CHILDREN’S ACCEPTABILITY OF VEGETABLES: THE RELATIONSHIP BETWEEN FOOD NEOPHOBIA, VEGETABLE NEOPHOBIA, PICKY EATING, BITTER SENSITIVITY, AND MOUTH BEHAVIOR

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TITLE: Children’s Acceptability of Vegetables: The Relationship between Food Neophobia, Vegetable Neophobia, Picky Eating, Bitter Sensitivity, and Mouth Behavior

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ABSTRACT

Children’s Acceptability of Vegetables: The Relationship between Food Neophobia, Vegetable Neophobia, Picky Eating, Bitterness Sensitivity, and Mouth Behavior

Tara Egigian

Although vegetables provide many beneficial nutrients and have been shown to help reduce the risk of dietary related chronic diseases, children in the United States are not meeting the national recommendations of vegetable servings. The overall goal of this research was to study the relationship between children’s vegetable acceptance and the following children’s characteristics: food neophobia (FN), vegetable neophobia (VN), picky eating (PE), 6-n-propylthiouracil (PROP) sensitivity, Mouth Behavior (MB). The specific objectives were to: (1) develop a novel method for evaluating children’s MB, (2) assess the FN, VN, PE, PROP sensitivity, and MB levels in children in San Luis Obispo County, (3) examine the relationship between FN, VN, PE, PROP sensitivity, and MB, (4) determine exposure and willingness to try familiar and unfamiliar vegetables of the two levels of each of the children’s characteristics, (5) to determine acceptability of familiar and unfamiliar vegetables of each level of each of the children’s characteristics, and (6) determine if the preference between two levels of each children’s characteristic differed.

Children’s acceptability of familiar and unfamiliar vegetables was conducted with 43 child and parent pairs. Parents completed five questionnaires: demographics, the Child Food Neophobic Scale, the Fruit and Vegetable Neophobia Instrument (vegetable subscale), the Child-Feeding Questionnaire (pickiness subscale), and the JBMB® typing
tool. Children participated in consumer acceptance testing of red carrots (stick, sliver, and puree) and broccoli (floret, sliver, and puree). Sensory attributes were measured using a 5-point facial hedonic scale. The children’s PROP sensitivity was determined by having the children place a control taste strip on their tongue for approximately ten seconds and report what they tasted. This procedure was repeated with a PROP taste strip. The children’s MB was determined through a guided discussion about their eating behaviors and food preferences with their parents.

Of the children in the study, there were 46.51% FN, 32.56% PE, 34.8% PROP sensitive, 44.19% VN, 60.47% chewers, 27.91% crunchers, 6.98% smooshers, and 4.65% suckers. From likelihood ratio chi-square analysis, the following characteristics were related: FN and VN (p<0.0001), FN and PE (p<0.0001), and VN and PE (p<0.001). The majority of the children had previously tried or seen all of the vegetable samples, except for the purees, and the majority of the children were willing to try all of the vegetables. There were some preference differences in the attributes of the vegetables for the different levels of the characteristics.

This study indicates there are possible trends between FN, PE, MB, and vegetable acceptance. Another trend that appeared was that the sensory attributes of the non-bitter, unfamiliar red carrots were often rated higher than the sensory attributes of the bitter, familiar broccoli. It may be possible to determine child’s MB through discussions with the child and their parent. In conclusion, knowledge of a children’s MB and understanding how their eating behaviors are associated with the acceptability of familiar and unfamiliar vegetables served in different product forms may be able to help increase children’s vegetable consumption.
Keywords: food neophobia, picky eating, mouth behavior, 6-\textit{n}-propylthiouracil (PROP), vegetable neophobia, children
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CHAPTER 1
INTRODUCTION

Vegetables are an important component of an individual’s diet. They are nutritious food sources that provide many beneficial minerals, vitamins, and other nutrients that are necessary for proper body function (Hanif et al., 2006). The consumption of an adequate amount of vegetables every day has been shown to help reduce the risks of dietary related chronic disease, such as cardiovascular disease and cancer (Liu, 2003). If an individual consumes the necessary amount of vegetables every day, they are taking the proper steps to help prevent future chronic diseases. According to the 2015 to 2020 Dietary Guidelines for Americans, children age 4 to 13 should be consuming 1.5 to 3 cup equivalents of vegetables daily, depending on their age and sex (USDHHS and USDA, 2015). From 2007 to 2010, most children in the United States did not meet national recommendations for vegetable servings, with 93% of all children ages 1-18 consuming less than the recommended vegetable servings (NCI, 2018).

Texture, taste, appearance, and aroma are four major sensory properties that play key roles in whether consumers will accept or reject food and beverage products (Barrett, Beaulieu, & Shewfelt, 2010). In relation to taste and vegetable consumption, consumers’ bitterness sensitivity plays a key role in the acceptability of these products because of the presence of bitter tasting compounds in vegetables. An individual’s ability to taste 6-\textit{n}-propylthiouracil (PROP) can alter their acceptance of vegetables (Sharafi et al., 2013). Similar to the importance of bitterness, texture is also an important component of understanding what influences consumers’ food preferences because it is a main cause for food rejection (Drewnowski, 1997). This makes understanding mouth behavior crucial.
because mouth behavior provides information about the way an individual manipulates food in their mouth. Understanding an individual’s mouth provides insight to the types of texture an individual prefers (Jeltema, Beckley, & Vahalik, 2016).

The objective of this research is to study the relationship between food neophobia, vegetable neophobia, picky eating, 6-n-propylthiouracil (PROP) sensitivity, and Mouth Behavior on children’s acceptability of familiar and unfamiliar vegetables.
2.1 Introduction

The purpose of this chapter is to provide a review of the literature related to the four major factors of the thesis: bitterness sensitivity, Mouth Behavior (MB), food neophobia (FN), vegetable neophobia (VN), and picky eating (PE). Taste sensitivity varies among individuals, and for bitterness specifically, individuals vary in their 6-n-propylthiouracil (PROP) sensitivity, with some perceiving PROP as bitter and others perceiving it as tasteless. Along with flavor, texture is an important sensory component of foods. Primarily, it is important to understand how a food’s texture fits with an individual’s MB, which is an individual’s preferred method of manipulating food in their mouth. Two common eating behaviors that contribute to the acceptance or rejection of foods are PE and FN. While PE is the rejection of both familiar and unfamiliar foods, FN is the rejection of specifically unfamiliar foods. VN is a subset of FN that describes the behavior of rejecting unfamiliar vegetables. Consumer evaluation is the process of measuring individual’s acceptance or rejection of the sensory attributes, such as flavor and texture, of food products. The purpose of this literature review is to provide:

1. Background information regarding the biology of taste and differences of PROP sensitivity
2. Overview of the definition, comparison of groups, development of JBMB® typing tool, and insight from distinguishing consumer’s classification of MB
3. Discussion of PE, FN, and VN
4. Brief background on sensory evaluation methods commonly utilized in consumer testing

2.2 Physiology of Taste

Humans have five main senses: sight (vision), hearing (audition), taste (gustation), smell (olfaction), and touch (somatosensation). The sense of taste is the ability to recognize and differentiate between the various taste, such as the five primary tastes: bitter, salty, sour, sweet, and umami. According to a study by Running, Craig, and Mattes (2015), there exists a sixth basic taste, fat (oleogustus). Taste and flavor are commonly confused, but flavor is made up of the interaction of gustatory stimuli and retronasal olfaction, which is the perception of odors originating from the oral cavity during consumption of foods and beverages (Rozin, 1982; Stokes, Matthen, & Biggs, 2017; Welge-Lussen et al, 2009). The primary organ for taste is the tongue because this muscular organ is covered in papillae, which is where taste buds are located (Bachmanov & Beauchamp, 2007; Latha & Lakshmi, 2012).

2.2.1 Taste Papillae

Papillae are the small bumps located on the tongue, which give the tongue its rough structure (Latha & Lakshmi, 2012). There are four types of papillae located on different sections of the human tongue: circumvallate, filiform, foliate, and fungiform (Gravina, Yep, & Khan, 2013). Circumvallate papillae are found on the posterior of the tongue in an inverted V formation. Filiform papillae are the most abundant papillae on the tongue, and they are found on the anterior two-thirds of the tongue (Lowe, Anderson, & Anderson, 2015). Foliate papillae are the grooves on the lateral sides of the tongue. Fungiform papillae are found on the surface, and the majority of them (87%) are
specifically located on the anterior 2 centimeters of the tongue (Gravina, Yep, & Khan, 2013). Papillae are considered to be the primary structure that house the sensory endings on the tongue because taste buds, which are chemoreceptors, are located on the circumvallate, foliate, and fungiform papillae. The filiform papillae are the only type of papillae that do not contain taste buds. Instead, filiform papillae transduce temperature, touch, and nociception (pain). Of these different types of papillae, filiform papillae are the only type that does not contain taste buds, which are chemoreceptors (Gravina, Yep, & Khan, 2013; Latha & Lakshmi, 2012).

2.2.2 Taste Buds

The primary sensory organs involved in the sense of taste are taste buds. Taste buds are primarily located in the oral cavity, specifically on the tongue, palate, epiglottis, pharynx, and larynx. Deshpande et al. (2010) unexpectedly discovered bitter taste receptors (TAS2Rs) in the smooth muscles that control the flow of air into the bronchi, which are the narrow airways in lungs, are able to detect and “taste” bitter substances in the air. Although these taste receptors are similar to taste buds in the oral cavity in that they detect the presence of bitter compounds, they do not send nerve impulses to the brain.

In the oral cavity, there are between 2,000 and 5,000 taste buds. On the tongue specifically, taste buds are located on the circumvallate, foliate, and fungiform papillae (Bachmanov & Beauchamp, 2007; Roper, 2013). Each taste bud on the papillae are made of groups of 50 to 100 taste cells. These cells have been separated into three main functional classes: Type I, Type II, and Type III. The classes differ based on the
morphological appearances, gene expression, and response to gustatory stimulation of the taste cells in each class (Roper, 2013).

Type I cells are the most abundant cells in taste buds, making up approximately 50% of the total number of cells. They are supporting cells that function similarly to glial cells in the nervous system (Lawton et al., 2000; Vandenbeuch, Clapp, & Kinnamon, 2008). Type II cells have been given the name “receptor” cells because of their ability to detect bitter, sweet, and umami taste (Tomchick et al., 2007). This occurs due to Type II cells ability to express G-protein-coupled receptors (GPCRs), which are what are responsible for bitter, sweet, and umami taste transduction (DeFazio et al., 2006; Tomchick et al., 2007). These cells do not directly respond to salty or sour stimuli, which some believe to result from these tastants not being transduced through GPCRs (Tomchick et al., 2007). Type III cells have been given the name presynaptic cells because they are the only type of cells that form synaptic contacts with nerve fibers (DeFazio et al., 2006; Huang et al., 2008; Kataoka et al., 2008). Some suggest that these cells are responsible for the transduction but not the transmission of sour taste (Kataoka et al., 2008; Huang et al., 2008).

A primary difference between Type II and Type III cells is that Type II cells express GPCRs but do not form conventional synapses, while Type III cells do not express GPCRs but do form conventional synapses (DeFazio et al., 2006; Tomchick et al., 2007). Of the five major tastes, salty is the only one that remains unknown as to which type of cells in the taste bud transduce this taste. There also exists a class known as Type IV cells, which are undifferentiated cells (Chaudhari & Roper, 2010), but unlike the
spindle shaped cells in Type I, II, and III, Type IV are cuboidal shaped cells (Lee et al., 2009).

2.3 Bitterness Sensitivity

It is widely accepted that bitter taste has evolved to protect humans by allowing them to detect and avoid the consumption of poisonous and/or toxic foods (Hayes et al., 2015; Nolden, McGeary, & Hayes, 2016; Roura et al., 2015). Humans are born with an innate dislike for bitterness; however, there is variation between humans regarding their bitterness perception, meaning there is a variation between human’s bitterness sensitivities (Capaldi & Privitera, 2008; Roura et al., 2015). Many factors impact an individual's bitterness perception, including, but not limited to, age, gender, morphology, environment, and the TAS2R38 gene.

2.3.1 Genetic Variation of Bitterness

Of all factors impacting bitterness perception, evidence indicates that it is the TAS2R38 gene that makes one of the more important contributions to bitterness perception compared to the other contributing factors (Behrens et al., 2013). Taste receptor cells (TRCs) for mammals belong to fungiform, foliate, and circumvallate papillae on the tongue (Bachmanov & Beauchamp, 2007). Humans are able to detect bitter compounds through the 25 Taste 2 Receptor (TAS2R), which are Type II taste bud cells. These bitter receptors are part of the G protein-coupled (GPCR) family, and are located on chromosomes 5p, 7q, and 12p (Roura et al., 2015; Tepper et al., 2014; Shi et al., 2003).

The taste 2 receptor member 28 (TAS2R38) gene has been the most studied bitter receptor in the TAS2R family (Behrens et al., 2013; Nolden, McGeary, & Hayes, 2016).
This specific gene is located on chromosome 7q36 (Duffy et al., 2004). The TAS2R38 gene is key in the detection of thiouracil compounds, including 6-n-propylthiouracil (PROP) and phenylthiocarbamide (PTC) (Roura et al., 2015). The variation in human’s PTC sensitivity is due in part to the two common haplotypes that are formed by three single nucleotide polymorphisms of TAS2R38. The two most common haplotypes are proline-alanine-valine (PAV) and alanine-valine-isoleucine (AVI), but there are also three rare haplotypes that have been observed: AAI, AAV, and PVI (Hayes et al., 2008; Roura et al., 2015). While PAV is the dominant taster variant, AVI is the non-taster recessive taster variant (Boxer & Garneau, 2015).

2.3.2 Bitterness Sensitivity Taster Categorization

Fox discovered human’s variation in phenylthiocarbamide (PTC) sensitivity when a laboratory incident resulted in some powdered PTC ‘[flowing] around in the air.’ While Fox’s co-worker, Noller complained the powder tasted bitter, Fox was unable to taste anything (Fox, 1932). Future research led Fox to find that most individuals are either able to taste the compound at very low concentrations, whom Fox referred to as “tasters,” or only able to taste the compound at very high concentrations, whom he referred to as “non tasters” or “taste blind” (Wooding, 2006).

An additional category of bitterness sensitivity was identified when Bartoshuk, Duffy, and Miller (1994) identified the existence of 6-n-propylthiouracil (PROP) “super tasters.” Super tasters are those who perceive PROP at a greater intensity than tasters or medium tasters, who perceive PROP as only moderately bitter (Bartoshuk, 2000). Depending on an individual’s genetics, they can be classified as a different type of bitter taster: “super tasters” have proline-alanine-valine (PAV) homozygotes, “medium tasters”
have heterozygotes, and “non tasters” have alanine-valine-isoleucine alanine-valine-isoleucine (AVI) homozygotes (Bell, Methven, & Wagstaff, 2017; Duffy et al., 2004). Although the percentages of super-, medium, and non-tasters vary around the world, approximately 75% of the human population are “tasters” and 25% are “non tasters” (Guo & Reed, 2001). Bartoshuk, Duffy, and Miller (1994) determined that the 75% tasters could be further broken down to 50% medium tasters and 25% super tasters.

The type of taster an individual is gives insight on their threshold to bitterness. Individuals who are tasters have low thresholds, while individuals who are non-tasters have higher thresholds than tasters (Duffy et al., 2004). Fox’s (1932) discovery of PTC lead to a rapid growth of research on the genetics of PTC and PROP. This knowledge of variation in bitter taste among individuals has also led to research investigating the difference in sensory experience between the different taster categories.

2.3.3 PROP Taster Status Association with Taste Preferences

Numerous studies have been conducted to look into the association between taster status and taste preferences for both adults and children (Anliker et al., 1991; Bell et al., 2017; Dinehart et al., 2006; Turnbull & Matisoo-Smith, 2002). Researchers have found that greater PROP sensitivity is often associated with a lower preference or consumption of bitter vegetables. For adults, PROP tasters reported asparagus, Brussels sprouts, and spinach, which are all bitter vegetables, as most bitter and least sweet (Dinehart et al., 2006). Drewnowski et al. (2000) found that adult women who were PROP medium-tasters or supertasters had lower acceptance of cruciferous vegetables (broccoli, Brussels sprouts, cauliflower, cooked cabbage, kale, radish, raw cabbage) and other green vegetables (artichoke, asparagus, cooked spinach, cooked celery, green beans, string
beans, peas) (p<0.05). Studies focusing on children’s acceptance of bitter vegetables have found similar results to studies investigating adult’s acceptance of bitter vegetables. Turnbull and Matisoo-Smith (2002) found a positive correlation of PROP sensitivity and dislike of raw spinach in 3- to 6-year-old children. Another study found that PROP nontasters consumed more bitter vegetables and vegetables in general than children who were PROP tasters (Bell & Tepper, 2006).

2.3.4 Methods for Determining PROP Sensitivity

Phenylthiocarbamide (PTC), a bitter compound, was the first taste compound found to show genetic variations, and it is one of the best-known Mendelian traits in human populations (Wooding 2006). Researchers shifted to using PROP instead of PTC in studies because PROP does not have the sulfurous odor of PTC and is less toxic than PTC (Duffy et al., 2004; Fischer, 1971). By identifying compounds that can be utilized in studies to determine if an individual is a “taster or “non taster” lead to the development of methodology to quickly determine an individual’s taster status. This in turn lead to an increase in studies of PTC/PROP sensitivity in human populations and the relationship between PTC/PROP sensitivity and dietary behaviors, such as consumption of vegetables, in children and adults.

Both 6-n-propylthiouracil (PROP) and phenylthiocarbamide (PTC), which are both bitter compounds, have been used in taste studies to determine individual’s bitterness sensitivity. Despite neither PROP or PTC being present in foods, glucosinolates and other thiourea-containing compounds are found in cruciferous vegetables. In part because the characteristic thiourea moiety (N=C=S) is responsible for
the bitter taste of thiourea-containing compounds, compounds such as PROP and PTC have been used in measuring bitterness sensitivity (Keller & Adise, 2016).

There are numerous methods used in studies to determine PROP sensitivity. For PROP classification, it is important to not use methods that do not have ratio properties because these types of classifications would not allow for comparisons between the ratings of different individuals. Categorical scales, such as seven-point and nine-point Likert scales, are an example of such a methodology that should not be used to determine individual’s PROP taster status (Keller & Adise, 2016). Commonly used measurement methods for determining a person’s PROP sensitivity includes forced choice, general labeled magnitude scale (gLMS), and using taste strips (Table 2.1).

The gLMS is a semantically labeled line scale, and it is a generalized version of the Labeled Magnitude Scale (LMS). While the top of the scale for the LMS is the strongest imaginable oral sensation, the top of the scale for the gLMS is the strongest imaginable sensation of any kind (Bartoshuk et al., 2004). Because the gLMS requires the cognitive skills required to rate intensities, studies investigating children’s PROP sensitivity commonly use simpler methodologies, such as the forced-choice method. In the forced-choice method, the participant is given one sample and asked if they can detect anything (Lawless, 1980). Of the PROP sensitivity determination methods in Table 2.1, the taste strips method is the only one that does not use PROP solutions. Instead, this method uses impregnated filter papers to present PROP to the test subjects (Dessai et al., 2011). Some advantages of taste strips include their long shelf life, easy to administer, and quick testing time (Mueller et al., 2003).
### Table 2.1 6-n-propylthiouracil (PROP) Sensitivity Methodologies for Adults and Children

<table>
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<td>Forced Choice</td>
<td>Presented with one solution containing low concentration of PROP in distilled water; subject points at Big Bird puppet if tastes water or nothing and points at Oscar the Grouch if tastes bitter, sour, or yucky (use of puppets for children)</td>
<td>Taster if tasted bitter, sour, or yucky; non-taster if tasted water or nothing</td>
<td>Burd et al. (2013); Carney et al. (2018); Drewnowski et al. (2001); Lawless (1980)</td>
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<tr>
<td>General Labeled Magnitude Scale (gLMS)</td>
<td>Subjects marked on vertical line scale to indicate the bitterness of each PROP solution</td>
<td>Supertaster had highest responses, medium taters had intermediate responses, non-tasters had lowest responses</td>
<td>Bartoshuk et al. (2004); Dinehart et al. (2006); Hayes et al. (2008)</td>
</tr>
<tr>
<td>Taste Strip</td>
<td>Place strip containing low concentration of PROP on tongue, touching roof of mouth; after 5 seconds give response of sweet, sour, bitter, or no taste</td>
<td>Taster if tasted PROP; non-taster if did not taste PROP</td>
<td>Dessai et al. (2011); Mueller et al. (2003)</td>
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</table>

#### 2.4 Bitterness in Vegetables

Bitterness is a key deterrent of vegetable consumption, especially for dark green vegetables (Dinehart et al., 2006). This bitterness in dark green vegetables is due to the presence of different bitter-tasting compounds, such as isothiocyanates and glucosinolates (Drewnowski & Gomez-Carneros, 2000). There are currently approximately 200 identified types of glucosinolates, and they are particularly common in the Brassicacea family, also called Cruciferae, of vegetables, which includes Brussels sprouts, broccoli,
and kale (Beck et al., 2014; Ishida et al., 2014). The Brassica vegetables are commonly referred to as cruciferous vegetables (Manchali, Murthy, & Patil, 2012). Major glucosinolates in cruciferous vegetables include glucobrassicin, progoitrin, and sinigrin (Ishida et al., 2014).

Glucosinolates are a type of phytonutrient, so they have many health benefits, including reducing the risk for dietary related chronic diseases, such as cancer and diabetes (Drewnowski & Gomez-Carnerors, 2000). If glucosinolates were to be removed from vegetables in order to decrease their bitterness, the health benefits that glucosinolates add to the vegetable would also be removed. For this reason, research has been conducted to determine how to mask the bitter taste imparted by glucosinolates and other bitter tasting compounds, such as through the use of sweeteners (Beck et al., 2014). A study looked at the effect of adding very low amounts of sugar or salt to three different green vegetable purees (broccoli, kale, and spinach) to mask the bitterness and improve adult’s acceptance of the sample. The purees were prepared with different levels of sugar (0%, 0.6%, 1.2%, 1.8%, and 2%) or salt (1% and 0.2%). With only the addition of small of amounts of sugar or salt, there was a significant decrease in bitterness, increase in sweetness or saltiness, and increase palatability (Bakke et al., 2018). By masking the glucosinolates in bitter tasting vegetables with sweet tasting compounds, the product will not be perceived as bitter as normal but continue to provide the health benefits that result from the presence of glucosinolates.

2.5 Texture as a Sensory Property

Along with taste, texture is an important aspect in understanding the influences of consumers’ preferences for food products. This is in part due to texture being an
additional cause for food rejection (Drewnowski, 1997; Scott & Downey, 2007). Many researchers define texture as, “the sensory and functional manifestation of the structural, mechanical, and surface properties of foods detected through the senses of vision, hearing, touch and kinesthetics” (Szczesiak, 2002). Though this definition, texture is conveyed to have four major components: it’s a sensory property, it’s a multi-parameter attribute, it’s derived from the structure of food, and it’s detected by a combination of senses.

Unlike flavor, which is a single attribute characteristic, texture is a multi-parameter attribute. With the existence of a wide variety of terms to describe texture, classification systems have been developed to help provide some organization. Szczesniak (1963) grouped the terms used to describe texture into three main classes: mechanical characteristics, geometrical characteristics, and other characteristics. These classes are then divided into main and secondary parameters. Mechanical characteristics are the textures that are created by the food’s reaction to stress. The five primary parameters of the mechanical class are hardness, cohesiveness, viscosity, springiness, and adhesiveness, and the three secondary parameters of the mechanical class are brittleness, chewiness, and gumminess. Geometric characteristics are the textures that are created by the arrangement of a food’s components. Unlike the other two classes that have primary and secondary parameters, the geometric characteristic class contains two general groups of qualities: qualities related to particle shape and size, and the qualities related to particle shape and orientation. The “other characteristics” class are the textures that are mainly due to a food’s moisture and fat content. The two primary parameters of the “other” class
are moisture content and fat content, and the two secondary parameters of the “other” class are oiliness and greasiness.

Although texture is a multi-parameter sensory property with a multitude of terms used to describe texture, most individuals have a hard time describing a food’s texture. Szcesniak and Kahn (1971) found that people have low textural awareness, so it is difficult for people to verbalize or distinguish textural characteristics. Texture is often taken for granted, as people tend to consider texture an integral component of the nature of food. Foods that are in their optimal condition are expected to have a certain texture, so for many people, a food’s texture symbolizes if the food is okay to eat or not.

Texture is a determined by a combination of several senses. As described in texture’s definition, the senses of vision, hearing, touch, and kinesthetics (sense of movement of the limbs and body) are involved in texture perception. Vision is typically the first sense used in texture perception, and this sense is used to judge the quality and edibility of a food. Hearing is associated with the sounds created during chewing. Of the senses involved in texture perception, touch and pressure are the key contributors, which are usually generated during oral processing. Therefore, oral processing is one of the most important stages of textural perception (Chen, 2009).

2.6 Food Oral Processing

Food oral processing is essential for ingestion, digestion, and appreciation of food (Foster et al., 2011; Chen, 2009). Oral processing is the first step in the digestive processes, and it is an important step in the breakdown of food and formation of a bolus, a rounded mass of chewed food (Feron & Salles, 2018; Stokes, Boehm, & Baier, 2013). There are many variables that may impact an individual's oral processing, such as speed
of bite, jaw movements, and chewing sequence. In turn, this can impact an individual’s appreciation of food because of the relationship between oral processing and sensory perception. Although sensory perception occurs throughout the entirety of oral processing, it is dynamic and changes during the different stages of processing (Foster et al., 2011). Oral processing is mainly influenced by the anatomy of the oral cavity, oral mechanical process of food destruction, and physiological condition of the human body (Xu, 2016).

The oral (masticatory) process is a complex, multi-step process. The main three steps in oral processing are the first bite, mastication, and swallowing. The first bite is commonly viewed as the first step of this process, and this step relies on the mechanical and geometrical properties of the food. The mechanical nature of the food is important for the force applied during the first bite. While, brittle foods having a very short biting cycle, plastic foods require an increase biting force until the food breaks. The food geometry also affects the first bite, but it is not clear what specific factor is affecting the perception of food hardness from the first bite (Chen, 2009). While some believe this perception is based on the applied force (Kohyama et al., 2005), others believe it is based on the amount of work necessary (Agrawal & Lucas, 2003).

Chewing, also known as mastication, is the second step in oral processing, and it is the major operation for the break down and consumption of solid and semi-solid foods. Chewing is a necessary step of this process as it is where food particles are fragmented into small particles that combine with saliva to form a bolus that can safely be swallowed (Chen, 2009). As defined by Bourne (2002), a food bolus is a mixture of chewed food particles and saliva in the mouth. A food’s texture has a large influence on the chewing
process, with the texture impacting the number of chewing cycles, chewing duration, and jaw movement (Chen, 2009; Feron & Salles, 2018; Foster et al., 2011).

The chewing process is where texture appreciation, as well as enhanced flavor and aroma release, take place. Sensory perception is dynamic, occurring throughout the chewing process. During chewing, food texture changes continuously, and the mouth is continuously analyzing these changes with real time feedback control and adaptations (van der Bilt et al., 2006). Lefant et al. (2009) found that texture perception in different breakfast cereals differed, but there was a common sensory trajectory observed throughout the mastication of each cereal. In all of the products, the gradual breakdown of the food matrix of the cereals during mastication lead to the change in texture perception.

Although it is challenging and currently not possible to follow the food bolus during oral processing to determine the ways in which it changes, one recent study has shown the relationship between bolus changes and sensory perception. A study by de Lavergne et al. (2015) used temporal dominance of sensations (TDS) to measure the dynamic texture perception of long duration eaters and short duration eaters during the consumption of sausages. The study defined long duration eaters as those who took on average twice as long to consume one piece of sausage compared to the short duration eaters. This research was able to show a clear relationship between the ways the food bolus properties changed during consumption and the chewing behavior, specifically duration of consumption, and sensory perception of an individual. It was determined that many of the bolus properties differed between the two chewing behavior groups, so the
texture perception during consumption of the same sausage can differ for the two chewing behavior groups.

Other research has highlighted how chewing behavior varies by individual and can influence their sensory perception of a food. Brown and Braxton (2000) suggested that there are four different chewing efficiency groups. From this study on biscuits, it was determined that the groups differed in the number of chews, chew duration, and chew rate during the mastication of the biscuits. This work demonstrated that there may be a link between chewing efficiency and preference based on the relative ease of oral breakdown of a food. Similarly, Engelen and van Doorn separated individuals into four different oral processing style groups based on the results of how subjects described chronologically how they orally processed a food after placing it in their mouth. These four groups were identified as: simple, taster, manipulator, and tongue. The groups vary in how an individual moved the food around in their mouth and how they used their tongue, palate, and teeth (Chen & Engelen, 2012).

Swallowing is the final stage of oral processing. This stage consists of three phases: oral, pharyngeal, and esophageal phase. In the oral phase, the bolus is formed and passed to the back of the mouth. The tongue creates the pressure necessary for the movement of the bolus to the back of the mouth. In the pharyngeal phase, the swallowing reflex is triggered by the stimulation of the posterior section of the oral cavity, and the bolus is transported to the distal esophagus. During the esophageal phase, the final transportation of the bolus take place, with the primary and secondary peristalsis causing the bolus to move towards the stomach. There is currently no evidence of either texture or flavor
perception during swallowing (Chen, 2009). Overall, swallowing is a means of transporting the bolus from the oral cavity to the stomach.

2.7 Mouth Behavior

In recent years, studies have been conducted to better understand texture as a variable contributing to consumer product preference. Jeltema, Beckley, & Vahalik (2014) proposed to have found a new method of understanding what drives texture preferences of individuals. According to their research, it is how a food’s texture fits with an individual’s preferred way to manipulate food in their mouth. The way different individuals manipulate their food during mastication has been separated into four different groups, defined as Mouth Behavior groups: crunchers, chewers, suckers, and smooshers. Based on a survey with a 500 participants, crunchers and chewers were the predominant groups, making up 33% and 43% of the individuals, respectively. smooshers and suckers were the smaller groups, making up 16% and 8%, respectively (Jeltema, Beckley, & Vahalik, 2015).

These groups can further be categorized into two different modes, which differ based on mouth actions. Mode 1 is made up of crunchers and chewers, and it represents individuals who enjoy using their teeth to physically break down food products during mastication. The main difference of the mouth behavior groups in mode 1 is that crunchers have a more forceful bite, while chewers enjoy foods that give some resistance to being broken down into smaller particles. Mode 2 is made up of suckers and smooshers, and it represents individuals who enjoy using their tongue and roof of the mouth to manipulate food during mastication. The main difference of the Mouth
Behavior groups in mode 2 is that suckers prefer hard foods, while smooshers prefer soft foods (Jeltema, Beckley, & Vahalik, 2016).

2.7.1 Development of Mouth Behavior Tool

The development of the JBMB® Mouth Behavior Typing Tool evolved over a 10-year period of qualitative and quantitative research conducted by Jeltema, Beckley, and Vahalik (2015) following Jeltema and Beckley’s hypothesis of the existence of mouth behavior in 2001. Their hypothesis was developed after reflecting on their previous quantitative and qualitative product research. Through a series of exploratory qualitative research to better understand the differences in the ways individuals interact with their food, which included over 350 hours of in-depth, face-to-face observation and listening, Jeltema, Beckley, and Vahalik (2015) hypothesized that there were four major Mouth Behavior groups: (1) chewers, (2) crunchers, (3) smooshers, and (4) suckers.

A need for developing a typing tool to determine individual's Mouth Behavior emerged after determining that qualitative interviews with follow-up in-depth discussions of the choices made in the interviews was a consistent way of typing individuals’ Mouth Behavior. At first, a traditional survey tool was created for this purpose, but this proved to be difficult due to individuals low of texture awareness, different interpretation of questions, individual behavior inconsistencies, and possibility of individuals modifying foods to meet their mouth behavior requirements. To address these difficulties, the researchers changed to using an approach that indicated patterns. This led to the final form of the tool where images are used to determine an individual’s Mouth Behavior.

With this new, final approach, the tool included four groupings of food images and corresponding questions, such as which was ‘most like you.’ This tool would come to
be known as the JBMB® (Jeltema/Beckley Mouth Behavior) typing tool. Jeltema, Beckley, and Vahalik (2015) selected images of specific foods that would aid in the ability to differentiate the mouth behavior groupings (e.g. ice cream with different toppings), and they used groupings of images instead of only one image to avoid participants having difficulty making their selection due to their dislike of a certain food or flavor.

With the creation of the JBMB® tool, quantitative validation was now possible. This was conducted through the use of a quantitative online survey (n=500, ages 15-65) in the United States. Participants of the survey began by using the typing tool to determine their Mouth Behavior, and then they answered a 67-question custom word-based behavioral survey. Responses to the behavioral survey were analyzed using chi-square analysis to determine if a difference existed between how the different mouth behavior groups were answering the questions, and then discriminant analysis (JBMB® tool as Y variable, word survey questions as X variable) was run to determine if individuals could be accurately separated into the four mouth behavior groups. The discriminate analysis confirmed the separation of individuals into different mouth behavior groups (p<0.0001). Based on this quantitative validation study, the JBMB® tool is able to accurately type individual’s mouth behavior.

2.7.2 Consumer Insight from Mouth Behavior

An individual’s Mouth Behavior group gives insight on the foods they enjoy consuming. Each Mouth Behavior enjoys different types of food products (Jeltema, Beckley, & Vahalik, 2015). The four groups prefer foods that can easily be consumed with their mouth behavior habits. If a chewer were to purchase a candy, they are most
likely to purchase a gummy candy that will give them the desired resistance and chewiness they prefer. Although this is the case for most situations, individuals are not limited to products that only fall in their Mouth Behavior category.

The majority of the time, an individual will eat products that are easy to consume with their Mouth Behavior because this is what they find most satisfying (Jeltema, Beckley, & Vahalik, 2015). However, they will still consume products that do not fit in their mouth behavior group. For example, a cruncher may enjoy eating hard candies, and a sucker may enjoy eating chips. Research also indicates that individuals will adapt to whatever food they are eating. If a chewer were to be purchasing a yogurt product, it is more likely that they will choose a yogurt with strawberry chunks than a plain yogurt because the fruit chunks will provide them with something they can chew (Jeltema, Beckley, & Vahalik, 2015).

Mouth Behavior may also be able to provide insight on the impact of the way an individual chews their food impacts their texture perception of that food. In a study conducted by Wilson et al. (2018), subjects (n=100) were given four different foods (Mentos, Walkers, Cheetos Puffs, Twix) and their jaw movements were video recorded while they consumed the food. These foods were chosen because they are products that varied in textures and can be chewed in different ways. For example, Mentos mints have a hard shell with a soft, chewable inside, so they are harder to smoosh or crunch but easier to chew or suck. Cheetos Puffs are an extruded cheese snack, and they can be chewed, crunched, smooshed, or sucked on. Each subject was also assigned to a Mouth Behavior group using the JBMB® Typing Tool. This study determined that an individual’s Mouth Behavior partially explains the way individuals change their jaw
movements when presented with foods of different textures that can be chewed in different ways. The results of this study showed that it was not possible to accurately predict an individual’s Mouth Behavior from only looking at the video recordings of their jaw movement and chewing sequence measures.

2.8 Children’s Eating Behavior

Sensory properties such as taste and texture impact humans eating behaviors. Eating behaviors are complex traits that result from a combination of multiple environmental and genetic factors, including psychological, social, and genetic factors, that drive food choices. These behaviors influence all aspects of food choices, from meal timing to food preference (Grimm & Steinle, 2011).

Although eating behaviors can develop and be reinforced across all stages of human development, childhood is the most vulnerable period of an individual’s life for the onset of eating behaviors (Birch, Savage, & Ventura, 2007; Johnson, Moding, & Bellows, 2018). It is important to understand children’s eating behaviors, as these behaviors impact children’s health and often predict adult eating behaviors (Birch, Savage, & Ventura, 2007; Brown & Ogden, 2004; Brown et al., 2016). It is especially important to consider the challenging eating behaviors that are associated with negative health and growth outcomes, such as picky eating and food neophobia (Johnson, Moding, & Bellows, 2018).

2.9 Picky Eating

Although picky eating (PE) does not have a universally accepted definition, it is best described as the rejection of both new and familiar foods. Many terms have been used to describe this eating behavior besides picky eating, including selective eating,
fussy eating, sensory food aversion (Toyama & Agras, 2016). A review by Taylor et al. (2015) examined 65 papers and abstracts that were published between 1990 and 2015 to examine the different ways picky eating has been defined. Definitions of picky eating include a combination of elements of picky eating, such as unwillingness to eat familiar or unfamiliar foods and restricted intake of foods (Dovey et al., 2008; Horst, 2012; Lumeng, 2005; Mascola et al., 2010; Taylor et al., 2015). Of the definitions that were reviewed, Taylor et al. (2015) supports the following definition by Lumeng (2005): “unwillingness to eat familiar foods or try new foods, severe enough to interfere with daily routines to an extent that is problematic to the parent, child, or parent-child relationship.”

Along with various terms and definitions describing this eating behavior, there is variation in the characteristics that describe picky eating, which includes limited consumption of variety of foods, unwillingness to try new foods, and rejecting foods based on their sensory characteristics, including appearance, aroma, texture, and flavor of foods. Due to variation in the definition and measurement of picky eating, there is a wide range of prevalence rates of picky eating across studies, which are reported as being between 14% and 60% in preschool-aged children and decreasing to 7% to 27% in later childhood (Johnson, Moding, & Bellows, 2018).

2.9.1 Measurement of Picky Eating in Children

Due to the lack of a universally accepted definition, there exists a variety of methodologies used in studies to assess children’s picky eating. The method of analysis of picky eating varies in different studies, ranging from subscales related to picky eating from larger questionnaires to a single question regarding if the parent thinks their child is
a picky eater (Table 2.2). Some studies have even created their own picky eating questionnaires designed specifically for their study (Smith et al., 2005).

The majority of the methods for determining if a child can be classified as a picky eater relies on the parents’ or primary caregivers’ report of how they perceive their child’s picky eating characteristics (Johnson, Moding, & Bellows, 2018). Although many of the methods use a Likert scale for scoring, the method of analyzing the scales varies between studies. Analysis methods include using mean scores and standard deviation scores of scale scores (Galloway et al., 2005; Jansen et al., 2012). There are instances where different studies using the same scale use different analysis methods to determine the response categories and subcategories, such as analyzing the CEBQ results by mean scores (Hendy, Williams, & Paul, 2010) or by standard deviation scores (Jansen et al., 2012).

Having a large amount of different picky eating measurement methods may have contributed to the confusion of the concept, influences, and outcomes of picky eating. The variability in measurement has been a suggested contributor to the variation in the findings of picky eating (Brown et al., 2016; Tharner et al., 2014). It is important for future research of picky eating for researchers to come to an agreement on the definition of picky eating, which will allow for the development of a validated picky eating questionnaire that all future picky eating studies can utilize.
Table 2.2 Instruments Used to Determine Children’s Picky Eating Status from Parent’s Perspective

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
<th>No. of items</th>
<th>Scale</th>
<th>Analysis of Scoring of Scale(^1)</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Behavior Checklist</td>
<td>Two items on the original 99-item questionnaire by Richman &amp; Graham (1971) relate to picky eating (lack of appetite, food fussiness)</td>
<td>2</td>
<td>3-point Likert scale anchored by “not at all applicable” and “often applicable”</td>
<td>Classified as picky eater if scored greater than or equal to four (Cardona Cano et al., 2015)</td>
<td>Cardona Cano et al. (2015); Jani Mehta et al. (2014)</td>
</tr>
<tr>
<td>Children’s Eating Behavior Questionnaire (CEBQ)</td>
<td>Food fussiness subscale from Wardle et al. (2001) questionnaire; three items on selectivity of variety of foods, and three items on neophobic behavior</td>
<td>6</td>
<td>5-point Likert scale anchored by “never” and “always”</td>
<td>Higher mean scores indicate higher presence of picky eating (Svensson et al., 2011)</td>
<td>Morrison et al. (2013); Svensson et al. (2011); Tharner et al. (2014); Viana, Sinde, &amp; Saxton (2008)</td>
</tr>
<tr>
<td>Child Feeding Questionnaire (CFQ)</td>
<td>Pickiness subscale from Birch et al. (2001) questionnaire; items on variety of diet, unwillingness to eat during mealtimes, and fussiness</td>
<td>3</td>
<td>5-point Likert scale anchored by “disagree” and “agree”</td>
<td>Higher mean scores represented higher levels of picky eating (Galloway et al., 2005)</td>
<td>Galloway et al. (2003, 2005); Quick et al. (2014)</td>
</tr>
<tr>
<td>Single Item Questionnaire</td>
<td>Parents asked, “Is your child a picky eater?”</td>
<td>1</td>
<td>5-point Likert scale anchored by “never” and “always”</td>
<td>Considered picky eater if scored “always,” “sometimes,” or “often;” considered non-picky eater if scored “rarely,” or “never” (Jacobi, Schmitz, &amp; Agras, 2008)</td>
<td>Carruth et al. (2004); Jacobi, Schmitz, &amp; Agras (2008); Mascola, Bryson, &amp; Agras (2010)</td>
</tr>
</tbody>
</table>

\(^1\)Some of the different studies used different scales and/or analysis method for categorizing the children; therefore, the scale and analysis method in the table only represents the method for one of the studies that used the corresponding instrument.
2.9.2 Factors that Influence Picky Eating

Picky eating is a common challenging eating behavior for young children during the critical years of developing healthy eating habits. Mascola, Bryson, and Agras (2010) conducted a longitudinal study following 120 children and their parents from the time the children were two years of age to six years of age. The children and parents completed assessments of picky eating, children’s height, children’s weight, and child and parent feeding behavior questionnaires at yearly intervals. Their study showed that the incidence of picky eating was highest in early childhood, specifically two years of age, and declined to low levels by 6 years of age. With the peak prevalence picky eating at around two years of age, factors that are associated with a child becoming a picky eater are those that are related to early years of life. The factors that influence picky eating can be classified as factors relating to the child and to the child-parent interaction.

Cole et al. (2017) conducted an in-depth systematic review and meta-analysis of existing peer-reviewed publications of picky eating in children two years of age and older. From their investigation, there were no conclusive associations between picky eating and age or sex (Carruth et al., 2004; Svensson et al., 2011). Brown et al. (2016) conducted a systematic review specifically on the association of picky eating and weight of children under ten, and they found that there is no clear association between picky eating and childhood weight status.

Factors relating to the parent/caregiver include parent feeding beliefs and practices. Studies show that there is an inverse relationship between picky eating and responsive eating, which are positive feeding practice. Responsive feeding practices are those that help children develop the ability to recognize their hunger and satiety cues.
Conversely, nonresponsive feeding practices, including pressure to eat and overt restriction, have been shown to be associated with picky eating (Cole et al., 2017; Galloway et al., 2005; Gregory, Paxton, & Brozovi, 2010).

### 2.10 Food Neophobia

Food neophobia (FN), a subset of picky eating, is defined as the rejection of new, novel, or unfamiliar foods (Dovey et al., 2008; Capiola & Raudenbush, 2012). This rejection entails that an individual who is food neophobic will be reluctant to eat or avoid unfamiliar foods they encounter (Pliner & Hobden, 1992). The term FN was derived from the term ‘omnivore’s dilemma,’ which describes the situation humans and other omnivorous animals must face when encounter a novel food. On one hand, humans and omnivorous animals should take advantage of being able to consume a large variety of foods, but on the other hand, they need to be careful of ingesting toxic novel foods (Pliner & Hobden, 1992). For this reason, FN is a survival mechanism that helps protect humans from potentially dangerous foods that they should not be ingesting.

There is evidence in the literature showing that FN increases for a few years in early childhood but then decreases with age (Addessi et al., 2005; Dovey et al., 2008; Koivisto-Hursti & Sjoden, 1997). In infancy, FN is minimal because parents are providing their infants with food at this time, but FN becomes more prevalent when children begin to explore their environment and choose what to eat themselves, which occurs in early childhood (Addessi et al., 2005). After the rapid rise of FN around ages two to six, FN begins to decrease with age, and FN begins to plateau in adolescence at age 13 and throughout adulthood (Nicklaus et al., 2005). In some circumstances, FN may increase again in old age, but the reason is currently unknown (Dovey et al., 2008).
2.10.1 Measurement of Food Neophobia in Children

Similar to picky eating, there are numerous methods for measuring adult’s and children’s food neophobia. Along with food neophobia being assessed like picky eating by basing the categorization of a child on the parents’ or caregivers’ perception of a child’s food neophobia/picky eating, food neophobia has been assessed using children self-reports or through observational measures (Johnson, Moding, & Bellows, 2018).

In a review of food neophobia instruments, Damsbo-Svendsen, Frost, and Olsen (2017) identified and reviewed thirteen different instruments. Different instruments were developed to measure different aspects of neophobia and willingness to try unfamiliar foods, such as the Variety Seeking Tendency Scale (VARSEEK) to measure variety seeking (van Trijp & Streenkamp, 1992) and the Domain Specific Innovativeness (DSI) scale to measure attitudes towards innovative food products (de Barcellos et al., 2009). The selection of which food neophobia instrument to use in a study depends on many factors, including the subjects (adults, children), measurement outcome, time, and cost (Damsbo-Svendsen, Frost, & Olsen, 2017).

Of the instruments that are used to measure food neophobia, the Food Neophobia Scale (FNS) that was developed by Pliner and Hobden (1992) is one of the most reliable and commonly used measurement instruments for adults. This is a 10-item questionnaire, and each item is rated on a 7-point hedonic scale that ranges from 1 = disagree strongly and 7 = agree strongly. Five of the items on this questionnaire are reverse scored because the items are positively worded, which in terms means they are measuring neophilic instead of neophobic behavior. The reverse scoring of these items ensures consistency between all ten items so that higher scores represent higher levels of food neophobia.
Mean scores were computed for the responses to the questionnaires, and higher scores indicated greater neophobia.

Due to the decrease in reliability of responses related to the decrease in age, it may be more appropriate to obtain data regarding young children by having parents’ or caregivers’ complete questionnaires on behalf of their children instead of the child completing the questionnaire about themselves (Borgers & Hox, 2000). The Child Food Neophobia Scale (CFNS), which was adapted from the FNS, is one of the most commonly used parent-reported instruments for measuring a child’s food neophobia (Johnson, Moding, & Bellows, 2018). The CFNS is a modified and shorter questionnaire of the FNS questionnaire, with the CFNS being a 6-item version of the 10-item FNS questionnaire. Four of the items from the FNS were excluded from the CFNS questionnaire because they were not considered age-appropriate (e.g. I like to try ethnic restaurants). Mean scores were computed from the responses to the 6-items, and higher scores indicated strong displays of neophobia in a child (Howard et al., 2012).

2.10.2 Factors that Influence Food Neophobia in Children

The literature on food neophobia covers a wide range of factors, both intrinsic and extrinsic that influence food neophobia in children. Due to the difference of how studies define food neophobia and the wide variety of instruments used to measure subject’s food neophobia, some conclusions about what factors influence food neophobia in children differ.

Some studies have found that there are sex differences related to food neophobia with women being more neophobic than males (Frank & van der Klaauw, 1994), while other studies have found that sex differences are not related to food neophobia (Koivisto-
Hursti & Sjoden, 1997). Another intrinsic factor associated with food neophobia in children is heritability. Cooke, Haworth, and Wardle (2007) studied the contribution of genetic influences on children’s food neophobia. The collected data from parents of twins aged 8-11 years old through questionnaires answered by the parents about their children. The results of this study showed that neophobia is a highly heritable trait with the heritability estimate of 78% in children.

The main extrinsic factors associated with child food neophobia are related to parents/primary guardians. Studies have shown that neophobia parents often have neophobic children (Galloway et al., 2003; Brown et al., 2016), which could result from genetic factors and/or variety of foods available and offered at home. Child feeding practices, including coercive control, autonomy support, and structured parental control, have also been associated with food neophobia (Vaughn, Ward, & Fischer, 2016). Of the different feeding practices, an increased use of pressure to have a child eat has been associated with food neophobia (Johnson, Moding, & Bellows, 2018).

2.10.3 Vegetable Neophobia

Hollar, Paxton-Aiken, & Fleming (2013) developed a fruit and vegetable neophobia instrument (FVNI) to evaluate children’s attitudes toward new fruits and vegetables, instead of the overall evaluation of individuals attitudes towards all new foods. This eighteen-item questionnaire was developed based on Pliner and Hobden’s (1992) Food Neophobia Scale, and it includes two nine item subscales for ‘fruit’ and ‘vegetables’ (Table 2.3; Hollar, Paxton-Aiken, & Fleming, 2013). The nine items in the two subscales are the same with the exception of the ‘fruit’ subscale asking the question in regard to fruit and the ‘vegetable’ subscale asking the question in regard to vegetables.
The FVNI is a self-reported scale that was tested on children ages 8-10 years old. In the 2009-2010 academic school year, Hollar, Paxton-Aiken, & Fleming (2013) conducted a study to test the validity of the FVNI with 1,485 third- to fifth-grade students from six schools in California and three schools in Oregon. This study showed the internal consistency of FVNI assessing the third- through fifth-grade student’s fruit and vegetable neophobia.

Table 2.3 The 18-Item Self-Reported Fruit and Vegetable Neophobia Instrument (FVNI) for Children

<table>
<thead>
<tr>
<th>How much do you like fruit?</th>
<th>How much do you like fruits that you have never tried?</th>
<th>How much do you like tasting new fruits?</th>
<th>Will you taste a fruit if you do not know what it is?</th>
<th>Will you taste a fruit if it looks strange?</th>
<th>Will you taste a fruit if you have never tasted it before?</th>
<th>When you are at a friend’s house, will you try a new fruit?</th>
<th>When you are at school, will you try a new fruit?</th>
<th>When you are at home, will you try a new fruit?</th>
<th>How much do you like vegetables?</th>
<th>How much do you like vegetables that you have never tried?</th>
<th>How much do you like tasting new vegetables?</th>
<th>Will you taste a vegetable if you do not know what it is?</th>
<th>Will you taste a vegetable if it looks strange?</th>
<th>Will you taste a vegetable if you have never tasted it before?</th>
<th>When you are at a friend’s house, will you try a new vegetable?</th>
<th>When you are at school, will you try a new vegetable?</th>
<th>When you are at home, will you try a new vegetable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Responses for these items included “a lot,” “a little,” “not very much,” and “not at all”</td>
<td>2 Responses for these items included “definitely,” “probably,” “probably not,” and “definitely not”</td>
<td></td>
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</tr>
</tbody>
</table>
2.11 Association of Picky Eating and Food Neophobia

Although many studies exist investigating food neophobia and picky eating, there are few studies investigating the association between these two children eating behaviors. A study by Elkins and Zickgraf (2018) was conducted, in part, to explore the relationship between picky eating and food neophobia. This study included young adults and their middle-aged parents, and it compared matched parent/student dyads (n=113) and parent respondents (n = 109). The nine-item ARFID Screen (Zickgraf & Ellis, 2018) was used to measure picky eating, and the adapted five-item Food Neophobia Scale (FNS) was used to measure the food neophobia. Three items from the FNS scale were removed because the university where the study took place was considered a diverse location, and two items from the FNS scale were removed because of overlap with picky eating. Parents and their young adult children responded to all of the questionnaires themselves, and the parents also answered the questionnaires about their child’s eating behavior. The results of this study showed that picky eating and food neophobia were highly correlated (r’s>0.67) in both the adult sample and young adult sample.

2.12 Sensory Evaluation

2.12.1 Traditional Sensory Testing

Sensory evaluation has been defined as, “a scientific discipline used to evoke, measure, analyze, and interpret those responses to products that are perceived by the senses of sight, smell, touch, taste, and hearing” (Anonymous, 1975). As indicated by this broad definition, sensory is not limited to food products. Over many decades, sensory evaluation has been utilized by various industries, both food and non-food companies. From granola bars to lipstick, sensory evaluation provides companies with valuable
insight from a target group on product acceptability, differences, and similarities. The three classes of traditional sensory methods currently practiced are affective, descriptive, and discrimination sensory testing.

Affective tests, also referred to as acceptance tests, are utilized to measure preference or acceptance of products. The measurement methods for this type of testing are either direct measurement or indirect measurement. While direct measurement methods determine which product is preferred by directly having participants directly compare two or more products and indicate which they prefer, indirect measurement methods determine which product is preferred by looking how the scores of the products tested in a multiproduct test compare. In the indirect method, the preferred product is the one that scored significantly higher than any other product tested. All affective testing measurement methods require a large sample size, ranging from 50-75 untrained participants.

The two most commonly used affective testing methods are paired-comparison and the 9-point hedonic scale. Paired comparison is a direct measurement method where subjects are required to indicate which one of two coded products they prefer. In some paired-comparison tests, additional choices are included for “no preference” or “dislike both equally.” The 9-point hedonic scale is an indirect measurement method where subjects rate different sensory attributes of a product, such as appearance, aroma, overall liking, flavor, texture, and aftertaste, on a linear 9-point scale (Stone, Bleibaum, & Thomas, 2012). Many other variations of the hedonic scale exist, including the 3-, 5-, and 7-point scales. All of the scales are labeled with descriptive phrases for each point on the scale. For example, the 9-point scale goes from 1 = dislike extremely to 9 = like.
extremely (Figure 2.1). Of the different hedonic scale variations, the 9-point scale is the most commonly used scale for consumer evaluation purposes, in part because it is a balanced bipolar scale with a neutral center (Lim, 2011).

![9-Point Hedonic Scale](image)

Figure 2.1 Example of the 9-Point Hedonic Scale

Descriptive analysis, one of the most sophisticated method available to sensory scientists, are utilized to compare products similarities, differences, and sensory attributes that impact preferences. Descriptive analysis has been defined as, “... a sensory methodology that provides quantitative descriptions of products, obtained from the perceptions of a group of qualified subjects. It is a complete description, taking into account all sensations that are perceived – visual, auditory, olfactory, kinesthetic, etc. – when the product is evaluated” (Stone, Bleibaum, & Thomas, 2012). Unlike affective testing, descriptive analysis requires a small number of participants, usually between 10 to 12 individuals, and the participants are trained and qualified.

Many methods exist for descriptive analysis, both qualitative and quantitative methods, including the Flavor Profile method, Texture Profile method, and Quantitative Descriptive Analysis® (QDA). All descriptive analysis methods The Flavor Profile method, the first formal descriptive method, was developed to rely less on an expert and to serve as an aid in solving flavor problems (Caul, 1957; Stone, Bleibaum, & Thomas,
The Texture Profile, a descriptive method, was developed to eliminate subject variability, compare results of analysis with known materials, and provide a relationship with instrument measurements. The QDA method, a quantitative method as the name implies, was developed to overcome the weaknesses of previous descriptive analysis methods, such as small number of subjects and using qualitative data (Stone, Bleibaum, & Thomas, 2012).

Discrimination tests are utilized when sensory professionals are interested in if two or more products are perceived as different. Although this test is quick and simple to execute, it only offers information about if the products tested are perceived as different or not. This type of sensory test offers no insight on acceptance or the magnitude of the perception, if there is one. A practical panel size for discrimination test is between 25 to 30 subjects (Stone, Bleibaum, & Thomas, 2012).

The three most commonly used discrimination tests are duo-trio, paired comparison, and triangle tests. All three methods use scorecards where the subject is instructed to circle the code of one of the samples they are presented. Of these three methods, paired comparison is the only method that is a two-product test. In paired comparison, subjects are presented with two different products, and they are required to indicate which of the products has more of the characteristic that is identified on the scorecard. The chance probability for paired comparison is \( p = \frac{1}{2} \). Duo-trio and triangle tests are three-product tests. In duo-trio, subjects are presented with three samples, one reference and two coded samples, and they are required to indicate which of the two coded samples is most similar to the reference sample. The chance probability for duo-trio is \( p = \frac{1}{2} \). The triangle test is the most well-known and difficult of these three
discrimination methods. In the triangle test, subjects are presented with three coded samples, and they are required to either indicate which two samples are the most similar or which one sample is the most different from the other two samples. Unlike the other two methods, the triangle test has a $p = 1/3$ (Stone, Bleibaum, & Thomas, 2012).

### 2.12.2 Consumer Testing with Children

Due to the difference in wants and needs of children and adults, consumer testing of food products targeted towards children and adults will need to be conducted in different ways. When developing methodology for conducting research with children as the subjects, it is important to take into consideration a combination of factors that may influence the children’s ability to participate in the research, including their cognitive, emotional, and physical development (ASTM, 2013; Popper & Kroll, 2004). ASTM’s Committee 18 on sensory testing methods provides a general guidelines for the expected skill levels and appropriate test methodology for children in the six different age groups (Infant – birth to 18 months, Toddler – 18 months to 3 years, Preschool – 3 to 5 years, Beginning Readers – 5 to 8 years, Pre-Teen – 8 to 12 years, and Teenage – 12 to 15 years). For example, toddlers are beginning to vocalize but are unable to read or write, cannot make complex decisions, and do not understand scales; therefore, the ASTM (2013) recommends using behavioral observations, diaries, and/or consumption or duration measurements for sensory testing with toddlers. On the other hand, preschoolers have early language development, usually are not yet able to read or write, limited decision making skills, and beginning understanding of only simple scales; therefore, the ASTM (2013) recommends using the techniques used for toddlers with the addition of paired comparison, sorting and matching, limited preference, ranking, and one-on-one
interviews. It is important that researchers of studies involving children take into consideration the skill level of each child involved in the study because there will be children in each age group who will perform above or below the skills described for each age group (ASTM, 2013).

Face or “smiley” scales, an adaptation of the hedonic scales, are commonly used in hedonic testing with children. Face scales differ from normal hedonic scales in that there is a facial expression associated with each number on the scale. In some instances, the image is anchored with words describing the facial expressions, such as “super bad” and “super good” (Guinard, 2001). There is a large variety of face scales that have been used in sensory studies with children that vary in the size of the scale, including 3-, 5-, and 7-point hedonic scales, and the images used in the scale. These types of scales were developed for studies that included children and/or individuals who would have a hard time reading or understanding the written words in other commonly used scales (ASTM, 2013). Although there is little or no evidence that face scales are better than other rating scales, facial scales have commonly been used in consumer testing with children for many years (ASTM, 2013; Popper & Kroll, 2004).

2.13 Conclusion and Objectives

By better understanding children’s taste sensitivities, such as 6-n-propylthiouracil (PROP) sensitivity, Mouth Behavior (MB), and eating behaviors, such as food neophobia (FN), vegetable neophobia (VN), and picky eating (PE), new methods of increasing children’s vegetable consumption may be developed. Literature on the association of these topics are still relatively unclear, with little to no research on VN and children’s MB.
The goal of this research is to study the relationship between the following factors for children’s vegetable acceptance: FN, VN, PE, PROP sensitivity, MB. Each factor had two levels: FN = FN and non-FN, VN = VN and non-VN, PE = PE and non-PE, PROP sensitivity = PROP sensitive and non-PROP sensitive, and MB = chewer and cruncher.

The specific objectives of this thesis are:

1) To develop a novel method for evaluating children’s MB

2) To assess the FN, VN, PE, PROP sensitivity, and MB levels in children in San Luis Obispo County

3) To examine the relationship between FN, VN, PE, PROP sensitivity, and MB

4) To determine exposure and willingness to try familiar and unfamiliar vegetables of the two levels of each factor

5) To determine acceptability of aroma, appearance, overall liking, taste, texture, and aftertaste of familiar and unfamiliar vegetables of each level for each factor

6) To determine if the preference between two levels of each factor differed
3.1 Participants

Participant recruitment was done via email. Elementary school children, age 6 to 10 years old, and one of their parents were recruited for the study. The selection process was based upon the following criteria: live in San Luis Obispo county, parent of a child/children age 6 to 10, child/children have no food allergies, and child/children no allergies or sensitivity to 6-n-propylthiouracil (PROP).

The parents were paired with their child to be able to link the family data. Parent’s received codes in the 2000’s, and children received codes in the 1000’s. Each parent and child pair received participant codes that ended with the same number (Table 3.1). Parents and children were instructed to enter their code to begin answering their respective questionnaires. If a parent had more than one child that participated in the study, they were given multiple codes, each code linking to one of their specific children. For example, if a parent brought in two children to participate in testing, the parent would receive two separate codes, with each code linking to one of their children. During testing, parents with multiple children were instructed to answer the questionnaires one time for each of their children that were participating in testing.
Table 3.1 Assigning Participant Codes to the Parents and Children

<table>
<thead>
<tr>
<th>Subject</th>
<th>Parent Code</th>
<th>Child #1 Code</th>
<th>Child #2 Code</th>
<th>Child #3 Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parent + child pair #1</td>
<td>2001</td>
<td>1001</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Parent + child pair #2</td>
<td>2002</td>
<td>1002</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2003</td>
<td>-</td>
<td>1003</td>
<td>-</td>
</tr>
<tr>
<td>Parent + child pair #3</td>
<td>2004</td>
<td>1004</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>-</td>
<td>1005</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>2006</td>
<td>-</td>
<td>-</td>
<td>1006</td>
</tr>
</tbody>
</table>

1Parent/guardian with 1 child participating in testing
2Parent/guardian with 2 children participating in testing
3Parent/guardian with 3 children participating in testing

3.2 Location of Testing

All components of testing were conducted at California Polytechnic State University, San Luis Obispo (Cal Poly SLO). Parents and children received a map of the building with directions for the three components of the study: parental questionnaires, children’s vegetable testing, and children’s Mouth Behavior (MB) focus group. While the parents were answering the parental questionnaires in one room, the children were in a separate room completing the vegetable acceptance testing. When both the parent and child finished their first respective components of testing, they went to the last room where the children’s MB focus group took place.

3.3 Food Samples and Sample Preparation

Two types of vegetables, broccoli and red carrots, were selected for consumer evaluation based on presence or absence in local elementary school cafeterias and bitterness. Broccoli was chosen because it is a common, bitter vegetable, and red carrots were chosen because they are uncommon, non-bitter vegetables. Heads of broccoli, broccoli florets (Green Giant Fresh), and organic red carrots were purchased one to two days prior to testing at local retailer and stored at refrigeration temperature (42°F) until
testing. Three different forms of red carrots and broccoli were used for testing, which totaled to six samples. For red carrots, the three forms were sticks, slivers, and purées. For broccoli, the three forms were floret, slivers, and purées. All samples were prepared approximately 24 hours prior to testing.

3.3.1 Red Carrot Sample Preparation

For the red carrot sticks, the red carrots were rinsed under cold water and peeled. The tops and ends of all the red carrots were cut off. The red carrots were sliced vertically in half, and each half was cut into multiple 4 cm pieces. One 4 cm piece was placed in a labeled 4 oz cup (Reditainer) with lid and stored at refrigerated temperature (42°F). Thirty minutes prior to serving, samples were removed from the refrigerator and held at room temperature (72°F).

For the red carrot slivers, the red carrots were rinsed under cold water and peeled. The tops and ends of all the red carrots were cut off. The red carrots were sliced vertically in half, and each half was cut into multiple 4 cm pieces. Each 4 cm piece was then cut into multiple slivers that were approximately 3 cm wide. Labeled 4 oz cup (Reditainer) were filled with 0.4 oz of carrot slivers and lidded. The filled cups were stored at refrigerated temperature (42°F). Thirty minutes prior to serving, samples were removed from the refrigerator and held at room temperature (72°F).

For the red carrot purées, the red carrots were rinsed under cold water and peeled. The tops and ends of all the red carrots were cut off. The red carrots were sliced vertically in half, and each half was cut into multiple 4 cm pieces. Four perforated pans were filled with a single layer the 4 cm red carrot sticks. The pans were placed in a convection oven, which was set to 225°F and the steam setting 10 minutes prior to the pans being placed in
the oven. After 15 minutes of steaming, the red carrots were removed from the oven and immediately submerged in an ice bath for four minutes. A colander was used to separate the red carrots from the water and ice before the red carrots were transferred to a food processor (Robot Coupe) and puréed for 60 seconds. One labeled 4 oz cups (Reditainer) was filled with 0.66 oz of purée and lidded. The filled cups were stored at refrigerated temperature (42°F). Thirty minutes prior to serving, samples were removed from the refrigerator and held at room temperature (72°F).

### 3.3.2 Broccoli Sample Preparation

For the broccoli florets, four bags of broccoli florets were rinsed under cold water. The florets were separated by size, and one floret that was approximately 3 to 4 cm long was placed in a labeled 4 oz cup (Reditainer) and lidded. Some larger florets were cut down to fit into the size requirements if needed. The samples were stored at refrigerated temperature (42°F). Thirty minutes prior to serving, samples were removed from the refrigerator and held at room temperature (72°F).

For the broccoli slivers, heads of broccoli were rinsed under cold water. The bottom of the stem was cut off, and the individual florets were separated. One floret was cut down to approximately 4 cm long. The crown of the floret was cut down so there were only a few pieces on the floret and for the floret to form a rectangular form. Two broccoli slivers were placed in a 4 oz Reditainer brand cup and lidded. The samples were stored at refrigerated temperature (42°F). Thirty minutes prior to serving, samples were removed from the refrigerator and held at room temperature (72°F).

For the broccoli purée, the leftover broccoli florets that were used for the floret samples were used to make the purée. Four perforated pans were filled with a single layer
of broccoli florets. The pans were placed in a convection oven, which was set to 225°F and the steam setting 10 minutes prior to the pans being placed in the oven. After 15 minutes of steaming, the broccoli florets were removed from the oven and immediately submerged in an ice bath for four minutes. A colander was used to separate the broccoli florets from the water and ice before the broccoli florets were transferred to a Robot Coupe food processor and puréed for 60 seconds. Labeled 4 oz cups (Reditainer) were filled with 0.66 oz of purée and lidded. The filled cups were stored at refrigerated temperature (42°F). Thirty minutes prior to serving, samples were removed from the refrigerator and held at room temperature (72°F).

3.4 Taste Strips and Sample Preparation

Control and n-propylthiouracil (PROP) taste test paper strips were purchased from Bartovation (Westchester, NY). The control strips were pieces of paper containing no added chemicals. For the PROP strip, each strip contains 3-5μg of PROP, which was determined to be a detectable and negligible, harmless level (Bartovation personal communication, January 31, 2019). Samples were prepared one day prior to testing. For the control taste test paper strips, one strip was placed in a 1 oz Reditainer brand cups. For the PROP taste test paper strip, one strip was placed in a 1 oz Reditainer brand cups. The strips were stored at room temperature (42°F).

3.5 Testing Protocol

The project was approved by the California Polytechnic State University, San Luis Obispo (Cal Poly SLO) Institutional Review Board (IRB) prior to testing. All parents electronically signed informed consent forms to participate in testing themselves as well as an informed consent form for their child or children to participate in testing
Testing was performed using RedJade® software, the JBMB™ Typing Tool, and focus groups. All subjects (parents and children separately) received a $25 gift card for participating (i.e. for one pair of parent and child, the parent received a $25 gift card and the child received a $25 gift card).

### 3.6 Parent Testing Protocol

The questionnaire the parents answered included five parts: demographic information, children’s food neophobia (FN), children’s vegetable neophobia (VN), children’s picky eating (PE), and their own Mouth Behavior (MB). RedJade was used to conduct the first four parts of the parental questionnaire, and JBMB® Typing Tool was used to conduct the final part of the parental questionnaire. As stated previously, parents who brought in more than one child to participate in testing answered the questionnaires separately for each child.

#### 3.6.1 Demographics

Parents began by reporting their child’s age, school grade, gender, name of school they attend, and ethnicity (Appendix C). They were then asked what their relationship is with the child they brought into testing (parent – mother, parent – father, grandparent, legal guardian, other). Parents reported their own education level from the following options: less than high school; some high school, no diploma; high school graduate, diploma or equivalent (i.e. GED); some college; college graduate – Associates degree; college degree – Bachelor’s degree; some post graduate education; college graduate degree – MS, PhD, MBA, JD, MD, DDS, etc.; other. Parents also reported their yearly family income from the following options: under $10,000; $10,001 to $39,999; $40,000 to $59,999; $60,000 to $79,999; $80,000 to $99,999; $100,000 to $119,999; $120,000 to
$139,999; above $140,000; prefer not to answer. Parents were asked to report their ethnicity.

### 3.6.2 Food Neophobia Scale

The Child Food Neophobic Scale (CFNS) was used to assess the children’s food neophobia (FN) through the parent’s perspective (Table 3.2; Appendix D). The CFNS is a modified version of the Food Neophobia Scale (FNS) developed by Pliner and Hobden (1992), and it is a validated tool to measure children’s food neophobia using parental reporting. The CFNS excluded four of the items from the original 10-item FNS questionnaire because those items were considered to not be age-appropriate for children (Howard et al., 2012).

Two of the items on the CFNS are reverse scored because these two items are positively worded; therefore, these items are assessing for food neophilia (Table 3.2). For these questions, a higher score would indicate higher willingness to try new foods (food neophilia) and lower unwillingness to try new foods (food neophobia). In the reverse scoring the numerical scoring scale is flipped. For the reverse scoring, a score of seven would represent “strongly disagree,” and a score of 1 would represent “strongly agree.”

Mean FN scores were computed. The higher scores indicated a stronger behavior of neophobia. In order to categorize the participants, mean scores of 4.7 to 7.0 were categorized as food neophobic, and mean scores of 1.0 to 3.5 were categorized as non-food neophobic. This left participants who scored 3.6 to 4.6 to fall into a category that could not be categorized as either food neophobic or non-food neophobic.
Table 3.2 The Child Food Neophobia Scale (CFNS)

<table>
<thead>
<tr>
<th>Item</th>
<th>Response Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>My child is constantly sampling new and different foods. (R)</td>
<td>1 = strongly disagree to 7 = strongly agree</td>
</tr>
<tr>
<td>My child doesn’t trust new foods.</td>
<td></td>
</tr>
<tr>
<td>If my child doesn’t know what is in a food, s/he won’t try it.</td>
<td></td>
</tr>
<tr>
<td>My child is afraid to eat foods that s/he has never tried before.</td>
<td></td>
</tr>
<tr>
<td>My child is very particular about the foods that s/he will eat.</td>
<td></td>
</tr>
<tr>
<td>My child will eat almost anything. (R)</td>
<td></td>
</tr>
</tbody>
</table>

Responses ranged from 1 = strongly disagree to 7 = strongly agree
R refers to items that had their responses reverse scored (1 = strongly agree to 7 = strongly disagree)

3.6.3 Vegetable Neophobia Scale

The vegetable neophobia subscale of the Fruit and Vegetable Neophobia Instrument (FVNI) was used to assess the children’s vegetable neophobia (VN) through the parent’s perspective (Table 3.3; Appendix E). Hollar, Paxton-Aiken, & Fleming (2013) based the FVNI on the Food Neophobia Scale (FNS). This instrument was developed to be an 18- self-reported scale with nine items targeting fruit neophobia and nine items targeting vegetable neophobia. The FVNI was used as a self-reported scale to assess FVN among 8- to 12-year-old children. In this study, the FVNI was modified to only include the nine items targeting vegetable neophobia, and the wording of the questions were modified so the parents answered the questions about their children.

Mean VN scores were computed. The higher the score indicated a stronger behavior of vegetable neophobia. In order to categorize the participants, mean scores of 2.6 to 4.0 were categorized as vegetable neophobic, and mean scores of 1.0 to 2.5 were categorized as non-vegetable neophobic.
Table 3.3 Modified Fruit and Vegetable Neophobia Instrument (FNVI)

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>How much does your child like vegetables?</td>
<td>a lot, a little, not very much, not at all</td>
</tr>
<tr>
<td>How much does your child like vegetables that s/he has never tried?</td>
<td>a lot, a little, not very much, not at all</td>
</tr>
<tr>
<td>How much does your child like tasting new vegetables?</td>
<td>a lot, a little, not very much, not at all</td>
</tr>
<tr>
<td>Will your child taste a vegetable if s/he does not know what it is?</td>
<td>definitely, probably, probably not, definitely not</td>
</tr>
<tr>
<td>Will your child taste a vegetable if it looks strange?</td>
<td>definitely, probably, probably not, definitely not</td>
</tr>
<tr>
<td>Will your child taste a vegetable if s/he has never tried it before?</td>
<td>definitely, probably, probably not, definitely not</td>
</tr>
<tr>
<td>When your child is at a friend’s house, will s/he try a new vegetable?</td>
<td>definitely, probably, probably not, definitely not</td>
</tr>
<tr>
<td>When your child is at school, will s/he try a new vegetable?</td>
<td>definitely, probably, probably not, definitely not</td>
</tr>
<tr>
<td>When your child is at home, will s/he try a new vegetable?</td>
<td>definitely, probably, probably not, definitely not</td>
</tr>
</tbody>
</table>

1 Responses for these items included “a lot,” “a little,” “not very much,” and “not at all”
2 Responses for these items included “definitely,” “probably,” “probably not,” and “definitely not”

3.6.4 Picky Eating Scale

The Child-Feeding Questionnaire: pickiness subscale was used to assess the children’s picky eating (PE) through the parent’s perspective (Table 3.4; Appendix F). Due to the lack of a universally accepted definition of picky eating, there are many different questionnaires developed to assess children’s picky eating. This particular subscale was chosen because it does not include any food neophobic characteristics, which were already assessed in the CFNS. It also does a good job of matching the definition that Taylor et al. (2015) recommends after reviewing 65 papers and abstract on picky eating, which is by Lumeng (2005). Lumeng (2005) defined picky eating as the “unwillingness to eat familiar foods or try new foods, severe enough to interfere with daily routines to an extent that is problematic to the parent, child, or parent-child relationship.”

Mean PE scores were computed. The higher the score indicated a stronger behavior of picky eating. In order to categorize the participants, mean scores of 3.66 to
5.0 were categorized as picky eaters, and mean scores of 1.0 to 2.5 were categorized as non-picky eaters. This left participants who scored 2.65 to 3.65 to fall into a category that could not be categorized as either picky eater or non-picky eater.

Table 3.4 Child-Feeding Questionnaire: Pickiness Subscale

<table>
<thead>
<tr>
<th>Statement</th>
<th>Responses ranged from 1 = Disagree to 5 = Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>My child’s diet consists of only a few foods.</td>
<td></td>
</tr>
<tr>
<td>My child is unwilling to eat many of the foods that our family eats at mealtimes.</td>
<td></td>
</tr>
<tr>
<td>My child is a fussy or picky about what s/he eats?</td>
<td></td>
</tr>
</tbody>
</table>

3.6.5 JBMB® Typing Tool

The JBMB® Typing Tool (https://www.mouthbehavior.com/) was used to determine the parent’s Mouth Behavior (MB). Parents were instructed to answer the questions in the JBMB® Typing Tool to identify their MB. Ultimately, this component of the research was conducted to serve as an introduction for the parents to the concept of MB. Later in the study the parents would be a key resource for determining the children’s MB, so it was important for the parents to enter that component of the study with a basic understanding of MB and knowledge of their own MB.

3.7 Children Testing Protocol

3.7.1 Vegetable Acceptance

Each child was paired with an undergraduate sensory team member for each testing session. The sensory member was there to read the questions to the children to account for the difference in reading ability of the children who participated in the testing. These sensory members went through training for testing before the first day of testing. They were taught to not supply the children with any additional information than
what was on the questionnaire. For example, if a child asked a sensory member what the vegetable sample was because the questionnaire did not specify this information, the sensory member was trained to not confirm or deny the child’s guess. The sensory members were trained how to further explain the wording of the questionnaire if a child did not know what exactly they were being asked. If a child did not know the meaning of aftertaste, the sensory member could try to define aftertaste by saying, “It’s the taste that remains in your mouth after you finish eating the food.” For the taste test strip component of testing, the sensory members were trained to make sure the children placed approximately half of the strip on their tongue and held it on their tongue for approximately 10 seconds. This was in order to make sure the children were using the strips properly. Most importantly, the sensory members were trained to not let the children distract or bias each other by talking or looking at each other during testing.

Before beginning with the vegetable testing, the team member read the children’s assent form to the child (Appendix G). Testing would only continue if the child agreed to participate in the study. If the child confirmed by saying “yes” they would continue, testing began by having the children answer a few demographic questions about themselves (Appendix H).

Hedonic tests were then performed with the child (Appendix I). The six vegetable products were presented to the children in a randomized order assigned to each child separately by the RedJade software. When first presented with the product, the children were asked if they had tried or seen that product before, and then they were given the option to eat the product. If the child was willing to eat the product, they moved forward to answer hedonic questions regarding the products look, smell, overall liking, taste, feel,
and aftertaste. A 5-point facial hedonic scale was used for all of the hedonic questions. If the child was not willing to eat the product, they were not asked the hedonic questions about that product, and they immediately moved onto the next sample. All participants were provided unsalted crackers (Nabisco unsalted tops Premium saltine crackers) and bottled water (DASANI®) as a palate cleanser to decrease carryover between samples.

3.7.2 PROP Sensitivity

At the end of the vegetable acceptance portion of the study, taste test strips were used to determine the children’s 6-\(n\)-propylthiouracil (PROP) sensitivity (Appendix J). The sensory members with the children were trained to not let the children know what was on the strips and that the test strips were being used to determine their PROP sensitivity. The children were first presented with the control strip. They were asked to place the strip on their tongue for approximately 10 seconds, and then indicate what they tasted: salty, sweet, bitter, sour, umami (savory), or nothing. This procedure was then repeated with the PROP strip.

3.7.3 Children’s Mouth Behavior Determination

After all the parents had finished answering their five questionnaires and the children had finished answering the vegetable acceptance testing, all the parents and children in one testing session gathered in one room to determine the children’s Mouth Behavior. Each testing session had between one to four children depending on how many parent and child pairs signed up for each particular testing session. This component of the study began when everyone in the testing session had completed their first portion.

The room was set up with tables organized in a square formation in the center of the study so all the parents and children in a testing session would be facing each other
and the discussion leader. In the corner of the room was a table with plates, napkins, and three types of chips (Lays, Ruffles, and Kettle chips).

As the parents and children entered the room where this component of testing took place, they were shown the table of chips and offered to take whichever chips they would like to eat. Once everyone in the testing session had time to help themselves to chips and take a seat at the tables, the discussion began. I was the designated discussion leader. I attended the weeklong MB workshop (Consumer Immersive Experience: In Food Texture) run by the women who discovered MB and created the JBMB® typing tool, Melissa Jeltema, Jacqueline Beckley, and Jennifer Vahalik. This workshop provided background on texture and MB, as well as the opportunity to watch how they conducted qualitative discussions with each MB group.

An introduction script going over this component of the study was read to explain this part of the testing (Appendix K). After parents and children were able to ask any questions they had concerning Mouth Behavior (MB) and this component of testing, the chips the children chose to eat were used as an introduction to the type of discussion that would follow. This part of the discussion was adapted from the potato chip study that Jeltema et al. (2014) used as an example of a study of individuals from the four different MB groups to better understand what satisfied the different groups.

Following the chip MB discussion, a qualitative in-depth discussion followed with the parents and children to better understand the product textural differences that drove the children’s acceptance or rejection of foods. Products that were discussed to help see differences in the texture preferences of the children included granola bars,
yogurt and ice cream toppings, cookies, and hard candy. Other eating behaviors, such as if the children were slow or long eaters, were discussed.

Both children and parents were encouraged to participate in the discussion. If there was a parent with more than one child participating in the discussion, it was encouraged to have the younger sibling add to the discussion on the topic being discussed before the older sibling(s) in order to avoid having the younger sibling just repeat exactly what the older sibling(s) said about their eating habits. At the end of this discussion, the children were typed as either a cruncher, chewer, smoisher, or sucker.

### 3.8 Statistical Analysis

The analyses were conducted using JMP® Pro (JMP, Version 14.2, SAS Institute Inc., Cary, N.C., 2018) and R (R Core Team, Vienna, Austria, 2019) statistical software. The children’s characteristics used in the analyses all had two levels: (1) food neophobia (FN) = FN and non-FN, (2) vegetable neophobia (VN) = VN and non-VN, (3) picky eating (PE) = PE and non-PE, (4) 6-n-propylthiouracil (PROP) sensitivity = PROP sensitive and non-PROP sensitive, and (5) Mouth Behavior (MB) = chewers and crunchers. The two levels of the five children’s characteristics were used as segments to analyze the data. Combined with the segment of all participants, there was a total of eleven segments.

The likelihood ratio chi-square analysis was conducted through JMP® to assess the relationship between all the children’s characteristics, which are all categorical variables. These chi-square tests were conducted with the significance level at $\alpha = 0.05$.

Exposure, willingness, and acceptability of all six attributes (appearance, aroma, overall liking, flavor, texture, and aftertaste) were analyzed using R software for all
participants and the ten segments from the children’s characteristics. Exposure, which refers to if the children had seen or tried the vegetables prior to acceptance testing, was examined to determine the percentage of children who had or had not previously been exposed to the vegetable samples. Willingness, which refers to if the children were willing to try the product or not, was examined to determine the percentage of children who were or were not willing to try the vegetable samples. Preference means of the six sensory attributes of the vegetables were calculated from the children who were willing to try the vegetables. For all these analyses, Tukey’s post hoc tests were run to determine if there were any differences in the samples for each segment at $\alpha = 0.05$. Acceptability of the sensory attributes of each vegetable sample compared between the two levels of each children’s characteristics was evaluated through two-sided t-tests with unequal variances using JMP® Pro.
CHAPTER 4

RESULTS

4.1 Participant’s Demographics

A total number of 43 child and parent pairs participated in the study. One parent was excluded from the study because the other parent of the child also participated in the study. For the majority of the parents who brought in two or three children for testing, only one parent would answer all the questionnaires for their children. There were four family units where both parents of the children participated in testing. In this situation, one parent answered the questionnaire for one child, and the other parent answered the question for their other child.

Children age six to ten participated in the study, and the mean age of children was 8.2 ± 1.44 years old. For grade level, many of the children were either in 1<sup>st</sup> grade (27.91%) or 4<sup>th</sup> grade (27.91%). There were more girls (55.81%) than boys (44.19%). In the questionnaire, parents were able to check all that apply for the question regarding the children’s race. The majority of the children were of White or Caucasian racial groups (87.50%), and only a few of the children were of Hispanic or Latino racial groups (12.50%) (Table 4.1).

Most parents who participated in the study were the children’s mothers (81.40%), and the remaining participants were either fathers (16.28%) or other – step father (2.33%). Same as the question regarding the children’s race, parents were able to check all that apply for the question regarding their own race. The majority of the parents were of White or Caucasian racial groups (91.11%), but there were some parents who identified as Hispanic or Latino (4.44%), Native American (2.22), and other –
Lebanese/Middle Eastern (2.22%). Parents mostly had college graduate degrees (MS, PhD, MBA, etc.) (58.14%) and reported having an income level before taxes was more than $140,000 in 2017 (Table 4.1).

Table 4.1 Children and Parent Demographics

<table>
<thead>
<tr>
<th>Children Variables</th>
<th>n</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 years old</td>
<td>7</td>
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<tr>
<td>8 years old</td>
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<td>16.28</td>
</tr>
<tr>
<td>9 years old</td>
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<td>23.26</td>
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<tr>
<td>10 years old</td>
<td>11</td>
<td>25.58</td>
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<tr>
<td>Other</td>
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<td>Grade</td>
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<td>3rd grade</td>
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<tr>
<td>5th grade</td>
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<td>9.30</td>
</tr>
<tr>
<td>Gender</td>
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<td></td>
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<tr>
<td>Male</td>
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<td>44.19</td>
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<td>12.50</td>
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<tr>
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<td>0.00</td>
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<tr>
<td>Native American</td>
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<td>0.00</td>
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<tr>
<td>Pacific Islander</td>
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<td>0.00</td>
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<tr>
<td>Other</td>
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<th>Parents</th>
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<th></th>
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<td>Highest level of education</td>
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<td>Less than High School</td>
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<td>0.00</td>
</tr>
<tr>
<td>Some High School, No Diploma</td>
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<td>0.00</td>
</tr>
<tr>
<td>High School Graduate, Diploma or Equivalent</td>
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<td>0.00</td>
</tr>
<tr>
<td>Some College</td>
<td>2</td>
<td>4.65</td>
</tr>
<tr>
<td>College Graduate – Associates Degree</td>
<td>4</td>
<td>9.30</td>
</tr>
<tr>
<td>College Degree – Bachelor’s Degree</td>
<td>9</td>
<td>20.93</td>
</tr>
<tr>
<td>Some Post Graduate Education</td>
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<td>6.98</td>
</tr>
<tr>
<td>College Graduate Degree (MS, PhD, MBA, etc.)</td>
<td>25</td>
<td>58.14</td>
</tr>
<tr>
<td>Other</td>
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<td>0.00</td>
</tr>
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<td>Parents Variables</td>
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<td>Frequency (%)</td>
</tr>
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<td>---------------</td>
</tr>
<tr>
<td>Relationship</td>
<td></td>
<td></td>
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<tr>
<td>Parent - Mother</td>
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<td>81.40</td>
</tr>
<tr>
<td>Parent – Father</td>
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<tr>
<td>Legal Guardian</td>
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<td>0.00</td>
</tr>
<tr>
<td>Other</td>
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<tr>
<td>Family income</td>
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<td>Under $10,000</td>
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<td>0.00</td>
</tr>
<tr>
<td>$10,001 - $39,999</td>
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<td>0.00</td>
</tr>
<tr>
<td>$40,000 - $59,999</td>
<td>5</td>
<td>11.63</td>
</tr>
<tr>
<td>$60,000 - $79,999</td>
<td>4</td>
<td>9.30</td>
</tr>
<tr>
<td>$80,000 - $99,999</td>
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<td>6.98</td>
</tr>
<tr>
<td>$100,000 - $119,999</td>
<td>3</td>
<td>6.98</td>
</tr>
<tr>
<td>$120,000 - $139,999</td>
<td>8</td>
<td>18.60</td>
</tr>
<tr>
<td>Above $140,000</td>
<td>20</td>
<td>46.51</td>
</tr>
<tr>
<td>Prefer not to answer</td>
<td>0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Race</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White or Caucasian</td>
<td>41</td>
</tr>
<tr>
<td>Hispanic or Latino</td>
<td>2</td>
</tr>
<tr>
<td>Asian or Asian American</td>
<td>0</td>
</tr>
<tr>
<td>Black or African American</td>
<td>0</td>
</tr>
<tr>
<td>Native American</td>
<td>1</td>
</tr>
<tr>
<td>Pacific Islander</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
<tr>
<td>Prefer Not to Answer</td>
<td>0</td>
</tr>
</tbody>
</table>

1Frequency totals to over 100% because the question was a choose all that apply

### 4.2 Participant’s Characteristics

From parental questionnaires, the majority of the children were categorized as food neophobic (46.51%), non-picky eaters (53.49%), and non-vegetable neophobic (55.81%). Some of the children were not able to be categorized as food neophobic or non-food neophobic (30.23%) or picky eater or non-picky eaters (13.95%). From children’s testing, there were more 6-n-propylthiouracil (PROP) sensitive (34.88%) than non-PROP sensitive (25.58%). Some of the children were not able to be categorized as PROP or non-PROP sensitive (39.53). The descending order of Mouth Behavior (MB) categories was the same for both parents and children: chewer, cruncher, smoosher, sucker. Because only three children were smoosher and two children were suckers, the
smoosher and sucker groups were used as supplemental data in the data analyses. Table 4.2 shows the determined characteristics of the children and parents.

Table 4.2 Summary of Parent and Children's Determined Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children - Food Neophobia (FN)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FN</td>
<td>20</td>
<td>46.51</td>
</tr>
<tr>
<td>Non-FN</td>
<td>10</td>
<td>23.26</td>
</tr>
<tr>
<td>N/A</td>
<td>13</td>
<td>30.23</td>
</tr>
<tr>
<td><strong>Children – Mouth Behavior (MB)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chewer</td>
<td>26</td>
<td>60.47</td>
</tr>
<tr>
<td>Cruncher</td>
<td>12</td>
<td>27.91</td>
</tr>
<tr>
<td>Smoosher</td>
<td>3</td>
<td>6.98</td>
</tr>
<tr>
<td>Sucker</td>
<td>2</td>
<td>4.65</td>
</tr>
<tr>
<td><strong>Parent – Mouth Behavior (MB)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chewer</td>
<td>25</td>
<td>58.14</td>
</tr>
<tr>
<td>Cruncher</td>
<td>13</td>
<td>30.23</td>
</tr>
<tr>
<td>Smoosher</td>
<td>4</td>
<td>17.39</td>
</tr>
<tr>
<td>Sucker</td>
<td>1</td>
<td>4.35</td>
</tr>
<tr>
<td><strong>Children – Picky Eating (PE)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PE</td>
<td>14</td>
<td>32.56</td>
</tr>
<tr>
<td>Non-PE</td>
<td>23</td>
<td>53.49</td>
</tr>
<tr>
<td>N/A</td>
<td>6</td>
<td>13.95</td>
</tr>
<tr>
<td><strong>Children PROP Sensitivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROP Sensitive</td>
<td>15</td>
<td>34.88</td>
</tr>
<tr>
<td>Non-PROP Sensitive</td>
<td>11</td>
<td>25.58</td>
</tr>
<tr>
<td>N/A</td>
<td>17</td>
<td>39.53</td>
</tr>
<tr>
<td><strong>Children - Vegetable Neophobia (VN)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VN</td>
<td>19</td>
<td>44.19</td>
</tr>
<tr>
<td>Non-VN</td>
<td>24</td>
<td>55.81</td>
</tr>
</tbody>
</table>

1If parent had 2 or 3 children participating in testing and they answered the questionnaires for all their children, their MB was counted 2 or 3 times accordingly
4.3 Associations between Children’s Characteristics

Contingency analysis was conducted to determine if there was a relationship between any of the five children’s characteristics. A significant association was found between food neophobia (FN) and vegetable neophobia (VN) (p<0.0001), FN and picky eating (PE) (p<0.0001), and VN and PE (p<0.001) (Table 4.3). There were no significant associations between PROP sensitivity or mouth behavior with any of the other children’s characteristics.

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>Chi-Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Neophobia</td>
<td>Vegetable Neophobia</td>
<td>28.809**</td>
</tr>
<tr>
<td>Food Neophobia</td>
<td>Picky Eating</td>
<td>19.784**</td>
</tr>
<tr>
<td>Food Neophobia</td>
<td>PROP$^1$ Sensitivity</td>
<td>0.037</td>
</tr>
<tr>
<td>Food Neophobia</td>
<td>Mouth Behavior</td>
<td>2.201</td>
</tr>
<tr>
<td>Vegetable Neophobia</td>
<td>Picky Eating</td>
<td>13.38*</td>
</tr>
<tr>
<td>Vegetable Neophobia</td>
<td>PROP Sensitivity</td>
<td>0.036</td>
</tr>
<tr>
<td>Vegetable Neophobia</td>
<td>Mouth Behavior</td>
<td>3.439</td>
</tr>
<tr>
<td>Picky Eating</td>
<td>PROP Sensitivity</td>
<td>0.061</td>
</tr>
<tr>
<td>Picky Eating</td>
<td>Mouth Behavior</td>
<td>0.081</td>
</tr>
<tr>
<td>PROP Sensitivity</td>
<td>Mouth Behavior</td>
<td>0.762</td>
</tr>
</tbody>
</table>

*<0.001; **<0.0001

$^1$PROP = 6-n-propylthiouracil

4.4 Acceptance Testing

4.4.1 Participant’s Exposure and Willingness to Try the Vegetable Samples

In order to determine the children’s exposure to the vegetables and vegetable forms that were tested in the vegetable acceptance testing, the children were asked if they had seen or tried that particular sample before. The data was segmented into the
following segment categories: all participants, food neophobia (FN), non-FN, vegetable neophobia (VN), non-VN, picky eating (PE), non-PE, 6-\textit{n}-propylthiouracil (PROP) sensitive, non-PROP sensitive, chewers, and crunchers.

For every segment except PE, there were more children who had been exposed to the vegetable samples than those who had not been exposed to the vegetables, with the exception of the broccoli and red carrot purees. For the PE segment, there were more children who had been exposed to the broccoli floret and broccoli sliver than those who had not been exposed. For all individual segments, there was no difference between the broccoli and red carrot purees. In the all participant segment for the children who had prior exposure to the samples, the broccoli was more familiar than the red carrots for both the traditional and slivered forms (p<0.05). In the FN, VN, non-VN, PE, and chewer segments for children who had prior exposure to the samples, only the traditional form of broccoli was more than familiar than the traditional red carrot (p<0.05). In the non-FN, non-PE, PROP sensitive, non-PROP sensitive, and cruncher segments for children who had prior exposure to the samples, there was no difference between the broccoli and red carrot samples in each of the difference forms (Table 4.4, Table 4.5).
Table 4.4 Frequencies (%)\(^1\) of Children Who Have (Yes) or Have Not (No) Tried or Seen Each of the Six Vegetable Samples before for the All Participants, Food Neophobia, Non-Food Neophobia, Vegetable Neophobia, and Non-Vegetable Neophobia Segments

<table>
<thead>
<tr>
<th>Sample</th>
<th>All (n=43)</th>
<th>FN (n=20)</th>
<th>Non-FN (n=13)</th>
<th>VN (n=19)</th>
<th>Non-VN (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Traditional</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Broccoli Floret</td>
<td>98(^\text{Aa}) 2(^\text{Cc})</td>
<td>100(^\text{Aa}) 0(^\text{Dc})</td>
<td>100(^\text{Aa}) 0(^\text{Bb})</td>
<td>100(^\text{Aa}) 0(^\text{Dc})</td>
<td>96(^\text{Aa}) 4(^\text{Cc})</td>
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<tr>
<td>Red Carrot Stick</td>
<td>65(^\text{Bb}) 35(^\text{Bb})</td>
<td>60(^\text{BCb}) 40(^\text{BCh})</td>
<td>85(^\text{Aa}) 15(^\text{Bb})</td>
<td>63(^\text{BCh}) 37(^\text{BCh})</td>
<td>67(^\text{Bb}) 33(^\text{Bb})</td>
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<tr>
<td>Slivered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>91(^\text{Aa}) 9(^\text{Cc})</td>
<td>80(^\text{ABab}) 20(^\text{CDbc})</td>
<td>100(^\text{Aa}) 0(^\text{Bb})</td>
<td>84(^\text{ABab}) 16(^\text{CDbc})</td>
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</tr>
<tr>
<td>Red Carrot</td>
<td>70(^\text{Bb}) 30(^\text{Bb})</td>
<td>65(^\text{Bb}) 35(^\text{Bb})</td>
<td>69(^\text{Aa}) 31(^\text{Bb})</td>
<td>68(^\text{Bb}) 32(^\text{Bb})</td>
<td>71(^\text{ABb}) 29(^\text{BCh})</td>
</tr>
<tr>
<td>Pureed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>21(^\text{Cc}) 79(^\text{Aa})</td>
<td>15(^\text{Dc}) 85(^\text{Aa})</td>
<td>23(^\text{Bb}) 77(^\text{Aa})</td>
<td>16(^\text{Dc}) 84(^\text{Aa})</td>
<td>25(^\text{Cc}) 75(^\text{Aa})</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>23(^\text{Cc}) 77(^\text{Aa})</td>
<td>25(^\text{CDc}) 75(^\text{ABa})</td>
<td>23(^\text{Bb}) 77(^\text{Aa})</td>
<td>26(^\text{CDc}) 74(^\text{ABa})</td>
<td>21(^\text{Cc}) 79(^\text{Aa})</td>
</tr>
</tbody>
</table>

\(^1\)Means sharing superscripts within a column do not differ at p<0.05
Upper case represents 95% Confidence Interval
Lower case represents 90% Confidence Interval
Column heading abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia
Table 4.5 Frequencies (%)\(^1\) of Children Who Have (Yes) or Have Not (No) Tried or Seen Each of the Six Vegetable Samples before for the Picky Eaters, Non-Picky Eaters, PROP Sensitive, Non-PROP Sensitive, Chewer, and Cruncher Segments

<table>
<thead>
<tr>
<th>Sample</th>
<th>PE (n=14)</th>
<th>Non-PE (n=23)</th>
<th>PROP Sensitive (n=15)</th>
<th>Non-PROP Sensitive (n=11)</th>
<th>Chewer (n=26)</th>
<th>Cruncher (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Yes</strong></td>
<td><strong>No</strong></td>
<td><strong>Yes</strong></td>
<td><strong>No</strong></td>
<td><strong>Yes</strong></td>
<td><strong>No</strong></td>
</tr>
<tr>
<td>Traditional</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli Floret</td>
<td>100(^Aa) 0(^Cc)</td>
<td>96(^Aa) 4(^Bb)</td>
<td>100(^Aa) 0(^Cc)</td>
<td>91(^Aa) 9(^Bb)</td>
<td>96(^Aa) 4(^Dc)</td>
<td>100(^Aa) 0(^Cc)</td>
</tr>
<tr>
<td>Red Carrot Stick</td>
<td>43(^Cc) 57(^Aa)</td>
<td>78(^Aa) 22(^Bb)</td>
<td>73(^Aab) 27(^Bbc)</td>
<td>55(^ABab) 45(^ABab)</td>
<td>54(^Cb) 46(^Bb)</td>
<td>83(^Aa) 17(^Cc)</td>
</tr>
<tr>
<td>Slivered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>86(^ABab) 14(^BCbc)</td>
<td>91(^Aa) 9(^Bb)</td>
<td>87(^Aab) 13(^Bbc)</td>
<td>91(^Aa) 9(^Bb)</td>
<td>88(^ABa) 12(^CDc)</td>
<td>92(^Aa) 8(^Cc)</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>50(^BCbc) 50(^ABab)</td>
<td>74(^Aa) 26(^Bb)</td>
<td>67(^ABb) 33(^BCb)</td>
<td>64(^ABa) 36(^ABb)</td>
<td>62(^BCb) 38(^BCb)</td>
<td>75(^ABab) 25(^BCbc)</td>
</tr>
<tr>
<td>Pureed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>21(^Cc) 79(^Aa)</td>
<td>22(^Bb) 78(^Aa)</td>
<td>27(^BCc) 73(^ABa)</td>
<td>18(^Bb) 82(^Aa)</td>
<td>23(^Dc) 77(^Aa)</td>
<td>17(^Cc) 83(^Aa)</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>29(^Cc) 71(^Aa)</td>
<td>22(^Bb) 78(^Aa)</td>
<td>20(^Cc) 80(^Aa)</td>
<td>18(^Bb) 82(^Aa)</td>
<td>15(^Dc) 85(^Aa)</td>
<td>33(^BCbc) 67(^Abab)</td>
</tr>
</tbody>
</table>

\(^1\)Means sharing superscripts within a column do not differ at p<0.05
Uppercase represents 95% Confidence Interval
Lowercase represents 90% Confidence Interval
Column heading abbreviations: PE = Picky Eater; PROP = 6-n-propylthiouracil
The children in the study had the option if they were willing to try each vegetable sample. If they chose to not try the sample, they did not answer any questions about that vegetable sample, and they immediately moved onto the next sample. The same segments categories were used for the analysis of the children willing to try each sample: all participants, food neophobia (FN), non-FN, vegetable neophobia (VN), non-VN, picky eating (PE), non-PE, 6-n-propylthiouracil (PROP) sensitive, non-PROP sensitive, chewers, and crunchers. For every segment, the participants were more willing to try than not try every sample. For the non-FN segment, all the participants (100%) were willing to try every product, except for the red carrot puree (92% willing). In all the individual segments, there was no difference between the willingness to try the broccoli or red carrots for each vegetable form (Table 4.6, Table 4.7).
Table 4.6 Frequencies (%)\(^1\) of the Children Who Were (Yes) or Were Not (No) Willing to Eat the Six Vegetable Samples for the All Participants, Food Neophobia, Non-Food Neophobia, Vegetable Neophobia, and Non-Vegetable Neophobia Segments

<table>
<thead>
<tr>
<th>Sample</th>
<th>All (n=43)</th>
<th>FN (n=20)</th>
<th>Non-FN (n=13)</th>
<th>VN (n=19)</th>
<th>Non-VN (n=24)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Traditional</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli Floret</td>
<td>93(^{\text{Aa}})</td>
<td>7(^{\text{Bb}})</td>
<td>85(^{\text{ABc}})</td>
<td>15(^{\text{ABCd}})</td>
<td>100(^{\text{e}})</td>
</tr>
<tr>
<td>Red Carrot Stick</td>
<td>95(^{\text{Aa}})</td>
<td>5(^{\text{Bb}})</td>
<td>95(^{\text{Aa}})</td>
<td>5(^{\text{Bb}})</td>
<td>100(^{\text{e}})</td>
</tr>
<tr>
<td>Slivered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>95(^{\text{Aa}})</td>
<td>5(^{\text{Bb}})</td>
<td>90(^{\text{ABcd}})</td>
<td>10(^{\text{ABCde}})</td>
<td>100(^{\text{e}})</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>98(^{\text{Aa}})</td>
<td>2(^{\text{Bb}})</td>
<td>100(^{\text{Aa}})</td>
<td>0(^{\text{Bb}})</td>
<td>100(^{\text{e}})</td>
</tr>
<tr>
<td>Pureed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>77(^{\text{BCb}})</td>
<td>23(^{\text{Aa}})</td>
<td>70(^{\text{BCcd}})</td>
<td>30(^{\text{ABd}})</td>
<td>100(^{\text{e}})</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>74(^{\text{BCb}})</td>
<td>26(^{\text{Aa}})</td>
<td>60(^{\text{Cc}})</td>
<td>40(^{\text{Aa}})</td>
<td>92(^{\text{e}})</td>
</tr>
</tbody>
</table>

\(^1\)Means sharing superscripts within a column do not differ at p<0.05
Uppercase represents 95% Confidence Interval
Lowercase represents 90% Confidence Interval
Column heading abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia
Table 4.7 Frequencies (%)\(^1\) of the Children Who Were (Yes) or Were Not (No) Willing to Eat the Six Vegetable Sample for the Picky Eater, Non-Picky Eaters, PROP Sensitive, Non-PROP Sensitive, Chewer, and Cruncher Segments

<table>
<thead>
<tr>
<th>Sample</th>
<th>PE (n=14)</th>
<th>Non-PE (n=23)</th>
<th>PROP Sensitive (n=15)</th>
<th>Non-PROP Sensitive (n=11)</th>
<th>Chewer (n=26)</th>
<th>Cruncher (n=12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Traditional</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli Floret</td>
<td>79(^{ABab})</td>
<td>21(^{ABab})</td>
<td>100(^{a})</td>
<td>0(^{b})</td>
<td>93(^{a})</td>
<td>7(^{b})</td>
</tr>
<tr>
<td>Red Carrot Stick</td>
<td>93(^{Aa})</td>
<td>7(^{Bb})</td>
<td>96(^{ab})</td>
<td>4(^{ab})</td>
<td>93(^{a})</td>
<td>7(^{b})</td>
</tr>
<tr>
<td>Slivered</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>86(^{ABab})</td>
<td>14(^{ABab})</td>
<td>100(^{a})</td>
<td>0(^{b})</td>
<td>93(^{a})</td>
<td>7(^{b})</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>100(^{Aa})</td>
<td>0(^{Bb})</td>
<td>96(^{ab})</td>
<td>4(^{ab})</td>
<td>100(^{a})</td>
<td>0(^{b})</td>
</tr>
<tr>
<td>Pureed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broccoli</td>
<td>71(^{ABab})</td>
<td>29(^{ABab})</td>
<td>78(^{a})</td>
<td>22(^{b})</td>
<td>80(^{a})</td>
<td>20(^{b})</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>57(^{Bb})</td>
<td>43(^{Aa})</td>
<td>78(^{b})</td>
<td>22(^{a})</td>
<td>73(^{b})</td>
<td>27(^{a})</td>
</tr>
</tbody>
</table>

\(^1\)Means sharing superscripts within a column do not differ at p<0.05
Upper-case represents 95% Confidence Interval
Lower-case represents 90% Confidence Interval
Column heading abbreviations: PE = Picky Eater; PROP = 6-\(n\)-propylthiouracil
4.4.2 Acceptance of the Sensory Attributes of the Vegetable Samples

Because the children were able to choose if they wanted to try each vegetable or not, the subject sample sizes for each vegetable varies. Table 4.8 provides the sample size for each segment for each vegetable sample. In each of the tables for the means of the different sensory attributes (appearance, aroma, overall liking, flavor, texture, and aftertaste) of the six vegetable samples, the total sample size of each segment is given in the first cell of the column (Table 4.9 – Table 4.14). Table 4.8 should be referenced for the specific sample size in sensory attribute tables.

In general, the appearance of both the carrot and broccoli purees were liked less than the other for samples for the majority of the segments, excluding PE, non-PROP, and crunchers (p<0.05). In the individual vegetable form categories, there was no difference between the broccoli and carrot samples (i.e. no difference between broccoli sliver and red carrot sliver) (Table 4.9).

The aroma of the traditional carrot stick was liked more than the aroma of the traditional broccoli floret for the all participant, FN, VN, non-VN, PE, non-PE, PROP sensitive segments (p<0.05). The aroma of the red carrot sliver was liked more than the aroma of the broccoli sliver for all segments, except the non-FN segment (p<0.05). There was no difference in the acceptability of aroma of the broccoli and red carrot purees for all of the segments (Table 4.10).

The overall liking of the traditional red carrot stick was more than the overall liking of the traditional broccoli floret for the all participants, FN, VN, PE segments (p<0.05). The overall liking of the red carrot sliver was more than overall liking of the broccoli sliver for the all participants, FN, VN, PE, non-PE, and chewer segments (p<0.05) (Table 4.11).
The flavor of the traditional red carrot sticks was liked more than the flavor of the traditional broccoli florets for the all participants, FN, VN, and PE segments (p<0.05). The flavor of the red carrot sliver was liked more than the flavor of the broccoli sliver for the all participants, FN, VN, PE, and chewer segments (p<0.05) (Table 12). There were not really any differences in the acceptability of the texture or aftertaste of the six vegetable samples (Table 13, Table 14).

### 4.4.3 Preference Difference between Children’s Characteristic Segments

There were significant differences in the acceptability of the appearance of the red carrot stick, broccoli sliver, and broccoli puree. The non-FN children rated the appearance of the red carrot stick higher than the FN children (p<0.05), and the non-PE children rated the appearance of the red carrot stick higher than the PE children (p<0.05). The non-VN rated the appearance of both the broccoli sliver (p<0.05) and the broccoli puree (p<0.05) higher than the VN children (Table 4.9).

There were significant differences in the acceptability of the aroma of the red carrot stick, broccoli sliver, broccoli puree, and carrot puree. The non-FN children rated the aroma higher than the FN children for the red carrot stick (p<0.05), broccoli sliver (p<0.05), and broccoli puree (p<0.05). The PROP sensitive children rated the aroma of the red carrot stick higher than the non-PROP sensitive children (p<0.05). The non-VN children rated the aroma of the broccoli puree higher than the VN children (p<0.01). The non-PE children rated the aroma of both the broccoli puree (p<0.05) and carrot puree (p<0.05) higher than the PE children (Table 4.10).

There were significant differences in the overall liking of all of the vegetable samples, except for the red carrot stick. The non-FN children had higher overall liking scores than the FN
children for the broccoli floret (p<0.01), carrot sliver (p<0.05), and broccoli puree (p<0.05). The non-VN children had higher overall liking scores than the VN children for the broccoli floret (≤0.001), broccoli sliver (p<0.01), carrot sliver (p<0.05), and broccoli puree (p<0.05). The non-PE children had higher overall liking scores than the PE children for the broccoli sliver (p<0.05), carrot sliver (p<0.01), broccoli puree (p<0.01), and carrot puree (p<0.05). The crunchers had higher overall liking scores for the carrot puree than the chewers (p<0.05) (Table 4.11).

There were significant differences in the acceptability of the flavor of all the vegetable samples, except for the red carrot sliver. The non-FN children rated the flavor of both the broccoli floret (p<0.01) and the broccoli sliver (p<0.05) higher than the FN children. The non-VN children rated the flavor higher than the VN children for the broccoli floret (p<0.01), broccoli sliver (p<0.05), and broccoli puree (p<0.05). The non-PE children rated the flavor higher than the PE children for the broccoli floret (p<0.05), carrot stick (p<0.05), broccoli sliver (p<0.05), and broccoli puree (p<0.05). The crunchers rated the flavor of the carrot puree higher than the chewers (p<0.05) (Table 4.12).

There were significant differences in the acceptability of the texture of the broccoli floret, carrot sliver, and carrot puree. The chewers rated the texture of the broccoli floret higher than the crunchers (p<0.05). The non-FN children rated the texture of the carrot sliver higher than the FN (p<0.05). The non-PE rated the texture higher than the PE for both the carrot sliver (p<0.05) and carrot puree (p<0.05) (Table 4.13).

There were significant differences in the acceptability of the aftertaste of the broccoli floret and carrot puree. The non-FN children rated the aftertaste of the broccoli floret higher than
the FN children (p<0.05), and the non-PE children rated the aftertaste of the carrot puree higher than the PE children (p<0.01) (Table 4.14).
Table 4.8 Sample Size by Segment by Vegetable Sample

<table>
<thead>
<tr>
<th>Sample</th>
<th>All</th>
<th>FN</th>
<th>Non-FN</th>
<th>VN</th>
<th>Non-VN</th>
<th>PE</th>
<th>Non-PE</th>
<th>PROP Sensitive</th>
<th>Non-PROP Sensitive</th>
<th>Chewer</th>
<th>Cruncher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total category size</td>
<td>43</td>
<td>20</td>
<td>13</td>
<td>19</td>
<td>24</td>
<td>14</td>
<td>23</td>
<td>15</td>
<td>11</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>Traditional Broccoli Floret</td>
<td>40</td>
<td>17</td>
<td>13</td>
<td>16</td>
<td>24</td>
<td>11</td>
<td>23</td>
<td>14</td>
<td>11</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>Red Carrot Stick</td>
<td>41</td>
<td>19</td>
<td>13</td>
<td>18</td>
<td>23</td>
<td>13</td>
<td>22</td>
<td>14</td>
<td>10</td>
<td>24</td>
<td>12</td>
</tr>
<tr>
<td>Slivered Broccoli</td>
<td>41</td>
<td>18</td>
<td>13</td>
<td>17</td>
<td>24</td>
<td>12</td>
<td>23</td>
<td>14</td>
<td>11</td>
<td>25</td>
<td>11</td>
</tr>
<tr>
<td>Red Carrot Puree</td>
<td>42</td>
<td>20</td>
<td>13</td>
<td>19</td>
<td>23</td>
<td>14</td>
<td>22</td>
<td>15</td>
<td>10</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>Puree Broccoli</td>
<td>33</td>
<td>14</td>
<td>13</td>
<td>14</td>
<td>19</td>
<td>10</td>
<td>18</td>
<td>12</td>
<td>7</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Puree Red Carrot</td>
<td>32</td>
<td>12</td>
<td>12</td>
<td>13</td>
<td>19</td>
<td>8</td>
<td>18</td>
<td>11</td>
<td>8</td>
<td>20</td>
<td>9</td>
</tr>
</tbody>
</table>

Abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia; PE = Picky Eating; PROP = 6-n-propylthiouracil
Table 4.9 Means\(^1\) for the 5-Point Hedonic Scores of the Appearance of the Six Vegetable Samples Evaluated

| Sample                | All (n=43) | FN (n=20) | Non-FN (n=13) | VN (n=19) | Non-VN (n=24) | PE (n=14) | Non-PE (n=23) | PROP Sensitive (n=15) | Non-PROP Sensitive (n=11) | Chewer (n=26) | Cruncher (n=12) |
|-----------------------|------------|-----------|---------------|-----------|---------------|-----------|---------------|-----------------------|--------------------------|---------------|----------------|----------------|
| Traditional           |            |           |               |           |               |           |               |                       |                           |               |                |                |
| Broccoli Floret       | 3.9\(^a\) | 3.8\(^a\) | 4.0\(^ab\)    | 3.6\(^ab\) | 4.1\(^a\)     | 3.9\(^a\) | 3.9\(^a\)     | 3.9\(^a\)                  | 4.1\(^a\)                    | 4.1\(^a\)     | 3.5\(^ab\)    |
| Red Carrot Stick      | 3.7\(^a\) | 3.4\(^ab\) | 4.1\(^a\*)    | 3.5\(^ab\) | 3.9\(^a\)     | 3.1\(^ab\) | 4.0\(^a\*)    | 3.8\(^a\)                  | 3.5\(^ab\)                    | 3.7\(^a\)     | 4.1\(^a\)    |
| Slivered              |            |           |               |           |               |           |               |                       |                           |               |                |                |
| Broccoli              | 3.7\(^a\) | 3.5\(^ab\) | 4.0\(^ab\)    | 3.3\(^abc\) | 3.9\(^a\*)   | 3.6\(^ab\) | 3.8\(^a\)     | 3.6\(^ab\)                  | 3.9\(^a\)                    | 3.8\(^a\)     | 3.3\(^ab\)    |
| Red Carrot            | 3.8\(^a\) | 3.7\(^a\) | 4.0\(^ab\)    | 3.8\(^a\) | 3.9\(^a\)     | 3.7\(^ab\) | 4.0\(^a\)     | 3.9\(^a\)                  | 3.8\(^ab\)                    | 3.9\(^a\)     | 3.7\(^ab\)    |
| Pureed                |            |           |               |           |               |           |               |                       |                           |               |                |                |
| Broccoli              | 3.0\(^b\) | 2.6\(^b\) | 3.4\(^ab\)    | 2.6\(^c\*) | 3.2\(^b\*)   | 2.7\(^b\) | 3.1\(^b\)     | 2.9\(^bc\)                  | 3.3\(^ab\)                    | 2.9\(^b\)     | 3.2\(^ab\)    |
| Red Carrot            | 2.8\(^b\) | 2.7\(^b\) | 3.1\(^c\)     | 2.8\(^bc\) | 2.8\(^b\)    | 2.7\(^ab\) | 3.1\(^b\)     | 2.7\(^c\)                   | 2.7\(^b\)                    | 2.7\(^b\)     | 3.0\(^b\)    |

\(^1\)Means sharing superscripts within a column do not differ at p<0.05

*p<0.05 is considered statistically significant from two-sided t-tests with unequal variances comparing the two levels of each children's characteristic factor for each vegetable sample (i.e. comparing FN and non-FN appearance acceptability of the broccoli floret)

Abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia; PE = Picky Eater; PROP = 6-\(n\)-propylthiouracil
Table 4.10 Means\(^1\) for the 5-Point Hedonic Scores of the Aroma of the Six Vegetable Samples Evaluated

<table>
<thead>
<tr>
<th>Sample</th>
<th>All (n=43)</th>
<th>FN (n=20)</th>
<th>Non-FN (n=13)</th>
<th>VN (n=19)</th>
<th>Non-VN (n=24)</th>
<th>PE (n=14)</th>
<th>Non-PE (n=23)</th>
<th>PROP Sensitive (n=15)</th>
<th>Non-PROP Sensitive (n=11)</th>
<th>Chewer (n=26)</th>
<th>Cruncher (n=12)</th>
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\(^1\)Means sharing superscripts within a column do not differ at p<0.05  
*\(p<0.05\) and **\(p<0.01\) are considered statistically significant from two-sided t-tests with unequal variances comparing the two levels of each children's characteristic factor for each vegetable sample (i.e. comparing FN and non-FN aroma acceptability of the broccoli floret)

Abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia; PE = Picky Eater; PROP = 6-\textit{n}-propylthiouracil
Table 4.11 Means\(^1\) for the 5-Point Hedonic Scores of the Overall Liking of the Six Vegetable Samples Evaluated

<table>
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<tr>
<th>Sample</th>
<th>All (n=43)</th>
<th>FN (n=20)</th>
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<th>VN (n=19)</th>
<th>Non-VN (n=24)</th>
<th>PE (n=14)</th>
<th>Non-PE (n=23)</th>
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<th>Non-PROP Sensitive (n=11)</th>
<th>Chewer (n=26)</th>
<th>Cruncher (n=12)</th>
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<td>2.9(^b)**</td>
<td>4.1(^ab)**</td>
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<td>4.1(^bc)</td>
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<td>3.8(^ab)</td>
<td>3.6(^bc)</td>
<td>3.9(^ab)</td>
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\(^1\)Means sharing superscripts within a column do not differ at p<0.05

\(^\ast\)p<0.05, \(^\ast\ast\)p<0.01, and \(^\ast\ast\ast\)p≤0.001 are considered statistically significant from two-sided t-tests with unequal variances comparing the two levels of each children's characteristic factor for each vegetable sample (i.e. comparing FN and non-FN overall liking acceptability of the broccoli floret)

Abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia; PE = Picky Eater; PROP = 6-n-propylthiouracil
Table 4.12 Means\(^1\) for the 5-Point Hedonic Scores of the Flavor of the Six Vegetable Samples Evaluated

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<th>VN  (n=19)</th>
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<th>PE  (n=14)</th>
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<th>Chewer (n=26)</th>
<th>Cruncher (n=12)</th>
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<td>4.4(^{ab**})</td>
<td>2.8(^{b**})</td>
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<td>4.0(^{ab})</td>
<td>3.7(^{abc})</td>
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<td>4.6(^a)</td>
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<td>4.4(^a)</td>
<td>4.0(^{ab*})</td>
<td>4.6(^{a*})</td>
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<td>4.1(^{ab})</td>
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<td>4.6(^{ab})</td>
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<td>3.1(^{b*})</td>
<td>4.1(^{ab*})</td>
<td>2.9(^{bc*})</td>
<td>3.9(^{abc*})</td>
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<td>3.3(^{c*})</td>
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<td>3.5(^{bc})</td>
<td>3.4(^b)</td>
<td>2.5(^{c})</td>
<td>2.8(^{c})</td>
<td>3.8(^{abc*})</td>
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\(^1\)Means sharing superscripts within a column do not differ at p<0.05
*p<0.05 and **p<0.01 are considered statistically significant from two-sided t-tests with unequal variances comparing the two levels of each children's characteristic factor for each vegetable sample (i.e. comparing FN and non-FN flavor acceptability of the broccoli floret)

Abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia; PE = Picky Eater; PROP = 6-\(n\)-propylthiouracil
Table 4.13 Means\(^1\) for the 5-Point Hedonic Scores of the Texture of the Six Vegetable Samples Evaluated

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<th>PE (n=14)</th>
<th>Non-PE (n=23)</th>
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<th>Chewer (n=26)</th>
<th>Cruncher (n=12)</th>
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\(^1\)Means sharing superscripts within a column do not differ at p<0.05

\(^*\)p<0.05 is considered statistically significant from two-sided t-tests with unequal variances comparing the two levels of each children's characteristic factor for each vegetable sample (i.e. comparing FN and non-FN texture acceptability of the broccoli floret).

Abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia; PE = Picky Eater; PROP = 6-\(n\)-propylthiouracil
Table 4.14 Means\(^1\) for the 5-Point Hedonic Scores of the Aftertaste of the Six Vegetable Samples Evaluated

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<td>3.4</td>
<td>3.2(^{ab})</td>
<td>3.2(^b)</td>
<td>3.0(^{ab})</td>
<td>3.3(^{b})</td>
<td>3.5</td>
<td>2.8(^{b})</td>
<td>3.0(^c)</td>
<td>3.6</td>
</tr>
<tr>
<td>Red Carrot</td>
<td>3.2(^c)</td>
<td>3.1(^{ab})</td>
<td>3.7</td>
<td>2.9(^b)</td>
<td>3.4(^{ab})</td>
<td>2.0(^{b,*})</td>
<td>3.8(^{ab,*})</td>
<td>3.8</td>
<td>2.6(^b)</td>
<td>3.0(^c)</td>
<td>3.7</td>
</tr>
</tbody>
</table>

\(^1\)Means sharing superscripts within a column do not differ at p<0.05

*p<0.05 and *p<0.01 are considered statistically significant from two-sided t-tests with unequal variances comparing the two levels of each children's characteristic factor for each vegetable sample (i.e. comparing FN and non-FN aftertaste acceptability of the broccoli floret)

Abbreviations: FN = Food Neophobia; VN = Vegetable Neophobia; PE = Picky Eater; PROP = 6-n-propylthiouracil
CHAPTER 5
DISCUSSION

5.1 Participant’s Characteristics

The JBMB® typing tool used to classify individual’s Mouth Behavior (MB) was validated for males and females, ages 15-65 (Jeltema, Beckley, & Vahalik, 2016). For this research, a novel method for determining children’s MB was developed mainly because the validated JBMB® typing tool should only be used by adults, with the possibility that teenagers may be able to use the tool. If children were to use the tool, they would immediately go to the sweet foods or the foods they recognize and like. This would result in inaccurate classification of MB group.

The distribution of the children’s and parent’s Mouth Behavior (MB) found in this work is similar to the distribution of MB in the U.S. adult population that was determined by Jeltema, Beckley, & Vahalik (2014) from a survey of 500 female and male adults. Chewers and crunchers were the two predominant MB groups, and suckers and smooshers were the smaller MB groups. At the end of the children’s MB discussions, a few parents commented on how determining their children’s MB helped them better understand their children’s eating habits. One mother had a revelation that their children’s rejection of many of the foods and meals they were presented with were occurring because she was offering foods that better fit her individual MB, which was smoosh, and not her child’s MB, which was cruncher. Overall, the method of determining the children’s MB through guided discussion with parental guidance and contribution shows determining a child’s MB may be possible.
As the concept of MB was hypothesized in 2001 with ten proceeding years of research, MB is still a relatively new concept (Jeltema, Beckley, & Vahalik, 2014). In the literature, there are currently only three articles on MB: the discovery, development, and validation of the typing tool (Jeltema, Beckley, & Vahalik, 2015), assessing how MB can explain food texture perception and preference (Jeltema, Beckley, & Vahalik, 2016), and comparing MB to chewing measures (Wilson et al., 2018). The articles by Jeltema, Beckley, & Vahalik (2015, 2016) reported the same validation study they conducted that determined the U.S. population MB categorization (43% chewers, 33% crunchers, 16% smooshers, 8% suckers). Wilson et al. (2018) obtained a slightly different distribution of MB (46% crunchers, 24% chewers, 22% smooshers, 8% suckers), but they conducted their study in New Zealand, which may have accounted for the difference.

It is possible that after many hours of qualitative discussion and research a validated typing tool similar to the JBMB® typing tool could be developed for children. In the future, a longitudinal study could be conducted where children’s MB can be analyzed as they grow older until they reach the age of 15, which is the youngest age for the JBMB® typing tool. Such a study could determine if children’s MB changes over their developmental years and if it matches the results of the JBMB® typing tool.

5.2 Association between Children’s Characteristics

As it was hypothesized, there were associations between food neophobia (FN) and vegetable neophobia (VN), FN and picky eating (PE), and VN and PE. It is not possible to be able to compare the association of FN and PE with VN to the other results of prior studies, as there are no studies in the literature that utilize the Fruit and Vegetable Neophobia Instrument (FVNI) by Hollar, Paxton-Aiken, & Fleming (2013). On the other
hand, there are many studies comparing FN and PE. Some researchers have found a strong relationship between FN and PE, which agrees with the findings of this study (Finistrella et al., 2012; Rigal et al., 2012).

There were no associations between PROP sensitivity or Mouth Behavior (MB) and the other factors. Because PROP sensitivity is related to flavor and MB is related to texture, it is understandable that neither FN nor VN are related to either of these characteristics. Both FN and VN are the rejection of foods, specifically vegetables for VN, prior to consumption (Dovey et al., 2008; Hollar, Paxton-Aiken, & Fleming, 2013). Along with the rejection of novel foods due to appearance, PE also reject familiar foods due to flavor, taste, and texture (Dovey et al., 2008; Johnson, Moding, & Bellows, 2018); therefore, it was hypothesized that PE would be associated with PROP sensitivity and MB. There might not have been an association between PE and PROP sensitivity due to the methodology of the PROP sensitivity. The taste strips used to determine the children’s PROP sensitivity were purchased from an outside company, so the results from the taste strips may be unreliable.

5.3 Acceptance Testing

5.3.1 Exposure and Willingness

With the exception of PE, all the segments had been exposed to the broccoli floret, red carrot stick, broccoli sliver, and red carrot sliver. It was expected that the majority of the children would be familiar with the broccoli floret and broccoli sliver, as broccoli was chosen to be the representation of a familiar vegetable in the study. It was anticipated that the percentage of children who had been exposed to the red carrot samples would be lower than what was reported because the red carrot was chosen to be
the representation of an unfamiliar vegetable in the study. In the questionnaires, the children were not informed of the name of each vegetable; therefore, the higher than expected exposure percentages may have resulted from the children incorrectly identifying the samples. For example, some children thought the red carrot slivers were red bell peppers. During testing, many children told the sensory team members what they though the vegetables were, but the sensory team members were trained to neither confirm nor deny what the children thought.

Overall, the majority the children had not previously been exposed to either the broccoli or red carrot purees for all the segments. This is consistent with what was expected, as pureed vegetables are not common for elementary age children. The frequency of children who said they had previously seen or tried these samples was higher than what was expected because, similar to the other samples, some of the children misidentified these samples. For example, one child thought the broccoli puree was guacamole.

For all segments, there was a larger percentage of children who were willing to try every vegetable sample than the percentage of children who were not willing to try the samples. The high frequency of children that were willing to try the vegetables may, in part, be explained by the findings of many studies that willingness to try novel foods is weakly correlated to FN (Flight, Leppard, & Cox, 2003; Tuorila et al., 2001). It has been suggested that children guess what the food is rather than admitting they don’t know what food they are looking at, and this association with a familiar food plays a role in their willingness to try the food that they have been presented with (Dovey et al., 2008).
Similar to the exposure, the high frequency of willingness may also in part be explained by children’s incorrect identification of the vegetables that were presented to them.

5.3.2 Acceptance of the Sensory Attributes of the Vegetable Samples

When looking at the acceptability of the sensory attributes of the six vegetable samples for each of the children’s characteristic segments, a statistical significance of either the means of an individual segment or the two-sided t-tests comparing the two levels of each characteristic indicates a possible trend. Although a lot can change with subject sample size, which was relatively small in this study, statistical significance indicates a trend in the data.

There was a trend of the non-FN and non-PE liking the appearance of the red carrot stick more than the FN and PE children, respectively. This agrees with findings that individuals who are FN primarily reject foods based on their visual appearance (Dovey et al., 2008), and it agrees with the definitions of PE, which often include the refusal of foods based on multiple sensory qualities, including appearance (Jacobi, Scmitz, & Agras, 2008; Johnson, Moding, & Bellows, 2018). There were no differences in the acceptability of the appearance of the red carrot sliver. This may have resulted due to the children incorrectly identifying this sample, which may have occurred because the small slivers of the red carrot have less of the distinguishing characteristics of the carrot, such as the inner core. Additionally, carrots are more often cut into sticks than slivers, while red bell peppers are often cut into thin strips.

For many of the vegetables, the non-FN, non-VN, and non-PE had overall liking scores higher than the FN, VN, and PE, respectively. There is little research investigating the acceptability of sensory attributes of vegetables for FN and PE, but many studies have
reported FN and PE children to consumer lower amounts of vegetables than non-FN and non-PE children (Cooke et al., 2006; Galloway et al., 2003; van der Horst, 2012). This low consumption of vegetables may relate to the lower overall liking scores of the FN, VN, and PE children. It was anticipated that the unfamiliar vegetable, the red carrot, would have lower overall liking than the familiar vegetable, the broccoli. For the all subjects, FN, VN, and PE segments, the red carrot stick was rated higher than the broccoli floret, and the red carrot sliver was rated higher than the broccoli sliver. This may have resulted from children’s rejection of bitter-tasting green vegetables such as broccoli (Turnbull & Matisoo-Smith, 2002), and/or the children misidentifying the red carrots.

There appeared to be no major taste difference between any of the samples for the PROP sensitive and non-PROP sensitive. For all the samples and sensory attributes, the only difference between the two segments of PROP sensitivity was seen for the aroma of the red carrot stick, where the PROP sensitive children exhibited a greater acceptability of the aroma of this sample. The results of little taste differences between the PROP sensitive and non-PROP sensitive children is consistent with findings of studies such as Anliker et al. (1991) who found no differences in the acceptability of the liking of raw broccoli among 5- to 7-year-olds between PROP taster and non-PROP taster status. Some studies support a relationship between PROP taster status and the liking of bitter vegetables. Bell and Tepper (2006) found that preschool children who were PROP non tasters consumed more vegetables than taster children. The methodology of evaluating the children’s PROP sensitivity may have also contributed to the lack of a difference between PROP sensitive and non-PROP sensitive children’s acceptability of the samples.
Chewers significantly liked the broccoli floret texture more than the crunchers. Because chewers enjoy chewing foods longer than crunchers, who prefer foods that fracture when bit into, it is consistent with the preference differences between these two MB groups that chewers would enjoy the broccoli floret texture (Jeltema, Beckley, & Vahalik, 2016). Broccoli florets can take time to process in the mouth because of the fibrous stalk and chewy flower buds of the floret, which would appeal to chewers. Although there were no other samples that showed a trend of a difference between the acceptability of the texture for chewers and crunchers, the crunchers rated the texture higher than the chewers when looking at the mean scores for the red carrot stick, broccoli sliver, broccoli puree, and carrot puree. These finding, except the findings for the purees, agree with the types of foods that crunchers prefer, which are foods that fracture when bitten (i.e. hard foods) (Jeltema, Beckley, & Vahalik, 2016). Both the red carrot stick and sliver can be classified as crunchy vegetables. Although broccoli is commonly more chewy than crunchy in texture, the slivered broccoli allows for bites that do not require as much chewing as the broccoli floret.

The broccoli and red carrot purees were included in the study to explore if smooshers and suckers would show a preference for these samples compared to the other samples. Because the children were not recruited based on MB because their MB was determined through the novel methodology evaluated during the study, only a small sample size of smooshers an suckers was obtained. A larger sample size is required to analyze and draw conclusions from these MB groups acceptability of the vegetable’s sensory attributes. There were no major differences between the crunchers rating of the texture any of the samples, including the purees, which does not agree with the finding by
Jeltema, Beckley, & Vahalik (2016) that crunchers show significantly more dislikes for “soft and smooshy” foods.

5.4 Limitations

The results of this study only apply to children in San Luis Obispo (SLO) County. SLO County is located on the central coast of California where there is a wide variety of fresh vegetables that are available at local farm stands, farmer markets, and supermarkets. Another limitation of this study was that the setting was only slightly ‘natural’ because it took place at a school setting. Unlike having the study in a laboratory setting where the children would feel uncomfortable, the study was located in classrooms at the university. Additionally, the analyses of this study were only able to include the chewer and cruncher Mouth Behavior (MB) group due to the low subject sample size of smoosher and sucker MB groups. This resulted because the children were not recruited by MB because there is not currently a validated tool for children to determine their MB.
CHAPTER 6

CONCLUSION

The current study provides preliminary research for future research as to how determining and understanding children’s Mouth Behavior (MB) can be incorporated into consumer evaluation and be provide beneficial information for parents of children with challenging eating behaviors, such as food neophobia (FN), vegetable neophobia (VN), and picky eating (PE). This study showed that there are possible trends between MB and vegetable acceptance. Although MB was not associated with PE or FN, a much larger subject sample size with all MB groups, specifically smooshers and suckers, represented is needed to be conclusive on the association with these eating behaviors.

Children in the study tended to prefer the non-bitter, food neophobic red carrot over the bitter, non-food neophobic broccoli. Because red carrots may have been misidentified and therefore not viewed as unfamiliar to the children, no conclusions can be draw on the impact of FN, VN, or PE on vegetable preference. In conclusion, understanding how children’s eating behaviors are associated with their acceptability of different types and forms of vegetables is critical to increase children’s vegetable consumption.
REFERENCES


APPENDICES

A. Parent’s Informed Consent

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT:
“The Investigation of Food Neophobia and Picky Eating of Vegetables in Elementary School Children”

INTRODUCTION
This form asks for your agreement to participate in a research project on the preferences of elementary aged children for vegetables. Your participation involves participating in a brief survey, determining your Mouth Behavior, and a focus group to determine your child or children’s Mouth Behavior. It is expected that your participation will take approximately 60-120 minutes. There are no risks anticipated with your participation. You may personally benefit from this study. If you are interested in participating, please review the following information.

PURPOSE OF THE STUDY AND PROPOSED BENEFITS
• The purpose of the study is to determine the level of acceptance of known foods and acceptance of new foods in school children ages 6-10.
• Potential benefits associated with the study include a better understanding of the way you prefer to breakdown food while eating and to the understanding of children’s acceptance of vegetables.

YOUR PARTICIPATION
• If you agree to participate, you will be asked to take a brief survey and questionnaire regarding your child or children’s level of picky eating and food neophobia, complete a questionnaire on Mouth Behavior, and participate in focus group session with your child or children to determine their Mouth Behavior.
• Your participation will take approximately 60-120 minutes.
• As an incentive, you will be offered a $25 gift card to a retail store market.

PROTECTIONS AND POTENTIAL RISKS
• Please be aware that you are not required to participate in this research, refusal to participate will not involve any penalty or loss of benefits to which you are otherwise entitled, and you may discontinue your participation at any time. You may omit responses to any questions you choose not to answer
• There are no risks anticipated with your participation in this study.
• Your responses will be provided anonymously to protect your privacy. A participant code will be used in place of a name, so identity will not be linked to any data collection.

RESOURCES AND CONTACT INFORMATION
• This research is being conducted by graduate student Tara Egigian and associate professor Dr. Amy Lammert in the Department of Food Science and Nutrition at Cal Poly, San Luis. If you have questions regarding this study or would like to be informed of the results when the study is completed, please contact the Dr. Amy Lammert at alammert@calpoly.edu.
• If you have concerns regarding the manner in which the study is conducted, you may contact Dr. Michael Black, Chair of the Cal Poly Institutional Review Board, at (805) 756-2894, mblack@calpoly.edu, or Ms. Debbie Hart, Compliance Officer, at (805) 756-1508, dahart@calpoly.edu.

AGREEMENT TO PARTICIPATE
If you agree to voluntarily participate in this research project as described, please indicate your agreement by completing and submitting the following questionnaire. Please retain a copy of this form for your reference, and thank you for your participation in this research.

[ ] Yes, I volunteer. [ ] No, I do not volunteer.

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B. Parent’s Informed Consent for Child

PARENT/GUARDIAN PERMISSION FOR CHILD PARTICIPATION IN A RESEARCH PROJECT: “The Investigation of Food Neophobia and Picky Eating of Vegetables in Elementary School Children”

INTRODUCTION
This form asks for your permission for your child/dependent to participate in a research project on the preferences of elementary aged children for vegetables. Your child’s/dependent’s participation involves participating in a sensory evaluation, a brief survey, a focus group to determine their Mouth Behavior, and a taste solution test. It is expected that their participation will take approximately 60-120 minutes. The potential risks from this project are considered minimal, as applicable. They may personally benefit from this. If you are interested in their participating, please review the following information.

PURPOSE OF THE STUDY AND PROPOSED BENEFITS
- The purpose of the study is to determine the level of acceptance of known foods and acceptance of new foods in school children ages 6-10.
- Potential benefits associated with the study include a better understanding of the types of vegetables children are willing to eat.

YOUR PARTICIPATION
- If you provide your permission, your child will be asked to participate in a sensory evaluation, in which he/she will sample different vegetables. They will be sampling and giving feedback on different vegetables. Your child will also participate in a brief survey, a focus group with you to determine their Mouth Behavior, and a taste test where your child will be presented with 6-n-propylthiouracil (PROP), a genetic marker of taste, and control test papers to determine their bitterness sensitivity.
- Their participation will take approximately 60-120 minutes
- As an incentive, they will be offered a $25 gift card to a retail store market.

PROTECTIONS AND POTENTIAL RISKS
- Please be aware that your child/dependent is not required to participate in this research, refusal to participate will not involve any penalty or loss of benefits to which they are otherwise entitled, and you or they may discontinue their participation at any time. They do not have to answer any questions they choose not to answer.
- The possible risks or discomforts associated with participation in this study include any risk normally associated with eating. Some physical risks of eating include choking, gastrointestinal issues such as upset stomach, or any allergic responses to carrots or broccoli. Subjects should not participate if they are allergic to any of the above ingredients. Subjects should also not participate if they have any known sensitivities to PROP. Some individuals are sensitive to PROP and could have symptoms after a period of ingesting clinically prescribed quantities of it. The amount of PROP on the test strips are insufficient to cause any symptoms.
- Their confidentiality will be protected by using a participant code in place of a name. Identity will not be linked to any data collection. Your child’s identity will not be disclosed to any outside parties. Their responses will be provided anonymously to protect their privacy.

RESOURCES AND CONTACT INFORMATION
- If your child/dependent should experience any negative outcomes from this research, please be aware that you may contact their personal physician or the Sierra Vista Regional Medical Center: Emergency room by calling (805) 545-7600 or going to the emergency room, which is located at 1010 Murray Avenue; San Luis Obispo, CA, 93405, for assistance. Please be aware that you would be responsible for costs related to their medical care.
• This research is being conducted by graduate student Tara Egigian and associate professor Dr. Amy Lammert in the Department of Food Science and Nutrition at Cal Poly, San Luis Obispo. If you or your child/dependent have questions regarding this study or would like to be informed of the results when the study is completed, please contact the student’s faculty advisor, Dr. Amy Lammert, at alammert@calpoly.edu.

• If you have concerns regarding the manner in which the study is conducted, you may contact Dr. Michael Black, Chair of the Cal Poly Institutional Review Board, at (805) 756-2894, mblack@calpoly.edu, or Ms. Debbie Hart, Compliance Officer, at (805) 756-1508, dahart@calpoly.edu.

AGREEMENT TO PARTICIPATE
If you permit your child/dependent to participate in this research project as described, please indicate your agreement by completing and submitting the following questionnaire. Please retain a copy of this form for your reference, and thank you for allowing your child/dependent to participate in this research.

Name(s) of Child/Children/Dependent(s) Involved in this research project:

[ ] Yes, I volunteer.  [ ] No, I do not volunteer
C. Parent’s Demographic Questionnaire

1. If you have more than one child, please answer the survey questions about your child that is testing today.

   How old is your child?
   - 6
   - 7
   - 8
   - 9
   - 10
   - Other

   NOTE: Only answer this question if you answered "other" on questionnaire page 1.

2. Please specify.

3. What grade is your child in?
   - 1st grade
   - 2nd grade
   - 3rd grade
   - 4th grade
   - 5th grade
   - 6th grade
4. What is the gender of your child?
   - Female
   - Male
   - Prefer not to answer

5. What school does your child attend?
   - Bishop's Peak Elementary School
   - Hawthorne Elementary School
   - Los Ranchos Elementary School
   - Pacheco Elementary School
   - Sinsheimer Elementary School
   - Taos Elementary School
   - C.L. Smith Elementary School
   - Other

*NOTE: Only answer this question if on question #1 of questionnaire page 4 your answer was one of the following: "Other"*

6. Please specify.
7 What is your relationship to your child?
   - Parent - Mother
   - Parent - Father
   - Grandparent
   - Legal Guardian
   - Other

P NOTE: Only answer this question if on question #1 of questionnaire page 5 your answer was one of the following: "Other"

8 Please specify.
9 How would you describe your child? Check all that apply.

- Asian or Asian American
- Black or African American
- Hispanic or Latino
- Native American
- Pacific Islander
- White or Caucasian
- Other
- Prefer not to answer

**NOTE:** Only answer this question if on question #1 of questionnaire page 5 your answer was one of the following: "Other"
11 What is your highest level of education

- Less than high school
- Some high school, no diploma
- High school graduate, diploma or equivalent (i.e. GED)
- Some college
- College graduate - Associates degree
- College degree - Bachelor’s degree
- Some post graduate education
- College graduate degree - MS, PhD, MBA, JD, MD, DDS, etc.
- Other

NOTE: Only answer this question if on question #1 of questionnaire page 7 your answer was one of the following: “Other”

12 Please specify.

13 In 2017, which of the following best describes your total family income from all sources before taxes?

- Under $10,000
- $10,001 to $19,999
- $20,000 to $29,999
- $30,000 to $39,999
- $40,000 to $49,999
- $50,000 to $59,999
- $60,000 to $69,999
- $70,000 to $79,999
- $80,000 to $89,999
- $90,000 to $119,999
- $120,000 to $139,999
- Above $140,000
- Prefer not to answer
14 How would you describe yourself? Check all that apply.

- Asian or Asian American
- Black or African American
- Hispanic or Latino
- Native American
- Pacific Islander
- White or Caucasian
- Other
- Prefer not to answer

**NOTE:** Only answer this question if on question #1, your answer was one of the following: "Other"

15 Please specify.
D. Parent’s Food Neophobia Questionnaire

1. Please select the response that best describe your child that is testing today.

My CHILD is constantly sampling new and different foods.

- Strongly Agree
- Agree
- Somewhat Agree
- Neither Agree Nor Disagree
- Somewhat Disagree
- Disagree
- Strongly Disagree

2. My CHILD doesn’t trust new foods.

- Strongly Agree
- Agree
- Somewhat Agree
- Neither Agree Nor Disagree
- Somewhat Disagree
- Disagree
- Strongly Disagree

3. If my CHILD doesn’t know what is in a food, s/he won’t try it.

- Strongly Agree
- Agree
- Somewhat Agree
- Neither Agree Nor Disagree
- Somewhat Disagree
- Disagree
- Strongly Disagree
4 My CHILD is afraid to eat foods that s/he has never tried before.
   - Strongly Agree
   - Agree
   - Somewhat Agree
   - Neither Agree Nor Disagree
   - Somewhat Disagree
   - Disagree
   - Strongly Disagree

5 My CHILD is very particular about the foods that s/he will eat.
   - Strongly Agree
   - Agree
   - Somewhat Agree
   - Neither Agree Nor Disagree
   - Somewhat Disagree
   - Disagree
   - Strongly Disagree

6 My CHILD will eat almost anything.
   - Strongly Agree
   - Agree
   - Somewhat Agree
   - Neither Agree Nor Disagree
   - Somewhat Disagree
   - Disagree
   - Strongly Disagree
E. Parent’s Vegetable Neophobia Questionnaire

1. How much does your CHILD like VEGETABLES?
   - Not At All
   - Not Very Much
   - A Little
   - A Lot

2. How much does your CHILD like VEGETABLES that s/he has never tried?
   - Not At All
   - Not Very Much
   - A Little
   - A Lot

3. How much does your CHILD like tasting new VEGETABLES?
   - Not At All
   - Not Very Much
   - A Little
   - A Lot
4. Will your CHILD taste a VEGETABLE if s/he does not know what it is?
   - Definitely Not
   - Probably Not
   - Probably
   - Definitely

5. Will your CHILD taste a VEGETABLE if it looks strange?
   - Definitely Not
   - Probably Not
   - Probably
   - Definitely

6. Will your CHILD taste a VEGETABLE if s/he has never tried it before?
   - Definitely Not
   - Probably Not
   - Probably
   - Definitely

7. When your CHILD is at a FRIEND'S HOUSE, will s/he try a new VEGETABLE?
   - Definitely Not
   - Probably Not
   - Probably
   - Definitely
8. When your CHILD is at SCHOOL, will s/he try a new VEGETABLE?
   - Definitely Not
   - Probably Not
   - Probably
   - Definitely

9. When your CHILD is at HOME, will s/he try a new VEGETABLE?
   - Definitely Not
   - Probably Not
   - Probably
   - Definitely
F. Parent’s Picky Eating Questionnaire

1. My Child’s diet consists of only a few foods.
   - Agree
   - Slightly Agree
   - Neutral
   - Slightly Disagree
   - Disagree

2. My Child is unwilling to eat many of the foods that our family eats at meal times.
   - Agree
   - Slightly Agree
   - Neutral
   - Slightly Disagree
   - Disagree

3. My Child is a fussy or picky about what s/he eats?
   - Agree
   - Slightly Agree
   - Neutral
   - Slightly Disagree
   - Disagree
G. Child Assent Form

ASSENT TO PARTICIPATE IN A RESEARCH PROJECT:
“The Investigation of Food Neophobia and Picky Eating of Vegetables in Elementary School Children”

I am asking for you to agree to participate in a research project on children’s acceptance and liking of vegetables. I am conducting this research because I am interested in how much children accept familiar and unfamiliar foods.

You will be asked to answer some survey questions about yourself, sample vegetables and give responses about how you like different features of the vegetables, use paper strips to see what and if you taste anything on them, and participate in a focus group with the parent that brought you to the test to determine what types food textures you like. I think it will take 60-120 minutes. You do not have to answer any questions you don’t want to answer.

The only possible risk includes the risks normally associated with eating, such as choking or an upset stomach, if you want to be part of the study. You should not be part of the study if you are allergic to carrots, broccoli, or 6-n-propylthiouracil (a genetic marker of taste). I will not use your name when I write my report, and those working on this research are the only ones who will see your answers to my questions. If you say “no,” then you might help with better understanding the types of vegetables children are willing to eat.

You do not have to agree, and you can stop at any time. Your parents have given you permission, but you can still say “no”. If you say “yes” and then change your mind or if something makes you uncomfortable, you can let your parents know. If you have questions, you can talk to graduate student Tara Egigian or associate professor Dr. Amy Lammert.

If you agree to participate, please answer the survey questions about your background, vegetables you are presented with, taste test strips you are presented with, and Mouth Behavior questions.
H. Children’s Demographic Questionnaire

1. What is your gender?
   - Boy
   - Girl
   - I don’t want to answer

2. What is your age?
   - 6
   - 7
   - 8
   - 9
   - 10
   - Other

(P NOTE: Only answer this question if on question #1 of questionnaire page 2 your answer was one of the following: “Other”)

3. Please indicate
4 Are you allergic to any food or do any foods bother you when you eat them?
   ○ Yes
   ○ No

5 Do you have any of the following allergies? Choose all that apply.
   ○ Egg
   ○ Fish
   ○ Milk
   ○ Peanuts
   ○ Shellfish
   ○ Soy
   ○ Tree nuts
   ○ Wheat
   ○ Broccoli
   ○ Carrots
   ○ Other

P NOTE: Only answer this question if on question A2 of questionnaire page 3 your answer was one of the following: “Other”

6 Please indicate.
I. Children’s Acceptance Testing Questionnaire

1. Have you tried (or seen) this product before?
   - Yes
   - No

2. Are you willing to eat this product?
   - Yes
   - No

3. Look at the product.
   How much do you like the LOOK of this product?
   - Dislike Very Much
   - Dislike
   - Neither Like nor Dislike
   - Like
   - Like Very Much

*NOTE: Only answer this question if on question #1 of questionnaire page 2 your answer was one of the following: "Yes"*
4 Smell the product.
How much do you like the SMELL of this product?

Dislike Very Much  Dislike  Neither Like nor Dislike  Like  Like Very Much

5 Eat some of the product.
How much do you like the product OVERALL?

Dislike Very Much  Dislike  Neither Like nor Dislike  Like  Like Very Much

6 How much do you like the TASTE of this product?

Dislike Very Much  Dislike  Neither Like nor Dislike  Like  Like Very Much
7. How much do you like how the product FEELS in your mouth when you are eating it?

- Dislike Very Much
- Dislike
- Neither Like nor Dislike
- Like
- Like Very Much

8. How much do you like the AFTERTASTE of this product? How do you like the taste in your mouth after you eat it?

- Dislike Very Much
- Dislike
- Neither Like nor Dislike
- Like
- Like Very Much
J. Children’s Taste Strip Questionnaire

1. Please place the strip on your tongue for about 10 seconds. Please indicate what you taste.
   - Salty
   - Sweet
   - Bitter
   - Sour
   - Umami (Savory)
   - None
K. Script for Children’s Mouth Behavior Discussion

Hello everyone. My name’s Tara Egigian, and I am a graduate student here at Cal Poly. I am conducting this research today for my thesis.

Before this stage of testing, the parents have completed survey questions and used the JBMB Typing Tool to determine your Mouth Behavior, and the children have completed an acceptance testing of vegetables to rate their liking of different products. Now, we will be working together to determine your children’s Mouth Behavior, which is their food texture preferences. This will take between 40 to 60 minutes. Mouth Behavior is the way we manipulate food in our mouth. There are four different groups of Mouth Behaviors – Crunchers, Chewers, Smooshers, and Suckers – and people can be typed into one of these groups. The different groups have shown differences in food texture preferences. Crunchers and Chewers are those who like to use their teeth to break foods down. Crunchers are more forceful in their bite and preferred foods that break up on biting. Chewers like foods that can be chewed longer and don’t facture on biting. Suckers and Smooshers prefer to manipulate food between the tongues and roof of the mouth. These Mouth Behaviors differ primarily in the hardness of preferred foods. Suckers like harder foods (like hard candies they can hold in their mouth) that can be sucked for a long time. Smooshers prefer soft foods that don’t require much mouth activity but would spread throughout the mouth and could be held in the mouth for a long time.

When determining your children’s Mouth Behavior is it important to separate flavor from texture. While flavor is what we taste from a food (bitter, salty, sour, sweet, umami ~ savory), texture is how the food feels in your mouth. For texture, is the food crunchy (like crisp apples and crunchy granola cereal), chewy (like soft oatmeal cookies and chewy granola bars), hard (like Jolly Ranchers), or mushy like cottage cheese and custard). Any questions?

Please remember, each individual’s MB category is determined by the following: (1) the choice of different types of foods and textures of foods, (2) how food is modified in certain ways in the mouth, and (3) determining which foods are more satisfying that others.