COMPARISON OF THE HEDONIC GENERAL LABELED MAGNITUDE SCALE TO THE HEDONIC 9-POINT SCALE

By

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To my parents and family who nurtured me in achieving this honorable milestone

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EVALUATION AND COMPARISON OF HEDONIC GLMS TO THE
HEDONIC 9-POINT SCALE

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Consumer acceptability can be measured in various ways using different scales, but currently, the most common scale used by the majority of food scientists is the hedonic 9-point scale. The hedonic 9-point scale is a useful tool to measure overall liking of food, but this scale may not provide valid across-group comparisons. The hedonic general Labeled Magnitude Scale (gLMS) ranging from -100 to 100, with -100 being "strongest imaginable disliking of any kind", zero being "neutral", and 100 being "strongest imaginable liking of any kind" may provide more valid comparisons of products across different groups. The main objective of this study is to compare the hedonic gLMS scale with the hedonic 9-point scale.

The first study tested both scales by asking panelists to rate the overall liking of different food products from memory and after tasting and experiences. The second study compared the two scales by using panelists who answered questions asked about the overall liking of food products from memory (including their favorite and least favorite foods), food tasted, and the intensity of different taste solutions (salty, sour, sweet, bitter).

The results were analyzed using SAS to perform analysis of variance between groups and calculate correlation coefficients. Panelists were grouped into three groups; gender, foodie type,

and quinine taster. Foodie type consisted of “foodies” or “nonfoodies” if the difference between their favorite and least favorite food ratings were above or below the mean, respectively. Panelist who rated the bitterness of the quinine solution above or below the mean were considered “high” or “low” quinine tasters.

The results showed the hedonic gLMS provided many correlations between acceptability ratings that the hedonic 9-point scale failed to show. The hedonic gLMS also performed better in identifying the significant correlations for food acceptability ratings in reference to taste intensities. The hedonic gLMS also showed more significant differences when analysis of variance was used, such as showing a difference across the three groups as well as within groups. These results lead to the conclusion that the hedonic gLMS provides more detailed results about food acceptability across and within groups than the hedonic 9-point scale.

CHAPTER 1
INTRODUCTION

Sensory evaluation measures panelists' responses to food products, and is therefore a integral part of food product development. Measuring human responses to products allows food companies to gain a better knowledge about the perception of consumers before placing the product on the market to be sold worldwide (Sidel and others 1981). In the food industry, "there are about 87,700 new products being developed for market every year competing against the 40,000 products that are on the market shelves today (Mintel 2009)." Once a new product is created, developers want to know if their creation will become successful in the market.

Consumer sensory tests, whereby consumers actually taste and rate product selections, are a useful tool to determine consumer preferences and acceptability. There are many possibilities where a company can use sensory evaluation to their advantage. They can use it to check product quality, packaging functionality, product characteristics, etc… Companies are feeling the increased need and importance of sensory evaluation (Stone and Sidel 2004). The pressure of the consumer awareness of food safety, the importance of flavor and the use of product characteristics in advertising their products all rely on sensory evaluation (Amerine and others 1965).

Researchers also conduct a myriad of sensory tests to compare different ingredients, range of flavors, textures, and tastes. Consumer "acceptability" can be measured in various ways using different scales, but currently, the most common scale used by most food scientists is the 9-point hedonic scale (Villanueva and others 2005).

During the 1950s, at the Quartermaster Food and Container Institute of the Armed Forces, Chicago, Illinois, a team of scientists developed the hedonic 9-point scale. They used soldiers as their subjects to test different word descriptors and scale types to determine the best scale to use for food acceptance (Meiselman and Schutz 2003). The hedonic 9-point scale is a scale that measures pleasure or displeasure (Bartoshuk and others 2005). Consisting of adjectives correlating to a number, the number range covers numbers one through nine with one being “dislike extremely,” five being “neither like nor dislike,” and nine being “like extremely.” Panelists are instructed to rate the sample according to how they feel about the sample. The data is then collected and analyzed. Statistical results from the analysis of the variance test show whether there are differences in likeability among different samples.

The hedonic 9-point scale is a useful tool to have for any examiner of food preference or overall liking of food. The scale is easy for the panelist to understand and use. The scale is self explanatory with little instructions from the moderator of the test (Lawless and Heymann 1998). This scale is also very versatile allowing a company to use this scale to answer question about new products, product matching, product improvement, process change, cost reduction and/or selection of a new source of supply, storage stability, and consumer acceptance and/or opinions (Lawless and Heymann 1998).

However, there are some weaknesses to this scale. This scale makes false assumptions, registering variable results, and does not take into account gender or cultural background (Cox and others 2001). For example, if an American taster rated an eight (meaning “like very much”) and a European taster rated a six (meaning “like slightly”), this rating seems to suggest a difference. How does one actually know? There are a lot of factors that play a role in tasting that this scale cannot account for, resulting in inconclusive data (Villanueva and others 2005).

Even though the hedonic 9-point scale provides very useful information about a product, there are flaws when it comes to any lasting results about across-group comparisons. Panelists may use the same descriptors or rating in different meanings; for example, not everyone has the same opinion as to what “moderate” likeability really represents. This fault is very important in the new findings from Dr. Bartoshuk, a psychophysics psychologist and researcher, who found that people have genetically developed into classes of tasters, whereby their taste receptors are different (Bartoshuk and others 1995). She has found that there are three groups of tasters: supertasters who experience the most intense taste sensations, medium tasters who perceive intermediate taste intensities and nontasters, who perceive the weakest taste intensities (Bartoshuk and others 2004b). Supertasting was first discovered using the bitter compound 6-*n*-propylthiouracil (PROP). The ability to taste PROP is controlled by a single gene (TAS2R38) located on chromosome 7. An individual with either one or both dominant alleles for the PROP gene is a PROP taster; an individual with both recessive alleles is a PROP nontaster. It is known that supertasters tend to have the largest number of fungiform papillae (structures that house taste buds). Thus supertasters of PROP have two characteristics: they are genetic tasters of PROP and also have the highest density of fungiform papillae (Bartoshuk and others 1995). Historically, PROP tasters and nontasters represented the first discovery of genetic diversity in human taste; out of respect for that discovery, we maintain the terminology “tasters,” but modify it appropriately (e.g., “supertasters” to refer to individuals who taste all tastes as more intense, “PROP supertasters” to refer to those who taste PROP to be the most bitter, etc.).

In sum, supertasters taste bitterness, saltiness, sweetness and sourness in stronger intensities than others (Bartoshuk and others 1998). Since people cannot directly share sensory or hedonic experiences, supertasters do not realize that they experience the most intense taste sensations. Using scales like the hedonic 9-point sensory scale leads to errors since each group (supertasters, medium tasters, nontasters) use “extremely strong” to refer to taste intensities. Yet the experiences each of these three groups perceives as “extremely strong” are very different:

"extremely strong" denotes taste intensities 2-3 times as strong for supertasters as for nontasters. These different sensory experiences result in different hedonic experiences.

As a result, a scale is needed that gives accurate results amongst across-group comparisons, captures their true rating of supertasters, and correctly represents gender and cultural differences. Magnitude Matching is the "gold standard" for providing accurate comparison across-groups (Bartoshuk and others 2004b, Marks and Bartoshuk 1979). Magnitude Matching is the process by which subjects compare sensory or hedonic intensities of different types on a common scale.

A scale which permits magnitude matching is the general Labeled Magnitude Scale (gLMS). This scale varies from zero to 100 with zero being "no sensation" and 100 being "strongest sensation of any kind imaginable (Bartoshuk and others 2003)." This scale worked for measuring intensities but needed to be altered to collect data for hedonics.

The hedonic general Labeled Magnitude Scale (hedonic gLMS) ranges from -100 to 100 with -100 being "most intense disliking of any kind", zero being "neutral", and 100 being "most intense liking of any kind" was derived from the gLMS. The key property of the hedonic gLMS is that it assesses liking for food in the context of all hedonic experiences (i.e., pleasure). If successful, it could have widespread beneficial applications. For example, this scale should allow supertasters to rate the liking of a food product without the ceiling effects which occurs with the hedonic 9-point scale. This ceiling effect causes the supertasters and nontaster's ratings to be so clustered together significant differences can not be seen. The scale may be a better predictor of success of new products and may provide a better "absolute likeability" of products across different groups.

The main objective of this study is to compare and evaluate the hedonic gLMS scale with the hedonic 9-point scale. In theory, most scales can provide valid within-subject comparisons because each subject experiences each of the stimuli to be compared. Thus correlations obtained with either the hedonic 9-point or the hedonic gLMS should be valid correlations. However, because the hedonic gLMS lacks the ceiling effects common in the hedonic 9-point scale, we may see more significant within-subject correlations with the hedonic gLMS.

However, we predict a different outcome when comparing the hedonic 9-point scale with the hedonic gLMS in terms of comparisons across groups (gender, age, cultural background, etc…). The hedonic gLMS should provide valid comparisons across groups while the hedonic 9-point scale may not. The adjective labels of the hedonic 9-point scale may denote different hedonic meaning to different groups and the real differences may fail to be revealed.

The strategy of this study was to select different groupings in order to see if the hedonic 9-point scale will fail to detect differences for some of them. The groupings under study are: sex, foodie type, and quinine tasters (in this experiment quinine tasters will represent supertasting). One expects the greatest difference between the scales for the supertasting grouping. Previous work has already revealed large differences (sensory and hedonic) between supertasters, medium tasters and nontasters (Bartoshuk and others 1998).

It has been theorized that the hedonic gLMS scale will provide better data in comparing consumer likeability towards products. Our hypothesis is that this scale will provide more “across-group comparisons.” The objective will be to compare the two scales using panelists to rate overall liking on different food products from memory and after tasting to see which scale provides more results.

CHAPTER 2
LITERATURE REVIEW

2.1 Taste and Odor Perception

Physical senses, i.e. smell, touch, sight, sound, and taste, not only allow humans to protect themselves from danger, but also allow for pleasures in life. Particularly, smell and taste allow humans to protect themselves from smoke, ingesting toxins, and enjoy the flavors and aromas of food consumption (Nelson 1998). The human gustatory system and olfactory system while not crucial for sustaining human life, serve as an important detection device.

The olfactory system is comprised of olfactory neuroepithelial cells in each nasal chamber which have pseudostratified neuroepithelium cells connected to olfactory receptors. When air containing a volatile compound passes through these ciliated skin cells, the neurons in the cells stimulate the olfactory receptors located in the glomerular structure of the olfactory bulb (Lawless and Heymann 1998). The brain then translates the information, identifying the smell.

There are two ways volatile compounds stimulate the olfactory receptors, “retronasal” or “orthonasal.” Retronasal is when a volatile is in the mouth and travels up into the nasopharynx to the olfactory receptors, whereas orthonasal is when the volatile is sniffed through the nostrils and contacts the olfactory receptors via the nasal passages (Lawless and Heymann 1998).

The gustatory system is comprised of taste buds, which are clusters of receptor cells. Taste buds are buried in the tissue of three types of papillae: fungiform, foliate and circumvallate. Taste receptor sites are located on extensions (called cilia) of the tops of some of the receptor cells; taste nerve fibers synapse with the bases of some of the receptor cells. Taste information is transmitted to the brain by way of the taste nerve fibers.

Fungiform papillae are located on the anterior two thirds of the tongue; cirumvallate papillae are located on the posterior two thirds of the tongue; foliate papilla are on the side boarders of the tongue; and a fourth type, filliform papilla do not contain any taste buds (Leopold and others 2006).

The chorda tympani nerve which innervates the fungiform papillae passes through the middle ear behind the eardrum (Lawless and Heymann 1998). The glossopharyngeal nerve attach to the rear of the tongue while the vagus nerve goes to the posterior root of the tongue. The fourth nerve, the greater superficial petrosal, connects to the palatal taste area (Lawless and Heymann 1998).

2.2 Genetic Variability

There is a great deal of genetic variability among individuals for taste and olfaction. Certain tastes and taste experiences are “hardwired” into the human brain upon birth to protect humans from dangerous material. For instance, inborn aversion to bitter taste helps to protect humans from eating poisons (Steiner 1977).

One important part of this genetic variability was discovered in mice. Some mice who tasted bitter much more intensely than others were found to have more taste buds (Miller and Whitney 1989). This led to the examination of humans to see if the number of taste buds associated with perceived taste intensities.

Bartoshuk has found that there are three groups of tasters; supertasters who experience the most intense taste sensations, medium tasters who perceive intermediate taste intensities, and non-tasters, who perceive the weakest taste intensities (Bartoshuk and others 2004b). In the United States, it has been reported that about 25, 50, and 25 percent of the population is a nontaster, medium taster, or supertaster, respectively (Bartoshuk and others 2004b). Supertasting was first discovered using the bitter compound 6-*n*-propylthiouracil (PROP). The ability to taste PROP is controlled by a single gene (TAS2R38) located on chromosome 7. An individual with either one or both dominant alleles for the PROP gene is a PROP taster; an individual with both recessive alleles is a PROP nontaster. It is now known that supertasters tend to have the largest number of fungiform papillae (structures that house taste buds). Thus supertasters of PROP have two characteristics: they are genetic tasters of PROP and also have the highest density of fungiform papillae (Bartoshuk and others 1995). Therefore, supertasters taste bitterness, saltiness, sweetness and sourness in stronger intensities than do others (Bartoshuk and others 1998).

Duffy found that tasters that have more papillae on their tongues have more of a dislike to alcohol (Duffy and others 2004). This is due to the fact that supertasters taste bitterness at a higher intensity than nontasters and alcohol tends to be bitter. Between the sexes, there are proportionally more women than men supertasters. Additionally, supertasters also taste caffeine as more bitter (Hall and others 1975) and taste salt as more saltier than nontasters (Bartoshuk and others 1998). On the other hand, nontasters do not taste the bitterness of saccharin and taste a lower level of sweetness from saccharin (Bartoshuk 1979). Since fungiform papillae are innervated by touch as well as taste fibers, supertasters report the viscosity of fats as thicker than nontasters (Duffy and others 1996).

Other taste differences that can occur in humans include ageusia, hypogeusia, and/or dysgeusia (taste loss, decrease in taste, abnormal taste) (Nelson 1998). Taste loss can occur from sickness or through normal body changes. Changes in hormones during pregnancy and menopause, or the growth of bacteria in poor dentition, and poor hygiene are common promoters of taste loss or taste change. Patients with certain diseases like Sjogren syndrome, zinc deficiency, and cancer may also experience taste changes due to the interactions of the medications prescribed to these patients. People who have experienced head trauma may also experience taste and olfactory losses (Nelson 1998). These people that experience taste change will also be affected by the way they perceive flavors and textures of foods. If varying degrees of saltiness, bitterness, sweetness, or sourness of a food product are perceived, this perception of taste may increase or decrease the acceptance level of a food product.

Humans perceive different flavors (garlic, chocolate, toasted, etc…) via nerve pathways from their olfaction system. If a person's sense of smell is lessened (hyposmia) or lost (anosmia), then their ability to distinguish flavors also is diminished or lost (Leopold and others 2006). All these genetic variabilities, olfaction conditions, and taste conditions play a role in testing a product. Sensory testing encompasses these conditions, compiles data and adjusts accordingly to record the most accurate perception of product acceptance.

2.3 Sensory Evaluation

Sensory evaluation measures panelists' responses to food products, and is therefore a viable part of the food industry. It encompasses perceived product characteristics, acceptability, quality, and product differences (Sidel and others 1981). Psychophysics, psychometrics, perception, learning, and cognition, sensory evaluation are valuable tools for food companies (Sidel and others 1981). Measuring human responses to products allows food companies to gain a better knowledge about the perception of consumers before placing the product on the market to be sold worldwide (Sidel and others 1981).

Sensory evaluation can be used in many ways by the food industry. For example, it allows companies to see how people perceive their products by knowing what attributes panelists like or dislike, as well as showing if panelist can tell a difference in a formula change (Lawless and Heymann 1998). There are many possibilities in which a company can use sensory evaluation to their advantage. They can use it to check product quality, packaging functionality, product characteristics, etc, and companies are increasingly using sensory evaluation (Stone and Sidel 2004). The pressure of the consumer awareness for food safety, the importance of flavor and the use of product characteristics in advertising their products, all rely on sensory evaluation (Amerine and others 1965).

2.3.1 History of Sensory Evaluation

Historically, the first category scale was a six point scale to rate the brightness of the stars which was created by the astronomer Hipparchus (190-120 BC). Primitive forms of sensory evaluation of food started when people began trading for different items (Meilgaard and others 1999). One would trade a food product to another and that person would inspect the product and purchase the product if the product met their quality criteria. In the 1900's, professional grades were used by industries to inspect products (Meilgaard and others 1999). Canning companies used "canning bees", employees who randomly opened cans daily to inspect the quality of the product and compare their own product with competitor's products (Hinreiner 1956). Many other food areas conducted the same sensory evaluations to evaluate their products. Methods of grading and scoring products evolved and started to become more scientific. Scorecards and number values were developed for different products to rate the level of the product's acceptance according to the values (Hinreiner 1956).

Since then, many scales have been created or improved for sensory evaluation. By 1945, WW II had ended and American soldiers returned home fueling an era of modern technologies, along with the start of the baby boomer generation. Due to this turn of historical events, mass food production increased, as well as the development of different food products. Because the demand for food companies' products increased, they wanted to give their customers the best product they could make. This led to the creation of the scientific method of sensory evaluation.

Sensory evaluation is "used to evoke, measure, analyze, and interpret responses to products" using all five human senses (Stone and Sidel 1993). "To evoke," guidelines are used for the application of the test in terms of preparation and serving of samples in controlled conditions (Lawless and Heymann 1998). These guidelines limit mishandling errors and keep the sample information confidential to the panelist. Samples are referred by code and panelists are seated in booths to limit distractions and to prevent others influences or body language to sway their opinion of the samples.

"To measure", techniques are used to collect data on sample to find panelists perception about the samples (Lawless and Heymann 1998). These techniques need to be followed and used in their intended manner in order to receive accurate data. Sensory panels can be separated into consumer panels or trained panels. Consumer panels test samples using people unfamiliar with the samples and who have no prior knowledge about the samples. Trained panels use panelists that have been instructed about the sample and are trained to evaluate certain attributes within the samples (Meiselman and Schutz 2003). "To analyze", data is complied and statistical analyses are performed to distinguish how the panelists perceived the samples (Lawless and Heymann 1998). Variability is a big concern due to human behavior. "To interpret" means conclusions will be made based on the quantitative data (Lawless and Heymann 1998). These conclusions will provide valuable information about the samples.

Sensory evaluation is very important to researchers, food companies, and consumers. It needs to be performed in a controlled, professional, and analytically measured environment. Sensory evaluation tests need to minimize variance error to provide the most accurate data in order to record the "true" response of the testing population.

2.3.2 Methods

Sensory evaluation has many different tests to accomplish various objectives, and using the correct test is very important. There is no one sensory test that will give all the answers (Stone and Sidel 2004). Relying on one method could cause greater damage and provide incorrect results in which the company may not realize at the time (Pangborn 1979).

When choosing a method to use for a test, some criteria need to be followed in order for the panelist to understand the task they will perform. The written and verbal instructions must be written in concise and clear terms that the panelists are familiar with and able to understand. The test needs to be easy for the panelists to use and sections of the test should flow so the panelist is not overwhelmed and loss of interest occurs (Stone and Sidel 2004). Tests should include unbiased scales not to sway the panelist's conclusion. Scales used in the test should be used for their intended purpose, as well as, to be able to pick out differences in order to acquire accurate data (Stone and Sidel 2004). The classification of sensory evaluation is divided into three types of tests; discrimination, descriptive, and affective.

Discrimination testing is used to tell if one product is different from another in any way as compared to the reference sample or other sample (Lawless and Heymann 1998). This test is used to determine if there is a perceived difference amongst samples from the panelists and if a difference is detected, another type of test could be done to determine the exact differences. Discrimination tests are used to minimize the failure rate of the introduction of a new product formulation. The test guides the panelist to make a concrete choice choosing one sample over the other. The analysis is then computed using the proportions of right and wrong answers.

The test that is mainly used in this type of testing is called the triangle test (Sidel and others 1981). Developed by Bengtsson and co-workers to evaluate beer (Helm and Trolle 1946), the test was meant to improve directional paired testing methods. The panelist is given two samples that are the same and one sample that is different. The panelist is instructed to distinguish the different sample. When panelists taste the third sample, they need to remember the characteristics of the previous two samples in order to determine the different sample (Stone and Sidel 1985). Panelists only have a 0.33 chance of guessing the correct sample which provides this test with a higher sensitivity than other tests (Stone and Sidel 2004). Fewer correct scores than other discrimination tests are needed from panelists to be significantly different which also strengthens the sensitivity of the test.

Another discrimination test that is commonly used is called the duo-trio test, developed in 1950 by Peryam and Swartz. This test is used for samples with strong odor or taste (Stone and Sidel 2004). The panelist is given two samples with a reference sample. The panelist is instructed to pick out the sample that tastes the same as the reference sample (Lawless and Heymann 1998). The main goal of this test is to try to strengthen the reference sample and increase detection of the different sample in order to pick out the smallest changes. This test's drawback is that a panelist could guess the right answer because there is a 50:50 chance; however this test is an easy way to check if there is a sensory difference between two samples (Meilgaard and others 1999).

A third discrimination test used is called the paired-comparison test. The panelists are given two samples to compare to each other. They are directed to determine the one with a specific characteristic (sweetness, saltiness, tenderness, etc…) in which the researcher is trying to find out (Stone and Sidel 1985). This test tests the panelist's ability to tell the difference amongst the sample and confirm the difference amongst samples. Because there is a 50:50 chance of picking out the different sample, researchers can not be too confident in the results because the panelist could have guessed incorrectly or could have understood the determine characteristic incorrectly. Due to the variability of panelist tasting abilities, this test is not used very often.

These tests are used by companies to see if a panelist can detect the difference in a new variation of their product. The company may have changed ingredient sources or used a new ingredient that was cheaper in the new product. If the panelist can tell the difference, the company might have to change the formulation of their new product (Stone and Sidel 2004).

Due to the nature of discrimination testing, the test provides many options in which to proceed to the next step in determining if consumers would like the new product. These tests do not tell the researchers if the panelists like the new formulation or not. Many times discrimination tests are combined with preference questions which will disrupt the results (Stone and Sidel 1978). When a difference is determined, the statistical significances maybe misinterpreted. Discrimination tests also need the correct number of panelists, too many or too few will change the statistical results.

Descriptive tests measure the intensities of sensory properties in a sample. This type of testing provides a great deal of information about a sample and is widely used for intentional or unintentional product changes (Lawless and Heymann 1998). These tests provide information about differences, similarities, and help in determining attributes that are important (Stone and Sidel 2004). These results help in determining product characteristics that are very important when using acceptance testing, primarily because "they break down a product into specific process variables and sensory characteristics of flavor, texture, aroma, color, etc… and describe the level at which these characteristics are found in the product (Stone and Sidel 1985)."

This type of test uses a trained panel that describes the different characteristics on the sample and notes the intensities of those characteristics (Sidel and others 1981). This method provides a larger amount of data on the different characteristics of the product instead of relying on the results of one person. Trained panel members are used in Flavor Profile®, Texture Profile®, and Quantitative Descriptive Analysis®.

Flavor Profile® is a qualitative description which evaluates products flavor interactions. This test was developed in the late 1940s by Arthur D. Little Incorporated (Meilgaard and others 1999). The process uses four to six screened and trained panelists to describe the flavor profile of the sample. This panel is done in an open session with a moderator leading the discussion attributes of the sample. After conclusions have been made, the moderator creates the file profile report. Panelists go through strict intensive training in which they are selected based on their availability, interest, and sensory accuracy to basic taste and odors to standards. Since there is a moderator leading the panel, this leader could possibly sway the panel to describe flavors he or she identifies. The results from these panels are quickly produced.

Similar to the Flavor Profile® test, the Texture Profile® evaluates the texture of components of food samples. The evaluation was developed at the General Foods Research Center (Brandt, Skinner and Coleman 1963), classifying textural characteristics by fat, moisture, geometrical, and mechanical attributes. The textural analysis begins at first bite and continues until complete mastication without any effects from other senses (Stone and Sidel 1985). These criteria are used so that data from these panels can be comparable to instrumental measurements by using a standardized rating scale for each texture attribute (Szczesniak 1963). A series of terms are used in each category with a specific rating scale to be used for that category. For example, hardness of the sample is described using the terms "soft, firm, and hard." The levels of these terms are rated on a scale using the hardness scale (Stone and Sidel 1985). As a result of having a specific scale for each texture category, the panel may forget or confuse the anchors of the scales. With so many attributes to consider defining the texture, panelists may feel sensory fatigue and ignore certain characteristics.

Another descriptive analysis approach is the Quantitative Descriptive Analysis (QDA®) (Stone and Sidel 1993) developed by the Tragon Company in the 1970s which analyzes the sample of all sensory characteristics. It is a method of quantifying the characteristics that shows a more precise description of the similarities and differences in a set of products (Stone and Sidel 1985). Six to ten panelists are trained according to references and evaluate samples (Meilgaard, Civille and Carr 1999). They describe and rate the level of specific characteristics including the appearance, aroma, flavor, and texture. This process is not limited to one product and provides rapid results. Results are presented from individual panelists, as well as, the panel of panelists requiring a replication of responses. This test uses a line scale which allows panelists to make accurate judgments, and data is analyzed using the Analysis of Variance (AOV) method. (Lawless and Heymann 1998). The results are displayed in a graphical form to see the levels of each characteristic.

This analysis was developed as a result of the growing importance of product development to provide competitive products throughout the market. Market researchers favor the results that are directly generated from the customer base because the characteristic descriptions produced provides them with advertising words. Comparing different formulations and processes can also be seen when during quality control checks (Stone and Sidel 1985).

The data gathered from descriptive tests are very helpful in determining changes in sensory characteristics when a change in the original formulation occurs (Stone and Sidel 1985). Product developers use this information to improve on future products. This information also helps with quality control in which researchers are able to detect the physical limitations of the product.

Affective hedonic testing shows if a panelist likes the sample or not (Lawless and Heymann 1998). Tests can compare two or more products to see which sample is preferred or to indicate the degree of acceptability. Results from statistical analyses from the AOV will also show which sample scored higher than another by the most people (Stone and Sidel 2004). However, affective testing does not provide information about price, advertising, market segmentation, or packaging (Cardello and others 2008). If a sample rates high in likeability on an affective test, this does not translate to a guarantee success in the market.

One type of affective hedonic testing involves preference tests. There are two types, the paired preference test and the preference ranking test. The paired preference test is used when two samples are compared to each other to see which sample panelists prefer. Panelists choose the sample they like the best (Lawless and Heymann 1998). This test is usually used when a company wants to compare their product to a competitor's product. The preference ranking test is also a forced choice test which makes the panelist rank their preference on several products in ascending or descending order (Lawless and Heymann 1998). A disadvantage to preference ranking test is that data on samples from two tests cannot be compared to each other. Neither test provides the researcher with information on the level of differences between the samples.

The hedonic 9-point scale is the most common scale used for affective testing. This test is easy for the panelist to understand and is does not require a lot of time to complete. Panelists rate a sample using numbers 1 thru 9 with 1 being "dislike extremely" and 9 being "like extremely". This scale measures the degree to how much a person likes or dislikes a product and the scale has a high level of variability amongst panelists (Sidel and others 1981). Data is collected analyzed using AOV and means separation to distinguish the samples that are significantly different.

2.4 Sensory Intensity

Sensory evaluation is not solely about food products. In a physiological and psychological perspective, humans have five senses; vision, audition, taste, smell, and touch. All five senses can work together or individually. These senses allow the human body to experience the effect of temperatures, pressures, pain and other environmental forces (Geldard 1972). When performing sensory evaluation tests and using different methods, the fact that humans use more than one sense to evaluate something needs to be taken into account. A food product is comprised of many different flavors, textures, aromas, colors, etc… To distinguish these characteristics, all five senses are needed (Stone and Sidel 2004).

Capturing the measure of preference for a product or perception is very difficult. It is difficult to find out if a panelist prefers a sample and how much they prefer that same sample compared to another panelist. Methods are continually being developed in order to rate these attributes into one scaling system.

2.5 Labeled Magnitude Scale

One method being used in sensory testing is a type of category-ratio scale, specifically the Labeled Magnitude Scale (LMS). This scale is a line scale with verbal anchors that are quasi-logarithmic spaced developed by Green, Shaffer, and Gilmore in 1993 and based on the work by Borg in 1982. The line scale consists of a rating of zero (“nothing detected”) to 100 (“strongest imaginable”) (Green and others 1993). “Barely detectable,” “weak,” “moderate,” “strong,” “very strong,” and “strongest imaginable” labels were placed along the scale to guide panelists, whereby they would place a mark on the line to indicate their answer. The spacing of the verbal anchors was distinguished by using subjects to “provide magnitude estimates of different verbal descriptors after giving magnitude estimates of familiar oral sensations (e.g., the bitterness of celery, the burn of cinnamon gum)” (Green and others 1993) creating “semantic scaling,” a scale containing intensity descriptors. The scale ranges from “barely detectable’ to “strongest imaginable” (Borg 1982).” Instructions are given to panelists to find the top anchor of strongest imaginable for each individual panelist. They are to compare the sample to their individual strongest imaginable experience (Lawless and others 2000). This scale has proven to be useful to evaluate the intensity of taste as well as rating the preference of a sample (Green and others 1993).

In 1996, Green found a problem with the LMS when trying to rate oral sensations like pain on the scale. This was due to the high end anchor, which in turn, created a smaller range of rating for taste stimuli. The scale's ranges should not restrict a panelist's perception of a sample (Cardello and others 2008). Bartoshuk (Bartoshuk and others 2004a) corrected this problem by stretching out the scale by using a top anchor of "strongest imaginable sensation of any kind" creating the general Label Magnitude Scale (gLMS). She tested the gLMS to magnitude matching with a tone standard to see if the gLMS would provide across-group comparisons. Results showed the methods were equivalent..

2.6 Hedonic Scale

Hedonic is defined as the study of pleasant and unpleasant sensations. When respect to foods, hedonic scaling is the affective rating of liking and disliking. The most well known and utilized scale to test product acceptance/preference is known as the hedonic 9-point scale (Stone and Sidel 2004). The hedonic 9-point scale was created in 1949 at the Quartermaster Food and Container Institute of the Armed Forces, Chicago, Illinois, by a team of scientists to try to predict soldiers' food choices (Peryam and Girardot 1952). This scale is based on the principle that consumers' likes and dislike can be categorized to show their preference towards food products.

The scale was later improved by choosing 51 hedonic descriptors and was tested on 900 soldiers using an unstructured 9-point bipolar category scale, ranging from -4 (greatest dislike) through 0 (neither like nor dislike) to +4 (greatest like) to distinguish which hedonic descriptors were the best ones to use in the final scale (Peryam and Girardot 1952). Using Thurstonian methods, z-scores were transposed from the raw scores which allowed for the means and standard deviations to be computed. This resulted in a statistical value for each word or categories along the scale. After choosing the appropriate phases for the scale, numbers were later added for statistical purposes (Jones and Peryam 1954). Jones also found that nine or eleven categorical descriptors were best for the scale. However, due to technical difficulties with paper size, only nine categories were able to be typed horizontally on the paper.

This scale originally was invented for the sole purpose of creating menus for soldiers. Companies now use it to detect differences in preference of different food samples and overall liking of food samples (Peryam and Girardot 1952). This scale is appropriate for within-subject comparisons.

The hedonic 9-point scale is a category scale (Peryam and Girardot 1952) that is used to test the overall liking of food products. In its present form, it is comprised of adjectives correlating to a number for panelists to rate the liking of a food product. The scale ranges from one through nine with one being “dislike extremely,” five being “neither like nor dislike,” and nine being “like extremely.” Panelists are instructed to rate the sample according to how they feel about the sample. The data is then collected and analyzed by AOV. Statistical results from the analysis of the variance test show whether there are differences in liking of the samples (Lawless and Heymann 1998).

The hedonic 9-point scale is a useful tool to have for any examiner of food preference or overall liking of food. The scale is easy for the panelist to understand and use. The scale is self explanatory with little instructions from the moderator of the test (Lawless and Heymann 1998). The panelist tastes a sample and decides whether or not they like it and then decides how much they like the sample. Next, the panelist just picks the category/number that corresponds to their liking/disliking. The results are easy to analyze using statistical software packages or manually, using an analysis of variance tests. The results from the test provide the examiner with concrete data to help in improving their product (Lawless and Heymann 1998). This data can be compiled and added to a companies' database to keep track of product changes (Stone and Sidel 2004).

The scale is also a bipolar magnitude scale, meaning that it has a negative (dislike) side and a positive (like) side creating ratios or proportions in the data (Vickers 1983). This has an advantage over a unipolar magnitude estimation which only has a positive side and does not account for the negative side of dislikes that a panelist may have towards a product.

Different questions about the samples can be asked and answers can be recorded using the hedonic 9-point scale. For example, flavor, texture, smell, appearance, etc… can all be rated using the hedonic 9-point scale. The scale has a great range of applications; new product development, product matching, product improvement, process change, cost reduction and/or selection of a new source of supply, storage stability, and consumer acceptance and/or opinions (Lawless and Heymann 1998). Therefore, this scale is very versatile and helps scientists with many product problems.

Another advantage for using the hedonic 9-point scale is that the data can be transformed into ranking or paired preference data for other possible analyses which provides more meaningful analysis (Lawless 1977). One of the analyses that can come from the paired preference data is preference mapping (Greenhoff and MacFie 1994). Preference mapping shows graphically how a panelist prefers different attributes of a sample.

Originally, the main purpose of this scale was to find out what types of foods army soldiers liked or disliked in order to adapt the menus to the soldiers likings. As Peryam and Gairardot in 1952 stated, "The hedonic scale method is not considered a polished system, because pertinent questions as to its interpretations, its reliability and the extent of its usefulness are yet unanswered. Unquestionably it can be improved."

The main problem with this scale is that when used for across-group comparison, the data have much subject to subject variability. The data can not be compared between different groups like gender, age, or cultural background. The scale does not have ratio properties, only ordinal properties (Meiselman and Schutz 2003). The adjectives used in the scales can be interpreted in different ways by panelists. Two different panelists could give the same adjective a totally different definition creating variability in the data collected. S.S. Stevens in 1958 stated "Mice may be called large or small, and so may elephants, and it is quite understandable when someone says it was a large mouse that ran up the trunk of the small elephant." The hedonic 9-point scale only accounts for an average of results from panelists. Some variability is lost to interpretation of anchor adjectives. The variability unaccounted for may be significant in the eyes of researchers who are trying to get an accurate result about their product from panelists. This in turn may result in major problems for the researcher who launches a product thinking it will be a big success, but instead may fail.

Variation is due to the fact that panelists use the scale in different ways. Some panelists may not use the extreme values while others will only use the middle values. Having a scale that has categories that are not evenly spaced and a neutral category of "neither like nor dislike," lessens the difference amongst samples and adds variability to the data (Moskowitz 1977). Sometimes panelists may just use the top or bottom portion of the scale (Gay 1988), or the panelist will avoid the midpoint of the scale (Stone and Sidel 2004). Clearly, this scale does not allow for the different mindsets of panelists, and places limits to only rate the sample from one to nine. If the scale contained more or less categories, panelists would still truncate the scale by not using the extreme values. Greater differences amongst food samples will be observed if longer scales were used (Cardello and others 2008).

Although the hedonic scale provides very useful information about a product, there are serious flaws when it comes to results about across-group comparisons. Panelists may use the same descriptors or rating in different meanings, i.e., not everyone has the same opinion as to what "moderate" likeability is. This is especially true with supertasters, whose "like moderately" may be quite different than the same rating for a non-taster of the same product. This scale's data makes false assumptions, registering variable results, and does not take into account for gender nor cultural background (Cox and others 2001). For example, if an American taster rated an eight (meaning "like very much") and a European taster rated a six (meaning "like slightly"), this rating seems to suggest a difference. There are a lot of factors that play a role in tasting that this scale cannot account for, resulting in inconclusive data (Villanueva and others 2005).

After calculating the results generated from the test, statistical calculations are done on that data to determine significant differences amongst the samples, using the Analysis of Variance (AOV) model. The main assumptions associated with an AOV model are normality and homoscedasticity and research done on the hedonic 9-point scale shows that data from this test does not always follow these assumptions (Villanueva and others 2005).

2.7 Hedonic gLMS Scale

Improvements in the LMS scale lead to the development of the hedonic general Labeled Magnitude scale (gLMS) (Bartoshuk and others 2006). The scale ranges from "strongest imaginable disliking of any kind" to "neutral" as the center to "strongest imaginable liking of any kind." This scale does not limit a panelist to just nine categories and allows the panelist to personalize the scale to their own experience. Enabling a panelist to rate on a scale with more categories increases the amount of information transmitted (Bendig and Hughes 1953) and produces a greater sensitivity to differences amongst food samples (Jones and Peryam 1954). It is hypothesized that the gLMS scale will provide stronger comparisons amongst panelists than the hedonic 9-point scale which will be tested in this study.

Category ratio scales were created to make across subject comparisons the hedonic 9-point scale was unable to achieve (Borg 1961; Moskowiz and Chandler 1977; and Green 1993). However, there were flaws with these scales, also. They assumed that the top anchor was the same for all people. This was found not to be true (Bartoshuk and others 2003). For instance, a supertaster who has more fungiform papillae has a more intense “maximum” taste than others. If a supertaster rates a product on the LMS scale, this scale would confine the true level of the experience. Therefore, Bartoshuk (Bartoshuk 2000) used “strongest imaginable sensation of any kind” as the top anchor of the scale, creating what is known as the General Labeled Magnitude Scale (gLMS) (Bartoshuk and others 2001). This scale led to the hedonic General Labeled Magnitude Scale (hedonic gLMS) to be used to test hedonic responses to foods.

The hedonic gLMS scale was created for the hedonic evaluations of foods. The scale takes two gLMS scales and puts them together. The scale consists of a horizontal line scale anchored by -100 to 100 with -100 being “strongest imaginable disliking of any kind,” and 100 being “strongest imaginable liking of any kind.” The scale’s descriptors include “barely detectable,” “weak,” “moderate,” “strong,” and “very strong.” These descriptors are placed on a 100 point scale at 1.4, 6, 17, 35, and 53, respectively (Green and others 1996) on an 11cm long horizontal line scale. Panelists are given verbal instructions on the scale and are asked to anchor the top of their scale with the strongest imaginable disliking or liking of any kind, unrestricted to food. The data is then collected and analyzed by AOV. Statistical results from the analysis of the variance test show whether there are differences in liking of the samples.

Because this scale is not related to taste, it does not create a ceiling effect which the LMS scale did by limiting the top anchor of the scale to "strongest imaginable oral sensation." This scale can be used for comparing within-subject and across-groups. This will allow researchers to study differences between ages, race, sex, etc… A study was done whereby panelists rated the bitterness of PROP using magnitude matching and the gLMS Scale (Bartoshuk and others 2004a). The results were very similar in both cases strengthening the evidence that this scale can provide across-group comparisons.

This scale is using the assumption that "strongest imaginable sensation of any kind" is similar across groups. If this is not true, the hedonic gLMS scale may be limited. However, because taste is not usually described as the top sensation, this scale provides valid differences fro taste (Bartoshuk and others 2004a).

The scale is different than most scales used in sensory evaluation and requires more verbal instructions to panelists taking the test. Panelists need to understand the purpose of the scale and how to use it, as well as, anchoring the top of their scale with something unrelated to the interested sensation (taste).

2.8 Other Studies

There have been few comparison studies between the hedonic 9-point scale and other types of sensory tests to see which tests performed the best. A study conducted by Nilda Villanueva in 2005, compared the performance of the hedonic 9-point scale to the hybrid hedonic scale whereby panelists rated the product on a line scale with middle and end verbal anchors, ranking scale, and to the self-adjusting scale. In this particular study, results showed stronger statistical data using the hybrid hedonic scale over the other two scales reflecting that panelists are able to rate their likeability with stronger accuracy.

Another study compared a rating method called positional relative rating to the hedonic 9-point scale. This study hypothesized which scale was better at differentiating samples. The results showed that both scales showed similar differences amongst samples and were equally useful (Cordonnier and Delwiche 2008).

Within the various studies, each scale has their advantages and disadvantages. There may not be one best scale to see panelists' likeability of a product. The goal is to find a scale that will get the closest measurement of the panelists' likeability.

2.9 Objectives

The main objective of this study was to compare and evaluate the hedonic gLMS scale with the hedonic 9-point scale. In theory, most scales can provide valid within-subject comparisons because each subject experiences each of the stimuli to be compared. Thus correlations obtained with either the hedonic 9-point or the hedonic gLMS should be valid correlations. However, because the hedonic gLMS lacks the ceiling effects common in the hedonic 9-point scale, we may see more significant within-subject correlations with the hedonic gLMS.

However, we predict a different outcome when comparing the hedonic 9-point scale with the hedonic gLMS in terms of comparisons across-groups and within-groups. The hedonic gLMS should provide valid comparisons across groups while the hedonic 9-point scale may not. The adjective labels of the hedonic 9-point scale denote different hedonic meaning to different groups and the real differences may fail to be revealed.

The strategy of this study was to select different groupings in order to see if the hedonic 9-point scale will fail to detect differences for some of them. The groupings under study are: sex, foodie type, and quinine tasters (in this experiment quinine tasters will represent supertasting).

It has been theorized that the hedonic gLMS scale will provide better data in comparing consumer likeability towards products. Our hypothesis is that this scale will provide better "across-group comparisons." The objective will be to compare the two scales using panelists to rate overall liking on different food products from memory and after tasting to see which scale performs the best.

Our first objective was to compare the two scales using panelists to rate overall liking on different food products from memory and after tasting. The second objective was to expand the first objective using a larger population and more food products while adding intensity ratings using both scales.

CHAPTER 3
MATERIALS/METHODS

3.1 Sensory Test Study 1

To compare the two scales, two days of testing were conducted by a panel comprised of students and staff from the University of Florida campus. Emails, signs, and classroom announcements were used to obtain the panelists needed for the study. The University of Florida Institutional Review Board approved all study procedures and panelists voluntarily gave written consent to perform the test. Compensation was provided to them for their time.

The study was conducted at the University of Florida's sensory lab from 1 to 3 pm. The sensory lab consists of individual booths equipped with a computer data center system (Compusense Five 3.6 Sensory Analysis Software for Windows, Compusense, Guelph, Canada). For this study, the two scales were created in the Compusense program along with appropriate questions. For all studies, panelists were asked ten demographic questions described in the Table 3-1.

Contact information in terms of an e-mail address was voluntarily requested from panelists for further studies. Throughout the test, a researcher also gave verbal instructions to the panelists, as well as, answering any questions.

For study one, 100 panelists were to answer questions about the overall liking of foods and experiences using the traditional hedonic 9-point scale. The scale ranges from one through nine with one being "dislike extremely," five being "neither like nor dislike," and nine being "like extremely." Panelists were instructed to rate the sample according to how they feel about the sample in question using the 9-point scale in Figure 3-1.

On day two of study one, 100 different panelists repeated this same process using the hedonic gLMS Scale. The center of the scale at zero is "neutral", meaning one neither liked nor disliked the sample. The most extreme value to the right of the scale was 100, labeled as "strongest imaginable liking of any kind," and the most extreme value to the left of the scale was -100 labeled as "strongest imaginable disliking of any kind." Panelists were instructed to think of the strongest imaginable liking of any kind and strongest imaginable disliking of any kind and write these items down. They were instructed to use these items as the top and bottom anchors of their scale a reference used throughout the test. They were then asked to rate the overall hedonic response of the samples and questions in comparison to those chosen experiences. Panelists were instructed to place a mark on a line scale using the computer (Figure 3-2).

Panelists were asked to write how much they like the following foods and experiences from memory: Coca-Cola®, milk chocolate, grapefruit juice, dark black coffee, orange juice, favorite song, favorite food, feeling hungry, and least favorite food. Then samples of orange juice and grapefruit juice were given to the panelists (Table 3-2). They were asked to cleanse their pallet with a bite of unsalted soda cracker and a sip of water before and after tasting the sample. The panelist would taste the samples and rate them on the overall liking using the scale on the computer. On the day of testing, Minute Maid® orange juice and Minute Maid® grapefruit juice premium-original, frozen concentrated was used. 354.9 mL of concentrate was mixed with 1064.6 mL of water for each juice and refrigerated until tasting began. Samples of 2 oz of each juice were presented in 4 oz plastic cups.

On both days after tasting the samples, panelists were asked to rate the sensory intensity of quinine papers. Quinine papers were prepared by soaking filter papers in a 0.001 M quinine solution and allowing them to dry. Panelists on day one rated the intensity of the bitterness of the paper using the 9-point intensity scale with one as "no sensation" and nine as "extreme sensation" (removing all other descriptors). Panelists on day two rated the intensity of the bitterness of the paper using the gLMS scale (Bartoshuk and others 2003). Panelists were instructed to think of the strongest sensation of any kind they had experienced; i.e. the brightest light ever seen (sun), the loudest sound ever heard (jet plane), or a particular pain. Whatever the sensation was became the top anchor of the scale at 100 in which panelists were instructed to write down as their reference point. Then the panelists were instructed to rate the overall bitterness of the paper.

3.2 Sensory Test Study 2

To expand upon study one in comparing the two scales, four days of testing were conducted using a panel comprised of students and staff from the University of Florida campus. Emails, signs, and class room announcements were used to obtain the panelists needed for the study. The University of Florida Institutional Review Board approved all study procedures and panelists voluntarily gave written consent to performing the test. Compensation was provided to them for their time. The study was conducted at the University of Florida's sensory lab from 1 to 3 pm as described previously. For this study, the two scales were created in the Compusense program along with appropriate questions.

In total, 200 panelist answered questions using the hedonic 9-point scale and 200 panelist answered questions using the hedonic gLMS. They were asked the same ten demographic questions on general information as in study one.

On day one and day three, 100 panelists each day were asked questions about the overall liking of foods from memory and taste using the hedonic 9-point scale. These foods included regular Coca-Cola®, milk chocolate, steamed broccoli, grapefruit juice, dark black coffee, orange juice, cheese cake, pepperoni, favorite food, and least favorite food. Then samples of cheese cake, pepperoni, dark black coffee, orange juice and grapefruit juice were given to the panelists and they were asked to taste the samples and rate them using the scale.

On the days of testing, Minute Maid® orange juice and Minute Maid® grapefruit juice premium-original, frozen concentrated was used. 354.9 mL of concentrate was mixed with 1064.6 mL of water and refrigerated until tasting began. 2 oz of each juice samples were presented in 4 oz plastic cups. Folgers French Roast coffee was brewed every 20 minutes to provide fresh warm coffee. Eight cups of water and 8 mounded tablespoons were used to make the coffee allowing the coffee to be constant of each batch. The coffee was served in 4 oz Styrofoam cups. Sara Lee original frozen cheesecake bites were kept in the freezer until 2 minutes before being presented in 4 oz sample cups to the panelist. Hormel original Pepperoni slices were placed in 4 oz sample cups.

On day two and four, 100 new panelists repeated this same process using the hedonic gLMS as described in study one. The panelists followed the same directions as in study one. Panelists were instructed to think about the strongest imaginable liking of any kind and strongest imaginable disliking of any kind and write these items down. They were instructed to use these items as the top and bottom anchors of their scale a reference used throughout the test. They were then asked to rate the overall liking of the samples in comparison to those chosen experiences. Panelists were instructed to place a mark on a line scale using the computer.

These foods were used because of their familiarity. Coca-Cola®, milk chocolate, orange juice, and cheese cake are considered sweet products. Steamed broccoli, grapefruit juice, and dark black coffee are all bitter products (Table 3-3). These two categories of products will hopefully allow for a separation in the data to distinguish possible supertasters from nontasters (Duffy and others 2007). The pepperoni is a meat product which will show how this type of product responds using both scales.

On all four days after tasting the samples, panelists were asked to rate the sensory intensity of four different taste solutions; NaCl, sucrose, citric acid, quinine. These solutions were presented in this order to ensure no possible transfer or interference of previous solutions occurred. The concentrations of the solutions include; 1 molar NaCl solution, 1 molar sucrose solution, 0.032 molar citric acid solution, and 0.001 molar quinine solution. 5mL of each solution was served in cups at room temperature to panelists. Unsalted soda crackers and water were available for panelists to use between solution samples.

Panelists on day one and three rated the intensity of the four solutions using the 9 point intensity scale with one as "no sensation" and nine as "extreme sensations" (removing all other descriptors). Panelists on day two and four rated the intensity of the four solutions using the gLMS scale as described in study one.

3.3 Statistical Analysis

3.3.1 Sensory Test Study 1

Data were retrieved from Compusense and transferred to EXCEL and then into SAS. Analysis of variance (AOV), least significant difference, correlation coefficients, and regression analyses were done using SAS or EXCEL. BMI calculations were made using the panelist's height and weight ((weight (lbs)/height^2 (inches)) x703). Panelist's hedonic gLMS anchors were compiled.

Data were sorted into three classification variables for AOV comparison; gender, foodie type, and quinine taster. Gender compared male to female. To determine the level of how much a panelist perceive the overall liking of food, foodie type grouping was created. Foodie type compared "foodie" vs. "nonfoodie." A "foodie" was defined by subtracting the panelist's rating for their least favorite food from their favorite food creating the variable difference in liking. The average for the difference in liking variable was generated and panelists above the mean were considered a “foodie” and everyone below the mean were considered a “nonfoodie.” In this study, the mean of the difference in liking for the hedonic 9-point scale was 6.75 and the mean for the hedonic gLMS was 124.05.

To determine the level and perception in which panelist taste bitter, a quinine taster classification variable was created. Since there is not a clearly defined definition to establish a supertaster, in this experiment “quinine tasters” represents a panelist experiences a high or low intensity to the taste of bitterness. This classification was broken into two groups, comparing “high” vs. “low.” These sub classifications were defined by taking the mean for the rating of the quinine paper. Those panelist’s who rated the intensity of the quinine paper higher than the mean were considered “high” and those who were lower then the mean were considered “low.” In study one, the mean of the bitterness rating for the hedonic 9-point scale was 6.75 and the mean for the hedonic gLMS was 45.9. Other classification variables (race, ethnic background, tonsillectomy, taste in the mouth, head injury, middle ear) were not studied due to insufficient population totals or no significant differences.

Analysis of variance was performed on gender, foodie type and quinine tasters for all measured attributes, for both the hedonic 9-point scale data and the gLMS data. Differences were considered significant at an alpha level of less than or equal to 0.05. Correlation and regression analyses were done on the data for both scales separately to identify relationships between measurable values. A correlation matrix was generated comparing each of the 12 questions to each other. Correlation coefficients that had a p-value less than 0.05 were considered significant. Regression graphs were plotted on the most significant correlations with the highest r value or the most interesting finding using EXCEL.

3.3.2 Sensory Test Study 2

Data for this second study was analyzed in the same manor as the first study. Data was retrieved from Compusense and transferred to EXCEL and then into SAS. Analysis of variance (AOV), correlation coefficients, and regression analyses were done using SAS or EXCEL. As in study one, BMI calculations were made using the panelist's height and weight and panelist's hedonic gLMS anchors were compiled.

Three classification variables were again studied; gender, foodie type, and quinine tasters. Gender compared male to female, while foodie type compared "foodie" vs. "nonfoodie," calculated as in study one. The means of the difference in liking were 7.15 for the hedonic 9-point scale and the hedonic gLMS scale had a mean of 120.35. Quinine tasters compared "high" vs. "low." These sub classifications were defined by taking the mean for the rating of the quinine solution. The mean of the bitterness rating for the hedonic 9-point scale was 8.10 and the mean for the hedonic gLMS was 64.24. As in study one, other classification variables were not studied due to insufficient population totals or no significant differences.

Analysis of variance was also performed on gender, foodie type, and quinine tasters. For all attributes measured differences were considered significant at an alpha level of less than or equal to 0.05. Correlation and regression analyses were done on the data for both scales separately to identify relationships between measurable values. A correlation matrix was generated comparing each of the 19 food, taste, and intensity questions to each other. Correlation coefficients that had a p-value less than 0.05 were considered significant. Regression graphs were plotted on the most significant correlations with the highest r value or the most interesting finding.

Table 3-1. Demographic questions

Gender
Age
Height
Weight
Race
Ethnic Background
Have you ever had a tonsillectomy?
Do you have persistent salty, sweet, or bitter tastes in your mouth?
Have you ever suffered from a head injury?
Have you ever suffered from middle ear infections?

dislike extremely	dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much	like extremely
1	2	3	4	5	6	7	8	9

Figure 3-1. Hedonic 9-point scale

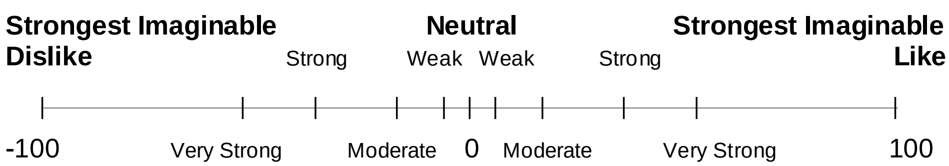


Figure 3-2. General Labeled Magnitude Scale

Table 3-2. Overall Likeability Questions Study One (in order of presentation to panelist)

Please rate the overall liking for a Coke.
Please rate the experience of listening to your Favorite Song.
Please rate the overall liking for Orange Juice.
Please rate the experience of eating your Favorite Food.
Please rate the overall liking for Grapefruit Juice.
Please rate the experience of being very Hungry.
Please rate the overall liking for Milk Chocolate.
Please rate the experience of eating your Least Favorite Food.
Please rate the overall liking for Dark Black Coffee.
Please taste and rate the overall liking for the sample of Orange Juice.
Please taste and rate the overall liking for the sample of Grapefruit Juice.

Table 3-3. Overall Likeability Questions Study Two (in order of presentation to panelist)

Please rate the overall liking for a Regular Coca Cola Classic Coke (not diet).
Please rate the overall liking for Steamed Broccoli.
Please rate the overall liking for Orange Juice.
Please rate the experience of eating your Favorite Food.
Please rate the overall liking for Grapefruit Juice.
Please rate the overall liking for Pepperoni.
Please rate the overall liking for Milk Chocolate.
Please rate the overall liking for Cheese Cake.
Please rate the experience of eating your Least Favorite Food.
Please rate the overall liking for Dark Black Coffee.
Please taste and rate the overall liking for the sample of Cheese Cake.
Please taste and rate the overall liking for the sample of Orange Juice.
Please taste and rate the overall liking for the sample of Pepperoni.
Please taste and rate the overall liking for the sample of Grapefruit Juice.
Please taste and rate the overall liking for the sample of Dark Black Coffee.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Results and Discussion

To see if the hedonic gLMS would provide better data for within subject and across-group comparisons, the hedonic 9-point scale and the gLMS were used in rating the overall liking of food products. To do so, three groups of data were analyzed within-subjects and across-groups: gender, foodie type, and quinine tasters.

Panelists were asked questions about food products from memory and then actually tasted food products during the sensory test. This was done to see if the results from the questions from memory were the same as the ratings for the samples the panelists tasted. The panelist's top and bottom anchors of the hedonic gLMS were complied and answers were categorized. The results were separated by group and analyzed.

4.2 Sensory Study 1

In study one, food and non-food items were rated overall liking by panelists using the hedonic 9-point scale and the hedonic gLMS. Non-food items were used to see where these items fit into a panelist's food world. These items also allowed for the use of the scales to rate across modalities.

Since this type of experimental design has never been used before, study one was an exploratory experiment used to see how the panelists would react to this type of questioning and if the data would show any significant results. Consequently, some very interesting findings were discovered from this study. Many significant correlations arose from the data that may lead to future studies to rationalize these results.

Across-group comparisons were analyzed using AOV to show significant differences between groups for each scale. This was done to see if the hedonic 9-point scale would be able to show significant differences across-groups. Within-group comparison was analyzed using correlation coefficients and regression graphs. This analysis was done to show that the hedonic gLMS will work for within-group comparisons, as well as, the hedonic 9-point scale.

4.2.1 Sensory Study 1 Across-Group Comparisons

AOV was used to identify significant differences between males and females for both scales. Both scales clearly showed that females rated bitterness of the quinine paper higher than did males (Table 4-1). These results imply that females taste the intensity of bitter components higher than males. The hedonic gLMS scale showed more significant differences between genders than the hedonic 9-point scale overall (Table 4-1). The hedonic gLMS scale showed significant differences for orange juice from memory, with the males liking orange juice more than the females did with an average of 33.2 vs. 23.6. The hedonic 9-point scale showed marginal, but not significant, differences. The hedonic gLMS scale was able to show that females rated their least favorite food lower (-65.9) as opposed to males (-51.1). This may show that food is more important to females. Using the hedonic gLMS scale, females (-44.0) also rated black coffee lower than males (-14.4). A negative value indicates dislike, showing that many people either do not like coffee in general or either sugar or milk are needed to combat the bitterness of the coffee. The hedonic 9-point scale did not show these differences to be significant. The hedonic 9-point scale did show differences in the liking of favorite song, showing that females liked their favorite song better than males. However, this difference was very small and may not be truly a difference since the hedonic gLMS did not show this difference to be significant.

The hedonic gLMS scale showed a larger and more significant difference between foodies and nonfoodies for the liking of their favorite song (Table 4-2). It showed that foodies liked their favorite song (70.7) more than nonfoodies (52.8), reflecting an importance between food and music. The hedonic gLMS scale also showed that foodies disliked black coffee more than nonfoodies. Furthermore, the hedonic gLMS scale found that foodies rated orange juice higher then nonfoodies. The gLMS also concluded that the foodies rated the bitterness intensity of quinine higher than the nonfoodies. The 9-point intensity scale failed to show these significant differences.

The hedonic 9-point scale showed that nonfoodies had a higher liking for orange juice from memory than foodies, as well as, the grapefruit juice they tasted. The other difference the hedonic 9-point scale showed was for the liking of grapefruit juice from memory. Foodies remembered disliking grapefruit juice more than nonfoodies.

Data was also sorted into categories of panelists who rated the bitterness of quinine either higher or lower than the average. Comparing the “high” and “low” of the bitterness classification within the two scales, the hedonic gLMS showed many more significant differences than the hedonic 9-point scale, specifically with the panelist’s least favorite food, black coffee, and the tasted grapefruit juice (Table 4-3). In each case, the panelists who rated bitterness lower than average had a significantly higher value for the liking of least favorite food, black coffee, and orange juice. The 9-point intensity scale did not show these differences. Both scales showed a significant difference in the rating of the bitterness of the quinine paper which was to be expected, because the data was sorted using the bitterness of the quinine paper ratings.

4.2.2 Sensory Study 1 Within-Subject Comparisons

A correlation-regression matrix was performed on the data to identify significant correlations. The correlations (r values) with a p-value of less than 0.05 were considered significant. Table 4-4 summarizes all the significant correlations in the study for both scales.

Comparing the hedonic gLMS and the hedonic 9-point scale, the hedonic gLMS shows a total of 30 significant correlations, while the hedonic 9-point shows 17 significant correlations

(Table 4-4). Ten of these correlations were reflected in both scales, resulting in the hedonic gLMS picking up 20 different correlations in which the 9-point scale failed to identify; while the hedonic 9-point scale showed six different correlations in which the hedonic gLMS failed to identify.

Some interesting correlations were reflected by both scales. Both scales showed a positive correlation between the overall liking of orange juice from memory and orange juice tasted (Figure 4-1). However, the hedonic gLMS showed a much stronger correlation. Both scales also showed a significant relationship between grapefruit juice to black coffee (Figure 4-2). In each case, the results are easily seen showing the more they dislike grapefruit juice the more they disliked black coffee using the hedonic gLMS figures. The hedonic gLMS showed a significant correlation between black coffee and grapefruit juice from memory (Figure 4-3). The more the panelist disliked black coffee, the more they disliked grapefruit juice from memory. This normally correlates because of the similarity of the products (higher bitterness), which the hedonic 9-point scale failed to identify.

Another interesting correlation seen from both scales was the relationship between the difference in liking variable and the panelist's favorite song. This correlation represents significance between panelists' modalities. Their difference between their favorite and least favorite foods increased as the liking of their favorite song increased. One can also see that the hedonic gLMS shows a much stronger correlation than the hedonic 9-point scale (Figure 4-4), indicating that the hedonic 9-point scale is not as good for measuring across modalities.

During this first study, panelists were asked questions on how much they liked a food or non-food item. Favorite and least favorite food corresponded better than expected with many of the food and non-food item questions asked. The non-food item questions were asked to see where those preferences ranged on the scales in relationship to food items. The hedonic 9 point scale never showed a significant correlation between favorite food and favorite song and least favorite food vs. favorite song, while the hedonic gLMS showed a strong significance difference of 0.5523 and -0.3072, respectfully (Figure 4-5).

Favorite song correlated significantly with favorite food, least favorite food, orange juice from memory, and the bitterness of the quinine paper when using the hedonic gLMS. As the rating of the panelist's favorite food increased, the rating for the panelist's favorite song also increased (Figure 4-5) showing a positive relationship between food and music. The more panelists liked their favorite song, the higher they rated the bitterness of the quinine paper. This correlation showed significance between sound and taste intensity. It seemed that the hedonic gLMS was able to show correlations with favorite food, least favorite food, and favorite song better than the 9 point scale. This could be a beneficial characteristic of the hedonic gLMS enabling the scale to be used in relating non-food questions to food questions. These results show an importance in future studies using this scale.

At the end of the test, panelists tasted and rated the level of the bitterness of quinine paper to see if the scales could show any significant correlations with food products and intensity of taste. The hedonic gLMS scale showed more correlations between the bitterness of the quinine paper and other questions than the 9 point scale. The hedonic gLMS scale showed a significant correlation between the bitterness of the quinine paper rating and black coffee, grapefruit juice, the panelist's favorite song, and their least favorite food. The ratings of grapefruit juice (figure 4-6) showed a negative correlation, due to the high bitterness of this product.

4.2.3 Sensory Study 1 Panelist Anchors

Panelists' top and bottom anchors of their "strongest imaginable liking of any kind" and "strongest imaginable disliking of any kind" for the hedonic gLMS were compiled. Categories were made from the panelists' descriptions (Tables 4-5 and 4-6). Playing or watching a sport and being in a specific place were the top two strongest imaginable likings panelists used. Many panelists felt good, physically and emotionally, doing these events. These results also were seen after separating the results into gender and type. With males and nonfoodies, sex was the second highest anchor used. Being sick, hurt, or having a medical issue and the fear of death or being involved in a life threatening event were the top two ratings for the panelists' -100 (bottom anchor) for the hedonic gLMS. These were also the top responses for gender and type. When identifying panelists' "strongest imaginable sensation of any kind" for rating the intensity of the quinine paper, pain was used the most as their 100 (top anchor). An emotional or sound sensation was tied for second most used anchor (table 4-7). Similar results were seen with gender and type.

4.3 Sensory Study 2

Findings generated from study one lead to the experimental design of study two. Seeing that the trends of study one showed that the hedonic gLMS was better at comparing within-subjects and across-groups, study two was performed to provide more evidence of these trends. To do so, study two increased the population and eliminated the non-food related questions in order to focus on the behavior of the scales relative to rating food products. Three other taste intensities, salty, sweet, and sour were also added to study two to determine how the scale would work with the other tastes, rather than just bitter. A liquid quinine solution was used in study two instead of the quinine paper. This was done because the liquid quinine solution flows better into the channel containing the taste receptors where the taste buds are located. With the paper, the quinine has to dissolve into the saliva, where upon it then makes contact with the taste receptors. The quinine solution eliminated the "middle man" to provide a more accurate level when panelists tasted the solution.

4.3.1 Sensory Study 2 Across-Group Comparisons

Using AOV to compare the hedonic 9-point scale to the hedonic gLMS scale for the significant differences between genders, both scales showed significant differences between males and females for intensity of saltiness and sourness (Table 4-8). The two scales showed that females rated the intensity of the saltiness and sourness of the solutions higher than did males. The hedonic gLMS scale showed a difference with females (70.2) experiencing a higher perceived intensity of bitterness than males (55.3), as in study one. However, the hedonic 9-point scale did not show a significant difference in this study. The gLMS seemed to perform better than the 9-point intensity scale for rating perceived intensities of various taste sensations, providing more significant differences.

Both scales provided comparable strength in distinguishing significant differences amongst genders. The hedonic 9-point scale and the hedonic gLMS showed significant differences between males and females for broccoli from memory (5.8 vs. 6.4; 5.1 vs. 14.3) and black coffee (3.6 vs. 2.8; -13.6 vs. -33.9). In both cases, the hedonic gLMS clearly showed higher differences than the hedonic 9-point scale. The data showed that females liked broccoli more than males and disliked black coffee more than males.

The hedonic 9-point scale distinguished two other significant differences between genders compared to the hedonic gLMS. The scale showed that males liked coke more then females and had a higher liking for pepperoni (from memory) than females (Table 4-8).

Analyzing the group “foodie type”, both scales found a difference between the favorite food, least favorite food, and difference in liking (Table 4-9). This was predicted because these questions were used to classify foodie type. The scales also showed that foodies disliked black coffee more than the nonfoodie panelists. Again, the hedonic gLMS showed a higher level of disliking than the 9-point scale showed (-33.3 vs. -18.8; 2.9 vs. 3.6).

The hedonic gLMS scale showed significant differences between foodies and nonfoodies for recalling their liking for orange juice, grapefruit juice, milk chocolate, and cheese cake (Table 4-9). It also showed significant differences after the panelists tasted the samples for cheese cake, coffee, grapefruit juice, and orange juice. The hedonic gLMS showed that foodies recalled liking orange juice, milk chocolate, and cheese cake more than nonfoodies and also liked the taste of cheese cake and orange juice significantly more than nonfoodies. As hypothesized, foodies largely did not like the taste of black coffee (-33.3) or grapefruit juice (-29.8) compared to the nonfoodies with means of -18.8 and -11.2, respectfully. The foodies also did not recall liking grapefruit juice as much as nonfoodies. This also can be supported by the fact that foodies rated the intensity of bitterness higher.

The gLMS scale performed better than the 9-point intensity scale for finding significant differences for the taste solutions. The gLMS showed a significant difference between foodies and nonfoodies for the perceived intensity of sourness and bitterness, with foodies rating both higher than nonfoodies. These results show that foodies taste the basic tastes greater than nonfoodies, supporting the importance of the taste of food for foodies.

Comparing the high and low of the quinine tasters, the hedonic gLMS showed many more significant differences than the hedonic 9-point scale (Table 4-10). Interestingly, both scales showed significant differences for all four taste solutions showing that the higher the panelists rated the intensity of quinine, the higher they rated the other solutions. These results confirm our assumption that high and low quinine tasters are supertasters or medium tasters and nontasters.

The hedonic gLMS showed differences between high and low quinine tasters for broccoli, grapefruit juice, black coffee, and least favorite food from memory. We had hoped to see these results, because the data was separated depending on the panelists' bitterness ratings. The hedonic 9-point scale was unsuccessful in showing any significant differences for these items. Interestingly, the hedonic gLMS scale showed a significant difference between quinine tasters for orange juice and favorite food from memory. High quinine tasters rated the overall liking of these items higher than the low quinine tasters. Tasting ratings for cheesecake, black coffee, and grapefruit juice were also seen as significantly different using the hedonic gLMS.

The hedonic 9-point scale only showed a difference with the rating of cheesecake from memory, failing to show many significant differences for quinine tasters. If industry researchers used the hedonic 9-point scale rating a product with the majority of the panel quinine tasters, they would not find a significant difference with the product. If the product was "launched" to market, this could possibly lead to failure, because the hedonic 9-point scale would not have shown a difference in liking of the product.

4.3.2 Sensory Study 2 Within-Subject Comparisons

After analyzing correlations amongst data in study two, with the larger population of panelists tested, many more total correlations were found significant. The hedonic gLMS provided many more significant correlations in each classification compared to the 9-point scale. These results are in agreement with the first study in that the hedonic gLMS provides more significant correlations than the hedonic 9-point scale. Analyzing the data of all the correlations, the hedonic gLMS showed about 2.5 times as many different significant correlations compared to the 9-point scale and half of the total number of correlations for the 9-point scale were also shown by the hedonic gLMS (Table 4-11).

In general, both scales did very well showing correlations for pepperoni between orange juice, coke, BMI, and preference for pepperoni from memory. Similar to study one, the hedonic gLMS had the stronger correlation values. The hedonic gLMS also showed better correlations between the tastes solutions that the hedonic 9-point scale failed to show.

There are many correlations in which both scales showed significant r values, and in most cases, the hedonic gLMS r value is larger showing a greater relationship between the products. Grapefruit juice correlated with both scales with grapefruit from memory (Figure 4-7), as in study one, showing that both scales can be used to rate products even if the panelists do not taste the product. Grapefruit juice correlated with least favorite food, but the 9-point scale showed a lower r value of 0.1814 compared to the hedonic gLMS with a r value of 0.3045 (Figure 4-8). Black coffee was also seen significant in regards to grapefruit juice due to the higher bitterness taste these products have (Figure 4-9). Both scales showed a significant correlation between the liking of milk chocolate from memory and orange juice (Figure 4-10), as well as, the panelists' favorite foods (Figure 4-11). These correlations might be expected due to the sweet taste and popularity of both products. Differences in liking vs. favorite food was significant by both scales, but highly correlated using the hedonic gLMS with a r value of 0.8865 vs. 0.4604 using the hedonic 9-point scale (Figure 4-12). This value should be high since the difference in liking is the difference of the panelists' favorite food rating and their least favorite food rating.

Similar to study one, the hedonic gLMS showed some interesting and significant correlations in which the 9 point scale did not show. As expected, cheese cake and cheese cake from memory and favorite food (Figure 4-13) were correlated. Cheese cake correlated positively with favorite food and negatively with least favorite food (Figure 4-14). Cheese cake also correlated nicely with orange juice and orange juice from memory (Figure 4-15). It seems as though the hedonic gLMS is showing correlations that the hedonic 9-point scale should have shown, especially in regards to sweet products that one would assume to be significant. Figure 4-16 reflected strong correlations between the differences in liking variable and milk chocolate from memory, grapefruit juice, and orange juice. This shows that the greater the difference between a person's favorite food and least favorite food, the greater they like either milk chocolate or orange juice and the least they like grapefruit juice.

In this second study, panelists rated the intensity of different taste solutions, specifically, salty, sweet, sour, and bitter using 9-point intensity scale and the gLMS. Although both scales showed a significant correlation between bitter vs. salty (Figure 4-17) and bitter vs. sour (Figure 4-18), the correlations were much better with the gLMS. Strong correlations were also seen with salty vs. sweet (Figure 4-19) and salty vs. sour (Figure 4-20). The gLMS also showed a cleaner, more visible regression graph than the 9-point intensity scale. Salty and least favorite food negatively correlated (Figure 4-21), however salty and favorite food was only significant using the hedonic gLMS (Figure 4-22). This shows that both favorite food and least favorite food is very important, which the hedonic 9-point scale did not show. Using the hedonic 9-point scale, one would only assume that a salty intensity would be nonpalatable, but using the hedonic gLMS, it shows that it is more feasible to having the right level of saltiness for a likeable product.

The hedonic gLMS scale showed numerous significant correlations between intensity ratings and hedonic ratings while the hedonic 9-point scale showed only a few. Bitterness correlated with coffee, grapefruit juice, favorite food, least favorite food, and difference in liking variable (Figure 4-23). These correlations were also seen in study one. These were also seen with the intensity of saltiness and sourness. One interesting correlation that the hedonic gLMS identified was the negative correlation between sour and grapefruit juice (Figure 4-24). Grapefruit juice is typically very sour, hence the stronger the sourness flavor perceived, the lower the liking of grapefruit juice became. Sweet correlated very well with panelist's favorite food, cheese cake, and chocolate (Figure 4-25). The 9-point scale was not able to identify these differences due to the ceiling effects it creates. All the values are so high on the scale that it does not show the significant correlations within-groups. The hedonic gLMS showed a significant correlation between the differences in liking variable and the bitterness rating of quinine (Figure 4-27). As ratings for of bitterness intensity increased, the larger the difference between the panelist's favorite and least favorite food becomes.

4.3.3 Sensory Study 2 Panelist Anchors

As in study one, panelists' top and bottom anchors of their "strongest imaginable liking of any kind" and "strongest imaginable disliking of any kind" for the hedonic gLMS were compiled. Categories were made from the panelists' descriptions (Table 4-12 and Table 4-13). Being with friends, family, and loved ones was the top strongest imaginable likings panelists used as their 100 on the hedonic gLMS in study two. Being loved or being in love and being at an event were tied for second. In the comparison to gender and type, the top choice was being with friends, family, and loved ones. However, the second top choice for gender was an event, and for type, it was being loved. Death of a loved one or friend and being sick, hurt, or having a medical issue were the top two ratings, respectfully, for the panelist's -100 (bottom anchor). These results were the same for gender and type. When identifying panelists' "strongest imaginable sensation of any kind" for rating the intensity of the taste solutions, pain again was used the most as their 100 (top anchor). An emotion was once again chosen as the second most used anchor (table 4-14). Gender and type showed similar results.

Table 4-1. Significant Means Differences between Gender for Study One

	9-point scale		gLMS	
	Male	Female	Male	Female
	n=47	n=53	n=45	n=55
Favorite Song from Memory	8.4 b[1]	8.6 a	61.2 a	63.1 a
Orange Juice from Memory	7.4 a	7.1 a	33.2 a	23.6 b
Least Favorite Food from Memory	1.9 a	1.8 a	-51.1 a	-65.9 b
Black Coffee from Memory	3.8 a	3.3 a	-14.4 a	-44.0 b
Bitterness of Quinine Paper	6.2 b	7.2 a	36.5 b	53.6 a

[1]Means followed by different letters represent significant differences.

Table 4-2. Significant Means Differences Between Foodie Type[1] for Study One

	9-point scale		gLMS	
	Foodie	NonFoodie	Foodie	NonFoodie
	n=67	n=33	n=53	n=47
Favorite Song from Memory	8.6 a[2]	8.4 a	70.7 a	52.8 b
Orange Juice from Memory	7.0 b	7.7 a	31.6 a	23.8 a
Favorite Food from Memory	8.8 a	8.1 b	79.3 a	48.4 b
Grapefruit Juice from Memory	4.9 a	5.9 b	2.4 a	-1.3 a
Least Favorite Food from Memory	1.3 b	2.9 a	-78.9 b	-37.1 a
Black Coffee from Memory	3.2 a	4.1 a	-39.5 b	-20.7 a
Orange Juice Taste	6.4 a	6.6 a	33.3 a	24.3 b
Grapefruit Juice Taste	3.2 b	4.4 a	-33.9 a	-29.3 a
Bitterness of Quinine Paper	6.9 a	6.4 a	51.2 a	39.9 b
Difference in Liking	7.5 a	5.2 b	158.2 a	85.6 b

[1]Sorted by Foodie and Nonfoodie representing panelists whose difference in liking value is above or below respectfully, the means (6.75 for the 9-point scale and 124.05 for the gLMS). [2]Means followed by different letters represent significant differences.

Table 4-3. Significant Means Differences Between Quinine Tasters[1] for Study One

	9-point scale		gLMS	
	Higher	Lower	Higher	Lower
	n=65	n=15	n=52	n=48
Least Favorite Food Memory	1.8 a[2]	1.9 a	-68.9 b	-48.8 a
Black Coffee from Memory	3.6 a	3.3 a	-40.9 b	-19.6 a
Grapefruit Juice Taste	3.8 a	3.5 a	-40.5 b	-22.3 a
Bitterness of Quinine Paper	8.0 a	4.5 b	67.6 a	22.4 b

[1]Sorted by Higher and Lower representing panelists whose rating of quinine is above or below respectfully, the mean (6.75 for the 9 point scale and 45.9 for the gLMS). [2]Means followed by different letters represent significant differences.

Table 4-4. Significant Correlations (p<0.05) (r values) for Study One

	9-point scale	gLMS
	n=100	n=100
Favorite Food vs. BMI	-0.1594	
Black Coffee from Memory vs. Grapefruit Juice from Memory		0.2168
Black Coffee from Memory vs. Least Favorite Food	0.3020	0.4599
Black Coffee from Memory vs. Orange Juice from Memory	0.1992	
Difference in Liking vs. Black Coffee from Memory	-0.2154	-0.3200
Difference in Liking vs. Favorite Food	0.5170	0.7997
Difference in Liking vs. Favorite Song	0.2121	0.4893
Difference in Liking vs. Grapefruit Juice	-0.2615	
Difference in Liking vs. Least Favorite Food	-0.8734	-0.8840
Difference in Liking vs. Milk Chocolate		0.2269
Difference in Liking vs. Orange Juice		0.2488
Difference in Liking vs. Bitterness of Quinine		0.2768
Favorite Food vs. Favorite Song		0.5523
Favorite Food vs. Orange Juice from Memory		0.2241
Grapefruit Juice vs. Black Coffee from Memory	0.2156	0.4241
Grapefruit Juice vs. Orange Juice from Memory		0.2642
Grapefruit Juice vs. Grapefruit Juice from Memory	0.5822	0.6377
Grapefruit Juice vs. Least Favorite Food	0.2093	0.2891
Grapefruit Juice from Memory vs. Orange Juice from Memory	0.2211	0.2544
Hungry vs. Orange Juice from Memory	0.1967	
Least Favorite Food vs. Favorite Food		-0.4263
Least Favorite Food vs. Favorite Song		-0.3072
Least Favorite Food vs. Orange Juice from Memory	0.2218	
Milk Chocolate vs. Favorite Food		0.3333
Milk Chocolate vs. Favorite Song		0.3184
Milk Chocolate vs. Orange Juice from Memory		0.2195
Orange Juice vs. Black Coffee from Memory	0.2516	
Orange Juice vs. Favorite Food		0.2510
Orange Juice vs. Favorite Song		0.2753

Table 4-4. Continued

Orange Juice vs. Milk Chocolate		0.2653
Orange Juice vs. Orange Juice from Memory	0.3750	0.5436
Orange Juice from Memory vs. Favorite Song		0.4045
Bitterness of Quinine vs. Black Coffee from Memory		-0.2394
Bitterness of Quinine vs. Favorite Song		0.2567
Bitterness of Quinine vs. Grapefruit Juice		-0.2590
Bitterness of Quinine vs. Least Favorite Food		-0.3583
Bitterness of Quinine vs. Grapefruit Juice from Memory	-0.2205	

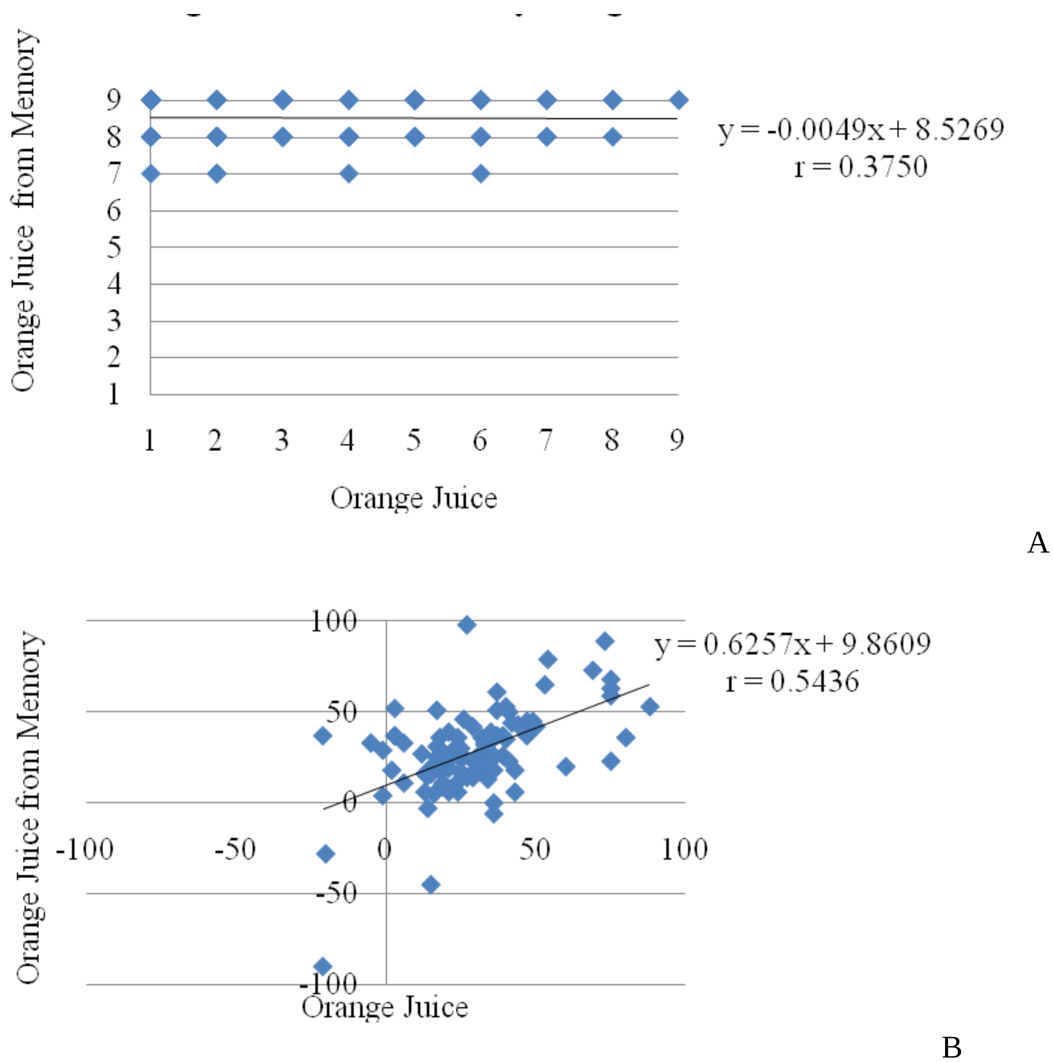


Figure 4-1. Correlation and Regression between Orange Juice and Orange Juice from Memory in study one. A) 9-point Scale B) gLMS

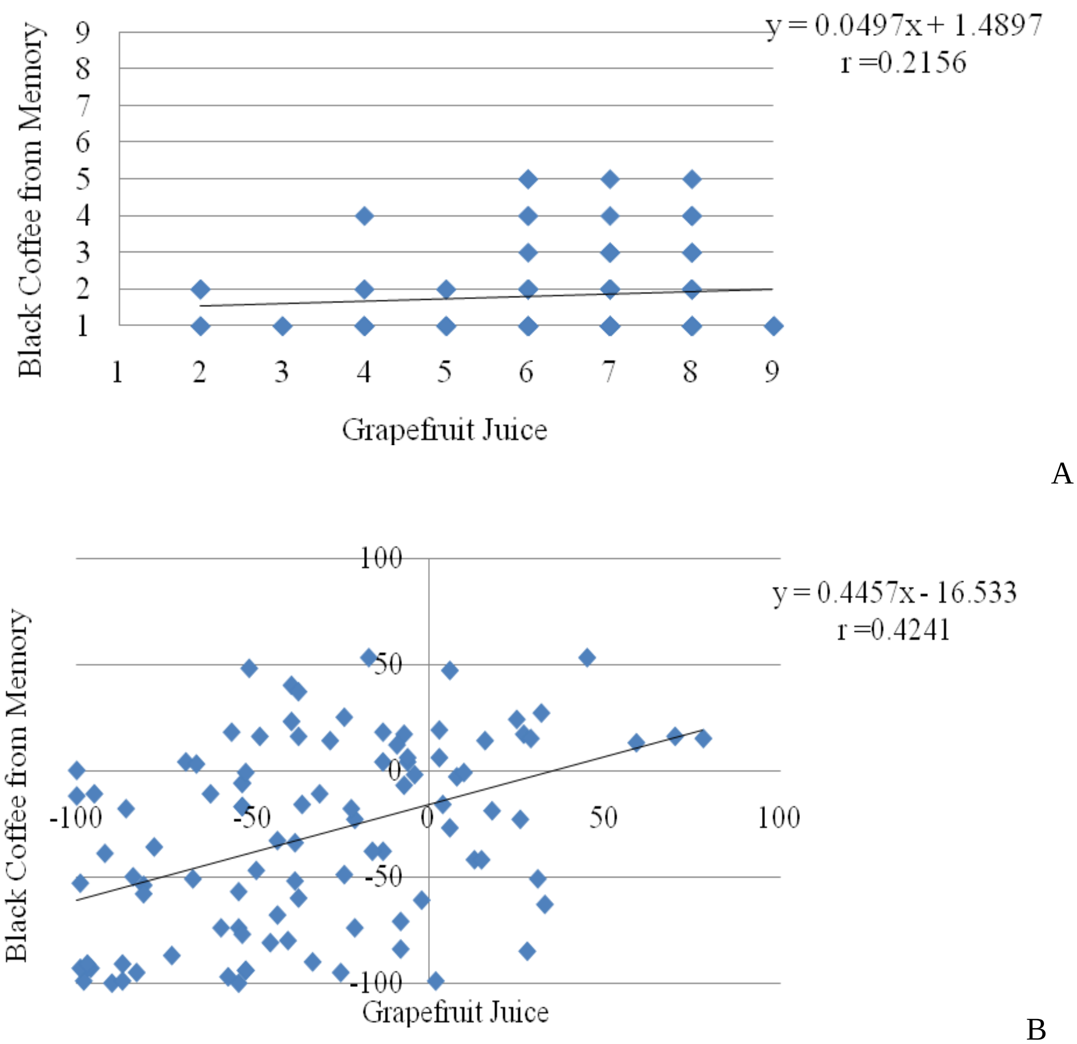


Figure 4-2. Correlation and Regression between Grapefruit Juice and Black Coffee from memory in study one. A) 9-point Scale B) gLMS

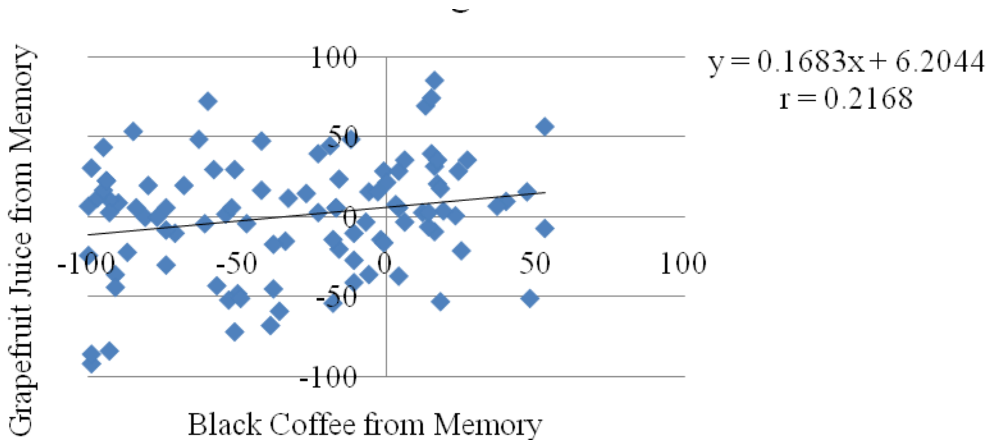
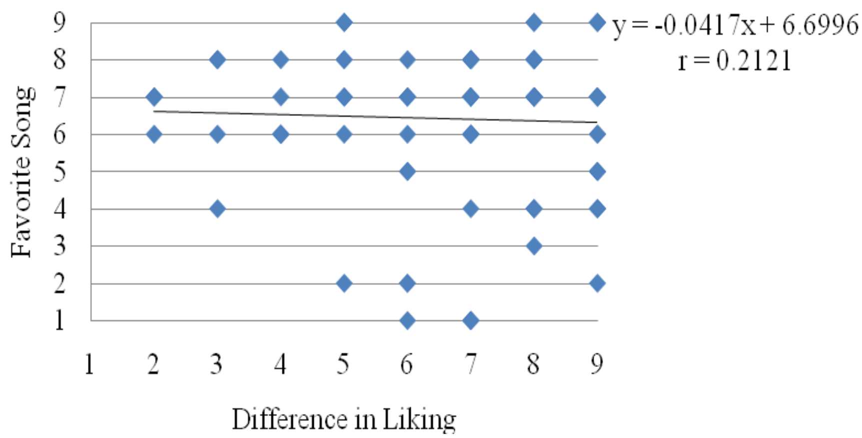
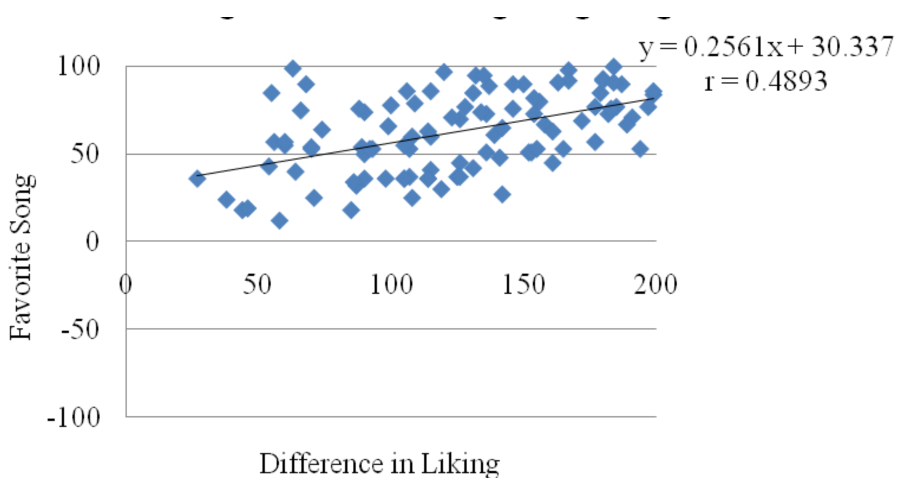


Figure 4-3. Correlation and Regression between Black Coffee from memory and Grapefruit Juice from memory in study one using the gLMS

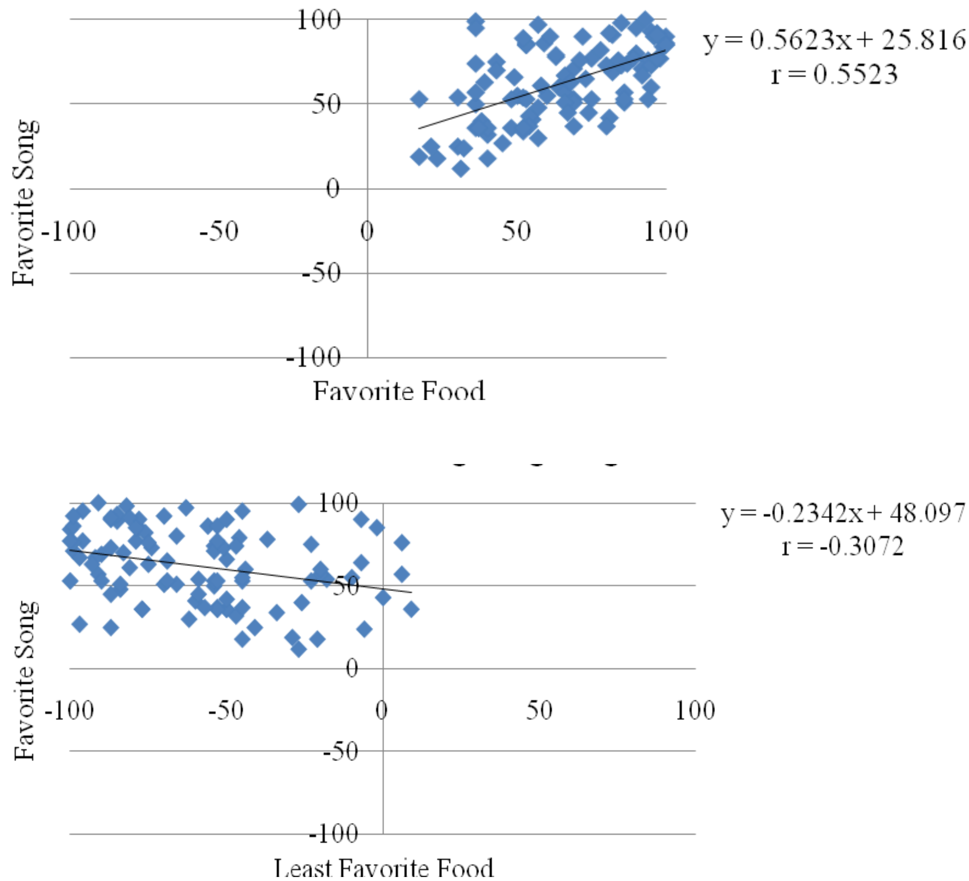


A



B

Figure 4-4. Correlation and Regression between Difference in Liking and Favorite Song in study one. A) 9-point scale B) gLMS



A

B

Figure 4-5. Correlation and Regression in study one using the gLMS between Favorite Song and A) Favorite Food and B) Least Favorite Food

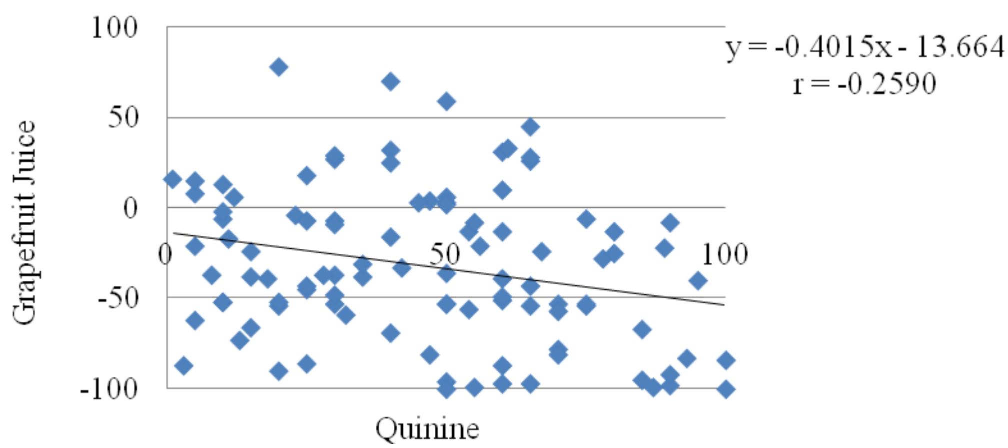


Figure 4-6. Correlation and Regression between Quinine and Grapefruit Juice in study one using the gLMS

Table 4-5. “Strongest imaginable LIKING of any kind” Anchors Totals for Study One

Key of Categories	Overall	Male	Female	Foodies[1]	NonFoodies[2]
An Event	13	4	9	8	5
Being at a Place	12	5	7	6	6
Being Happy/Laughing	6	1	5	4	2
Being Loved/Being in Love	6	1	5	2	4
Being Successful	4	1	3	2	2
Being with Friends/Family/Loved Ones	9	5	4	5	4
Food/Beverage	10	2	8	7	3
Hugging/Kissing	4	3	1	1	3
Playing/Watching a Sport	17	8	9	9	8
Riding a Rollercoaster	3	1	2	1	2
Security	1	1	0	1	0
Sex	7	6	1	0	7
Sleeping	3	3	0	2	1
Things	5	4	1	5	0
Total	100	45	55	53	47

[1] Represents panelists whose difference in liking value was above 124.05. [2] Represents panelists whose difference in liking value was below 124.05.

Table 4-6. “Strongest imaginable DISLIKING of any kind” Anchors Totals for Study One

Key of Categories	Overall	Male	Female	Foodies[1]	NonFoodies[2]
Activity	7	2	5	4	3
Being Sick/Hurt/Medical	58	25	33	30	28
Bugs/Spiders/Animals	7	5	2	5	2
Cleaning	2	2	0	1	1
Death of Loved One/Friend	6	3	3	2	4
Eating Something	3	1	2	3	0
Hatred	2	0	2	0	2
Life Threatening Event/Fear of Death	15	7	8	8	7
Total	100	45	55	53	47

[1] Represents panelists whose difference in liking value was above 124.05. [2] Represents panelists whose difference in liking value was below 124.05.

Table 4-7. "Strongest imaginable SENSATION of any kind" Anchors Totals for Study One[1]

Key of Categories	Overall	Male	Female	Foodies[1]	NonFoodies[2]
Brightest Light	12	5	7	6	6
Emotion	13	2	11	5	8
Food/Beverage	2	1	1	1	1
Pain	59	30	29	34	25
Sound	13	7	6	6	7
Temperature	1	0	1	1	0
Total	100	45	55	53	47

[1] Represents panelists whose difference in liking value was above 124.05. [2] Represents panelists whose difference in liking value was below 124.05.

Table 4-8. Significant Means Differences between Gender for Study Two

	9-point scale		gLMS	
	Male	Female	Male	Female
	n=97	n=103	n=80	n=120
Coke from Memory	6.9 a[1]	6.3 b	16.9 a	17.4 a
Broccoli from Memory	5.8 b	6.4 a	5.1 b	14.3 a
Black Coffee Memory	3.9 a	3.0 a	-6.1 a	-24.8 b
Pepperoni from Memory	6.7 a	6.2 b	16.3 a	12.9 a
Black Coffee Taste	3.6 a	2.8 b	-13.6 a	-33.9 b
Salty	7.5 b	8.0 a	40.1 b	49.5 a
Sour	5.4 b	6.4 a	36.8 b	45.0 a
Bitter	7.9 a	8.3 a	55.3 b	70.2 a

[1]Means followed by different letters represent significant differences.

Table 4-9. Significant Means Differences Between Foodie Type[1] for Study Two

	9-point scale		gLMS	
	Foodie	NonFoodie	Foodie	NonFoodie
	n=106	n=94	n=96	n=104
Broccoli from Memory	5.5 b[2]	6.8 a	12.2 a	9.1 a
Orange Juice from Memory	7.4 a	7.3 a	31.9 a	22.3 b
Favorite Food from Memory	9.0 a	8.6 b	83.0 a	49.8 b
Grapefruit Juice from Memory	4.4 a	4.9 a	-2.3 b	6.3 a
Milk Chocolate from Memory	7.5 a	7.3 a	44.5 a	29.4 b
Cheese Cake from Memory	7.3 a	7.4 a	38.2 a	27.7 b
Least Favorite Food from Memory	1.0 b	2.5 a	-77.6 b	-33.5 a
Black Coffee from Memory	3.3 a	3.9 b	-22.5 a	-12.5 a
Cheese Cake Taste	7.4 a	7.4 a	29.9 a	18.7 b
Black Coffee Taste	2.9 b	3.6 a	-33.3 b	-18.8 a
Grapefruit Juice Taste	3.2 a	3.4 a	-29.8 b	-11.2 a
Orange Juice Taste	6.9 a	6.6 a	38.5 a	28.3 b
Pepperoni Taste	6.9 a	6.4 b	16.1 a	15.7 a
Sour	6.0 a	5.9 a	48.0 a	35.9 b
Bitter	8.0 a	8.2 a	74.3 a	55.0 b
Difference in Liking	8.0 a	6.2 b	160.6 a	83.2 b

[1]Sorted by Foodie and Nonfoodie representing panelists whose difference in liking value is above or below respectfully, the means (7.15 for the 9-point scale and 120.35 for the gLMS). [2]Means followed by different letters represent significant differences.

Table 4-10. Significant Means Differences Between Quinine Tasters[1] for Study Two

	9-point scale		gLMS	
	High	Low	High	Low
	n=116	n=84	n=116	n=84
Broccoli from Memory	6.4 a[2]	5.8 a	13.8 a	6.2 b
Orange Juice from Memory	7.5 a	7.2 a	30.2 a	22.4 b
Favorite Food from Memory	8.8 a	8.8 a	72.1 a	59.9 b
Grapefruit Juice from Memory	4.6 a	4.7 a	-2.1 b	8.1 a
Cheese Cake from Memory	7.6 a	7.0 b	33.7 a	31.4 a
Least Favorite Food from Memory	1.7 a	1.7 a	-61.2 b	-45.7 a
Black Coffee from Memory	3.4 a	3.9 a	-24.0 b	-8.0 a
Cheese Cake Taste	7.4 a	7.4 a	27.0 a	20.0 b
Black Coffee Taste	3.1 a	3.5 a	-34.6 b	-13.6 a
Grapefruit Juice Taste	3.1 a	3.5 a	-27.5 b	-9.8 a
Salty	8.0 a	7.5 b	60.3 a	25.6 b
Sweet	7.4 a	6.9 b	56.9 a	25.3 b
Sour	6.2 a	5.6 b	54.5 a	24.0 b
Bitter	9.0 a	6.8 b	85.7 a	34.7 b
Difference in Liking	7.2 a	7.1 a	133.2 a	102.6 b

[1]Sorted by Higher and Lower representing panelists whose rating of quinine is above or below respectfully, the mean (8.10 for the 9 point scale and 64.24 for the gLMS). [2]Means followed by different letters represent significant differences.

Table 4-11. Significant Correlations (p<0.05) (r values) for Study Two

	9-point scale	gLMS
	n=200	n=200
Bitter vs Broccoli from Memory		0.1612
Bitter vs Cheese Cake		0.1936
Bitter vs Cheese Cake from Memory	0.1536	
Bitter vs Black Coffee		-0.2207
Bitter vs Black Coffee from Memory		-0.1453
Bitter vs Favorite Food		0.3360
Bitter vs Grapefruit Juice		-0.2700
Bitter vs Grapefruit Juice from Memory		-0.1466
Bitter vs Least Favorite Food		-0.3399
Bitter vs Orange Juice from Memory		0.1723
Bitter vs Salty	0.1975	0.6956
Bitter vs Sour	0.1520	0.6446
Bitter vs Sweet		0.6515
Cheese Cake vs Broccoli from Memory		0.1407
Cheese Cake vs Cheese Cake from Memory	0.4543	0.3567
Cheese Cake vs Milk Chocolate from Memory	0.3180	0.4041
Cheese Cake vs Favorite Food		0.4478
Cheese Cake vs Least Favorite Food		-0.2977
Cheese Cake vs Orange Juice from Memory		0.6884
Cheese Cake vs Pepperoni from Memory	0.1470	0.2086
Cheese Cake from Memory vs BMI	0.1822	
Cheese Cake from Memory vs Broccoli from Memory	0.1367	
Cheese Cake from Memory vs Milk Chocolate from Memory	0.3010	0.2627
Cheese Cake from Memory vs Coke from Memory from Memory		0.2532
Cheese Cake from Memory vs Favorite Food		0.3059
Cheese Cake from Memory vs Orange Juice from Memory		0.2720
Cheese Cake from Memory vs Pepperoni from Memory		0.3625
Milk Chocolate from Memory vs BMI	0.1949	
Milk Chocolate from Memory vs Favorite Food	0.1435	0.4934
Milk Chocolate from Memory vs Grapefruit Juice from Memory		0.1449
Milk Chocolate from Memory vs Orange Juice from Memory		0.4011
Milk Chocolate from Memory vs Pepperoni from Memory		0.1723
Black Coffee vs Black Coffee from Memory	0.7010	0.7734
Black Coffee vs Favorite Food		-0.2406

Table 4-11. Continued

Black Coffee vs Grapefruit Juice from Memory	0.2205	
Black Coffee vs Least Favorite Food	0.2646	0.2445
Black Coffee from Memory vs Broccoli from Memory	0.1625	
Black Coffee from Memory vs Grapefruit Juice from Memory	0.2504	
Black Coffee from Memory vs Favorite Food	0.2454	
Black Coffee from Memory vs Least Favorite Food		0.1918
Black Coffee from Memory vs Pepperoni from Memory	0.1523	
Black Coffee from Memory vs Orange Juice from Memory	0.1421	
Difference in Liking vs Bitter		0.3743
Difference in Liking vs Cheese Cake		0.1285
Difference in Liking vs Cheese Cake from Memory		0.2713
Difference in Liking vs Milk Chocolate from Memory		0.4264
Difference in Liking vs Broccoli from Memory	-0.3277	
Difference in Liking vs Black Coffee from Memory	-0.2577	-0.1822
Difference in Liking vs Favorite Food	0.4604	0.8865
Difference in Liking vs Grapefruit Juice		-0.3263
Difference in Liking vs Grapefruit Juice from Memory	-0.1871	
Difference in Liking vs Least Favorite Food	-0.9404	-0.9177
Difference in Liking vs Orange Juice		0.4062
Difference in Liking vs Orange Juice from Memory		0.3370
Difference in Liking vs Salty		0.2764
Difference in Liking vs Sour		0.1916
Difference in Liking vs Sweet		0.3239
Favorite Food vs Orange Juice from Memory	0.1435	0.4214
Grapefruit Juice vs Black Coffee	0.2341	0.3020
Grapefruit Juice vs Black Coffee from Memory	0.2241	0.2392
Grapefruit Juice vs Favorite Food		-0.2835
Grapefruit Juice vs Grapefruit Juice from Memory	0.6584	0.5759
Grapefruit Juice vs Least Favorite Food	0.1814	0.3045
Grapefruit Juice vs Orange Juice from Memory	0.1715	
Grapefruit Juice vs Pepperoni from Memory	0.1487	
Grapefruit Juice from Memory vs Broccoli from Memory	0.2769	
Grapefruit Juice from Memory vs Orange Juice from Memory	0.2617	
Least Favorite Food vs Broccoli from Memory	0.3603	
Least Favorite Food vs Cheese Cake from Memory		-0.1926
Least Favorite Food vs Milk Chocolate from Memory		-0.2922
Least Favorite Food vs Favorite Food		-0.6296
Least Favorite Food vs Grapefruit Juice from Memory	0.2480	

Table 4-11. Continued

Least Favorite Food vs Orange Juice from Memory		-0.2040
Orange Juice vs Cheese Cake		0.4042
Orange Juice vs Milk Chocolate from Memory	0.1661	0.3463
Orange Juice vs Coke from Memory	0.1556	0.2156
Orange Juice vs Favorite Food	0.1990	
Orange Juice vs Grapefruit Juice	0.1892	
Orange Juice vs Orange Juice from Memory	0.4082	0.3513
Orange Juice vs Least Favorite Food		-0.2646
Orange Juice vs Pepperoni from Memory	0.2585	0.2613
Orange Juice from Memory vs BMI		0.1575
Orange Juice from Memory vs Broccoli from Memory	0.2117	
Orange Juice from Memory vs Coke from Memory		0.2040
Pepperoni vs BMI	0.1794	0.1825
Pepperoni vs Cheese Cake		0.2307
Pepperoni vs Cheese Cake from Memory		0.3594
Pepperoni vs Milk Chocolate from Memory		0.1764
Pepperoni vs Coke from Memory	0.1446	0.2189
Pepperoni vs Grapefruit Juice	0.2364	
Pepperoni vs Grapefruit Juice from Memory	0.1407	
Pepperoni vs Orange Juice	0.2766	0.3552
Pepperoni vs Orange Juice from Memory	0.1965	0.2966
Pepperoni vs Pepperoni from Memory	0.6586	0.7441
Pepperoni from Memory vs BMI	0.1944	0.2142
Pepperoni from Memory vs Coke from Memory	0.2168	0.2419
Pepperoni from Memory vs Orange Juice from Memory	0.1490	0.3135
Salty vs BMI		-0.1421
Salty vs Milk Chocolate from Memory		0.1895
Salty vs Black Coffee		-0.1688
Salty vs Black Coffee from Memory		-0.1490
Salty vs Favorite Food		0.2280
Salty vs Grapefruit Juice		-0.2205
Salty vs Least Favorite Food	-0.1425	-0.2683
Sour vs Cheese Cake	0.2040	0.2047
Sour vs Black Coffee		-0.1944
Sour vs Black Coffee from Memory		-0.1709
Sour vs Favorite Food		0.2202
Sour vs Grapefruit Juice		-0.1825
Sour vs Orange Juice		0.1533

Table 4-11. Continued

Sour vs Orange Juice from Memory		0.1517
Sour vs Salty	0.2375	0.5773
Sour vs Sweet	0.2907	
Sweet vs Broccoli from Memory		0.1435
Sweet vs Cheese Cake		0.2356
Sweet vs Cheese Cake from Memory		0.1411
Sweet vs Milk Chocolate from Memory		0.2608
Sweet vs Favorite Food		0.3257
Sweet vs Least Favorite Food		-0.2642
Sweet vs Orange Juice		0.1539
Sweet vs Orange Juice from Memory		0.2088
Sweet vs Salty	0.2998	0.7233

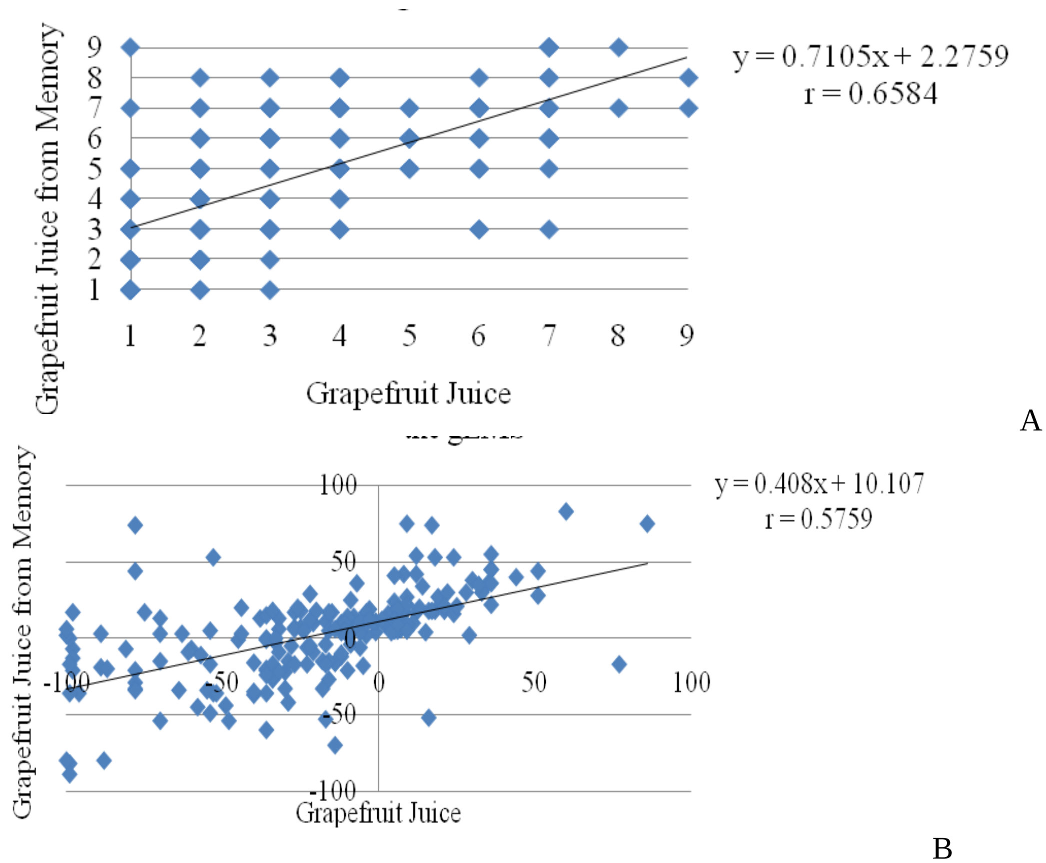
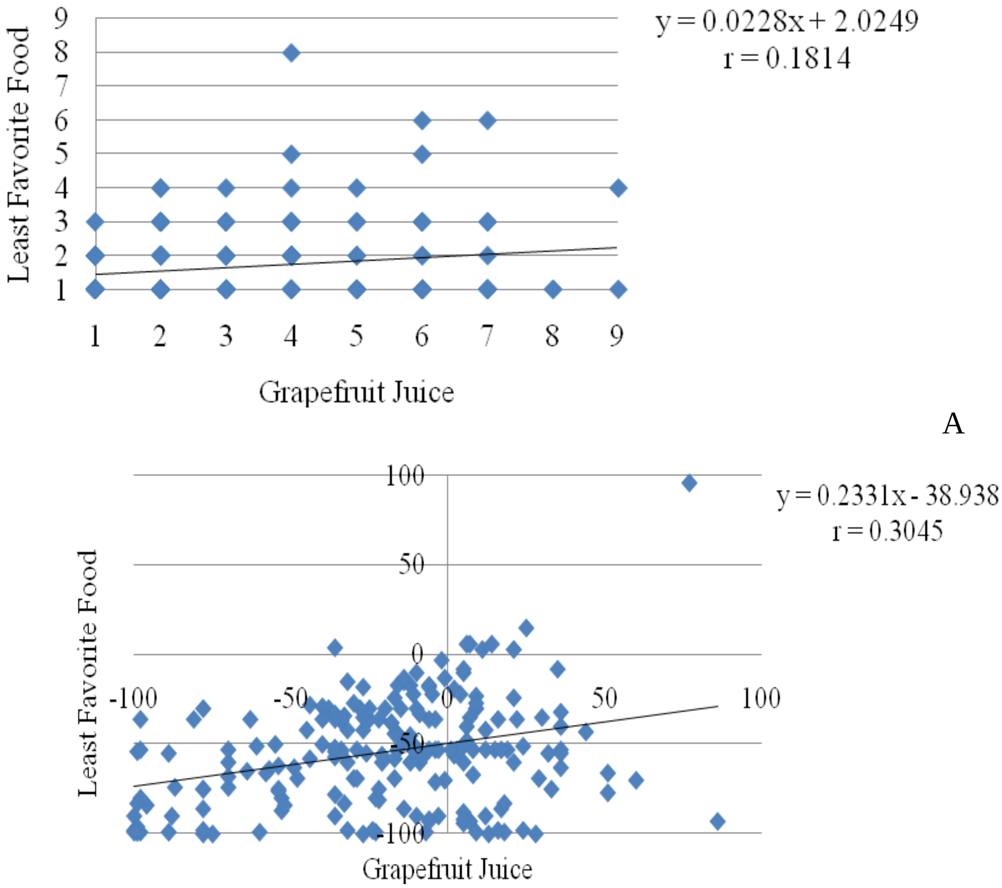


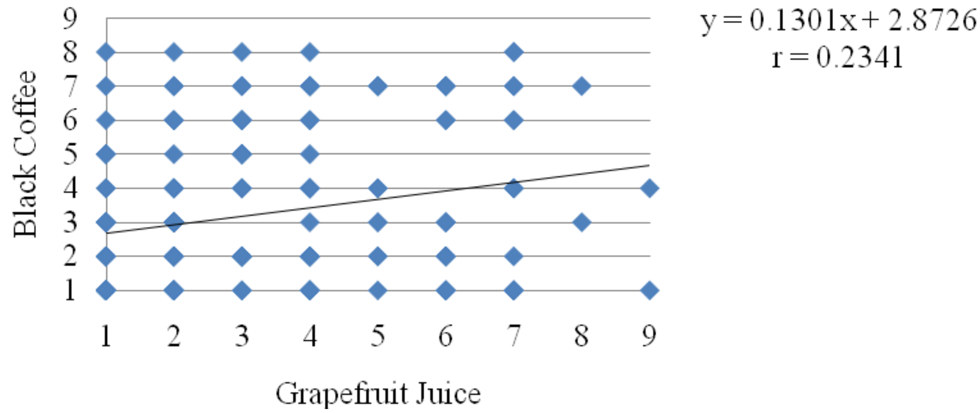
Figure 4-7. Correlation and Regression between Grapefruit Juice and Grapefruit Juice from Memory in study two. A) 9-point scale B) gLMS



A

B

Figure 4-8. Correlation and Regression between Grapefruit Juice and Least Favorite Food in study two. A) 9-point scale B) gLMS



A

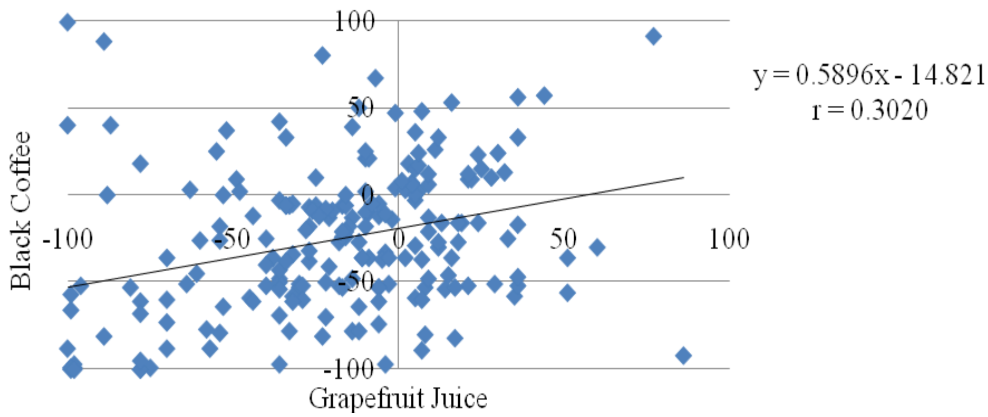


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Figure 4-9. Correlation and Regression between Grapefruit Juice and Black Coffee in study two. A) 9-point scale B) gLMS

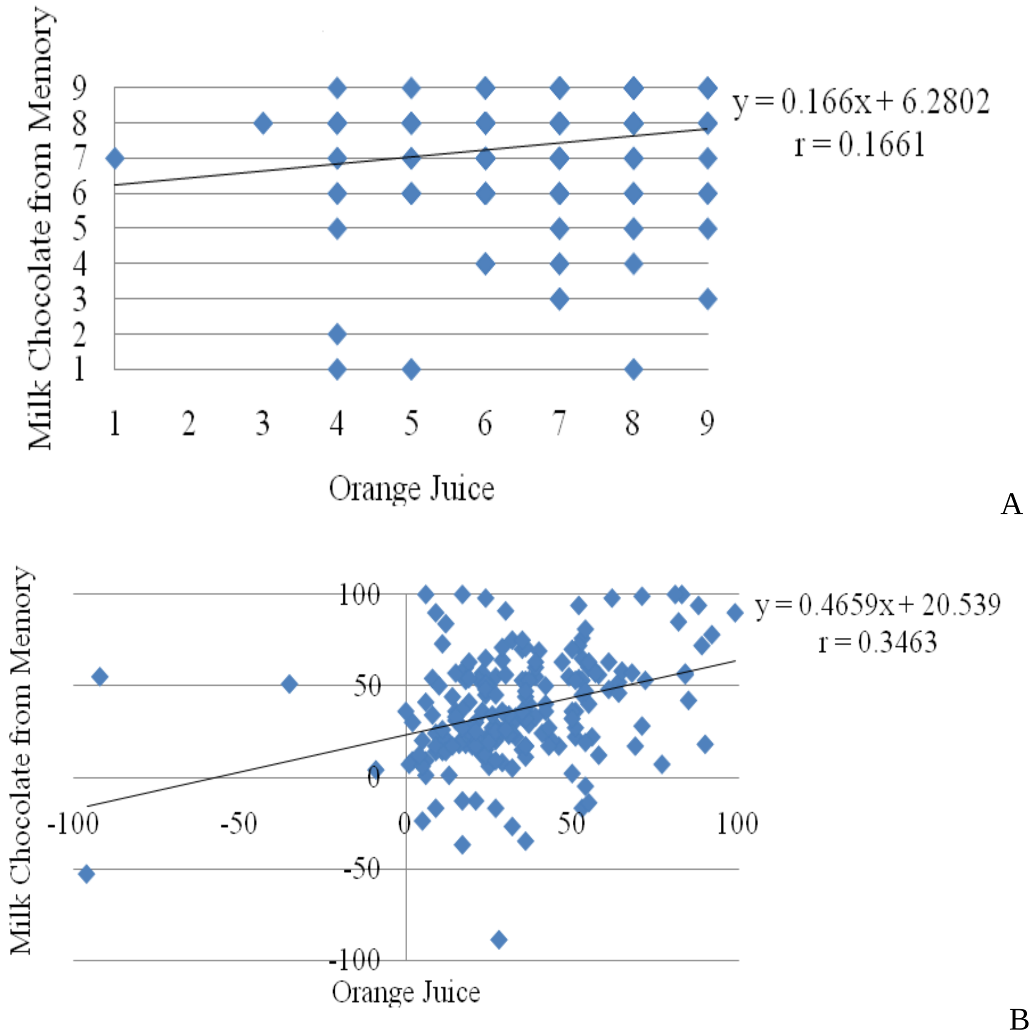
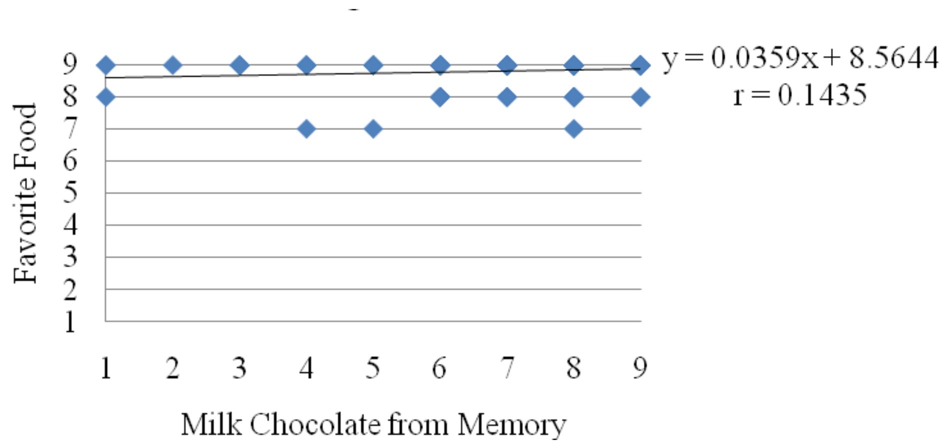


Figure 4-10. Correlation and Regression between Orange Juice and Milk Chocolate from Memory in study two. A) 9-point scale B) gLMS



A

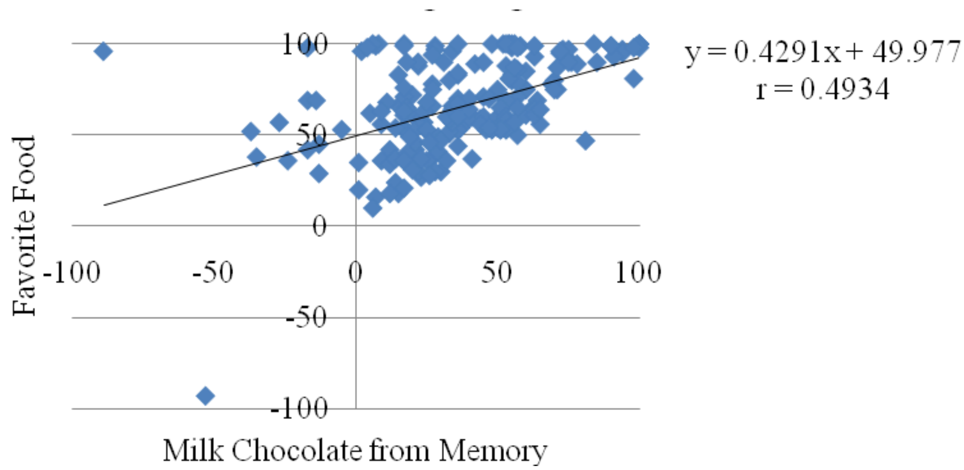


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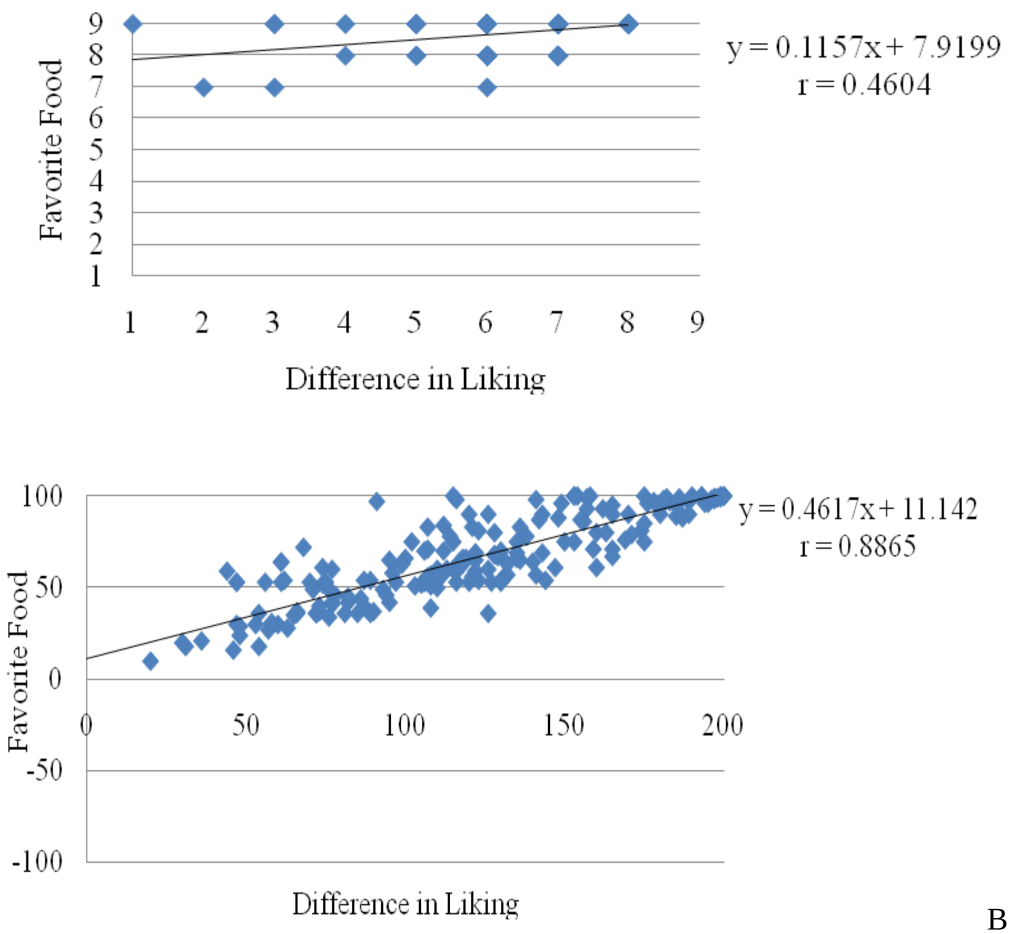
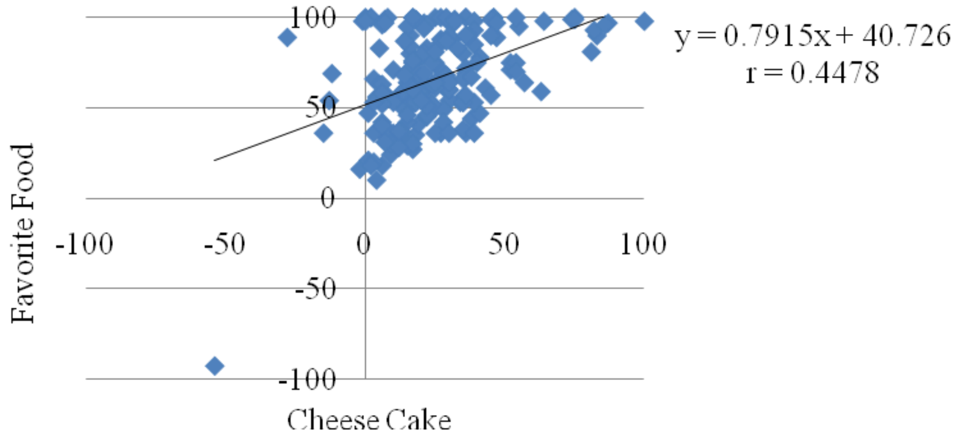
Figure 4-11. Correlation and Regression between Milk Chocolate from Memory and Favorite Food in study two. A) 9-point scale B) gLMS



A

B

Figure 4-12. Correlation and Regression between Difference in liking and Favorite Food in study two. A) 9-point scale B) gLMS



A

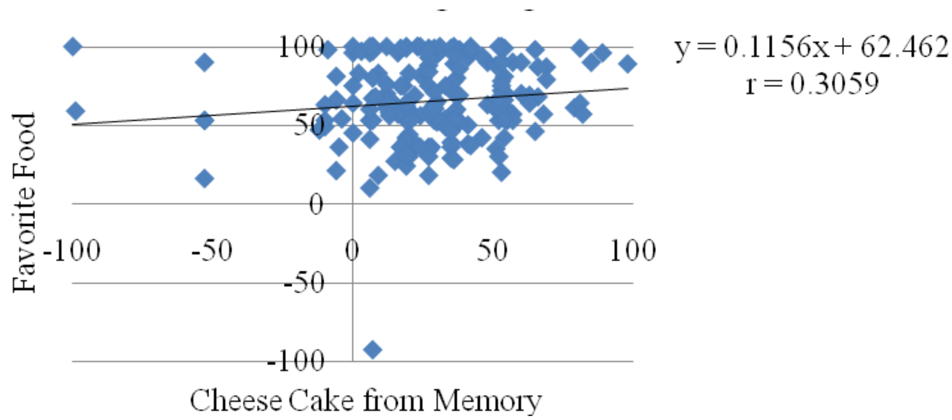


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Figure 4-13. Correlation and Regression in study two using the gLMS between Favorite Food and A) Cheese Cake and B) Cheese Cake from Memory

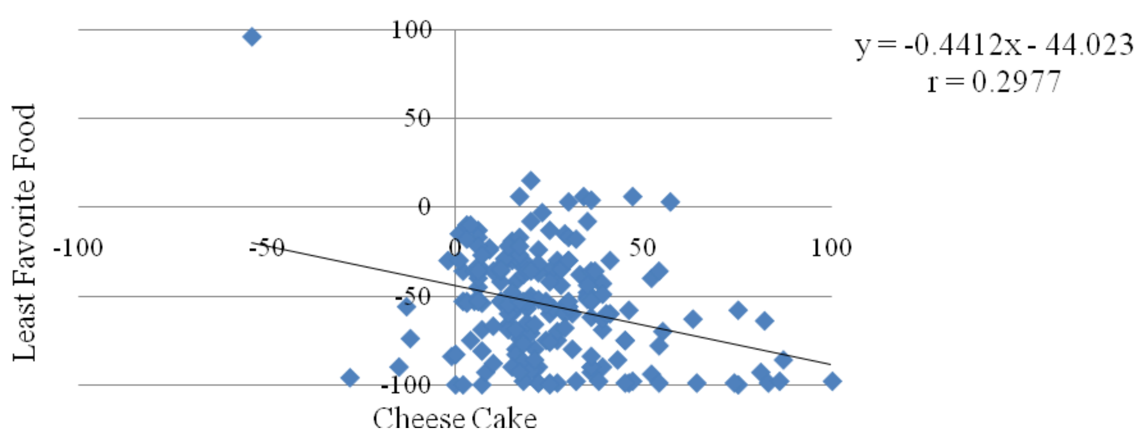
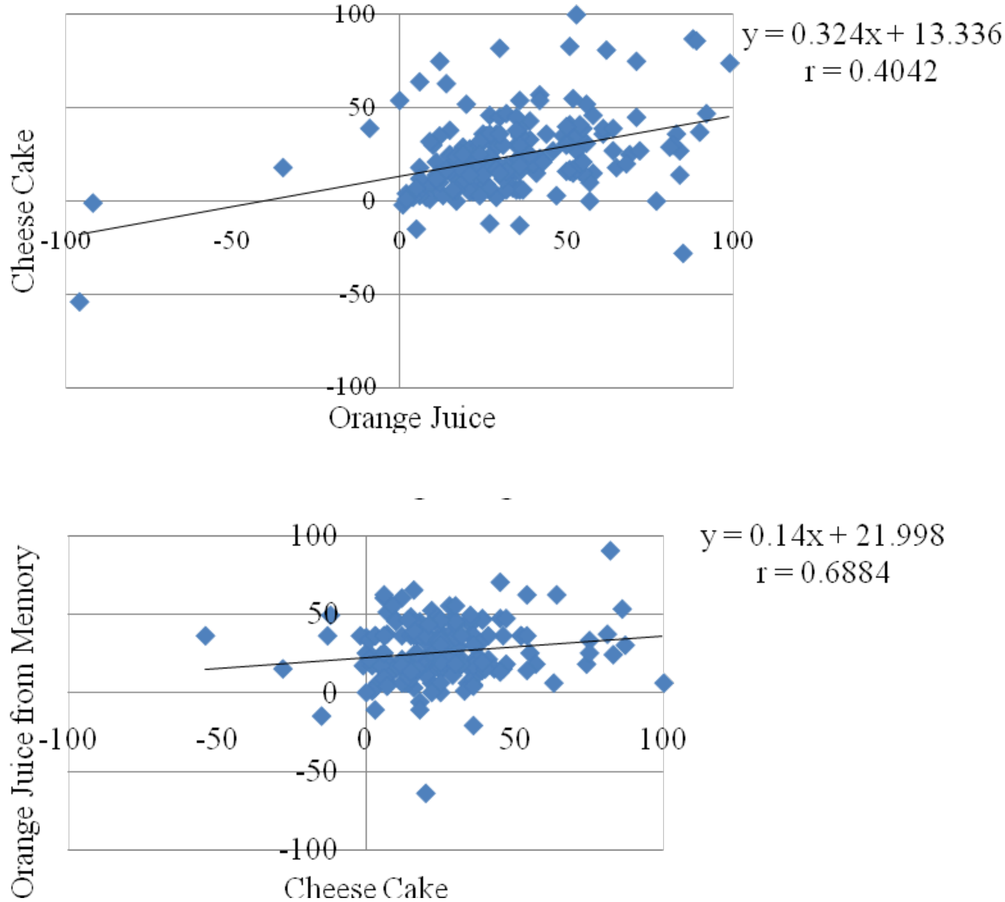


Figure 4-14. Correlation and Regression Cheese Cake and Least Favorite Food in study two using the gLMS



A

B

Figure 4-15. Correlation and Regression in study two using the gLMS between Cheese Cake and A) Orange Juice and B) Orange Juice from Memory

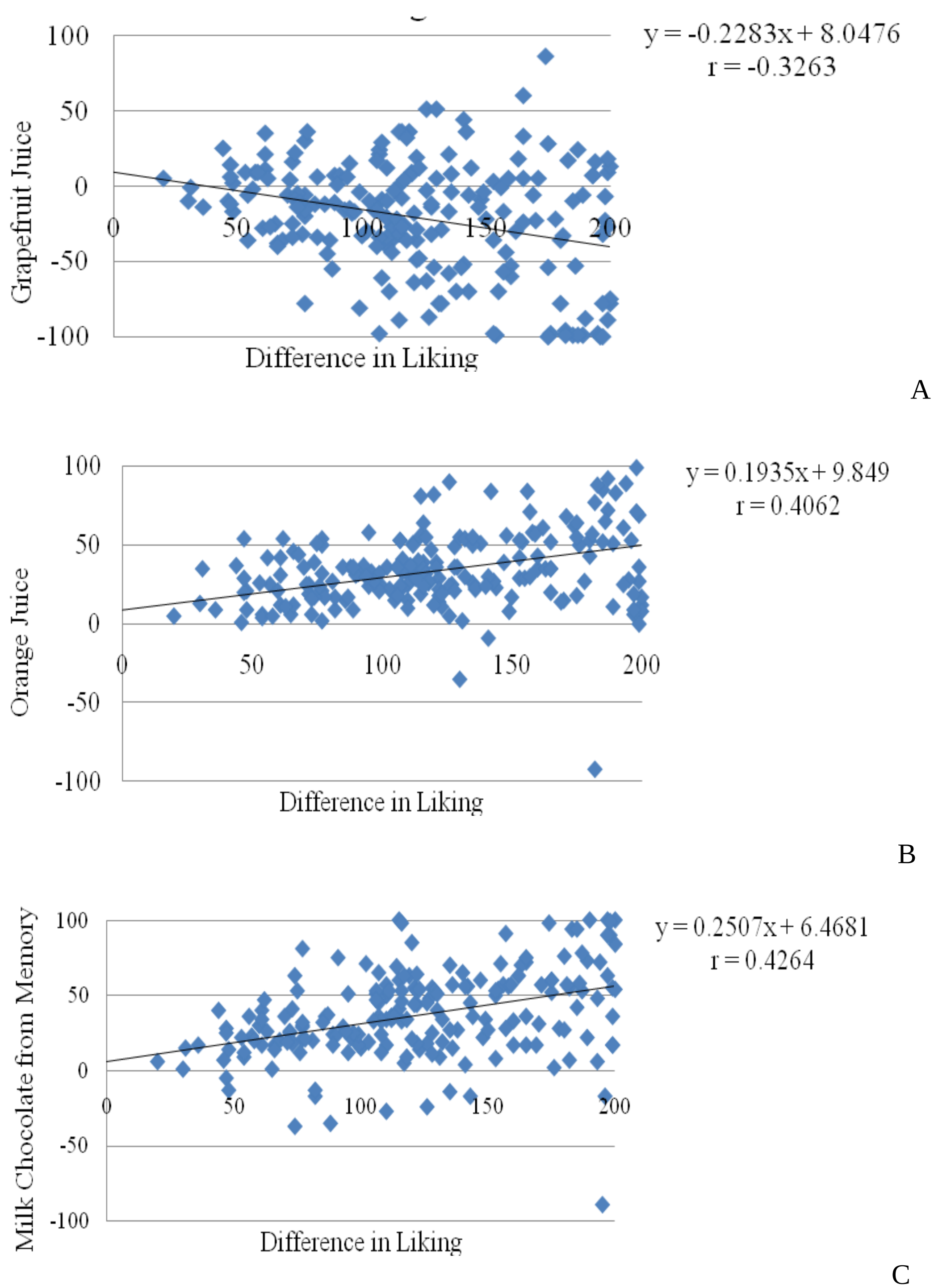
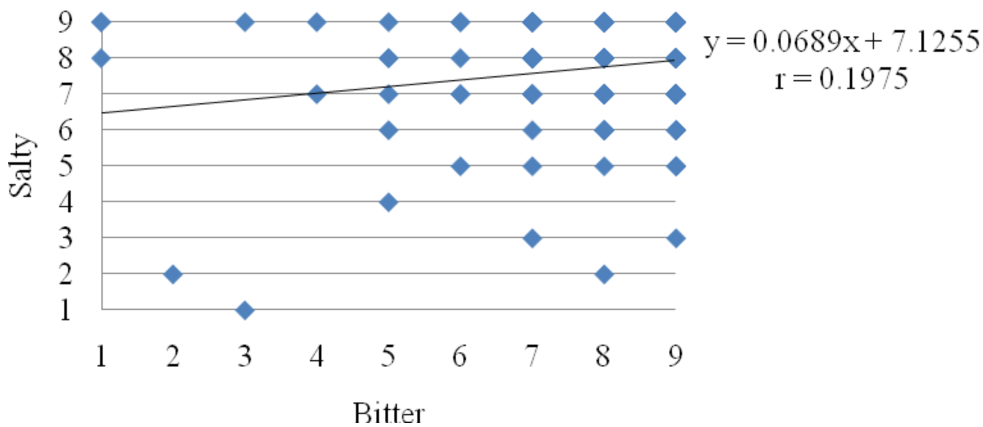


Figure 4-16. Correlation and Regression in study two using the gLMS between Difference in Liking and A) Grapefruit Juice and B) Orange Juice C) Chocolate from Memory



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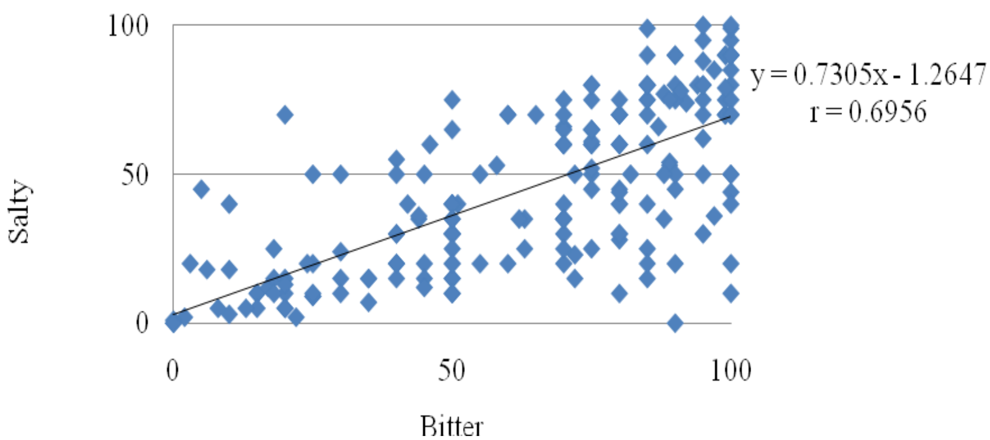


B

Figure 4-17. Correlation and Regression between Bitter and Salty in study two. A) 9-point scale B) gLMS

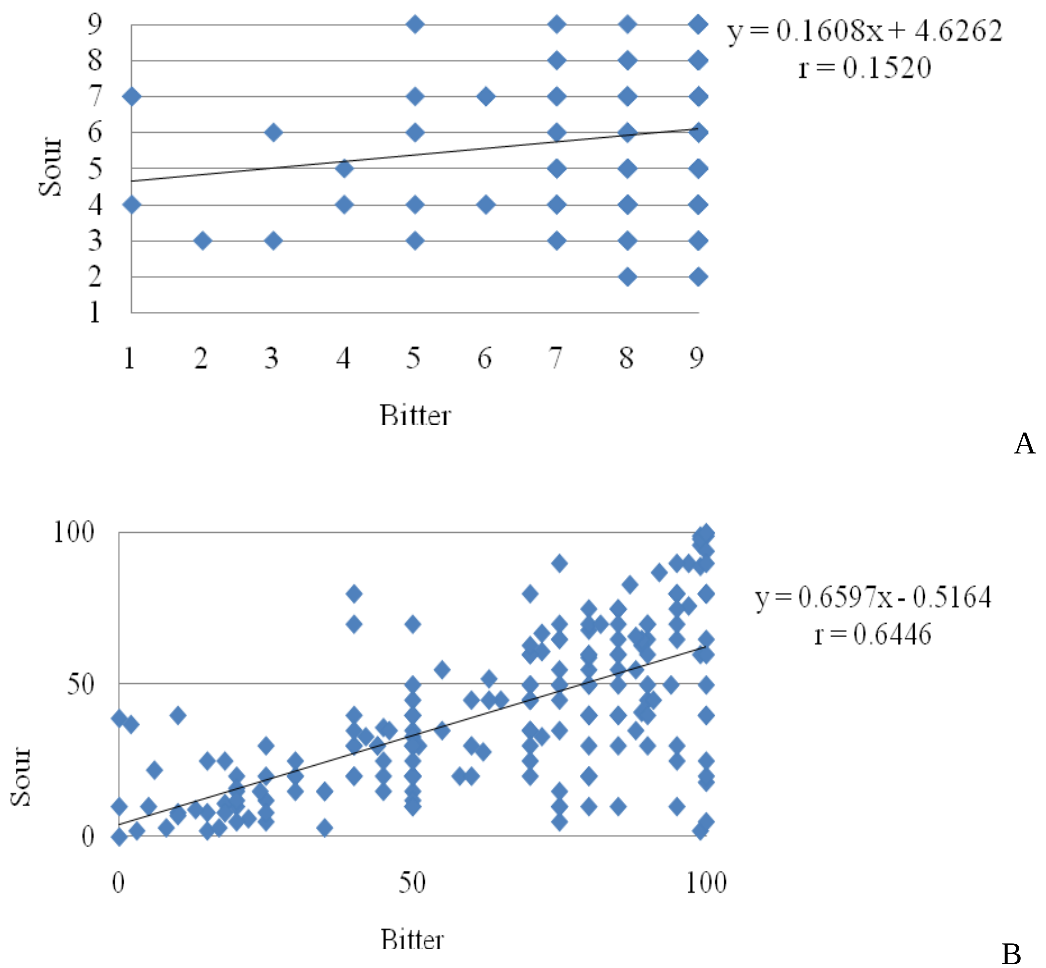
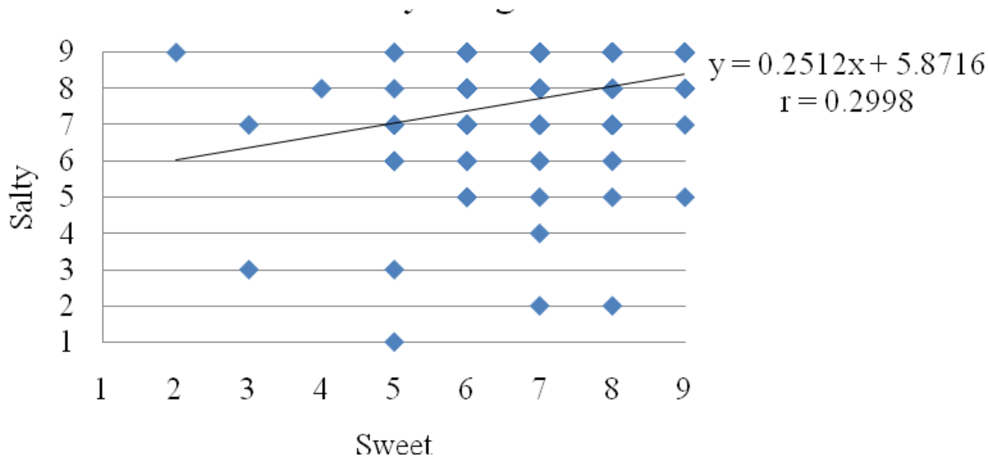
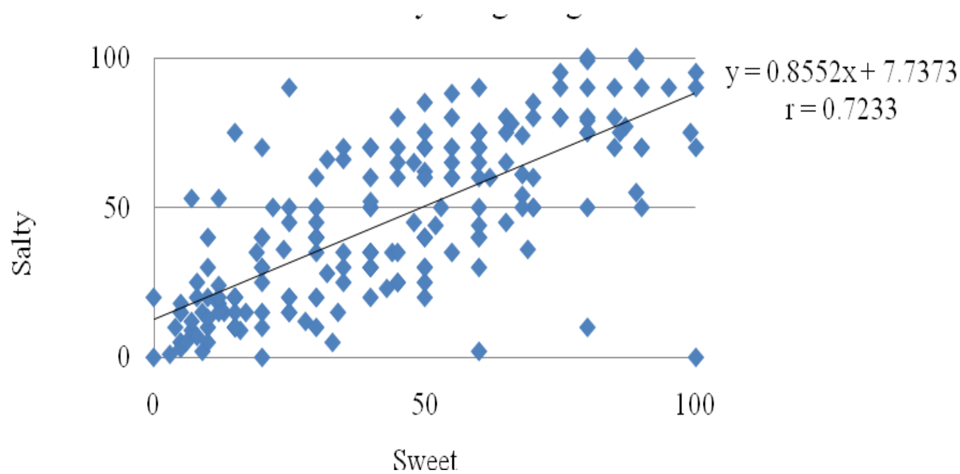


Figure 4-18. Correlation and Regression between Bitter and Sour in study two. A) 9-point scale B) gLMS

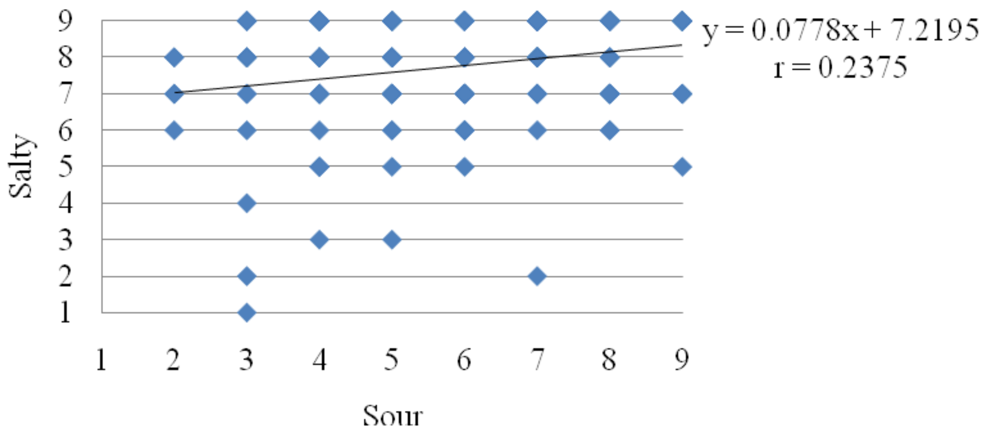


A



B

Figure 4-19. Correlation and Regression between Sweet and Salty in study two. A) 9-point scale B) gLMS



A

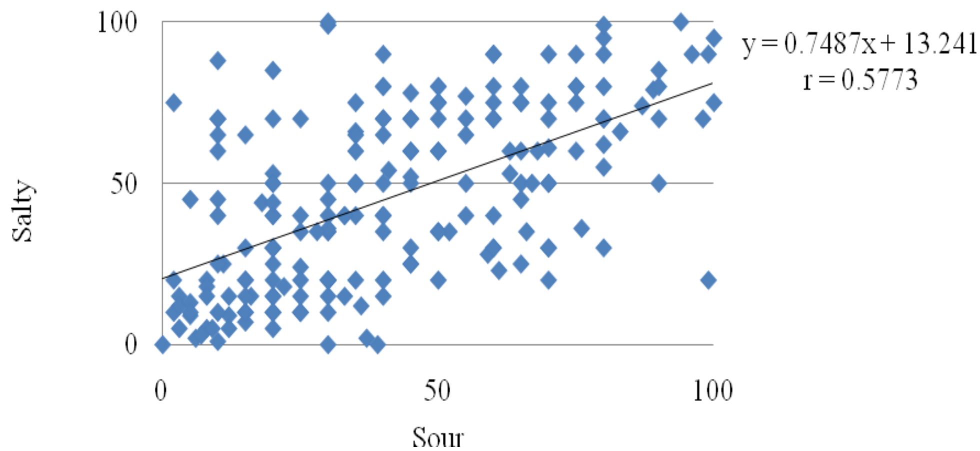


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Figure 4-20. Correlation and Regression between Sour and Salty in study two. A) 9-point scale B) gLMS

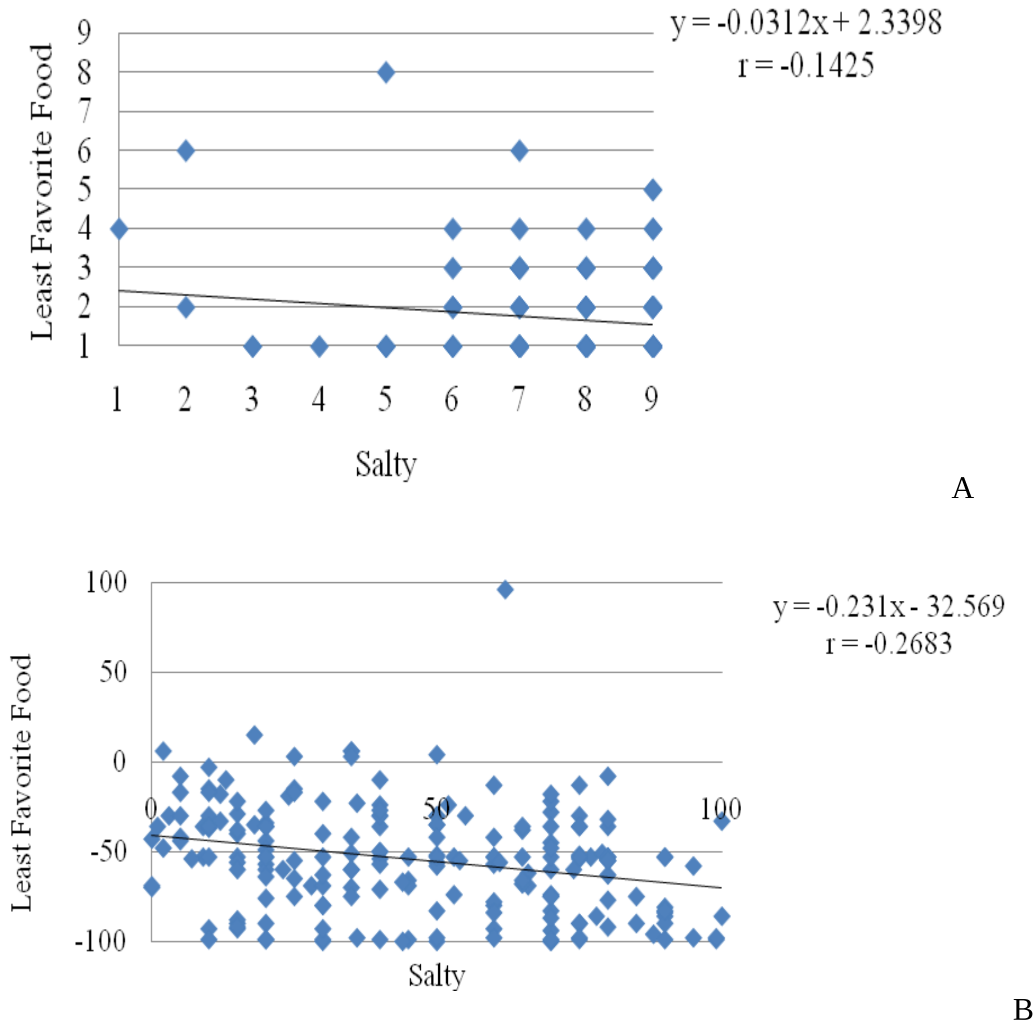

Figure 4-21. Correlation and Regression between Salty and Least Favorite Food in study two. A) 9-point scale B) gLMS

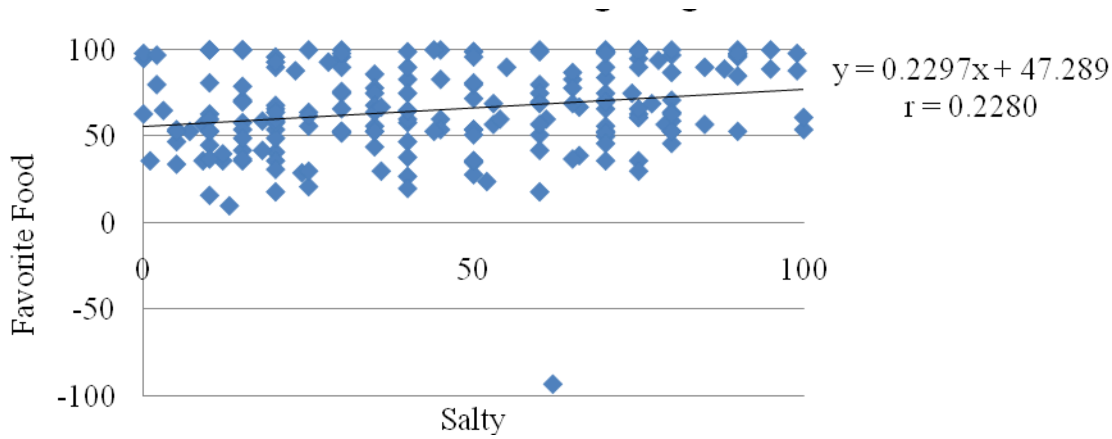

Figure 4-22. Correlation and Regression Salty and Favorite Food in study two using the gLMS

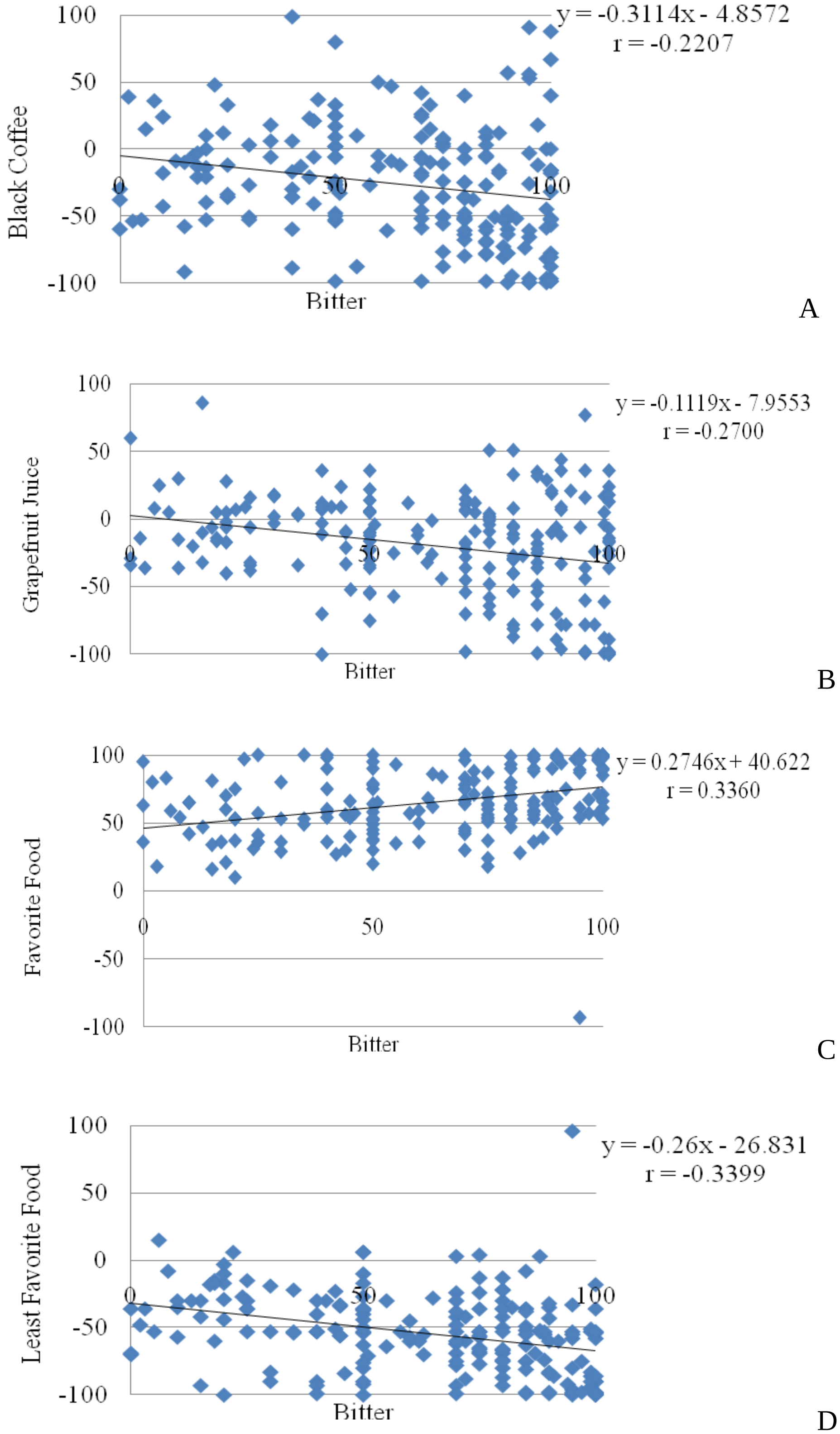

Figure 4-23. Correlation and Regression in study two using the gLMS between Bitter and A) Black Coffee, B) Grapefruit Juice, C) Favorite Food, D) Least Favorite Food

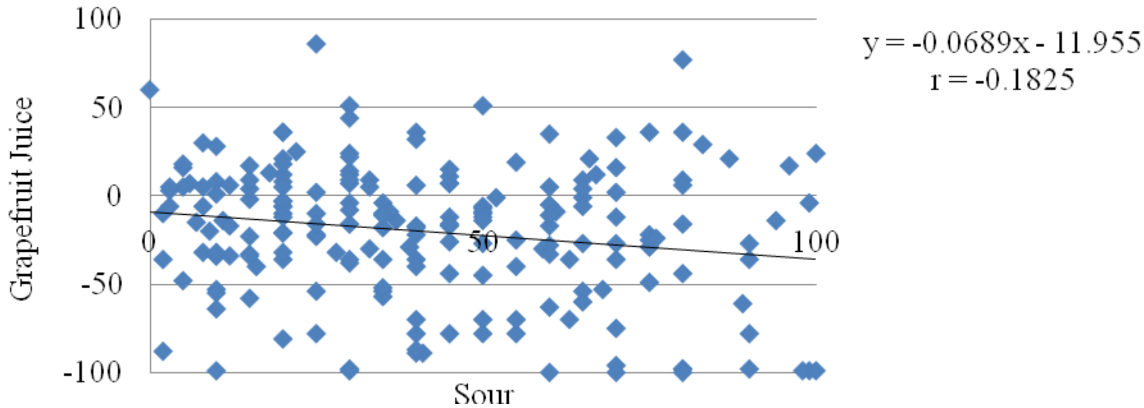

Figure 4-24. Correlation and Regression between Sour and Grapefruit Juice in study two using the gLMS

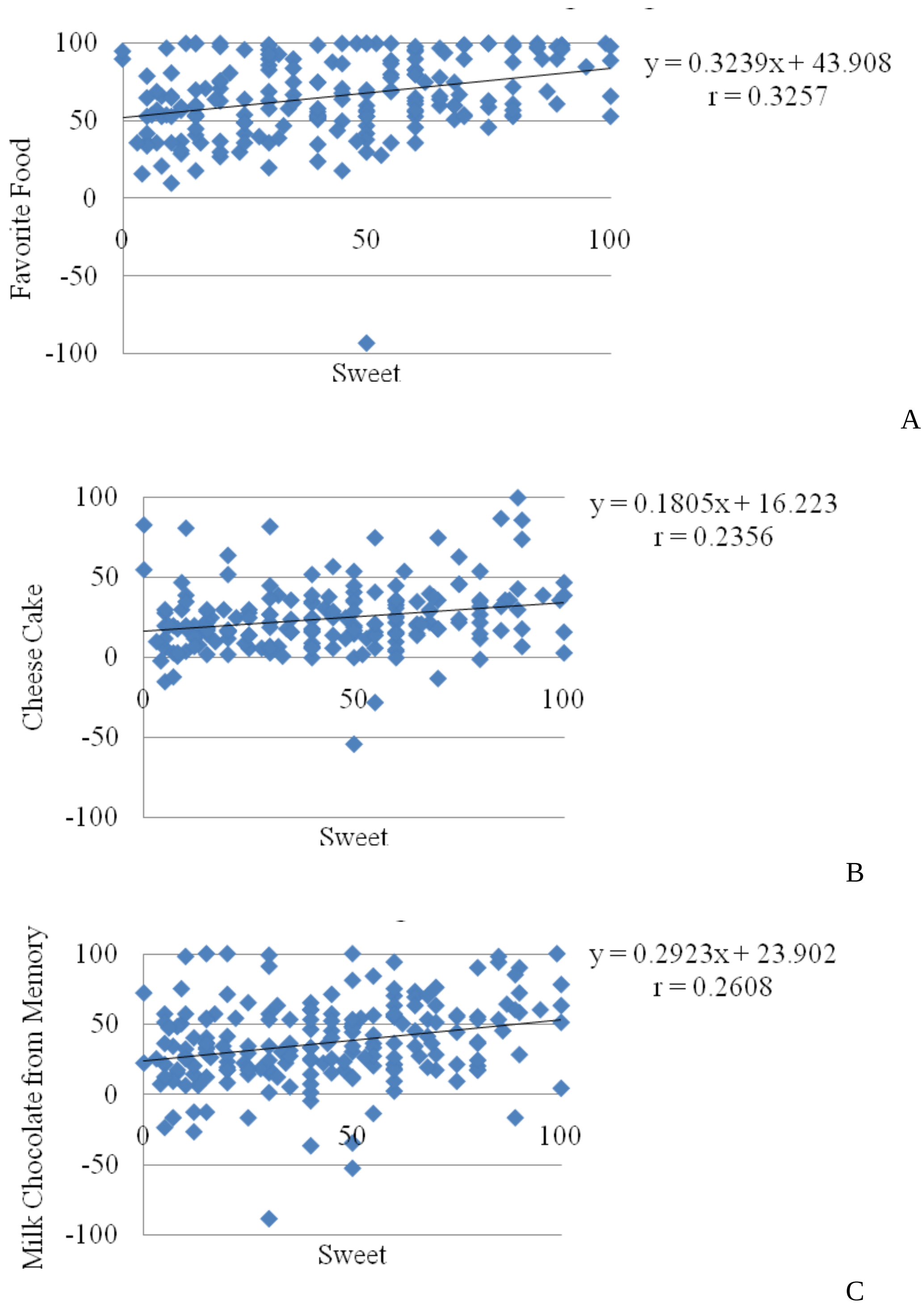

Figure 4-25. Correlation and Regression in study two using the gLMS between Sweet and A) Favorite Food, B) Cheese Cake, and C) Milk Chocolate from Memory

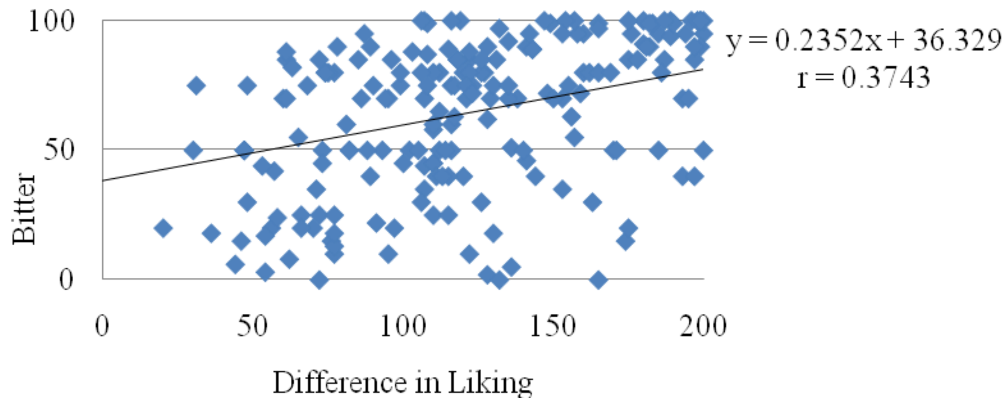

Figure 4-26. Correlation and Regression between Difference in Liking and Bitter in study two using the gLMS

Table 4-12. "Strongest imaginable LIKING of any kind" Anchors Totals for Study Two

Key of Categories	Overall	Male	Female	Foodies[1]	NonFoodies[2]
An event	28	15	13	11	17
Being at a Place	13	3	10	6	7
Being Happy/Laughing	8	2	6	4	4
Being Loved/Being in Love	28	7	21	12	16
Being Successful	14	10	4	4	10
Being with Friends/Family/Loved Ones	39	13	26	21	18
Food/Beverage	17	7	10	11	6
Hugging/Kissing	3	1	2	1	2
Playing/Watching a Sport	20	10	10	11	9
Riding a Rollercoaster	4	4	0	2	2
Security	0	0	0	0	0
Sex	12	6	6	5	7
Sleeping	3	0	3	3	0
Things	11	2	9	5	6
Total	200	80	120	96	104

[1] Represents panelists whose difference in liking value was above 120.35. [2] Represents panelists whose difference in liking value was below 120.35.

Table 4-13. “Strongest imaginable DISLIKING of any kind” Anchors Totals for Study Two

Key of Categories	Overall	Male	Female	Foodies[1]	NonFoodies[2]
Activity	21	11	10	14	7
Being Sick/Hurt/Medical	64	23	41	31	33
Bugs/Spiders/Animals	8	1	7	5	3
Cleaning	0	0	0	0	0
Death of Loved One/Friend	61	23	38	25	36
Eating Something	10	5	5	6	4
Hatred	1	0	1	1	0
Life Threatening Event/Fear of Death	35	17	18	14	21
Total	200	80	120	96	104

[1] Represents panelists whose difference in liking value was above 120.35. [2] Represents panelists whose difference in liking value was below 120.35.

Table 4-14. “Strongest imaginable SENSATION of any kind” Anchors Totals for Study Two

Key of Categories	Overall	Male	Female	Foodies[1]	NonFoodies[2]
Brightest Light	15	6	9	8	7
Emotion	48	26	22	15	33
Food/Beverage	3	2	1	2	1
Pain	107	38	69	57	50
Sound	21	7	14	9	12
Temperature	6	1	5	5	1
Total	200	80	120	96	104

[1] Represents panelists whose difference in liking value was above 120.35. [2] Represents panelists whose difference in liking value was below 120.35.

CHAPTER 5
CONCLUSION

In conclusion, the hedonic gLMS provides stronger and more data across-groups and within-groups than the hedonic 9-point scale for the population studied. Using AOV, correlations, and regression graphs in comparison, the hedonic gLMS reflects new insight towards sensory evaluation procedures.

We have seen from the results that the hedonic 9-point scale clearly falters in comparing across-groups and ceiling effects. The hedonic gLMS does not show these ceiling effects and provide stronger significant differences across-groups. With comparing gender, foodie type, and quinine tasters with AOV, the hedonic gLMS differences were stronger than the hedonic 9-point scale. The hedonic gLMS also performed well with nonfood questions (favorite and least favorite food and favorite song). The hedonic gLMS provides significant differences when analyzing overall liking of food product and intensity ratings of tastes.

The correlation coefficients and regression graphs show that both scales have significant correlations for the overall liking of many different food products. However, it is clearly seen that the hedonic gLMS shows much more results and stronger correlations. The hedonic 9-point scale is unable to separate the data from the ceiling effect which limits the amount of significant differences the scale shows. Since the hedonic gLMS personalizes the ceiling or top anchors to each panelist, it allows for better separation of the data. The regression graphs produced from the hedonic gLMS correlations provide a clearer understanding of the panel results. The data is more specific and accurate to the panelist's ratings, establishing a stronger connection between sensory testing and feelings. Stronger correlations from the hedonic gLMS produce a stronger bond of likability to a food product, based on panelists' sensory abilities.

Having the scale customized to each individual panelist with regard to their own opinions allows for more accurate ratings from panelists. They know exactly how they are rating each product based upon their self-generated anchors, similar to having built-in reference points on the scale.

The hedonic gLMS assesses liking for food in the context of all hedonic experiences proving better results across group comparisons. Therefore, the ability of the hedonic gLMS to provide more valid across-subject comparisons will provide the industry with more accurate data with regard to consumer acceptance. Companies will be able to separate out the data to see the overall liking of their product for different groups. This will allow the company to better market their product to target specific groups.

Further Research: Even though the hedonic gLMS scale has proven to provide more accurate data, more work needs to be done analyzing and adjusting the hedonic gLMS. Different anchors need to be explored in order to limit the variability between panelists. Adding different nonfood anchors to the scale would provide more across group comparison.

Since this study's findings only apply to the population test further research is needed. There limited groups of people due to the testing location. This study needs to be done with larger age groups, ethnic backgrounds, in different states and countries to make sure the hedonic gLMS is truly the ultimate scale to use. Another step in testing the hedonic gLMS scale compared to the hedonic 9-point scale is to do numerous sensory panels with both scales using just one product or the same group of products over a certain time period. A study also needs to be performed to see what other nonfood items would prove to be valuable anchors.

LIST OF REFERENCES

Amerine MA, Pangborn RM, Roessler EB. 1965. Principles of sensory evaluation of food. New York, NY.:Academic Press.

Bartoshuk L, Duffy V, Fast K, Kyeton J, Lucchina L, Phillips M. 2001. What makes a supertaster? Chem. Senses 26(8):1074.

Bartoshuk LM. 2000. Comparing sensory experiences across individuals: Recent psychophysical advances illuminate genetic variation in taste perception. Chem Senses 25(4):447-60.

Bartoshuk LM. 1979. Bitter taste of saccharin related to the genetic ability to taste the bitter substance 6-normal-propylthiouracil. Science 205(4409):934-5.

Bartoshuk LM, Duffy V, Green BG, Hoffman HJ, Ko CW, Lucchina LA, Marks LE, Snyder DJ, Weiffenbach JM. 2004a. Valid across-group comparisons with labeled scales: the gLMS versus magnitude matching. Physiol Behav 82(1):109-14.

Bartoshuk LM, Duffy VB, Chapo AK, Fast K, Yiee JH, Hoffman HJ, Ko CW, Snyder DJ. 2004b. From psychophysics to the clinic: missteps and advances. Food Quality and Preference 15(7-8):617-32.

Bartoshuk LM, Duffy VB, Fast K, Green BG, Prutkin J, Snyder DJ. 2003. Labeled scales (eg, category, Likert, VAS) and invalid across-group comparisons: what we have learned from genetic variation in taste. Food Quality and Preference 14(2):125-38.

Bartoshuk LM, Duffy VB, Lucchina LA, Prutkin J, Fast K. 1998. PROP (6-n-propylthiouracil) supertasters and the saltiness of NaCl. In: Anonymous Olfaction and Taste Xii. P793-6.

Bartoshuk LM, Duffy VB, Miller IJ. 1995. PTC/PROP tasting- anatomy, psychophysics, and sex effects. Physiol Behav 58(1):203.

Bartoshuk LM, Fast K, Snyder DJ. 2005. Differences in our sensory - Invalid comparisons with labeled scales. Current Directions in Psychological Science 14(3):122-5.

Bartoshuk LM, Snyder DJ, Duffy VB. 2006. Hedonic gLMS: Valid comparisons for food liking/disliking across obesity, age, sex and PROP status. Chem Senses 31(5):A50.

Bendig AW, Hughes JB. 1953. Effect of amount of verbal anchoring and number of rating-scale categories upon transmitted information. J Exp Psychol 46(2):87-90.

Borg G. 1982. A category scale with ratio properties for intermodal and interindividual comparisons. Psychophysical judgment and the process of perception. Berlin: VEB Deutscher Verlag der Wissenschaften 25-33.

Borg G. 1961. Interindividual Scaling and Perception of Muscular Force. Report from the Departm. of psychiatry, medical school, No.1, April 1961. Umea, Sweaden: Departm. of Psychiatry, Medical School.

Brandt MA, Skinner E, Coleman J. 1963. Texture profile method. Journal of Food Science 28:404-10.

Cardello A, Lawless HT, Schutz HG. 2008. Effects of extreme anchors and interior label spacing on labeled affective magnitude scales. Food Qual Prefer 19(5):473-80.

Cordonnier S, Delwiche J. 2008. An alternative method for assessing liking:Positional relative rating versus the 9-point hedonic scale. Journal of Sensory Studies 23:284-92.

Cox DN, Clark MN, Mialon VS. 2001. A cross-cultural methodological study of the uses of two common hedonic response scales. Food Quality and Preference 12(2):119-31.

Duffy VB, Lanier SA, Hutchins HL, Pescatello LS, Johnson MK, Bartoshuk LM. 2007. Food Preference Questionnaire as a Screening Tool for Assessing Dietary Risk of Cardiovascular Disease within Health Risk Appraisals. J Am Diet Assoc 107(2):237-45.

Duffy VB, Bartoshuk LM, Lucchina LA, Snyder DJ, Tym A. 1996. Supertasters of PROP (6-n-propylthiouracil) rate the highest creaminess to high-fat milk products. Chemical Senses 21:598.

Duffy VB, Peterson JM, Bartoshuk LM. 2004. Associations between taste genetics, oral sensation and alcohol intake. Physiol Behav 82(2-3):435-45.

Gay C. 1988. A statistical assessment of taste-testing methods. The University of Reading.

Geldard FA. 1972. The Human Senses. 2nd ed. New York, NY: Wiley.

Green BG, Dalton P, Cowart B, Shaffer G, Rankin K, Higgins J. 1996. Evaluating the 'labeled magnitude scale' for measuring sensations of taste and smell. Chem Senses 21(3):323-34.

Green BG, Shaffer GS, Gilmore MM. 1993. Derivation and evaluation of a semantic scale of oral sensation magnitude with apparent ratio properties. Chem Senses 18(6):683-702.

Greenhoff K, MacFie HJ. 1994. Preference mapping in practice. Measurement of Food Preferences 137-66.

Hall MJ, Bartoshuk LM, Cain WS, Stevens JC. 1975. PTC taste blindness and taste of caffeine. Nature 253(5491):442-3.

Helm E, Trolle B. 1946. Selection of a taste panel. Wallerstein Lab Community 9(28):181-194.

Hinreiner EH. 1956. Organoleptic evaluation by industry panels-the cutting bee. Food Technology 31(11):62-67.

Jones LV, Peryam DR. 1954. Development of a scale from measuring soldiers food preferences. Food Technol 8(12):S22.

Lawless HT. 1977. Pleasantness of mixtures in taste and olfaction. Sens Processes 1(3):227-37.

Lawless HT, Heymann H. 1998. Sensory evaluation of food; principles and practices. New York, NY. Chapman and Hall.

Lawless HT, Horne J, Spiers W. 2000. Contrast and range effects for category, magnitude and labeled magnitude scales in judgements of sweetness intensity. Chem Senses 25(1):85-92.

Leopold DA, Holbrook EH, Noell CA, Mabry RL. 2006. Disorder of taste and smell. 2008(November 20): http://www.emedicine.com/ent/TOPIC333.HTM.

Marks LE, Bartoshuk LM. 1979. Ratio scaling of taste intensity by a matching procedure. Percept Psychophys 26(5):335-9.

Meilgaard M, Civille G, Carr BT. 1999. Sensory evaluation techniques. CRC Press, London.

Meiselman HL, Schutz HG. 2003. History of food acceptance research in the US Army. Appetite 40(3):199-216.

Miller IJ, Whitney G. 1989. Sucrose octaacetate-taster mice have more vallate taste-buds than non-tasters. Neurosci Lett 100(1-3):271-5.

Mintel. 2009. Global Consumer Groups: Impact on New Product Development. 2007(Nov 02): http://www.gnpd.com/sinatra/gnpd/frontpage/&s_item=home.

Moskowitz HR. 1977. Magnitude estimation: Notes on what, how, when, and why to use it. Journal of Food Quality 1195-228.

Moskowitz HR, Chandler JW. 1977. New uses of magnitude estimation. Sensory Properties of Foods. 189-210.

Nelson G. 1998. Biology of taste buds and the clinical problem of taste loss. New Anatomy 253:70-78.

Pangborn RM. 1979. Physiological and psychological misadventures in sensory measurement or the crocodiles are coming. In: M. Johnson, editor. Sensory evaluation methods for the practicing food technologists Chicago, IL: Institute of food technologists. P21-22.

Peryam DR, Girardot NF. 1952. Advanced taste-test method. Food Engineering 24(July):58-61,194.

Sidel JL, Stone S, Bloomquist J. 1981. Use and misuse of sensory evaluation in research and quality control. Journal of Dairy Science 64:2296-2302.

Steiner JE. 1977. Facial expressions of the neonate infant indicating the hedonics of food-related chemical stimuli. Taste and Development: The Genesis of Sweet Preference 176–189.

Stevens SS. 1958. Adaptation-level vs the relativity of judgment. Am J Psychol 71(4):633-46.

Stone H, Sidel JL. 1985. Sensory Evaluation Practices. Food science and technology. Orlando, FL: Academic Press, Inc.

Stone H, Sidel JL. 1978. Computing exact probabilities in sensory discrimination tests. Journal of Food Science 43:1028-29.

Stone H, Sidel JL. 1993. Sensory Evaluation Practices. 2nd ed. San Deigo: Academic Press, Inc.

Stone H, Sidel JL. 2004. Sensory Evaluation Practices. 3rd ed. Oxford: Academic. 377.

Szczesniak AS. 1963. Classification of textural characteristics. Journal of Food Science 28:385-89.

Vickers ZM. 1983. Magnitude estimation vs category scaling of the hedonic quality of food sounds. J Food Sci 48(4):1183-6.

Villanueva ND, Petenate AJ, Da Silva M. 2005. Performance of the hybrid hedonic scale as compared to the traditional hedonic, self-adjusting and ranking scales. Food Quality and Preference 16(8):691-703.

BIOGRAPHICAL SKETCH

Born in Springfield, Massachusetts, from a very young age Jaclyn loved everything associated with food. She grew up in northern Connecticut, experimenting and developing different dishes. Making homemade applesauce became a hobby. She received her associates degree in Biology from Macon State College in Macon, Georgia in 2005 whereby she discovered an interest in food science. After finishing her first year at the University of Florida in 2006, she was the first intern of the Checkers Restaurant Company in Tampa, FL learning the ins and outs of the business, as well as, working on the quick service restaurant's product development projects. After graduating from the University of Florida with her B.S. in food science in 2007, she worked with the USDA in the Agricultural Marketing Service, Fruit and Vegetable Program, grading products for the government as a summer intern.

In May 2009, Jaclyn earned a M.S. degree in food science at the University of Florida. When not involved in formal academic activities, she is either at the gym working out, cooking, or doing research. She looks forward to all the future challenges that life will bring.