The Effect of Taste and Temperature on Lingual Swallowing Pressure

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Abstract

Swallowing is a complex sensorineural process that is affected by many components, one of which being the tongue. The tongue plays a crucial role in swallowing because it prepares and subsequently propels the bolus into the pharynx, initiating a swallow. It was hypothesized that the taste of a liquid would have an effect on the lingual pressure used in swallowing. This study used the Iowa Oral Performance Instrument (IOPI) to measure lingual pressure while the participant swallowed sweet, salty, bitter, and sour liquids. The lingual pressure in these trials was then examined against the participant's baseline sample to determine the effectiveness of using different tasting liquids to elicit a more forceful swallow. Results for the control group and experimental group were compared to determine the impact of dysphagia on taste and lingual pressure.

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INTRODUCTION

Swallowing is a complex and multi-step process meant to provide individuals with adequate nutrition and hydration. A disturbance in any of the many components of swallowing can cause a disruption in the process, known as dysphagia. One of the most important components of the swallowing process is the tongue. The tongue plays many roles including bolus formation and propulsion into the pharynx. Without adequate lingual pressure, individuals will often present with dysphagia. Little research has been completed regarding the effect of different factors related to lingual pressure and how they affect the overall swallow. This study sought to investigate the effect of taste and temperature on an individual's lingual pressure as they swallowed liquids. Lingual pressure was assessed with the use of the Iowa Oral Performance Instrument (IOPI). The IOPI is an air-filled bulb that is placed in the patient's mouth while they perform various activities. When the bulb is compressed it sends a pressure rating in kilopascals (kPa) to a handheld device. The implications of this study are potentially far reaching. The use of different tasting liquids to elicit more lingual pressure may lead to an overall stronger, and therefore safer, swallow for patients with dysphagia.

Chapter II

LITERATURE REVIEW

Swallowing

Swallowing is a complex process that involves transporting food from the mouth to the stomach. It involves voluntary actions as well as reflexive activity that is coordinated by more than 30 nerves and muscles. Swallowing requires complex neuromuscular coordination (Ioana & Gabriela, 2014). The goal of swallowing is to provide adequate nutrition and hydration to keep an individual healthy. This goal is attained through the four phases of swallowing.

Oral-preparatory phase. The first phase is referred to as the oral preparatory phase. During this phase food is held in the oral cavity and prepared for swallowing. Prior to swallowing, the bolus is held between the tongue and the hard palate. The upper dental arch prevents the bolus from escaping anteriorly or laterally. The bolus is prevented from spilling posteriorly by the tongue and soft palate. These two structures contact to prevent the bolus from spilling into the pharynx before the swallow is initiated. Chewing and moistening of the food are the first steps to forming a bolus suitable for swallowing. The muscles directly involved in chewing include the masseter, temporalis, and the medial and lateral pterygoid. The muscles of mastication are all innervated by the trigeminal nerve (CN V). CN V is the largest cranial nerve and is responsible for mastication as well as touch, pain, and temperature sensation of the face.

In addition to the muscles of mastication there are many facial muscles involved in the process of swallowing. The orbicularis oris helps create a seal that prevents anterior leakage of liquid boli. The buccinator muscle tenses in order to close the lateral sulcus and prevent food from falling between the mandible and the cheek. Both the orbicularis oris and the buccinator are innervated by the facial nerve (CN VII). The facial nerve also innervates the submandibular and sublingual glands, two of the glands responsible for salivary production. CN VII has a sensory component that carries information regarding taste from the anterior 2/3 of the tongue. This sensory component is important in the recognition and acceptance of a bolus.

The final cranial nerve involved in the oral preparatory phase of the swallow is the glossopharyngeal nerve (CN IX). The glossopharyngeal nerve innervates the parotid gland, one of the three salivary glands of the mouth. Saliva is mixed with a bolus while it is being masticated to help begin to break it down and form a cohesive bolus. CN IX also carries sensation from the posterior portion of the mouth including taste from the posterior 1/3 of the tongue and sensation from the soft palate and the superior portions of the pharynx. When a bolus is adequately masticated and contained in the central groove of the tongue, it is ready to swallow and the oral phase of the swallowing process can begin.

Oral phase. The oral phase of swallowing begins when the tongue initiates posterior movement of the bolus. The tongue preforms an anterior to posterior rolling movement that propels the bolus into the pharyngeal cavity. The tongue will receive special consideration in a subsequent section of this document. In addition to the lingual muscles needed for swallowing, all muscles used during the oral preparatory phase must continue to stay contracted to prevent spillage of the bolus. As the pharyngeal phase of the swallow begins the velum elevates and retracts to close the velopharyngeal port. This closure prevents a bolus from entering the nasal cavity and helps build pressure in the pharyngeal cavity. This increase in pharyngeal pressure is important for bolus propulsion and initiation of the pharyngeal phase of the swallow (Logemann, 1998).

Pharyngeal phase. When the bolus reaches the anterior faucial pillars it triggers the pharyngeal phase of the swallow. This phase may be triggered later in older individuals but should be triggered before the bolus reaches the level of the vallecula (Martin-Harris, Brodsky, Michel, Lee, & Walters, 2007). The pharyngeal phase of the swallow is involuntary and reflexive. During the swallow, the hyoid and larynx move superiorly and anteriorly to close the airway and open the upper esophageal sphincter (UES) so the bolus can pass into the esophagus. While this is happening, peristalsis begins in the pharynx to propel the bolus downward toward the esophagus.

Esophageal phase. The fourth and final phase of the swallow begins when the bolus passes through the upper esophageal sphincter. This phase is known as the esophageal phase. Similar to the pharyngeal phase, the esophageal phase is involuntary and controlled largely by muscle activity. After its passage through the esophagus, the bolus enters the stomach through the lower esophageal sphincter.

Airway protection during the swallow. During a swallow, the larynx must close to prevent aspiration. Airway protection is achieved through several mechanisms, all of which are innervated by the vagus nerve (CN X). The lowest anatomical point of airway protection occurs at the true vocal folds. During a swallow the true vocal folds contract to cease respiration and close off the airway. Above the true vocal folds the ventricular folds, or false vocal folds, contract and close to provide an additional level of protection. The highest and final level of airway protection occurs when the epiglottis inverts to close off the laryngeal vestibule. After a swallow, respiration is usually resumed on an exhalation to prevent inhalation of any food that may still be present in the pharynx (Logemann, 1998).

Failure of any of the mechanisms of swallowing or airway protection can result in penetration or aspiration of food or liquids. Penetration is defined as entry of food or liquid into the larynx above the level of the true vocal folds. Aspiration occurs when food or liquid passes through the vocal folds (Matsuo & Palmer, 2008). Aspiration can occur before, during, or after a swallow and poses risks to a patient's health such as infection and pulmonary complications. In a healthy individual aspiration is followed by a strong coughing reflex to clear the foreign material from the airway. In patients with swallowing disorders this coughing reflex may not be triggered leading to possible airway obstruction or pneumonia.

The Muscles of the Tongue

The tongue is a muscular organ covered in mucosa. It is composed of intrinsic and extrinsic muscles, all of which are innervated by the hypoglossal nerve (XII). The intrinsic muscles provide fine, precise control while the extrinsic muscles help to move the tongue around the oral cavity.

Intrinsic tongue muscles include two muscles running longitudinally (superior longitudinal and inferior longitudinal) as well as muscles running transversely and vertically. The superior longitudinal muscle helps to elevate the tip of the tongue as well as elevate the sides of the tongue to help prepare and contain a bolus. The inferior longitudinal muscle pulls the tip of the tongue downward. Both the superior and inferior longitudinal muscles assist in tongue retraction and deviation. The transverse muscles of the tongue assist in narrowing and the vertical muscles flatten the tongue (Logemann, 1998).

The largest of the extrinsic tongue muscles is the genioglossus. It makes up most of the bulk of the tongue and is responsible for most gross motor movements of the tongue. The genioglossus assists in protrusion, retraction, and cupping motions of the tongue, making it a crucial component in bolus control. In addition to the genioglossus, the extrinsic tongue muscles include the styloglossus, chondroglossus, hyoglossus, and palatoglossus. The styloglossus inserts into the inferior sides of the tongue and draws them back and up to press the bolus against the hard palate. Often referenced as part of the hyoglossus, the chondroglossus is a small muscle that inserts into the hyoglossus. It assists in lingual depression. The final two extrinsic muscles often work in opposition. The hyoglossus pulls the sides of the tongue down while the palatoglossus elevates the tongue and depresses the soft palate. The palatoglossus is the only lingual muscle not innervated by the hypoglossal nerve, it is instead innervated by the spinal accessory (CN XI) and vagus nerve (CN X) (Logemann, 1998).

Role of the Tongue in Swallowing

The largest and most intricate component of the swallowing process is the tongue. The tongue is involved in normal swallowing and is responsible for bolus mastication and formation, gustatory sensation, salivation initiation, and propulsion of a bolus into the pharynx (Park, Oh, & Chang, 2016; Utanohara, Y., Hayashi, R., Yoshikawa, M., Yoshida, M., Tsuga, K., & Akagawa, Y., 2008). Many researchers recognize the importance of the tongue in a normal swallow and the role it plays in bolus formation and propulsion (Nicosia, M. A., Hind, J. A., Roecker, E. B., Carnes, M., Doyle, J., Dengel, G. A., & Robbins, J., 2000; Pelletier & Dhanaraj, 2006; Robbins, J., Gangnon, R. E., Theis, S. M., Kays, S. A., Hewitt, A. L., & Hind, J. A., 2005; Utanohara et al., 2008). According to Nicosia et al. (2000), "contraction of intrinsic and extrinsic lingual musculature as well as pharyngeal musculature provide the driving forces for the oropharyngeal swallow" (p. 634).

During the swallowing process the tongue plays a crucial role in forming a cohesive bolus and then propelling it into the pharynx to initiate a swallow reflex. A loss of strength or coordination in any of the tongue muscles can negatively impact an individual's ability to form a cohesive bolus, manipulate a bolus during mastication, or propel the bolus into the pharynx to initiate a swallow (Standring, Borley, & Gray, 2008).

Lingual pressure. To propel a bolus into the pharynx, the tongue must generate pressure within the oral cavity. There are many devices designed to measure this pressure and they provide a valuable resource for researchers. In a study regarding the effect of taste and palatability on lingual swallowing pressure Pelletier and Dhanaraj (2006) found that, "some individuals showed consistently high lingual pressures across all tastants, while other individuals showed consistently medium or low pressures across all samples" (p. 127). Lingual pressures can vary greatly across individuals, but they are fairly consistent in the same person, (Pelletier & Dhanaraj, 2006) meaning an individual's swallowing pressure can be a good tool to assess swallowing changes over time. Park et al. (2016) found that lingual pressure generated during a swallow was less than an individual's maximum isometric pressure. This means that as an individual swallows they only use a small portion of their overall tongue strength. Not using all available isometric pressure creates a reserve of strength that can be used when overall strength is lessened by fatigue or illness.

Age-Related Swallowing Changes

There is a decrease in maximum lingual pressure as well as an increase in the time it takes to reach maximum lingual pressure that is associated with the normal aging process (Pelletier & Dhanaraj, 2006). While maximum tongue strength is lower in older adults compared with young adults, the two groups do not exhibit significant differences in swallowing-related strength (Nicosia et al., 2000; Park et al., 2016). In healthy older adults a decrease in maximum pressure does not have an effect on swallowing safety and efficiency. While a decrease in strength may not affect a normal individual, the onset of illness might make it more difficult for an older individual to generate adequate lingual pressure because of their decreased pressure reserve (Pelletier & Dhanaraj, 2006; Robbins et al., 2005).

A decline in pressure reserve has many clinical implications in older individuals who may be at risk for dysphagia (Park et al., 2016). Pelletier and Dhanaraj (2006) stated that "individuals with inherently low swallowing pressures may be at increased risk for dysphagia as they age" (p. 127). Despite the recognition that lingual pressure and strength play a crucial role in a safe swallow; very limited research has been done to investigate how to measure lingual pressure generated during the act of swallowing. Even fewer studies have investigated ways to increase lingual pressure without the use of behavioral tasks like effortful swallows or lingual exercises.

In addition to decreased muscle strength, Pelletier and Dhanaraj (2006) found a "reduced taste sensitivity in older individuals" (p. 122). Reduction in taste sensitivity may also hinder an individual's swallow. An understanding of chemesthesis and its effect on swallowing can help a clinician diagnose and treat dysphagia in older individuals. Few studies have been completed on the effect of reduced taste sensation and its effect on chemesthesis and swallowing.

Dysphagia

Dysphagia is an alteration in the swallowing process that causes difficulty in transporting saliva, food, and liquids from the mouth, through the pharynx and esophagus, and into the stomach (Ioana & Gabriela, 2014). Dysphagia can negatively affect a person's ability to stay well-nourished and hydrated, putting patients at an increased risk for illness. Dysphagia leads to malnutrition, dehydration, and increased risk of infections, as well as impairments in a patient's mental and physical condition (Ioana & Gabriela, 2014). Thompson (2016) stated that, the causes of dysphagia can be broadly divided into three categories: neurological, muscular, and obstructive. Most oropharyngeal dysphagia is neurologic in origin (Ioana & Gabriela, 2014).

Neurogenic dysphagia. Neurogenic dysphagia is a sensorimotor impairment of the oral or pharyngeal phases of swallowing caused by a neurogenic disorder. The causes may include stroke, traumatic brain injury, motor neuron disease, Parkinson's disease, or myopathy. Symptoms of neurogenic dysphagia include "drooling, difficulty initiating swallowing, nasal regurgitation, difficulty managing secretions, choke/cough episodes while feeding, and food sticking in the throat" (Buchholz, 1994, p. 143). Treatment of neurogenic dysphagia first involves treatment of the underlying neurological cause, if possible. In addition to treating the neurologic origin, swallowing therapy can increase the likelihood of a patient's positive outcome (Buchholz, 1994). When treating a patient with neurogenic dysphagia clinicians must address the underlying neurological impairment, not just the swallowing symptoms. The management of dysphagia can take many forms and it is up to the speech-language pathologist to choose a method that is best suited to the patient's needs.

Age-related dysphagia. A swallowing disorder may occur in healthy older adults without any neurological disease. This is referred to as age related dysphagia, or presbyphagia (Park et al., 2016). Presbyphagia is an age-dependent change in swallowing functions that is not associated with an injury or disease process; however, it may be worsened by disease. Muscle weakness and incoordination are the two most prevalent causes of age-related dysphagia.

In addition to presbyphagia, the decrease in lingual pressure observed with aging can be attributed to sarcopenia. According to Yeates, Molfenter, and Steele (2008), sarcopenia is a progressive loss of skeletal muscle mass and strength associated with aging. Individuals 60 years of age and older may show considerable atrophy of their muscles. Age-related muscle atrophy affects all parts of the body, including the muscles needed for swallowing. Loss of muscle mass can lead to decreased tongue strength in older adults, which can cause sarcopenic dysphagia. Sarcopenic dysphagia can affect the oral and pharyngeal phases of a swallow that often presents as premature spillage of the bolus into the pharynx, pharyngeal residue, and aspiration (Park et al., 2016).

Assessment of dysphagia. The assessment of a patient with dysphagia is a multi-step process that involves evaluating the patient as a whole, in addition to evaluating their speech and swallowing deficits. Videofluoroscopy (VFSS) and fiberoptic endoscopic evaluation of swallowing (FEES) are both commonly used to assess an individual's swallowing function. VFSS uses radiation to visualize swallowing function in the lateral or anterior-posterior plane. Videofluoroscopy enables visualization or the oral and pharyngeal cavity before, during, and after the swallow. FEES involves the use of a flexible scope inserted through the nose to the level of the soft palate, meaning the oral phase cannot be visualized. In addition, FEES only provides a view before and after a swallow; however, it allows the clinician to visualize laryngopharyngeal physiology including secretion management and the appearance of the vocal folds (Logemann, 1998).

Along with assessing the patient's swallow as a continuous process, evaluating the individual parts of the swallowing process can have positive outcomes for treatment. Utanohara et al. (2008) noted how important it is to evaluate tongue strength in the treatment of feeding and swallowing disorders. Tongue strength assessment is often performed with instruments like the IOPI that use objective measures to record pressure. While the IOPI is a valuable tool to objectively measure a patient's lingual strength, there is limited research about the efficacy of using the IOPI during the act of swallowing a liquid bolus. The IOPI and its uses will be discussed in detail later in this manuscript.

Management of dysphagia. When choosing a treatment strategy, a clinician must consider the patient as a whole to determine the best plan of care. To accurately diagnose swallowing disorders in older individuals, it is important to differentiate normal aging related changes in swallowing physiology from disease related changes (Nicosia et al., 2000). According to Bülow, Olsson, and Ekberg (2003), different treatment strategies are necessary depending on the cause of a patient’s oral and pharyngeal dysfunction. Due to concomitant issues such as neurologic changes, lung disease, or debility; many older individuals have deficits in other areas in addition to swallowing.

The main goal of dysphagia rehabilitation is to identify and treat swallowing pathologies while maintaining safe and efficient nutrition for the patient (Ioana & Gabriela, 2014). Dysphagia treatment often includes compensatory strategies as well as positioning and postural techniques. Compensatory strategies are designed to minimize effort required to perform activities of daily living, including eating. They can range from dietary modification, such as thickening liquids, to behavioral modification. Behavioral modification strategies include reducing bolus size or moistening dry food to assist in bolus flow and control (Robbins et al., 2005). While these compensatory strategies may reduce a patient’s risk of aspiration, they do nothing to address the underlying physiology, or cause of a patient’s swallowing deficits. They are only temporary solutions that do not reduce a patient’s future risk of dysphagia (Robbins et al., 2005). There are many different treatment approaches, the most common of which fall under the category of traditional approaches.

Diet modification. Bülow et al. (2003) states the importance of diet modification in patients who lack the cognitive capacity to understand and follow instructions about swallowing maneuvers. For cognitively impaired patients, diet modification may be the only solution to reduce their risk of aspiration. Some patients may also fatigue too easily to be an ideal candidate for swallowing therapy and may require diet modification until they regain their strength.

Dietary modifications can include anything from thickening a patient's liquids to restricting types of food and liquids a patient is allowed to consume. Diet modifications are designed to make a bolus easier for a patient to control in their mouth in hopes of reducing the risk of aspiration (Thompson, 2016). While diet modifications may reduce aspiration in individuals, they can have detrimental effects on the patient's overall health and quality of life. A study conducted by Thompson (2016) reported that "dysphagia made life less enjoyable for 55% of those surveyed" (p. 46). The study went on to say that providing patients with a safe, yet visually appealing modified diet is a huge challenge for many speech-language pathologists because as the level of alteration of a food consistency increases, food attractiveness decreases. Thickened liquids have a different appearance and palatability than thin liquids which often leads to patients rejecting a thickened liquid diet recommendation. Rejection of thickened liquids can cause severe dehydration, especially in older patients. In the older adult population, dehydration is a prevalent issue that can have many detrimental effects such as infection, constipation, confusion, and prolonged hospital stays (Carlaw, C., Finlayson, H., Beggs, K., Visser, T., Marcoux, C., Coney, D., & Steele, C. M., 2012). The ability for patients to safely swallow liquids on an unrestricted diet may have implications for increased hydration as well as an increased quality of life secondary to having control over what food and liquids are consumed. More research needs to be completed to find alternate ways of managing dysphagia without significantly altering a patient's diet.

Traditional dysphagia treatment. Types of traditional dysphagia treatment include exercise programs, pharyngeal swallowing maneuvers, meal observations to reinforce compensatory strategies, thermal stimulation via deep pharyngeal neuromuscular stimulation, and therapeutic feeding. Exercise programs can include a variety of exercises focused on increasing strength in the muscles used in swallowing. Labial exercises consisting of lip protrusion, lip smacking, and pushing lips against a tongue blade for resistance are commonly used. In addition, lingual exercises consisting of protruding, retracting, depressing, elevating, and lateralizing the tongue work to improve lingual strength and mobility. Pharyngeal swallowing maneuvers like the supraglottic swallow and effortful swallow techniques are also used during traditional treatment approaches. While a patient eats, observation helps to reinforce the use of compensatory strategies. These strategies include sitting upright, chin tucking, turning/tilting of head to weak side, multiple swallows, and alternating bites and sips. The compensatory strategies used depend on the individual patient and the physiologic cause of their dysphagia (Burgos, R., Bretón, I., Cereda, E., Desport, J. C., Dziewas, R., Genton, L. & Bischoff, S. C., 2018).

Biofeedback as a tool for dysphagia treatment. Swallowing is an internal act that is not easily visualized. This lack of visual feedback can lead to the patient not fully understanding where their weaknesses lie. Patients often have a hard time self-monitoring their exercises without some kind of feedback (Jo, E., Lewis, K., Directo, D., Kim, M. J., & Dolezal, B. A., 2016). Biofeedback allows an individual to visually see what is occurring during the disordered phase of the swallow and allows them to visualize when improvements are being made. Biofeedback is used to provide individuals with information about a task as it is being performed, in hopes of improving their deficits. Robbins et al. (2005) found that when patients carried out tasks with biofeedback, they generated greater oral pressures than at baseline. The study consisted of 10 healthy adults aged 70 to 89 years old. Peak isometric lingual pressure and oral swallowing pressure were measured at baseline as well as at weeks two, four, six, and eight for each participant. Each participant completed an eight-week lingual exercise program that used the IOPI to provide continuous biofeedback throughout the exercises. The idea of biofeedback is that if a patient can see his muscle activity in real time, rather than just feeling his muscles contract, he will be better able to perform required tasks and will train his muscles faster than without a biofeedback tool (Bogaard, 2009). The IOPI device is a commonly used biofeedback tool that allows patients to see the lingual pressure that they are producing in real time.

The Iowa Oral Performance Instrument. IOPI is a small, portable biofeedback device used to measure oral pressure. Before the rise in popularity of the IOPI and other similar objective tools, the methods used to evaluate tongue function and strength were highly subjective. Methods relied heavily on a speech-language pathologist's judgment regarding what was adequate or disordered tongue function. Subjective judgments make it very difficult to diagnose the degree of dysfunction in an individual as well as evaluate the effects of treatment over time (Youmans & Stierwalt, 2006). IOPI Medical describes the IOPI as a device that:

> Measures the strength of the tongue by measuring the maximum pressure that an individual can produce in a standard-sized air-filled bulb by pressing the bulb against the roof of the mouth with the tongue. The peak pressure achieved is displayed on a large, easy-to-read LCD. The units displayed are kilopascals (kPa), based on the internationally-recognized unit of pressure, the Pascal (Pa). (IOPI Medical, 2017)

Many studies have been completed to investigate the relationship between tongue strength, pressure, and swallowing to compare the differences in tongue function of patients with dysphagia and control patients (Hewitt, A., Hind, J., Kays, S., Nicosia, M., Doyle, J., Tompkins, W., & Robbins, A., 2008; McCormack, Casey, Conway, Saunders, & Perry, 2015; Robbins et al., 2005; Youmans & Stierwalt, 2006). These studies have also examined the effect of tongue strengthening exercises on both experimental participants with dysphagia and control participants. Robbins et al. (2005) monitored ten healthy participants aged 70 to 89 as they performed an eight-week lingual resistance exercise program consisting of compressing an IOPI bulb between the tongue and the hard palate. Each participant completed a VFSS evaluation to assess their baseline swallowing function as well as their swallowing function following the eight-week lingual exercise program. The researchers found that older individuals with no history of swallowing problems significantly increased their maximum lingual pressure after an eight-week exercise period. Even though no swallowing tasks were targeted during the exercise period, the participants demonstrated significantly higher swallowing pressures in three of the four swallowing conditions (Robbins et al., 2005). The findings indicate that muscle weakness caused by sarcopenia can be reversed through the use of exercise. While coordination and endurance also play a large role in swallowing safety; increasing lingual strength through an exercise program may directly enhance the progress toward dysphagia rehabilitation. This exercise program can be completed in the absence of swallowing any food or liquids, so it is ideal for patients who are not cleared for oral consumption.

Naturalistic or task specific dysphagia treatment. However, for those who are capable of swallowing, a recently evolving treatment strategy for dysphagia is the use of task specificity in treatment. Because of the newness of task specificity in the field of speech-language pathology, there is not much research that has been conducted. Exercise physiology programs, on the other hand, have copious amounts of research regarding task specificity in athletic training and its benefits. A study completed in 1975 (Magel, J. R., Foglia, G. F., McArdle, W. D., Gutin, B., Pechar, G. S., & Katch, F. L.) reported that athletes who were trained in one form of cardiovascular exercise did not demonstrate a training effect in other forms of endurance-based cardiovascular exercise. For example, participants who received swim training demonstrated an increase in endurance and cardiovascular performance in swimming but when running, no significant training effect was observed. The results of the Magel et al. (1975) study show the importance of task specificity on athletic training. While task specificity has been proven highly effective in athletic training, speech-language pathologists often have a hard time integrating task specificity into the initial stages of dysphagia rehabilitation. Clinicians frequently work with patients who cannot safely swallow due to poor postural control, bolus manipulation, or pharyngeal swallow initiation. These obstacles make it difficult for clinicians to safely implement a task-specific treatment in patients with severely impaired swallowing. Due to this, a more traditional therapy approach may be used initially to help the patient regain oral strength and range of motion, so that a safe swallow can be achieved (Burkhead, Sapienza, & Rosenbek, 2007).

The Frazier Free Water Protocol was developed as a way to provide patients on a thickened liquid diet an option to consume un-thickened water between meals to improve hydration and quality of life. Langmore, S. E., Terpenning, M. S., Schork, A., Chen, Y., Murray, J. T., Lopatin, D., and Loesche, W. J. (1998) reported the risk factors for aspiration pneumonia and concluded that aspiration will result in pneumonia only if the aspirated material is pathogenic to the lungs and the individual's resistance to the pathogen is compromised. Carlaw et al. (2012) found that the risk of pneumonia with free water protocols is low when oral care plans are implemented. Implementing free water protocols allows patients with dysphagia the opportunity to use the task specific exercise of swallowing thin liquids to improve their swallowing function with minimal risks for pneumonia or other adverse health effects.

The Effect of Taste on Swallowing

Research involving the effects of taste on swallowing is fairly limited. The most well-known and accepted study regarding the topic was performed by Pelletier and Dhanaraj (2006). The participants consisted of ten healthy adult individuals with no history of dysphagia between the ages of 18 and 35 years old. Lingual pressure during the swallow was measured using a three-bulb lingual array that was adhered to the participants' hard palate using adhesive strips. Each participant was presented with twenty-two 10 mL samples. The samples included sweet, salty, sour, and bitter tastants at moderate and high levels of concentration. The moderately concentrated samples were intended to be easily recognized tastes while the high concentration samples included tastants with low palatability. Participants were instructed to swallow each liquid normally then immediately rate their degree of liking/disliking on a nine-point hedonic scale (see Appendix A).

Perhaps the most important finding from this study is that “taste may alter the timing and amplitude of muscle contractions associated with swallowing” (Pelletier & Dhanaraj, 2006, p. 122). The fact that the taste of a liquid has significant effects on an individual’s swallowing physiology can have very important clinical ramifications in the treatment of patients with dysphagia. The researchers also found that sweet and sour tastant stimuli evoked earlier muscle activation compared with the no-taste stimuli. Due to the prevalence of dysphagia in the older population, more research needs to be carried out before manipulating the taste of stimuli can be used as an adequate treatment approach. However, the idea of improving a patient’s swallow without having to substantially alter their diet is a crucial step in the management of dysphagia in order to lower the risk for diet rejection and dehydration.

While the study by Pelletier and Dhanaraj (2006) provided valuable insight into the effects of different tasting liquids on swallowing physiology, there were some flaws in the study; the most outstanding of these was the high rate of gagging among participants. Due to the large size of the study’s three-bulb lingual array, four participants were dismissed due to issues with tolerating the array. Three participants experienced gagging with the array and the fourth was not able to adhere the array to their hard palate due to increased salivation. After data analysis, an additional three participants were eliminated when a review of their data showed gagging behaviors. In addition to the gagging caused by the lingual array, participants rated the liquids very low on a hedonic scale of taste. The 9-point hedonic scale is the most widely used measure to assess taste preferences. It is believed to be more discriminating than shorter scales and has been adapted for use across many different areas of research regarding preference

(Jones, Peryam, & Thurstone, 1955). Pelletier and Dhanaraj stated that “many of the samples were rated extremely low using the nine-point hedonistic scale” (2006, p. 126). Low hedonic ratings limit the clinical applicability of using different tastants to increase lingual pressure. If patients extremely dislike the taste of a liquid, it is unlikely they will continually participate in therapeutic activities requiring them to drink these liquids. The present study sought to improve the palatability of the tastants administered by using liquids that patients will drink in their everyday lives.

In addition to the Pelletier and Dhanaraj (2006) study, Bülow et al. (2003) completed a study investigating how carbonated liquids affect aspiration rates in patients with dysphagia. The study analyzed the effect that carbonation had on the swallowing physiology of forty participants. The participants ranged in age from 28 to 95 years old. All of the participants presented with aspiration of thin liquids before participating in the study. Thirty-six of the participants were neurologically impaired, 19 of them having had a cerebral vascular accident. Each participant was administered thin liquid, carbonated thin liquid, and thickened liquid during a videoradiographic swallow study. Comparisons regarding the amount of aspiration and penetration were made between thin liquids, carbonated thin liquids, and thickened liquids. The researchers found that carbonated liquids significantly reduced penetration when compared to non-carbonated thin liquids as well as thickened liquids. The reduction in penetration is thought to be an effect of chemesthesis activated by the carbonation in the liquid. Chemesthesis is defined as “a sensation of irritation produced by chemical stimulation and mediated by the trigeminal nerve” (Pelletier & Dhanaraj, 2006, p. 125). Irritation of the trigeminal nerve enhances input to the central nervous system and can modify swallowing behaviors. A strong chemesthesis reaction may increase lingual pressure or activate a swallow initiation earlier (Pelletier & Dhanaraj, 2006). The results of the study confirmed the researchers' hypothesis that the use of carbonated liquids could reduce the number of aspiration incidences into a patient's airway.

The findings of these two studies provide a promising new treatment strategy for patients with dysphagia. While more research is needed to understand the effects of different tasting liquids on all populations, the initial findings point in a positive direction. The use of carbonation and strong-tasting liquids could be used in the future to reduce the risk of aspiration and pharyngeal retention without substantially altering a patient's diet with thickened liquids.

Purpose

The purpose of this study is to further examine the efficacy of using different tasting liquids to increase lingual pressure in both a control population as well as in patients with dysphagia. The implications of this study are potentially far reaching. The incorporation of strong tasting liquids to aid in dysphagia treatment can provide an alternative to restricting liquid levels. The restriction of thin liquids can lead to dehydration and a decreased quality of life in some patients; thus, creating a diet that allows patients to continue drinking thin liquids can have very positive outcomes. In addition, the study aims to determine if the IOPI can be used during a task-specific exercise to measure peak lingual pressure when swallowing a liquid bolus. Previous research that attempted to measure lingual pressure while swallowing liquid boluses reported high incidences of gagging caused by the large lingual array that was adhered to the participants' palatal vault. The ability to accurately measure lingual pressure without inducing gagging during a task-specific exercise allows clinicians to accurately assess a patient's deficits in both swallowing and non-swallowing activities.

Research Questions

The current study sought to investigate the effects of taste and temperature on the lingual pressure exhibited by individuals with and without dysphagia. To that end, the following experimental questions were addressed:

1. Are there differences in lingual tongue pressure as a function of taste and group (control group vs. experimental group)?
2. Are there differences in lingual tongue pressure as a function of temperature and group (control group vs. experimental group)?

Hypotheses

It is hypothesized that taste and temperature will both have a significant effect on the lingual pressure of healthy participants as well as participants with dysphagia. The researcher believes that the activation of chemesthesis by irritating the trigeminal nerve with various tastants and temperatures will result in higher lingual pressures associated with the different boluses. In addition, many speech-language pathologists stress the importance of using a cold-water bolus during swallowing evaluation and treatment. It is believed that the increased sensation provided by a cold bolus increases the strength, and therefore the safety of a swallow. The researcher expects to see the increased swallow strength demonstrated by an increase in lingual pressure upon the administration of a cold-water bolus.

Chapter III

METHODS AND PROCEDURES

Methods

All procedures were approved by the Valdosta State University Institutional Review Board (IRB). The IRB approval and consent forms can be found in Appendices A and B.

Participants

The current study utilized two groups: a relatively young, healthy control group and an elderly group of individuals diagnosed with dysphagia. The healthy participants consisted of 23 female graduate students enrolled in the Communication Sciences and Disorders program at Valdosta State University. The average age of the participants was 23.73 years with a range of 22.42-28.58. All participants participated in a pre-experimental oral mechanism examination to ensure all structures were functional and there was no history of swallowing difficulties.

The experimental group consisted of five participants with a diagnosed history of dysphagia. A list of the diagnoses and dysphagia types for each participant can be found in Table 1. The average age of the participants in the experimental group was 60.55 years with a range of 54.35–64.34. All participants in the experimental group were clients of the Valdosta State University Speech and Hearing Clinic with goals to target their specific areas of weakness. They were all deemed safe to use thin liquids in therapy without risk of excessive aspiration.

Procedures

To test the effect of taste on lingual swallowing pressure the participants were administered two 10-ml samples of each of the following liquid via straw: coffee, soda, cherry Kool-Aid, lemonade, saltwater, and water. All samples were administered at room temperature. The presentation order of each of the liquid boluses was counterbalanced across participants. After multiple practice swallows with water, participants were instructed to swallow each liquid as normally as possible with the IOPI bulb inserted in their mouth just behind the alveolar ridge. The liquids were administered via a straw placed in the corner of the mouth on whatever side was more comfortable for the participant. To test the effect of temperature on lingual swallowing pressure the participants were administered two 10-ml samples of water at the following temperatures via a straw: room temperature (70-74°), cold (40-45°), and hot (125-130°). Patients were instructed to swallow the liquids as they did in the previous trials with the IOPI bulb inserted in the same position.

After drinking each sample, participants were asked to rate their like or dislike of the sample on a nine-point hedonistic scale that is included in Appendix A. Mean peak lingual pressure was calculated from every trial for each participant. Maximum pressure attained was displayed numerically on the IOPI in kilopascals (kPa). No other feedback features of the IOPI were utilized in this study.

Measures

Mean peak lingual pressure was gathered and assessed for each participant. The independent variables were the different taste and temperature of the samples. The dependent variable was the peak lingual pressure of each participant in each trial.

Palatability of each tastant was acquired using a 9-point hedonic scale. The independent variables were the different taste and temperature of the samples. The dependent variable was the participant's rating of each sample.

Analysis

Initially, the lingual pressure data were examined in regard to taste. The participant ratings from the 9-point hedonistic rating scale (Jones et al. 1955) were subjected to a one sample t-test. A score of 5 indicated neutrality ("neither like nor dislike") and was used as the test value for this analysis.

In order to investigate the experimental question regarding lingual pressure as a function of taste and group, a series of analyses were completed to investigate this question from multiple viewpoints. Initially, to analyze the combined data sets, a repeated measures analysis of variance ANOVA was conducted on the lingual pressure data as a function of group and taste. A subsequent one-way ANOVA was conducted on the lingual pressures to identify any differences between each of the tastes as a function of group.

It was then determined that a closer examination could be achieved if each of the groups were examined in isolation. To that end, two separate series of paired samples t-tests were conducted on the lingual pressure data. Room-temperature water was used as the baseline comparison for each of the additional five liquids (coffee, soda, Kool-Aid, lemonade, and saltwater).

The second experimental question was concerned with lingual pressure as a function of temperature. To address this question, a repeated measures ANOVA was completed on the lingual pressure data as a function of temperature (room temperature water, cold water, and hot water) and group.

Chapter IV

RESULTS

In order to investigate the experimental question which asked if there were differences in lingual peak pressure as a function of taste and group, a repeated measures ANOVA was conducted on the lingual pressure data that were obtained as a function of liquid and group. An overall main effect was found for group, $F(1, 23) = 13.09$, $p = .001$, with the control group obtaining lower mean peak lingual pressures (18.21 kPa) than did the experimental group (35.79 kPa) (see Figure 1). Post-hoc testing consisted of a series of one-way ANOVAs. This subsequent analysis revealed significant differences between groups when consuming all liquids other than salt water. All other main effects and interactions were not found to be significant.

In order to investigate the experimental question which asked if there would be differences in lingual peak pressure as a function of temperature and group, a repeated measures ANOVA was conducted on the lingual pressure data that were obtained as a function of temperature and group. An overall main effect was found for group, $F(2, 22) = 14.47$, $p = .001$, with the control group obtaining lower mean peak lingual pressures (17.04 kPa) than did the experimental group (36.58 kPa) (see Figure 2). Post-hoc testing consisted of a series of one-way ANOVAs. This subsequent analysis revealed significant differences between groups when consuming all liquids other than saltwater. All other main effects and interactions were not found to be significant.

9-Point Hedonistic Scale Analysis

In order to gain an understanding of the participants' opinions regarding the taste of the liquids that were consumed, a one sample t-test was conducted on the ratings that were provided by the participants using the 9-point hedonistic rating scale. A score of 5 indicated neutrality ("neither like nor dislike") and was used as the test value. Mean values for participant ratings are presented in Figure 4. Participants reported significantly disliking the coffee, $t(27) = -4.43$, $p < .01$, the saltwater, $t(27) = -7.65$, $p < .01$, and the hot water, $t(27) = -3.40$, $p < .01$. Participants reported significantly liking Kool-Aid, $t(27) = 2.74$, $p = .01$ and cold water, $t(27) = 2.43$, $p < .02$. No significant preferences were rated for the room temperature water, lemonade, or the soda. A repeated measures ANOVA was conducted on the 9-point hedonistic scale as well. No significant main effects or interactions were found between group and taste.

Lingual Pressure as a Function of Group and Taste

The first experimental question asked if there were significant differences in lingual pressure as a function of group and taste. Results from the repeated measures ANOVA revealed significant differences between the two groups overall, $F(1, 26) = 4.61$, $p = .04$, $\eta^2 = .15$. The experimental group exerted more lingual pressure (25.67 kPa) than did the control group (17.98 kPa).

In order to assess if there were differences between the groups among any of the individual liquids, a one-way ANOVA was conducted on the lingual pressures that were obtained during the swallowing of each of the five different liquids (coffee, soda, Kool-Aid, lemonade, saltwater, and room temperature water) with a factor of group. Significant differences were revealed between the control group and room temperature water, $F(1, 26) = 10.72$, $p = .04$, $\eta^2 = .29$. All other comparisons yielded no significant differences.

As previously mentioned, the data were split, and each group was examined in isolation to address the experimental question which asked if there were significant differences in lingual pressure as a function of taste. A paired samples *t*-test was completed for both the control and the experimental group.

Control Group. The paired *t*-test analysis revealed significant differences for the control group between water and Kool-Aid, $t(22) = -3.50$, $p < .01$, with Kool-Aid being associated with higher mean lingual pressures (19.67 kPa) than water (16.50 kPa). In addition, significant differences were revealed between lemonade and water, $t(22) = -4.44$, $p < .01$, with lemonade being associated with higher lingual pressures (19.5 kPa) than water. Finally, a significant difference was revealed between saltwater and water, $t(22) = -3.58$, $p < .01$, with saltwater being associated with higher levels of lingual pressure (19.5 kPa). All other comparisons yielded no significant differences.

Experimental Group. The paired t-test analyses revealed only a significant difference between Kool-Aid and water, $t(4) = 2.89$, $p = .044$, with Kool-Aid being associated with higher levels of lingual pressure (38.3 kPa) than water (28.40 kPa). All other comparisons yielded no significant differences.

Lingual Pressure as a Function of Temperature

To answer the experimental question which asked if there were significant differences in lingual pressure as a function of temperature, a repeated measures ANOVA was completed on the lingual pressure data as a function of temperature (room temperature water, cold water, and hot water) and group. Mean lingual pressures can be viewed in Table 2. A significant main effect of group was found, $F(1, 26) = 6.07$, $p = .02$,

$\eta^2 = .189$. The experimental group exhibited higher levels of lingual pressure (26.2 kPa) when swallowing water regardless of temperature than did the control group (17.04 kPa).

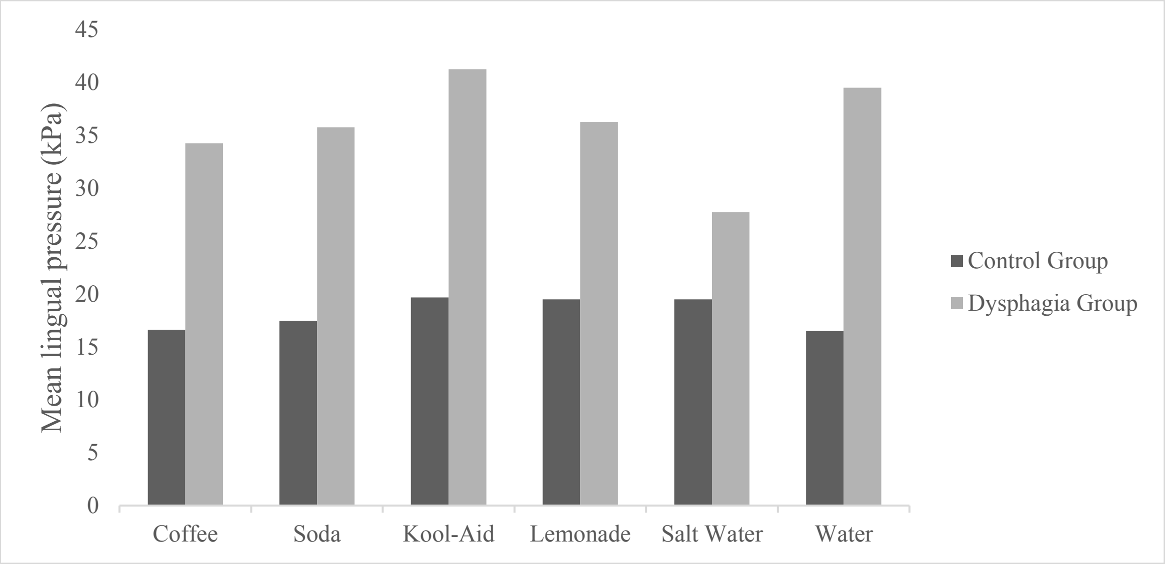

Figure 1. Lingual pressure averages (kPa) across groups as a function of taste

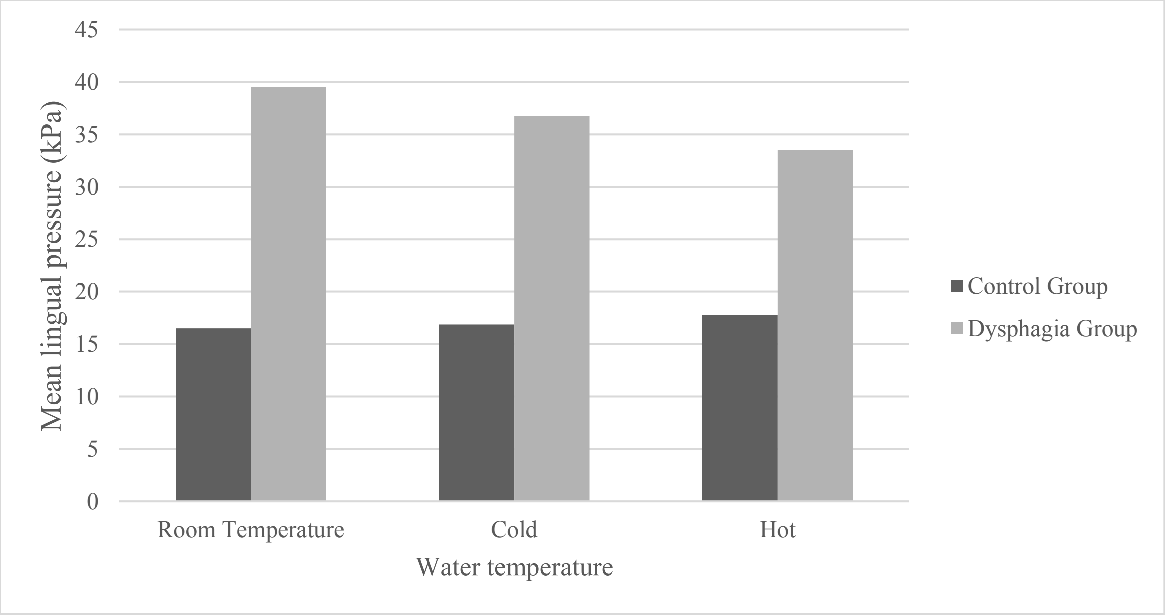

Figure 2. Lingual pressure averages (kPa) across groups as a function of temperature

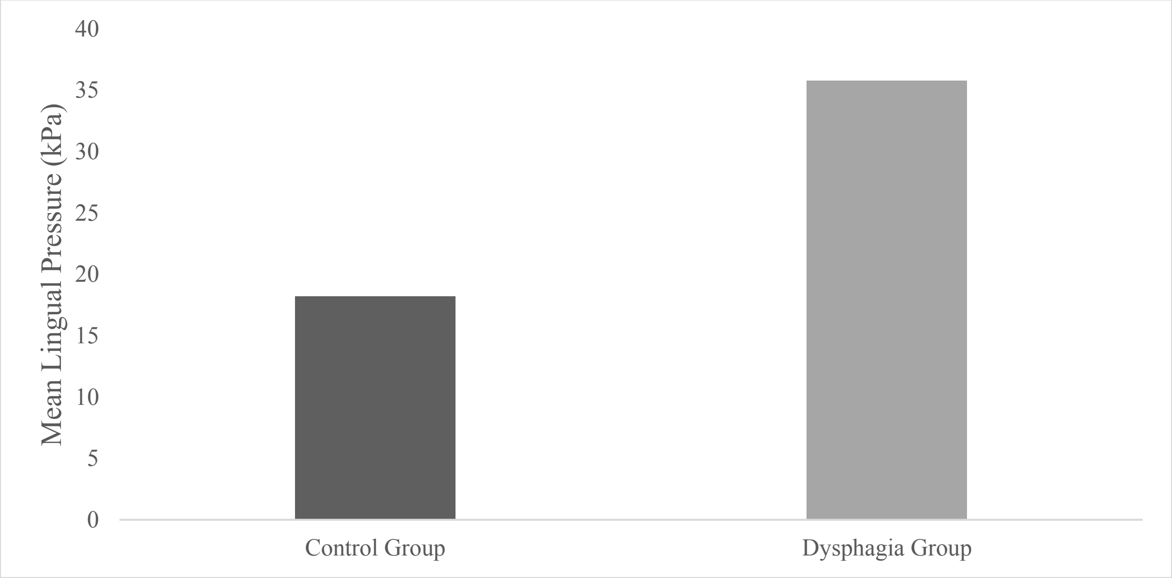

Figure 3. Overall mean lingual pressure averages (kPa) across groups

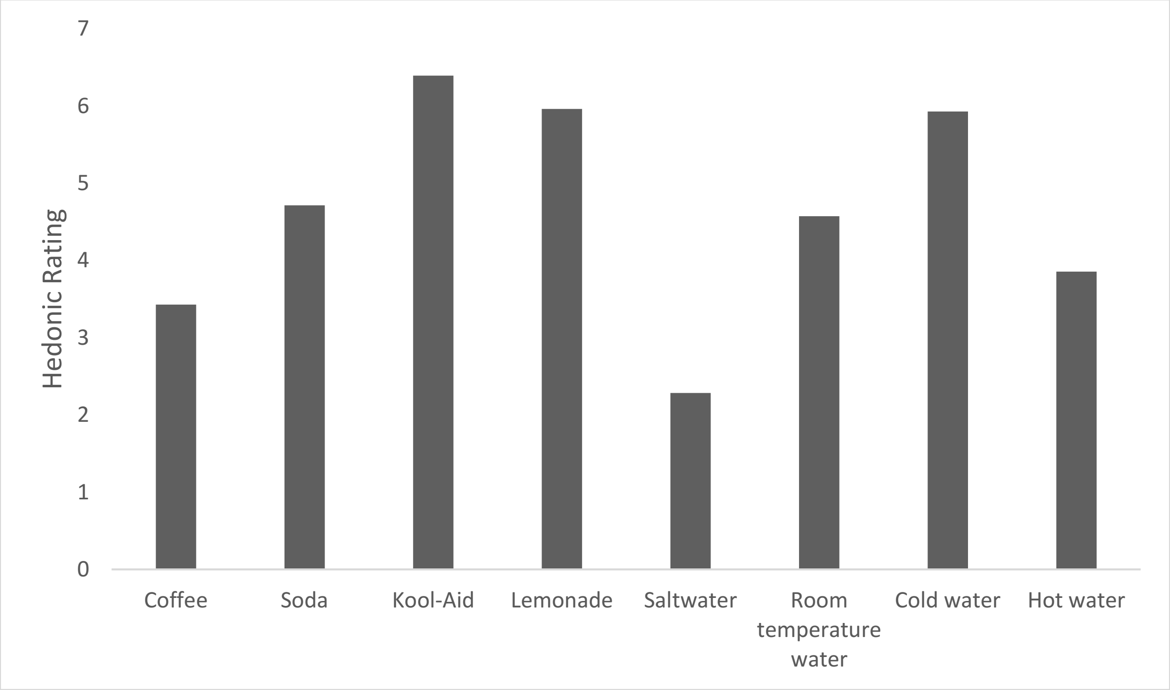

Figure 4. Mean values for participant ratings

Table 1.

Diagnoses and dysphagia types for experimental group.

Participant Number	Age	Sex	Diagnosis	Dysphagia Severity
24	63.9	Female	CVA	Severe oral dysphagia Mild pharyngeal dysphagia
25	59.67	Male	Partial glossectomy following oral cancer	Moderate oropharyngeal dysphagia
26	64.34	Male	Mandibulectomy and radiation tx following oral cancer	Mild to moderate oropharyngeal dysphagia
27	60.5	Male	Cervical gunshot wound to right neck	Mild oropharyngeal dysphagia
28	54.35	Female	Odynophagia following parapharyngeal schwannoma removal	Mild oropharyngeal dysphagia

Table 2.

Mean lingual pressure (kPa) as a function of temperature across groups.

	Control Group	Experimental Group
Room temperature water	16.5	21.7
Cold water	16.869	21.4
Hot water	17.739	21.1

Chapter V

DISCUSSION

Relation of Data to Hypothesis

The hypothesis that taste and temperature will both have a significant effect on the lingual pressure of healthy participants as well as participants with dysphagia, was supported. The control group demonstrated significant increases in lingual pressure when comparing Kool-Aid, lemonade, and saltwater with room temperature water. In addition, the experimental group also displayed significantly increased lingual pressure associated with Kool-Aid when compared to water. Neither the control group nor the experimental group exhibited significant changes in lingual pressure as a function of temperature; however, the experimental group exhibited higher levels of lingual pressure when swallowing water, regardless of temperature. The liquids associated with the highest lingual pressures were also rated the highest in terms of palatability. Kool-Aid was the highest rated liquid in palatability, and it was also associated with the highest lingual pressures in both the control group and the experimental group.

Interpretation

While the control group exhibited significant differences in lingual pressure with more tastants than the experimental group; both groups showed increased lingual pressures with Kool-Aid when compared with water. In the experimental group, only the palatable tastants showed an increase in lingual pressure. In contrast, the control group exhibited increases in lingual pressures with both the highly palatable tastants (Kool-Aid) and the highly unpalatable tastants (coffee and saltwater). This difference may be due to a loss of taste sensitivity in older individuals. This loss of taste sensitivity may also lead to a loss of chemesthesis, resulting in relatively similar lingual pressures when swallowing, regardless of the taste of a bolus.

Overall, the higher lingual pressures exhibited by the experimental group indicate that they are producing much more effortful swallows. While water swallows resulted in the lowest lingual pressures for the control group, the experimental group had relatively high pressures for the plain water swallows. This could be due to the increased effort they exhibit in addition to the fact that water is the most common liquid used in their swallowing therapy and therefore it is the liquid that they have the most practice swallowing. In addition, effortful swallows are a common therapeutic tool that may become habitual in individuals with dysphagia and may result in increased lingual pressures even after swallowing therapy has been ceased.

Implications

The results of this study are important for guiding future dysphagia evaluation and treatment. The significant differences in the lingual pressures of both the control group and the experimental group as a function of taste may point to a possible treatment strategy following much more research.

This study may also provide a starting point for future research regarding the effects of palatability on tongue strength and swallow efficiency. A low hedonic rating did not result in an increase in lingual pressures with the experimental group like it did with the control group. Bitter coffee and saltwater had the lowest hedonic ratings and were also associated with the lowest lingual pressures in the experimental group. This is an important consideration when deciding whether to alter a patient's diet. If decreased palatability results in lower lingual pressures, a highly altered diet (i.e. thickened liquids, puree, supplemental shakes) may result in lower lingual pressures when swallowing. Clinicians must weigh this evidence with the patient's full medical picture to determine if an altered diet truly is the best option for the patient.

Limitations

The largest limitation of this study was the small sample size of the experimental group. Without more participants on whom to collect data, there are only a few conclusions that can be drawn regarding the implications of using tastants as a valid treatment approach. More research that includes more participants with dysphagia as well as age-matched controls are required before any direct conclusions can be drawn.

Recommendations

Recommendations for future research on this topic include the incorporation of more participants with dysphagia as well as age-matched control participants. In addition to a larger sample size, future studies may wish to consider administering tastant liquids at the temperature that they are typically consumed. For this study, all tastants were administered at room temperature. While this helped limit the number of variables present, it did not mirror real-life applications. In an average setting; individuals would typically drink hot coffee or cold soda, rather than consuming all liquids at room temperature.

In addition, it is recommended that speech-language pathologists be mindful of the liquids that they are utilizing as part of swallowing therapy. The current results join a growing body of evidence that supports the finding that various aspects of the swallow can be drastically affected by the characteristics of the bolus that is being swallowed. If one is seeking the highest attainable lingual pressures for an individual client, then the current results indicate that highly palatable liquids should be considered. If one is attempting to challenge their client, then perhaps the clinician should consider something less palatable. It should be noted that the specific clinical recommendation that is currently being made is to be mindful, not to automatically utilize a certain type of tastant. The premise of this research is to assist in developing naturalistic swallowing assessment and treatment. Repeatedly swallowing Kool-Aid, for example, would not be representative of a naturalistic swallowing exercise unless the client intends to solely drink Kool-Aid. By being mindful of the specific characteristic of the swallow that is associated with each tastant, the clinician can tailor treatment in order to render the client as an individual who is capable of swallowing a vast array of liquid boluses safely and efficiently.

Conclusion

This study sought to fill a gap in dysphagia research regarding the effects of different tastes and temperatures on the lingual pressures exhibited while swallowing. It provided a firm foundation that confirmed the efficacy of using the IOPI to measure lingual pressure during the task specific exercise of swallowing a liquid bolus. The study also confirmed the hypothesis that different tasting liquids would have an effect on lingual pressure exhibited while swallowing in healthy participants as well as in those with dysphagia. More research is needed to determine the effect of different taste and temperature liquids on lingual pressure in the elderly and dysphagia populations but clinicians should consider the taste of the liquids that are used as part of treatment.

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APPENDIX A:

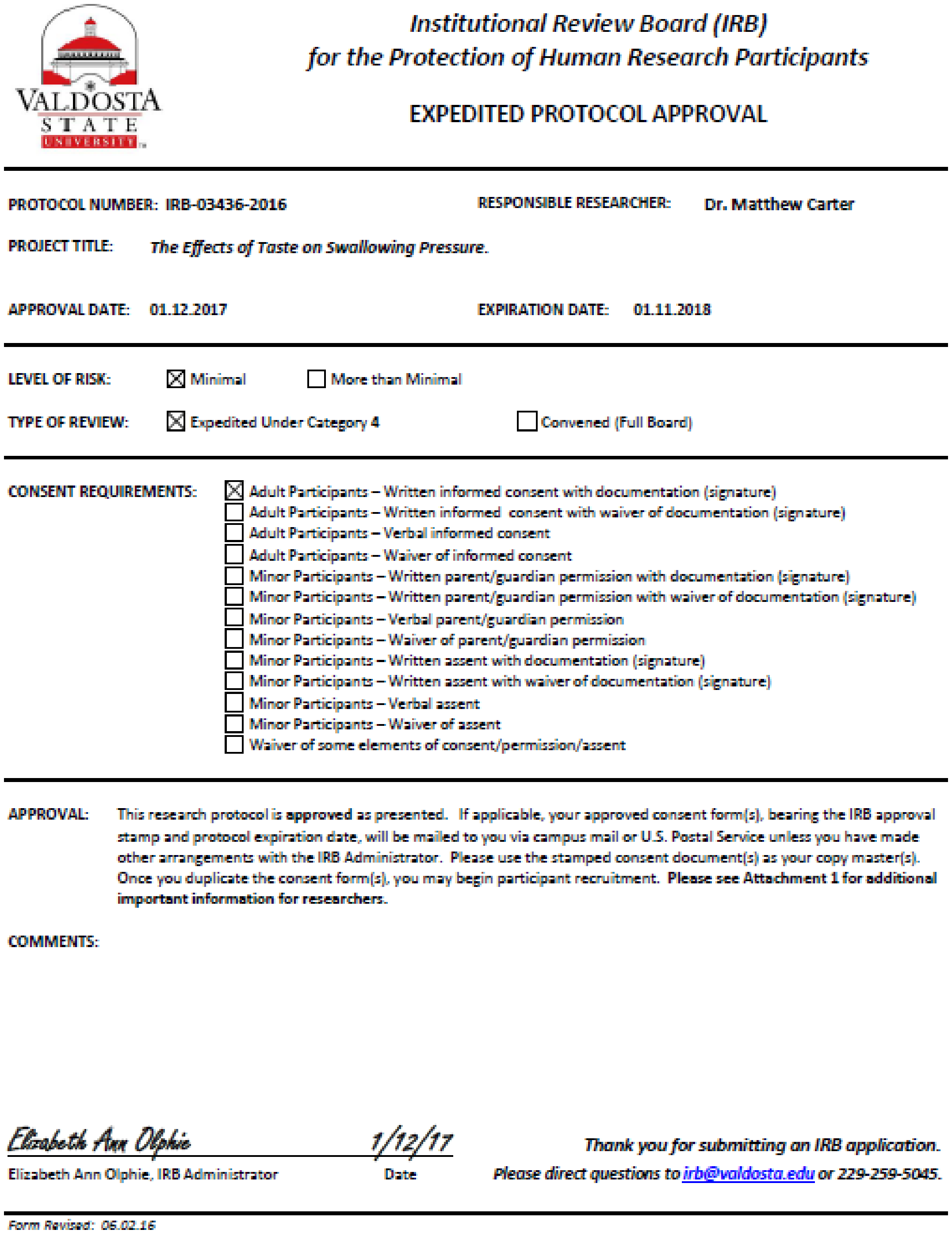
9-Point Hedonic Scale

9-Point Hedonic Scale

9	Like Extremely
8	Like Very Much
7	Like Moderately
6	Like Slightly
5	Neither Like Nor Dislike
4	Dislike Slightly
3	Dislike Moderately
2	Dislike Very Much
1	Dislike Extremely

APPENDIX B:

Intuitional Review Board



VALDOSTA STATE UNIVERSITY

Institutional Review Board (IRB)
for the Protection of Human Research Participants

EXPEDITED PROTOCOL APPROVAL

PROTOCOL NUMBER: IRB-03436-2016 **RESPONSIBLE RESEARCHER:** Dr. Matthew Carter

PROJECT TITLE: *The Effects of Taste on Swallowing Pressure.*

APPROVAL DATE: 01.12.2017 **EXPIRATION DATE:** 01.11.2018

LEVEL OF RISK: ☒ Minimal ☐ More than Minimal

TYPE OF REVIEW: ☒ Expedited Under Category 4 ☐ Convened (Full Board)

CONSENT REQUIREMENTS:

☒ Adult Participants – Written informed consent with documentation (signature)
☐ Adult Participants – Written informed consent with waiver of documentation (signature)
☐ Adult Participants – Verbal informed consent
☐ Adult Participants – Waiver of informed consent
☐ Minor Participants – Written parent/guardian permission with documentation (signature)
☐ Minor Participants – Written parent/guardian permission with waiver of documentation (signature)
☐ Minor Participants – Verbal parent/guardian permission
☐ Minor Participants – Waiver of parent/guardian permission
☐ Minor Participants – Written assent with documentation (signature)
☐ Minor Participants – Written assent with waiver of documentation (signature)
☐ Minor Participants – Verbal assent
☐ Minor Participants – Waiver of assent
☐ Waiver of some elements of consent/permission/assent

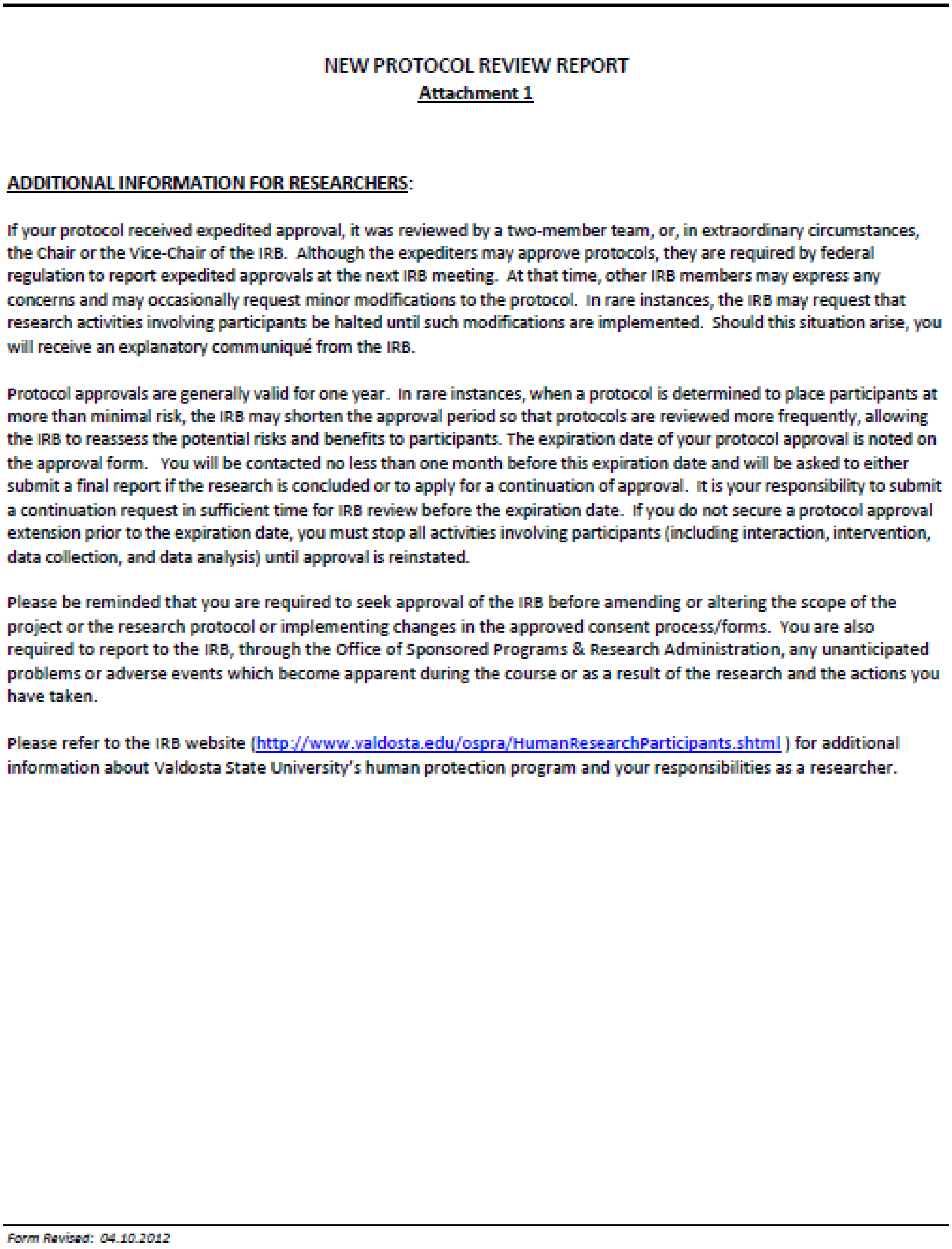
APPROVAL: This research protocol is **approved** as presented. If applicable, your approved consent form(s), bearing the IRB approval stamp and protocol expiration date, will be mailed to you via campus mail or U.S. Postal Service unless you have made other arrangements with the IRB Administrator. Please use the stamped consent document(s) as your copy master(s). Once you duplicate the consent form(s), you may begin participant recruitment. **Please see Attachment 1 for additional important information for researchers.**

COMMENTS:

Elizabeth Ann Olphie 1/12/17
Elizabeth Ann Olphie, IRB Administrator Date

Thank you for submitting an IRB application.
Please direct questions to irb@valdosta.edu or 229-259-5045.

Form Revised: 06.02.16



NEW PROTOCOL REVIEW REPORT

Attachment 1

ADDITIONAL INFORMATION FOR RESEARCHERS:

If your protocol received expedited approval, it was reviewed by a two-member team, or, in extraordinary circumstances, the Chair or the Vice-Chair of the IRB. Although the expediters may approve protocols, they are required by federal regulation to report expedited approvals at the next IRB meeting. At that time, other IRB members may express any concerns and may occasionally request minor modifications to the protocol. In rare instances, the IRB may request that research activities involving participants be halted until such modifications are implemented. Should this situation arise, you will receive an explanatory communiqué from the IRB.

Protocol approvals are generally valid for one year. In rare instances, when a protocol is determined to place participants at more than minimal risk, the IRB may shorten the approval period so that protocols are reviewed more frequently, allowing the IRB to reassess the potential risks and benefits to participants. The expiration date of your protocol approval is noted on the approval form. You will be contacted no less than one month before this expiration date and will be asked to either submit a final report if the research is concluded or to apply for a continuation of approval. It is your responsibility to submit a continuation request in sufficient time for IRB review before the expiration date. If you do not secure a protocol approval extension prior to the expiration date, you must stop all activities involving participants (including interaction, intervention, data collection, and data analysis) until approval is reinstated.

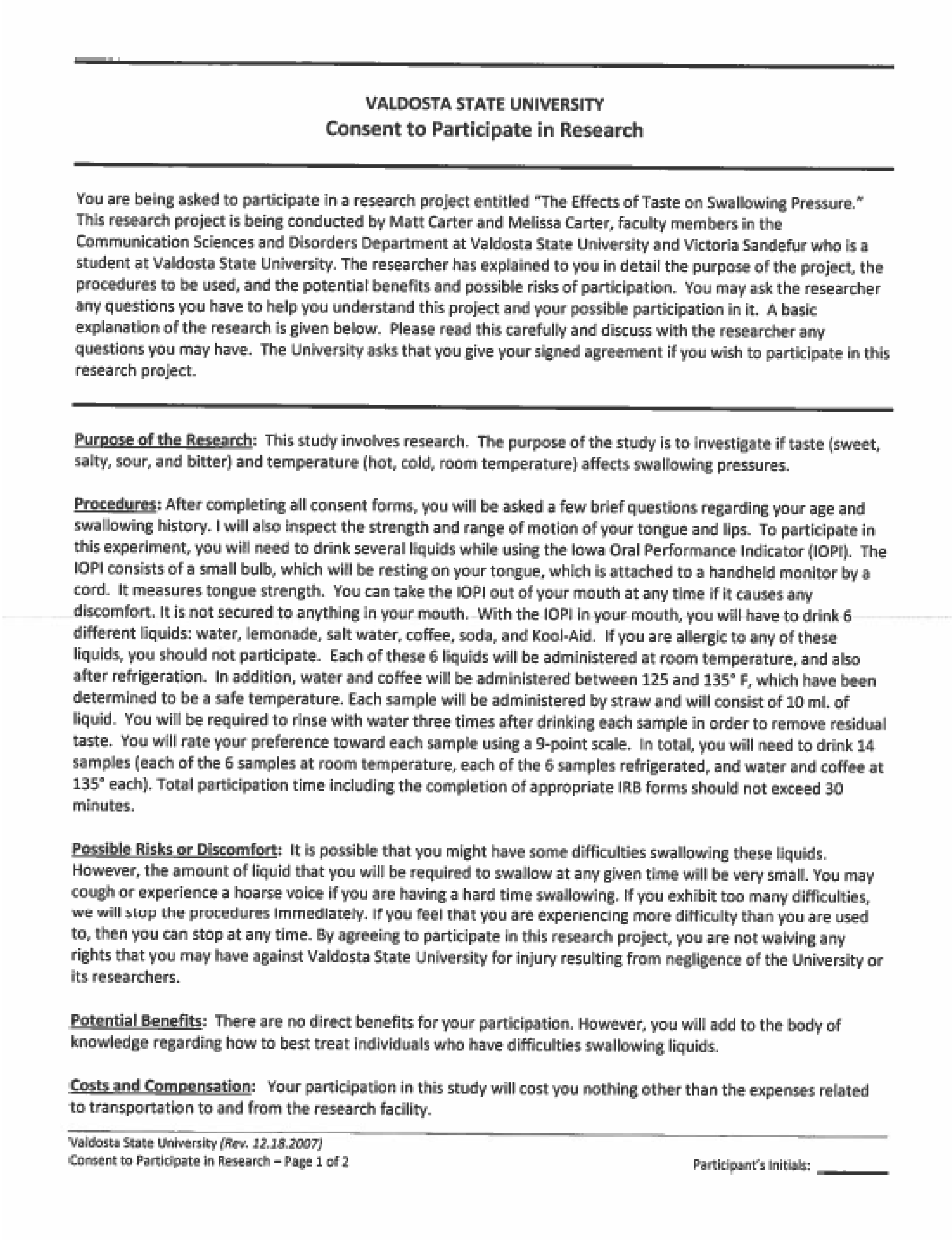
Please be reminded that you are required to seek approval of the IRB before amending or altering the scope of the project or the research protocol or implementing changes in the approved consent process/forms. You are also required to report to the IRB, through the Office of Sponsored Programs & Research Administration, any unanticipated problems or adverse events which become apparent during the course or as a result of the research and the actions you have taken.

Please refer to the IRB website (http://www.valdosta.edu/ospra/HumanResearchParticipants.shtml) for additional information about Valdosta State University's human protection program and your responsibilities as a researcher.

Form Revised: 04.10.2012

APPENDIX C:

IRB Participant Consent Form



VALDOSTA STATE UNIVERSITY
Consent to Participate in Research

You are being asked to participate in a research project entitled "The Effects of Taste on Swallowing Pressure." This research project is being conducted by Matt Carter and Melissa Carter, faculty members in the Communication Sciences and Disorders Department at Valdosta State University and Victoria Sandefur who is a student at Valdosta State University. The researcher has explained to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask the researcher any questions you have to help you understand this project and your possible participation in it. A basic explanation of the research is given below. Please read this carefully and discuss with the researcher any questions you may have. The University asks that you give your signed agreement if you wish to participate in this research project.

Purpose of the Research: This study involves research. The purpose of the study is to investigate if taste (sweet, salty, sour, and bitter) and temperature (hot, cold, room temperature) affects swallowing pressures.

Procedures: After completing all consent forms, you will be asked a few brief questions regarding your age and swallowing history. I will also inspect the strength and range of motion of your tongue and lips. To participate in this experiment, you will need to drink several liquids while using the Iowa Oral Performance Indicator (IOPI). The IOPI consists of a small bulb, which will be resting on your tongue, which is attached to a handheld monitor by a cord. It measures tongue strength. You can take the IOPI out of your mouth at any time if it causes any discomfort. It is not secured to anything in your mouth. With the IOPI in your mouth, you will have to drink 6 different liquids: water, lemonade, salt water, coffee, soda, and Kool-Aid. If you are allergic to any of these liquids, you should not participate. Each of these 6 liquids will be administered at room temperature, and also after refrigeration. In addition, water and coffee will be administered between 125 and 135° F, which have been determined to be a safe temperature. Each sample will be administered by straw and will consist of 10 ml. of liquid. You will be required to rinse with water three times after drinking each sample in order to remove residual taste. You will rate your preference toward each sample using a 9-point scale. In total, you will need to drink 14 samples (each of the 6 samples at room temperature, each of the 6 samples refrigerated, and water and coffee at 135° each). Total participation time including the completion of appropriate IRB forms should not exceed 30 minutes.

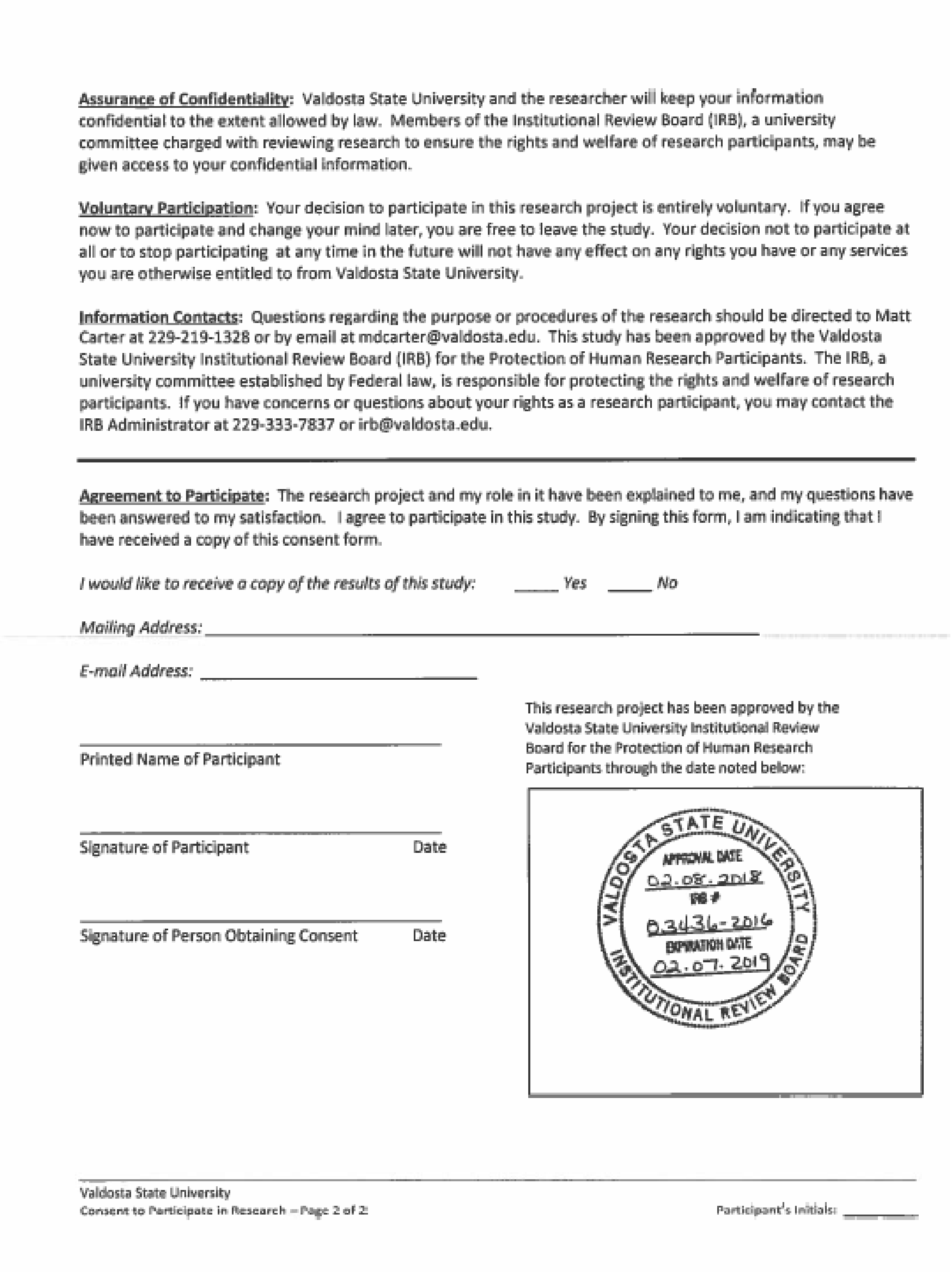
Possible Risks or Discomfort: It is possible that you might have some difficulties swallowing these liquids. However, the amount of liquid that you will be required to swallow at any given time will be very small. You may cough or experience a hoarse voice if you are having a hard time swallowing. If you exhibit too many difficulties, we will stop the procedures immediately. If you feel that you are experiencing more difficulty than you are used to, then you can stop at any time. By agreeing to participate in this research project, you are not waiving any rights that you may have against Valdosta State University for injury resulting from negligence of the University or its researchers.

Potential Benefits: There are no direct benefits for your participation. However, you will add to the body of knowledge regarding how to best treat individuals who have difficulties swallowing liquids.

Costs and Compensation: Your participation in this study will cost you nothing other than the expenses related to transportation to and from the research facility.

Valdosta State University *(Rev. 12.18.2007)*
Consent to Participate in Research – Page 1 of 2

Participant's Initials: ______



Assurance of Confidentiality: Valdosta State University and the researcher will keep your information confidential to the extent allowed by law. Members of the Institutional Review Board (IRB), a university committee charged with reviewing research to ensure the rights and welfare of research participants, may be given access to your confidential information.

Voluntary Participation: Your decision to participate in this research project is entirely voluntary. If you agree now to participate and change your mind later, you are free to leave the study. Your decision not to participate at all or to stop participating at any time in the future will not have any effect on any rights you have or any services you are otherwise entitled to from Valdosta State University.

Information Contacts: Questions regarding the purpose or procedures of the research should be directed to Matt Carter at 229-219-1328 or by email at mdcarter@valdosta.edu. This study has been approved by the Valdosta State University Institutional Review Board (IRB) for the Protection of Human Research Participants. The IRB, a university committee established by Federal law, is responsible for protecting the rights and welfare of research participants. If you have concerns or questions about your rights as a research participant, you may contact the IRB Administrator at 229-333-7837 or irb@valdosta.edu.

Agreement to Participate: The research project and my role in it have been explained to me, and my questions have been answered to my satisfaction. I agree to participate in this study. By signing this form, I am indicating that I have received a copy of this consent form.

I would like to receive a copy of the results of this study: _____ *Yes* _____ *No*

Mailing Address: ______________________________

E-mail Address: ______________________________

____
Printed Name of Participant

____
Signature of Participant Date

____
Signature of Person Obtaining Consent Date

This research project has been approved by the Valdosta State University Institutional Review Board for the Protection of Human Research Participants through the date noted below:

APPROVAL DATE 02.08.2018
IRB # 03436-2016
EXPIRATION DATE 02.07.2019

APPENDIX D:

Individual Participant Data

Participant #: 1

Age: 22.92

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

[redacted]	Average	Hedonistic
Room Temp Water	14	8
Cold Water	11	9
Hot Water	27	1
Coffee	12	4
Soda	21.5	5
Kool Aid	20	2
Lemonade	19	6
Saltwater	24.5	1

Participant #: 2

Age: 24.58

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

[redacted]	**Average**	**Hedonistic**
Room Temp Water	20	9
Cold Water	15.5	9
Hot Water	23.5	3
Coffee	17.5	1
Soda	19	4
Kool Aid	19	9
Lemonade	17.5	7
Saltwater	26	1

Participant #: 3

Age: 22.75

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	**Hedonistic**
Room Temp Water	12	6
Cold Water	10.5	5
Hot Water	7.5	6
Coffee	9.5	2
Soda	10.5	5
Kool Aid	12.5	7
Lemonade	17	6
Saltwater	11.5	3

Participant #: 4

Age: 24

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

[redacted]	**Average**	**Hedonistic**
Room Temp Water	32	6
Cold Water	38.5	6
Hot Water	22.5	3
Coffee	26.5	4
Soda	26	4
Kool Aid	28	9
Lemonade	28	7
Saltwater	29.5	1

Participant #: 5

Age: 23.83

Group: [✓ **Control**] Dysphagia

Oral Mechanism Exam: [✓ **P**] F

	Average	**Hedonistic**
Room Temp Water	13	5
Cold Water	14.5	4
Hot Water	19	2
Coffee	15	1
Soda	18	4
Kool Aid	17.5	7
Lemonade	20	3
Saltwater	15	1

Participant #: 6

Age: 23.5

Group: [✓ **Control**] Dysphagia

Oral Mechanism Exam: [✓ **P**] F

[redacted]	**Average**	**Hedonistic**
Room Temp Water	7	6
Cold Water	8.5	7
Hot Water	11	6
Coffee	9.5	2
Soda	12	6
Kool Aid	12	7
Lemonade	12.5	4
Saltwater	9.5	1

Participant #: 7

Age: 24.5

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

[redacted]	**Average**	**Hedonistic**
Room Temp Water	22	7
Cold Water	30	8
Hot Water	23	4
Coffee	7.5	1
Soda	13.5	4
Kool Aid	22	6
Lemonade	20.5	7
Saltwater	30	1

Participant #: 8

Age: 22.67

Group: [✓ **Control**] Dysphagia

Oral Mechanism Exam: [✓ **P**] F

[redacted]	**Average**	**Hedonistic**
Room Temp Water	21.5	5
Cold Water	18	6
Hot Water	20.5	1
Coffee	31	4
Soda	24.5	5
Kool Aid	28	8
Lemonade	25.5	6
Saltwater	27	1

Participant #: 9

Age: 22.92

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	Hedonistic
Room Temp Water	7.5	6
Cold Water	8.5	3
Hot Water	8	6
Coffee	8.5	1
Soda	9	8
Kool Aid	12	9
Lemonade	10.5	9
Saltwater	12.5	1

Participant #: 10

Age: 22.42

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	**Hedonistic**
Room Temp Water	30.5	7
Cold Water	35	5
Hot Water	46.5	1
Coffee	46.5	1
Soda	40.5	2
Kool Aid	33.5	7
Lemonade	38	7
Saltwater	38.5	1

Participant #: 11

Age: 23.5

Group: **Control** Dysphagia

Oral Mechanism Exam: **P** F

	Average	**Hedonistic**
Room Temp Water	23.5	1
Cold Water	16	9
Hot Water	18.5	7
Coffee	13.5	8
Soda	14	5
Kool Aid	25.5	2
Lemonade	26.5	9
Saltwater	24	8

Participant #: 12

Age: 23.17

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	Hedonistic
Room Temp Water	15.5	7
Cold Water	13.5	9
Hot Water	8	6
Coffee	16.5	7
Soda	16.5	6
Kool Aid	14	9
Lemonade	16	7
Saltwater	9.5	1

Participant #: 13

Age: 22.75

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	**Hedonistic**
Room Temp Water	18	7
Cold Water	17	8
Hot Water	18	4
Coffee	24	2
Soda	26	5
Kool Aid	23.5	1
Lemonade	25.5	1
Saltwater	21.5	1

Participant #: 14

Age: 24

Group: [✓ **Control**] Dysphagia

Oral Mechanism Exam: [✓ **P**] F

	Average	**Hedonistic**
Room Temp Water	12.5	5
Cold Water	12	7
Hot Water	15	2
Coffee	18	2
Soda	12.5	5
Kool Aid	21	7
Lemonade	16.5	7
Saltwater	17.5	1

Participant #: 15

Age: 23.58

Group: [✓ **Control**] Dysphagia

Oral Mechanism Exam: [✓ **P**] F

	Average	**Hedonistic**
Room Temp Water	15	3
Cold Water	15	5
Hot Water	14.5	6
Coffee	13.5	4
Soda	16	7
Kool Aid	23.5	8
Lemonade	17.5	4
Saltwater	16.5	1

Participant #: 16

Age: 23.5

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	**Hedonistic**
Room Temp Water	15.5	5
Cold Water	16	8
Hot Water	14.5	5
Coffee	13.5	4
Soda	24.5	2
Kool Aid	12	6
Lemonade	18	7
Saltwater	20.5	2

Participant #: 17

Age: 23.33

Group: [✓ **Control**] Dysphagia

Oral Mechanism Exam: [✓ **P**] F

	Average	**Hedonistic**
Room Temp Water	13.5	5
Cold Water	9.5	5
Hot Water	13	3
Coffee	17	2
Soda	21	9
Kool Aid	21	8
Lemonade	14	6
Saltwater	16	1

Participant #: 18

Age: 28.58

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	Hedonistic
Room Temp Water	19.5	5
Cold Water	24	6
Hot Water	15.5	3
Coffee	18	6
Soda	15.5	8
Kool Aid	32.5	9
Lemonade	26.5	7
Saltwater	16.5	1

Participant #: 19

Age: 23.67

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	**Hedonistic**
Room Temp Water	14.5	4
Cold Water	17	5
Hot Water	17.5	4
Coffee	14.5	6
Soda	17	6
Kool Aid	18	8
Lemonade	19.5	7
Saltwater	14.5	2

Participant #: 20

Age: 24.25

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	Hedonistic
Room Temp Water	19.5	2
Cold Water	20.5	3
Hot Water	18.5	2
Coffee	17	4
Soda	12.5	3
Kool Aid	22.5	6
Lemonade	20	1
Saltwater	26	1

Participant #: 21

Age: 22.75

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	Hedonistic
Room Temp Water	13.5	3
Cold Water	16	3
Hot Water	23	2
Coffee	12	1
Soda	12.5	4
Kool Aid	11	6
Lemonade	18.5	6
Saltwater	14.5	1

Participant #: 22

Age: 22.75

Group: [✓ **Control**] Dysphagia

Oral Mechanism Exam: [✓ **P**] F

	Average	**Hedonistic**
Room Temp Water	12.5	5
Cold Water	12.5	4
Hot Water	12.5	3
Coffee	12	1
Soda	12	7
Kool Aid	11	7
Lemonade	11.5	8
Saltwater	13	1

Participant #: 23

Age: 26.17

Group: [✓ Control] Dysphagia

Oral Mechanism Exam: [✓ P] F

	Average	**Hedonistic**
Room Temp Water	7	3
Cold Water	9	7
Hot Water	11	5
Coffee	9	2
Soda	7.5	6
Kool Aid	12.5	4
Lemonade	10	4
Saltwater	14.5	1

Participant #: 24

Age: 63.9

Group: Control [✓ Dysphagia]

Oral Mechanism Exam: P [✓ F]

	Average	**Hedonistic**
Room Temp Water	45	8
Cold Water	42	9
Hot Water	38.5	5
Coffee	39	7
Soda	36.5	8
Kool Aid	46.5	7
Lemonade	42.5	9
Saltwater	43	1

Participant #: 25

Age: 59.67

Group: Control [✓ Dysphagia]

Oral Mechanism Exam: P [✓ F]

	Average	**Hedonistic**
Room Temp Water	34	6
Cold Water	31.5	4
Hot Water	28.5	3
Coffee	29.5	1
Soda	35	7
Kool Aid	36	4
Lemonade	30	2
Saltwater	18	1

Participant #: 26

Age: 64.34

Group: Control [✓ Dysphagia]

Oral Mechanism Exam: P [✓ F]

	Average	Hedonistic
Room Temp Water	23	1
Cold Water	20	4
Hot Water	14.5	4
Coffee	12.5	4
Soda	16	1
Kool Aid	15	6
Lemonade	21	6
Saltwater	22	8

Participant #: 27

Age: 60.5

Group: Control **Dysphagia**

Oral Mechanism Exam: P **F**

	Average	**Hedonistic**
Room Temp Water	21	3
Cold Water	15	5
Hot Water	22	5
Coffee	26	5
Soda	18	2
Kool Aid	16	5
Lemonade	14	6
Saltwater	21	5

Participant #: 28

Age: 54.35

Group: Control [✓ Dysphagia]

Oral Mechanism Exam: P [✓ F]

	Average	**Hedonistic**
Room Temp Water	19	2
Cold Water	19	4
Hot Water	20	6
Coffee	14	3
Soda	20	1
Kool Aid	17	1
Lemonade	22	8
Saltwater	23	6