	o	o
Low Fat/Fat Free Milk (Skim, 1%, Buttermilk, Soymilk)	o	o	o	o	o	o	o	o	o	o	o	o
Milk (*Cow's*) in Food (Cereal, Smoothies, etc.)	o	o	o	o	o	o	o	o	o	o	o	o
Milk (*Cow's*) or cream in Hot/Cold Tea or Coffee	o	o	o	o	o	o	o	o	o	o	o	o
Soymilk	o	o	o	o	o	o	o	o	o	o	o	o
Almond Milk	o	o	o	o	o	o	o	o	o	o	o	o
Cashew Milk	o	o	o	o	o	o	o	o	o	o	o	o
Rice Milk	o	o	o	o	o	o	o	o	o	o	o	o
Coconut Milk	o	o	o	o	o	o	o	o	o	o	o	o
Other: ____________	o	o	o	o	o	o	o	o	o	o	o	o
Other: ____________	o	o	o	o	o	o	o	o	o	o	o	o

Please answer the following questions:

1. Would you consider yourself a consumer of cow's milk as a beverage?
   Yes, I drink cow's milk often as a beverage
   No, typically milk is used in other products or for cooking use
   Comments:

2. What is your age? (Optional)

[a]Hedrick, V. E., Savla, J., Comber, D. L., Flack, K. D., Estabrooks, P. A., Nsiah-Kumi, P. A., Ortmeier, S., & Davy, D. M. (2012). Development of a brief questionnaire to assess habitual beverage intake (BEVQ-15): Sugar-sweetened beverages and total beverage energy intake. *Journal of the Academy of Nutrition and Dietetics, 112*, 840-849.

A.7 Qualitative Assessment of Dairy Beverages

Panelist No. _______________
Date: _____________________
IRB No. 14-229

Part 2

You have been given the samples again. If needed, please feel free to sample taste the samples to refresh your memory. Please respond to each question as completely as you can.

1. We would like to know more about the thoughts and feelings you experienced before you selected how you rated the samples (in the previous experiment). **Please be specific about which thought went with which sample.** How did you feel towards each of the samples when evaluation? What did you think about the samples? An example response has been provided.

Sample Identifier	Comments – Thoughts and Feelings
Example:	Example answer: When I tasted this sample, I thought it was really [sensory description, e.g. sweet] and I [example of response, e.g. liked] it. In response, I [action, e.g. smile] because [reason, e.g. the product or sensory experience reminded] me of ….]. I was [emotion, e.g. happy] about [that memory and the sample tasted good].
White	
Yellow	
Pink	
Orange	

Panelist No. _______________
Date: _____________________
IRB No. 14-229

Sample Identifier	Comments – Thoughts and Feelings
Red	
Purple	
Black	
Green	

2

Panelist No. _______________
Date: _____________________
IRB No. 14-229

2. We want to have an estimate of your **familiarity** with the flavors.

Sample Identifier	Flavor Descriptor	Confidence in your flavor guess (circle the best response)	Comments – Thoughts and Feelings about that flavor in milk
White		None Uncertain High	
Yellow		None Uncertain High	
Pink		None Uncertain High	
Orange		None Uncertain High	
Red		None Uncertain High	
Purple		None Uncertain High	
Black		None Uncertain High	
Green		None Uncertain High	

3

Panelist No. _______________
Date: _____________________
IRB No. 14-229

3. We are interested in the **30 second wait time effect on the acceptability rating** (liking).

Sample Identifier	Initial perception of liking immediately after tasting the sample (circle one)	Liking rating after 30 seconds (circle one)	Was the rating you provided in the previous test based on the initial perception or after 30 seconds?	Were you thinking about the product (flavor, aftertaste, what was going on in your mouth) throughout the 30 seconds or did you get distracted with other things?
White	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted
Yellow	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted
Pink	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted
Orange	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted
Red	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted
Purple	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted
Black	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted
Green	Like Neutral Dislike	Like Neutral Dislike	Before After	Focused on product Distracted

4

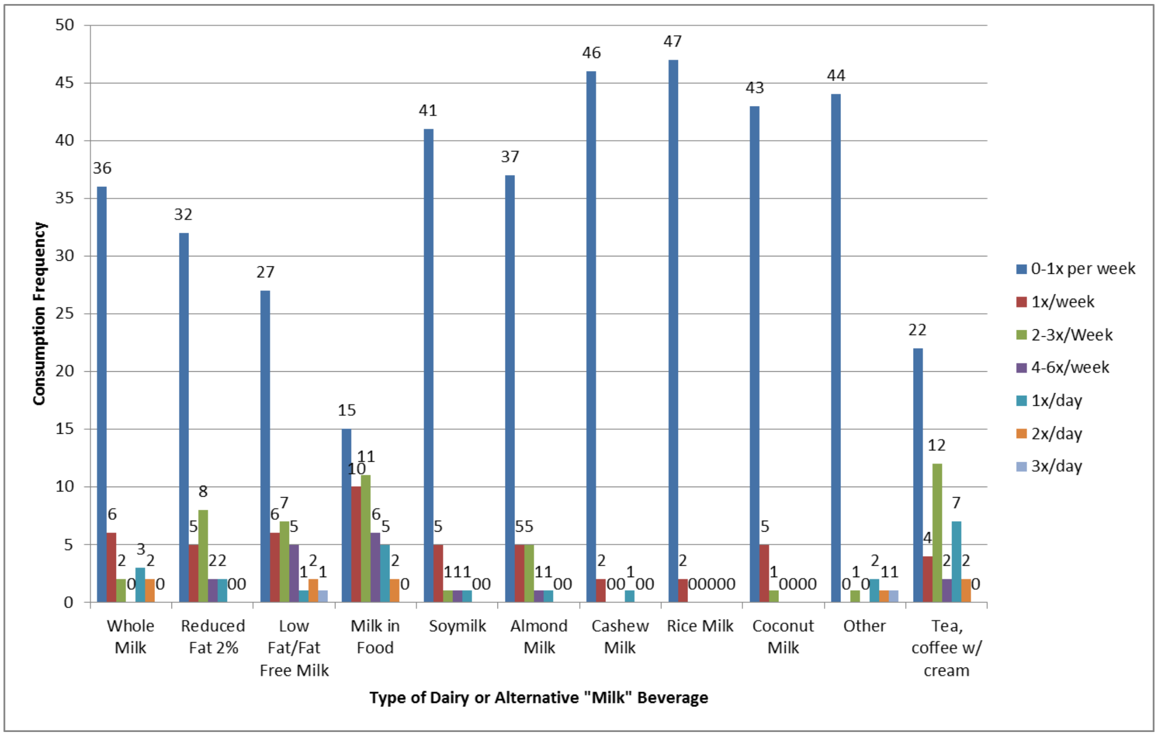
Panelist No. _______________
Date: _____________________
IRB No. 14-229

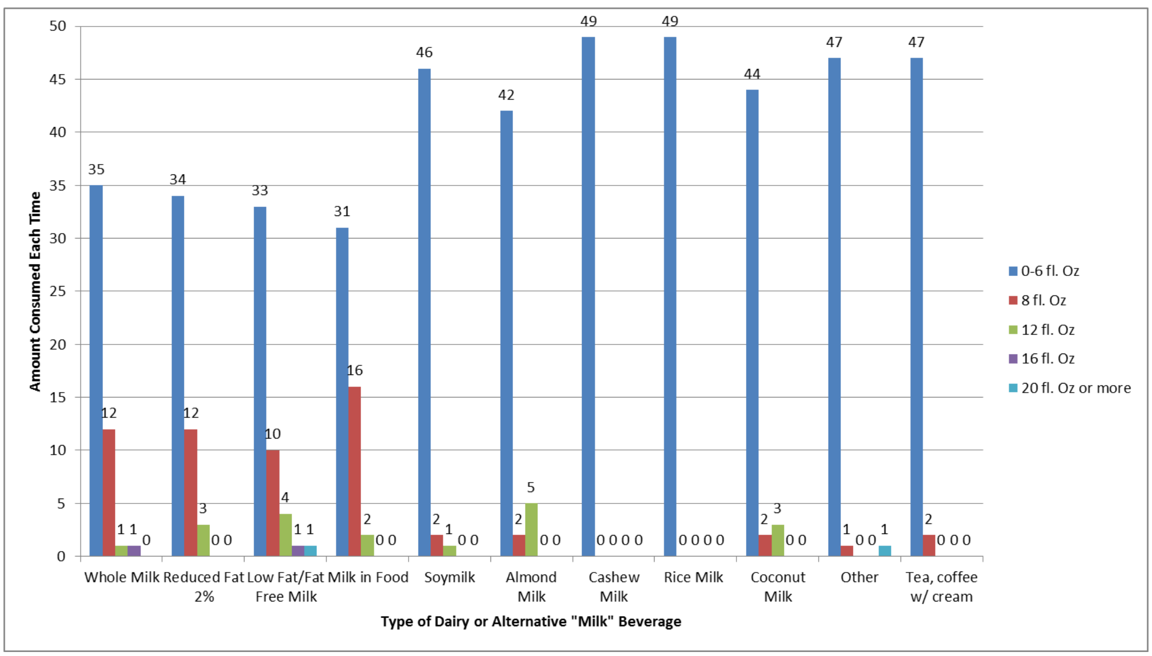
4. Are there any other thoughts or feelings you had in regards to the samples that would be vital understanding your evaluation?

Thank you for your participation. Please exit the lab and go to the incentives table to sign for and collect your reward card/stamp and other incentives as compensation for your participation.

5

A.8 Supplemental Data – Beverage Questionnaire





[a] Data based on participant (n=49) completion of the Beverage Questionnaire (Appendix A.6)

A.9 Supplemental Data – Qualitative Assessment of Dairy

Treatment[2]				
Descriptors[1]	Vanilla Syrup		Descriptors[1]	Salty
Sweet	40		Sour	11
Sugar	12		Salty	26
Artificial Sweet	2		Acidic	3
Candy	3		Bitter	4
Dessert	2		Tart	1
Honey	1		Sweet	1
Cake	1		"Not Milk"	1
Milkshake/Ice Cream	10		"Warm Milk without Being Warm"	1
Creamer	6		Powdered Milk	1
Milk (Skim, 1%, 2% Whole)	3		Milk	1
Cereal Milk	3		Buttermilk	2
Cheesy	1		Buttery	1
Buttermilk	1		Mac n' Cheese	1
Rice Milk	1		Sharp	1
Soy Milk	4		Off-Flavor	1
Vanilla Extract or Vanilla	15		Rancid (Old)	5
Nutty or Almond	5		Oily	1
Coconut	3			
Caramel	1			
Savory	1			
Salty	1			
Thick	1			
Light	1			
Floral	1			
Bland	1			
Positive	4		Gross	10
Happy	13		Disgust	9
Love	2		Repulsive	2
Delicious	3		Hate	4
Good	8		Terrible	3
Liked	1		Unpleasant	2
Pleasant	2		Awful	3
Excited	1		Nasty	2
Confused	1		Bad	5
Surprised	2		Liked Slightly	1
Unpleasant	1		Negative	1
Overpowering	2		Unexpected	4
Refreshing	1		Surprised	3
			Weird	5

			Betrayed	1
			Laughed because so bad	1
			Grimaced	7
			Headache	1
			Confused	2
			Unfamiliar	1
			Mad	1
			Unhappy	1
			Panic	1
			Overwhelmed	2
Nostalgic	2		Reminiscent of Salt Water at Beach	5
			Childhood	1

[1] Descriptors, emotions, memories, and associated mentioned by participants (n=49) during the qualitative assessment of dairy beverages

[2] Solutions in Milk: Vanilla syrup (0.02g/ml); salty (0.004g salt/ml)

Treatment[2]				
Descriptors[1]	Malty		Descriptors[1]	Green Tea
Cereal Milk	10		Tea	7
Cereal	5		Feed/Hay/Grass	5
Malty/Grape Nuts	5		Toasted Rice	1
Crackers	2		Vegetable	2
Bitter	1		Dirt/Earth	2
Sour	2		Seaweed/Fish	15
Sweet	3		Bland	1
Savory	2		Off-Flavor	3
Nutty	7		Distinct	1
Almond	5		Oxidized (Rancid)	5
Cashew	2		Bitter	4
Rice	2		Sour	4
Cooked/Evaporated Milk	2		Metallic	2
Creamy	2		Sweet Aftertaste	1
Soy	2		Non-Milk Product	1
Cheese	1		Buttermilk	1
Watered Down	2		Hemp Milk	1
Milk (Skim, 1%, 2%, Whole)	12		Rice Milk	2
Well-balanced	1		Cashew Milk	1
Rancid (Old)	3		Milk (Skim, 1%, 2%, Whole)	5
Tomato	1		Water	2
Filtered	1		Sweet Rose Water	1
Baking Ingredient	1			
Fatty	2			
Warm Taste	1			
Too Strong	1			
Unhappy	3		Confused	1
Disgust	2		Odd	1
Nasty	2		Weird	3
Gross	2		Disgust	6
Uncomfortable	1		Grimaced	2
Upsetting	1		Hate	1
Mad	1		Bad	1
Negative	1		Gross	4
Boring	1		Horrific	1
Not Favorite	1		Nasty	1
Confused	3		Angry	1
Weird	4		Unpleasant	2
Neutral	8		Neutral	5
Pleasant	2		Boring	1
Happy	4		Comforting	1

Good	1		Happy	1
Decent	1		Familiar	1
Interesting	1		Unfamiliar	1
Distracting	1		Strong	1
Reminded of Wife	1		Pleasant Memories	2
Reminds of Cooking	1			
4-H Camp	1			
Reminds of Sisters	1			
Childhood	1			
Not the “milk” I love	1			
Reminded of first time I had cereal	1			

[1] Descriptors, emotions, memories, and associated mentioned by participants (n=49) during the qualitative assessment of dairy beverages

[2]Solutions in Milk: malty (Solution 1: 0.15g grape nuts /ml milk; Solution 2: 0.05g Solution1 /ml milk); green tea (Solution 1: Prepared as manufacturer’s instructions in distilled water; Solution 2: 0.11g/ml).

Treatment[2]				
Descriptors[1]	Vanilla Extract		Descriptors[1]	Sour
Vanilla	22		Milk (Skim, 1%, 2%, whole)	12
Ice Cream	5		Creamy	3
Almond Milk	7		Butter/y	4
Soy Milk	11		Buttermilk	4
Nutty	6		Sour Cream	1
Coconut	2		Yogurt	4
Cocoa	1		Cheese	3
Milk Alternative	1		Cottage Cheese	2
Cashew Milk	1		Fermented	2
Sweet	13		Mac n’ Cheese	1
Too Sweet	4		Breast Milk	1
A Little Sweet	3		Cereal Milk	1
Not Sweet/No Sugar	4		Grain	1
Natural Sugar	1		Tea	1
Bitter	1		Soy	1
Candy	2		Bitter	3
Off-Flavor	1		Sour	10
Green Beans	1		Salty	4
Not Creamy	1		Sweet	2
Creamer	1		Fatty	1
Powdered Milk	1		Fishy	1
Milk (Skim, 1%, 2%, Whole)	4		Bland/Flavorless	7
Tangy	1		Rancid (Old)	6
Minty	1		Mild	1
Orange	1		Meat/Chicken	2
Mild	1			
Chemical/Medicinal	2			
Unnatural	1			
Good	2		Neutral	12
Positive	3		Decent	0
Happy	4		Unhappy	2
Smile	4		Frowned	1
Pleasant	3		Upset	1
Enjoyed	1		Disappointed	1
Delicious	1		Not good/great	2
Good	2		Disgusted/Grossed Out	6
Relaxed	1		Betrayal	1
Calm	1		Bored	4
Comforted	1		Confused	1
Neutral	4		Happy	1

Interested	1		Good	1
Surprised	2		Pleasant	2
Indecisive	1		Interested	1
Negative	3		Familiar	2
Familiar	1		Subtle	1
			Weird	1
			Reminds of Coffee	1
Sad/Happy: Reminds of sister	1			
Reminds of 4th of July	1			
Reminds of Family	1			
Reminds of Childhood	1			
Beach	1			

[1] Descriptors, emotions, memories, and associated mentioned by participants (n=49) during the qualitative assessment of dairy beverages
[2]Solutions in Milk: Sour (0.02g buttermilk/ml); vanilla extract (0.02g/ml)

Treatment[2]				
Descriptors[1]	Coconut		Descriptors[1]	Milk
Tropical	7		Milk (Skim, 1%, 2%, Whole)	45
Coconut	35		Cereal Milk	1
Vanilla	1		Plain/Regular/No Flavor Added/Normal	20
Nutty (Almond, Cashew, Hazelnut)	4		Common	2
Spicy	1		Bland	2
Cinnamon	1		Wholesome	2
Sweet	21		Creamy	4
Sugar	1		Creamer	2
Dessert	1		Slightly Sweet/Sweet	5
Ice Cream	2		Savory	1
Sunscreen	1		Sour	1
Creamer	1		Fatty	3
Artificial	1		Rich	1
Floral	1		Warm	2
			Slightly Old	1
			Bad Aftertaste	1
			Watery	1
Happy	5		Pleasant	1
Smiled	2		Happy	5
Positive	2		Content	3
Pleasant	4		Awesome	1
Excited/Fun	2		Good	4
Good	2		Smiled	1
Delicious	2		Enjoyable	1
Enjoyable	1		Familiar	8
Love	2		Comforting	4
Nice	1		Calm	3
Neutral	2		Neutral	6
Disgust	1		Unpleasant	1
Negative	1		Acceptable	2
Healthy	1		Confused	2
Warm	1		Boring	3
Comforting	1			
Relaxing	1			
Confused	1			
Intense/Strong Flavor	4			
Familiar	1			

Unique	1			
Fancy	1			
			Reminds of Childhood	2
			Reminds of Family	2

[1] Descriptors, emotions, memories, and associated mentioned by participants (n=49) during the qualitative assessment of dairy beverages
[2]Solutions in Milk: (2% reduced fat milk); coconut syrup (0.02g/ml)

APPENDIX B

Application of Automated Facial Expression Analysis Technology to Acceptability Using an Aqueous Bitter Model

B.1 Approval Letter

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: February 19, 2016

TO: Susan E Duncan, Elizabeth Amalia Arnade, Virginia C Fernandez-Plotka, Kristen Leitch, Courtney Alissa Crist

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires January 29, 2021)

PROTOCOL TITLE: Facial Expression Analysis Recruitment

IRB NUMBER: **13-037**

Effective February 19, 2016, the Virginia Tech Institution 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:	**March 19, 2016**
Protocol Expiration Date:	**March 18, 2017**
Continuing Review Due Date*:	**March 4, 2017**

*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

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

B.2 Informed Consent Form

IRB Approval Date: Participant ID number:
IRB Approval Number:

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.

Virginia Tech Institutional Review Board Project No. 13-037
Approved March 19, 2013 to March 18, 2014

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 chose 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 _______________________________________

IRB Approval Date: Participant ID number:
IRB Approval Number:

-----------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
Virginia Fernandez-Plotka	tplotka@vt.edu
Elizabeth Arnade	elizaaa@vt.edu
Kristen Leitch	kaleitch@gmail.com
David Moore Chair, Virginia Tech Institutional Review Board for the Protection of Human Subjects Office of Research Compliance	(540) 231-4991; moored@vt.edu

B.3 Pre-Screening 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: XXXX.

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!

B.4 Sensory Ballot and Hedonic Scorecard

Facial Expression Analysis Pre-screen_Instructions_Hedonic and Intensity Scorecard

Instructions [Instructions and Evaluation will be on the touch screen monitor]: You will be provided a total of 4 samples to evaluate. For each sample, you are to determine a taste intensity rating and evaluate how well you like each taste sample. For each product, take the full sample into your mouth and then swallow.

It is important that you follow specific protocols while evaluating the sample in order for the response to be collected.

- **Focus your attention on the monitor in front of you. Refrain from looking to your left/right or looking up/down.**
- **Do not lean your head; keep your posture comfortable but alert.**
- **Immediately after taking in the sample from the cup, drop your hand/cup below your chin as quickly as possible.**
- **Refrain from touching your face after sample consumption.**
- **Face the monitor while you are evaluating the sample.**

Samples 1-4:

Please consume the sample in front of you. Sample ___________

[20-30 second timer will display]

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

Like extremely	______
Like very much	______
Like moderately	______
Like slightly	______
Neither like nor dislike	______
Dislike slightly	______
Dislike moderately	______
Dislike very much	______
Dislike extremely	______

Indicate the intensity of the bitter taste you just sampled.

Extremely strong bitter taste ______
Very strong ______
Moderately strong ______
Slightly strong ______
Neither strong nor weak ______
Slightly weak ______
Moderately weak ______
Very weak ______
Extremely weak/no bitter taste ______

When you are finished, hit "Next". Pass your tray through the slot to receive your next sample. Rinse your mouth with water, take a bite of cracker, and rinse your mouth again.

You are done tasting all the samples.

Please take a moment to answer a few questions related to interest in future related and approved studies (IRB 12-1100 and 13-244).

Future Study 1 (IRB 12-1100): This study requires approximately 15 minutes at each session (2 total sessions over the course of two separate days). At each session, participants will taste basic taste (sweet, sour, salty, bitter) solutions in water and answer some questions relating to the taste perception. Participants will be video-recorded during the session. Participants will be invited to participate based on availability, today's experience, and interest as noted below. Participants will be rewarded per session with a $2 gift card (Kroger, Panera, or other local store), snacks, as well as canned foods (total value about $5). Participants 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.

- o I am interesting in participating.
- o I am not interested in participating.

Future Study 2 (IRB 13-244): This study requires approximately 40 minutes per day (2 sessions per day; may be done sequentially). Each participant will be expected to participate in up to 8 sessions (4 days). At the first session on each day, participants will taste sweet cold tea (no ice) and asked to evaluate the tea. Participants will be video-recorded during the session. In the second session on each day, participants will complete additional information-surveys and evaluations about product use and personal response to the product. Participants are invited to participate based on availability, today's experience, and interest as noted below. Participants will be rewarded per session with a

$2 gift card (Kroger, Panera, or other local store), snacks, as well as canned foods (total value about $5). Participants can keep the gift card and snacks and may keep or choose to donate the canned food, to the Montgomery County Emergency Assistance Program.

- I am interested in participating.
- I am not interested in participating.

You may conclude the test (touch “finished”). Please pass your tray through the slot.

Thank you for your participation. Please exit the lab and go to the incentives table to sign for and collect your gift card and other incentives as compensation for your participation.

APPENDIX C

Application of the Theory of Planned Behavior to Elucidate Student Reusable Water Bottle Use on a College Campus **–AND–** Assessment of Drinking Water Quality and User Perceptions between Filling Stations and Water Fountains on a College Campus: A Mixed Methods Approach

C.1 Approval Letter

VirginiaTech

Office of Research Compliance
Institutional Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE:	October 29, 2015
TO:	Susan E Duncan, Courtney Alissa Crist, Diana Opal Woodrum, Kayla Moberg, Taylor Duncan, Lily L Yang, Matthew W Schroeder
FROM:	Virginia Tech Institutional Review Board (FWA00000572, expires July 29, 2020)
PROTOCOL TITLE:	Influence of water delivery sources, motivation, and perception on water consumption using the Theory of Planned Behavior
IRB NUMBER:	**15-031**

Effective October 29, 2015, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

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

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

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

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

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

PROTOCOL INFORMATION:

Approved As:	**Expedited, under 45 CFR 46.110 category(ies) 6,7**
Protocol Approval Date:	**July 6, 2015**
Protocol Expiration Date:	**July 5, 2016**
Continuing Review Due Date*:	**June 21, 2016**

*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

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

C.2 Informed Consent Form

IRB Approval Date: Participant ID number:
IRB Approval Number:

Virginia Polytechnic Institute and State University

Informed Consent for Participants in Research Projects Involving Human Subjects (*Focus Groups*)

Title Project: Influence of water delivery sources, motivation, and perception on water consumption using the Theory of Planned Behavior

Investigators: Courtney Crist, Susan E. Duncan, Matt Schroeder, Lily Yang, Kayla Moberg, Taylor Duncan, Diana Woodrum

I. Purpose of this Research/Project
You are invited to participate in a focus group study intended to elucidate and understand the behavior behind consumer's use of reusable water bottles and water filling stations on campus. Participation and successful completion of the survey and responses from candidates will assist in collecting data on use and perception of reusuable water bottles and water delivery sources.

II. Procedures
Initially you will be asked your interest in participating again upon arrival. The researcher will go through the informed consent in person and you will have the opportunity to read over the informed consent prior to study start. Sessions will be audio recorded. After consent, participants will be asked to complete a beverage emotional questionnaire (EsSense Profile Ballot) prior to starting the focus group (15-20 min). The focus group itself will last 60 – 120 minutes. Participants will be asked a series of questions regarding personal reusable water bottle use and water filling stations on campus. Specifically, the objective of the study is to determine the attitudes, subjective norms, perceived behavioral control and intention to explain behavior associated with water consumption and water delivery sources on campus using a focus group script rooted in The Theory of Planned Behavior. The script questions include use of filling stations, reusable water bottles, water availability on campus, perceived barriers, opinions of solutions, sugar sweetened beverage (SSB) intake and obesity prevalence in college

III. Risks
There are no more than minimal risks for participating in this study. Some individuals may be uncomfortable about being audio recorded in the focus group session.

IV. Benefits
Your participation in this study will provide valuable information about consumer usage of reusable water bottles, influence on water intake and use of water filling stations. This information will be useful in determining ways to inspire consumers to consume water for health.

Virginia Tech Institutional Review Board Project No. 15-031
Approved October 29, 2015 to July 5, 2016

V. Extent of Anonymity and Confidentiality
The results of your performance as a participant will be kept strictly confidential except to the investigators. Individual panelists will be referred to by a code number and/or pseudonyms for data analyses and for any publication of the results.

Collected audio files may be used for educational, research (research publications, research presentations, research videos, research audios) and demonstration purposes including promotion or marketing videos and audios about this sensory or health application. These circumstances will maintain confidentiality, use of code number and/or pseudonyms to prevent identifying information given by participants.

VI. Compensation
Upon completion of the session, you will be compensated with snacks and a $10 gift card. 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 are not a student (undergraduate) 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:

- Answer questions fully and to the best of your knowledge.
- Willing to have session audio recorded.

IRB Approval Date: Participant ID number:
IRB Approval Number:

IX. Subject's Permission and Audio 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 audio recording associated with my participation for educational, research, and/or demonstration purposes. I waive any audio rights of compensation or ownership thereto. I acknowledge that my confidentiality will be maintained and no identifying information will be released should my statements in the focus group be used. There is no time limit on the validity of this audio release nor is there any geographic specification of where these materials may be distributed. This release applies to audio footage collected as part of the sensory sessions associated with the identified IRB study # listed on this document:

Date ____________________

Subject Signature____

Subject Printed Name _______________________________________

Virginia Tech Institutional Review Board Project No. 15-031
Approved October 29, 2015 to July 5, 2016

IRB Approval Date: Participant ID number:
IRB Approval Number:

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

Should I have any pertinent questions about this *research or the study*. I may contact:

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

Courtney Crist cacrist@vt.edu

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

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

Virginia Tech Institutional Review Board Project No. 15-031
Approved October 29, 2015 to July 5, 2016

C.3 Pre-Screening Survey

<u>Influence of water delivery sources, motivation, and perception on water consumption using the Theory of Planned Behavior: Recruitment Survey</u>

Your participation in this survey infers informed consent in future use of this data for research information related to a research study, IRB NUMBER: 15-031.

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 participants for a research focus group study in the Food Science and Technology (FST) Sensory Laboratory or in a HABB1 seminar room. This study is to assess potential candidates for invitation to a study of usage of reusable water bottles and water delivery sources on campus. The questions in this survey are grouped based on identifying

- interest in and availability for participating in the study
- use of products that relate to the research question
- personal characteristics and usage that influence data collection (i.e. reusable water bottle usage)

Panelists will be rewarded for their participation with reward stamp towards a $10 gift card (Kroger) and snacks (total of about $12). Panelists can keep the snacks and upon completion received the gift card.

The sensory study will be completed in the Food Science and Technology Sensory laboratory or other seminar room located in HABB1 on campus at the corner of Duckpond Dr. and Washington St.

Interest In and Availability for Participating in Preliminary Study

Availability: During the next 3 weeks, are you routinely available for at least 1 hour to 2 hours, 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.

- o Monday November 2, 8:00 am-10:00 am
- o Monday November 2, 9:00 am-11:00 am
- o Monday November 2, 10:00 am-12:00 pm
- o Monday November 2, 11:00 am-1:00 pm
- o Monday November 2, 12:00 pm-2:00 pm
- o Monday November 2, 1:00 pm-3:00 pm
- o Monday November 2, 2:00 pm-4:00 pm
- o Monday November 2, 3:00 pm-5:00 pm
- o Monday November 2, 4:00 pm-6:00 pm
- o Monday November 2, 5:00 pm-7:00 pm
- o Monday November 2, 6:00 pm-8:00 pm

- Tuesday November 3, 8:00 am-10:00 am
- Tuesday November 3, 9:00 am-11:00 am
- Tuesday November 3, 10:00 am-12:00 pm
- Tuesday November 3, 11:00 am-1:00 pm
- Tuesday November 3, 12:00 pm-2:00 pm
- Tuesday November 3, 1:00 pm-3:00 pm
- Tuesday November 3, 2:00 pm-4:00 pm
- Tuesday November 3, 3:00 pm-5:00 pm
- Tuesday November 3, 4:00 pm-6:00 pm
- Tuesday November 3, 5:00 pm-7:00 pm
- Tuesday November 3, 6:00 pm-8:00 pm
- Wednesday November 4, 8:00 am-10:00 am
- Wednesday November 4, 9:00 am-11:00 am
- Wednesday November 4, 10:00 am-12:00 pm
- Wednesday November 4, 11:00 am-1:00 pm
- Wednesday November 4, 12:00 pm-2:00 pm
- Wednesday November 4, 1:00 pm-3:00 pm
- Wednesday November 4, 2:00 pm-4:00 pm
- Wednesday November 4, 3:00 pm-5:00 pm
- Wednesday November 4, 4:00 pm-6:00 pm
- Wednesday November 4, 5:00 pm-7:00 pm
- Wednesday November 4, 6:00 pm-8:00 pm
- Other:

Study information: This is a study requiring approximately 1 hour-to-2 hours of time. Participants will participate and be asked questions regarding their use of reusable water bottles and water delivery sources (i.e. water fountains, tap water, water filling stations) on campus. During the study, panelists will be audio recorded. Collected audios may be used for educational, research (research publications, research presentations, research videos) and/or demonstration purposes. The personal information and performance related to audios 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 carry a reusable water bottle?

Yes:

No:

Other
(Explain):

Do you use the water filling stations on campus:
Yes
No
Other
(Explain):

Do you have a preference about where you refill your reusable water bottle?
Yes
No
Other
(Explain):

Is there a reason you carry a reusable bottle?
Yes
No
Other
(Explain):

Do you think your water intake and other beverage intake is influenced by carrying a reusable water bottle?
Yes
No
Other
Explain:

Does water taste different from different sources?
Yes (Please explain)
No (Please explain)
Other (Please explain)

Do you have a personal attachment to your reusable water bottle?
Yes (Please explain)
No (Please explain)
Other (Please explain)

What is your age?

What is your year in college?

What is your gender?

Thank you for your participation!

C.4 Participant Demographic Form

Are you an undergraduate?

Circle one: Commuter   or   Resident

What is your age?

What is your gender?

Do you carry a reusable water bottle on a regular basis?

C.5 Emotional Ballot Check-All-That-Apply (CATA) (Modified EsSense Profile)

Picture ________________

Please look through the pictures in the folder and check the emotion term(s) that you associate with the picture.

○ Active	○ Enthusiastic	○ Peaceful
○ Adventurous	○ Free	○ Pleasant
○ Affectionate	○ Friendly	○ Pleased
○ Aggressive	○ Glad	○ Polite
○ Angry	○ Good	○ Quiet
○ Annoyed	○ Good-natured	○ Sad
○ Bored	○ Guilty	○ Satisfied
○ Calm	○ Happy	○ Scared
○ Daring	○ Interested	○ Secure
○ Discouraged	○ Irritated	○ Steady
○ Disgusted	○ Mild	○ Surprised
○ Eager	○ Nervous	○ Tender
○ Energetic	○ Nostalgic	○ Worried

Circle one: Do you use this for drinking water? Yes No

Comments:

If yes, is this your predominant source for drinking water? Yes No

Comments:

Do you have any other thoughts or feelings associated with the source?

[a]King, S.C, & Meiselman, H.L. (2010). Development of a method to measure consumer emotions associated with foods. *Food Quality and Preference, 21*, 168 – 177.

[b]King, S.C, Meiselman, H.L., & Carr, B.T. (2010). Measuring emotions associated with foods in consumer testing. *Food Quality and Preference, 21*, 114-116.

C.6 Pictures used for the Emotional Ballot

5

C.7 Focus Group Script

	Focus Group Script [a,b,c]
	Hello, my name is Courtney. I am a current student at Virginia Tech and I would really appreciate your help today in teaching me about your attitudes and beliefs about water, water sources, and water consumption, especially if you have a strong preference or opinion. We are interested in developing material and infrastructure to encourage water consumption. Any feedback is welcome and appreciated to this project.
TPB Type	**Opening Questions**
	To begin, I would like you to look at the screen in front. Please look at the picture of the water delivery source and complete the EsSense Ballot and associated questions. Please specify the ones you most commonly retrieve water for consumption. Please add any sources not shown that you consume water from. Also, please take time to write down any feelings, thoughts or draw any pictures that come to mind when thinking about these sources.
Attitude	I would like to start with introductions. Let's go around the table, say your name and tell us about your opinions about the pictures you circled, why you use them and how often.
Attitude	Tell me about the feelings or thoughts that you associated with these water sources.
Perceived Behavioral Control	Tell me what influences your water choices. [Probe] Why do you drink from these sources?
Attitude/Behavior	Let's specifically focus on your weekday habits. Reflect on how much water you consume and where this water comes from. What influences your decisions to drink water throughout the day starting from in the morning until you go to sleep? [Probe] Specific times of the day.
Perceived Behavioral Control	If you wanted to change the drinks you consume on a weekday, tell me what would make that hard.
Perceived Behavioral Control	If you wanted to change the drinks you consume on a weekday, tell me what would make that easy.
Attitude/Behavior	Tell me about your beverage habits on the weekends. [Probe] for differences and/or similarities between

	weekdays and weekends.
Perceived behavioral control	If you wanted to use or access certain water sources, what makes that hard.
Perceived behavioral control	If you wanted to use or access certain water sources, what makes that easy.
	Friends and Family
	Now, take out the other sheet of beverage pictures. Then, I want you to circle the sources that your family and friends drink from most often. You can think about your children, your spouse, you co-workers, and/or your friends. Again, you can add any beverages that are not shown on the paper and you please write down any feelings or thought and draw pictures that come to mind when thinking of these drinks."
Subjective Norms	Now we are going to go around the table again and I want you to introduce the group to one or a few of your family and/or friends, and tell us about the water sources your family and friends drink most often. [PROBE] What about any feelings or thoughts associated with the water sources that your family and friends are drinking from.
Attitude	Do you think water is healthy? Why do you think water is 'healthful'; how does it compare to other beverages?
Attitude (indirect-behavioral belief)	When people think of healthy and safe water which sources come to mind? [Probe] What makes these better?
Attitude (indirect-behavioral belief)	When people think of unhealthy sources, which ones come to mind? [Probe] What makes these unhealthy in your opinion?
Attitude	Let's talk again about the sources viewed as being "healthy". Talk to me about how being labeled "healthy" impacts the amount that is being consumed?
Attitude	Let's talk again about the sources viewed as being "unhealthy". Talk to me about how being labeled "unhealthy" impacts the amount that is being consumed?
Subjective Norms	Tell me why it is or is not important to drink from these sources as your friends and family.
	Water – Specific Questions
	Now, let us talk specifically about water and

	beverages on campus.
Attitude	Tell me about the good things associated with water sources on campus.
	Tell me about the bad things associated with water sources on campus.
	Can you talk to me specifically about the differences between drinking city water, well water and bottled water?
	What positive things come to mind when you think of each water source, city water, well water and bottled water?
	What negative things come to mind when you think of each water source, city water, well water and bottled water?
	Tell me about the decisions you make when selecting a source of water on campus.
	Tell me about the decisions you make when you are selecting beverages to drink on campus including water, coffee, SSB, etc.
Subjective Norms	Health professionals recommend that people to drink 5-8 cups of water per day. [SHOW PARTICPANTS BEVERAGE MODELS TO INDICATE 5-8 CUPS]
Subjective Norms (Motivation to comply)	Tell me how you feel about this recommendation. [Probe] Do you currently meet this recommendation?] [Probe] If so, what makes it easy for you to drink this amount now? [Probe] If not, what prevents you from drinking this amount?]
Behavioral Intention	Now I want you to tell me about your intentions to meet the drink recommendation of 5-8 cups of water per day in the next month. We are going to go around the table again and if you have no plans to meet this recommendation, why not; and if you do plan to meet this recommendation, why.
Perceived behavioral control	For one moment, let's pretend that you all decided you really wanted to meet this recommendation to drink 5-8 cups of water per day, what would your plan look like?
Perceived behavioral control	What would you and/or your friends need to help meet this recommendation for water? [Probe] for more details.
Implementation intentions	If you intend to increase your intake, what does your plan look like? When, where and what water sources would you used to meet this? If you already meet the daily intake, what will you do to sustain it?

Perceived behavioral control	What makes it easy to drink water per day?
	What makes it hard to drink water per day?
	What makes it easy to drink water per day?
Perceived behavioral control	What would it take for someone to convince you and/or your family and friends that it is important to drink 5-8 cups of water each day?
	Environmental
	Where do you learn about the benefits or harmful effects of certain drinks?
	Who influences the types of drinks you purchase? [Probe] Any family members or friends in your social networks?
	I want you to think about media advertisements on the TV or magazines, talk to me about if these ads influence your drink choices.
	What would motivate you to drink more water?
	What kind of information, graphics, or technology would draw your attention to water refill stations?
	What kind of information, graphics, or technology would draw your attention to increase your water consumption?

[a]Zoellner, J., Estabrooks, P. A., Davy, B. M., Chun, Y., & You, W. (2012). Exploring the theory of planned behavior to explain sugar-sweetened beverage consumption. *Journal of Nutrition Education and Behavior*, *44*, 172-177.

[b]Zoellner, J., Krzeski, E., Harden, S., Cook, E., Allen, K., & Estabrooks, P. A. (2012). Qualitative application of the theory of planned behavior to understand beverage consumption behaviors among adults. *Journal of the Academy of Nutrition and Dietetics*, *112*(11), 1774-1784.

[c] Krzeski, E. (2011). Using the theory of planned behavior to understand drink choices in southwest virginians (Master's thesis). Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

C.8 Assessment rubric [a,b] to evaluate the water delivery sources upon sampling

Delivery	Type	Characteristic	Possible Answers
Water Filling Station Water Fountain	Hygiene	Visible Debris	1 (excessive), 2, 3, 4 (none)
		Cleanliness	1 (poor), 2 (fair), 3 (good), 4 (excellent)
	Water Acceptability	Water Turbidity	1 (turbid), 2 (fair), 3 (good), 4 (clear)
		Water Odor	1 (pungent, off), 2, 3, 4 (none)
		Water Color	1 (brown), 2, 3, 4 (clear)
		Water Flavor	1 (poor flavor), 2 (fair), 3 (good), 4 (excellent flavor)
		Overall Quality of Water	1 (poor quality), 2 (fair), 3 (good), 4 (excellent quality)
		Other comments	

[a]University of California –Berkeley, University Health Services Department. (n.d.). Water Fountain Assessment. Retrieved from https://uhs.berkeley.edu/facstaff/healthmatters/watercoolerconversion/WaterFountainAssessment.pdf

[b] Patel, A. I., Chandran, K., Hampton, K. E., Hecht, K., Grumbach, J. M., Kimura, A. T., Braff-Guajardo, E., & Brindis, C. D. (2012). Observations of drinking water access in school food service areas before implementation of federal and state school water policy, California, 2011. Prevention Chronic Disease: Public Health Research, Practice and Policy, 9, e121.