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Title:

The identification of perceived intensity and agreeability of sensory and chemesthetic properties of taste stimuli among a selected non-dysphagic population.

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Abstract

The identification of perceived intensity and agreeability of sensory and chemesthetic properties of taste stimuli among a selected non-dysphagic population.

Background: Morbidity and mortality from aspiration pneumonia is a significant health issue in dysphagic patients. Therapeutic techniques which facilitate safe swallowing in these patients are needed. Identification of new sensory characteristics of food or drinks could improve treatments for dysphagia.

Objectives: This pilot study was designed to identify intense and/or agreeable sensory and chemesthetic stimuli and to identify groups of perceived tastes signified by common or opposing factors in a female non-dysphagic population and to ascertain whether there are identifiable groups within the sample in terms of taste perception.

Methods: Participant's fungiform papillae were counted using a blue dye test and categorised as non-, medium- or super-tasters. Then data from a completed questionnaire on intensity and agreeability of 54 tastes based on sweet, sour, salty, bitter, umami tastes and chemosthetic stimuli were analysed using descriptive and inferential statistics to determine differences between groups, taste groupings and correlations between taste agreeability and intensity.

Results: Lemon juice was considered the most intense, while liver and seawater were shown as most disagreeable tastes. Differences between medium and non-taster groups were limited to fennel, fudge and black pepper. Factor analysis demonstrated distinct taste groupings of strong tastes, spicy/tangy and herbal tastes. A limited number of tastes demonstrated modest positive or negative correlations ($r<0.5$) between intensity and agreeability.

Conclusions: Overall this pilot study demonstrates that herbal and spicy tastes may be worth examining in future studies into stimuli for dysphasia treatment as these stimuli do not demonstrate a negative correlation between intensity and agreeability.

Keywords: Dysphagia, fungiform papillae, chemesthetic stimuli, tastes.

1. Introduction

The interactions between sensory inputs (such as taste) and swallowing physiology is complex or at least not fully understood. This complexity is illustrated by findings that show a spectrum of modulation of swallow reflex by sensory stimulation. A better understanding of this topic could prove useful in the management of dysphagia. Some key articles are analysed which explore this relationship.

1.1 Physiology of the swallow reflex

Normal swallowing function has been described as having four main stages; the pre-oral, oral, pharyngeal, and oesophageal stages (Corbin-Lewis *et al* 2005). In addition to the sensory input during the pre-oral stage, sensory modulation comes from the bolus through its taste, texture, consistency, volume, viscosity, and temperature via the trigeminal, facial, glossopharyngeal, and vagus cranial nerves and contribute to a safe swallow (Corbin-Lewis *et al* 2005). As sensory input has been demonstrated to have effects on swallowing, sensory stimulation is considered a useful approach in managing patients with dysphagia (Hamdy, 2003). As gustatory and olfactory stimuli are both forms of sensory stimulation they may be useful in this regard.

1.2 The use of taste sensation and chemesthesis to modulate the swallow reflex

Bolus modification techniques which change the sensory quality of food are often prescribed for patients with dysphagia. An examination by McCurtin (2012) of Speech and Language Therapist's clinical practices revealed that almost one third of the top-ten therapies used by dysphagia Speech and Language Therapist (SLTs) in Ireland are bolus-modification techniques such as volume regulation. The most frequently used is texture modification therapies (80%) followed by thickening of liquids (76.6%) modifications to food/liquid taste (26.6%) (McCurtin 2012). Although thickened liquids are frequently prescribed (Glassburn and Deem 1998; Germin *et al* 2006) they are often disliked resulting in non-compliance (Garcia *et al* 2005). Other compensatory techniques include bolus volume (Bisch 1994; Miller and Watkin 1996) and thermal tactile, (Kaatzke-McDonald *et al* 1996). It is known that when bolus concentration levels of stimulants such as salt (NaCl) and citric acid reach a particular threshold they activate chemesthesis, a sensation of irritation produced by chemical stimulation mediated by the trigeminal nerve (Todd *et al* 2012). Chemesthesis is not a taste per se but produces the sensation from sensory stimuli (Sørensen *et al* 2003) such as carbonation in drinks, hotness of a chili pepper, or coolness of menthol. Trigeminal stimulation, with sour bolus (Pelletier and Lawless 2003) and carbonation (Bulow *et al* 2003) are sometimes used in dysphagia compensatory therapy (Speyer et al 2010). Indeed, carbonation has been reported to improve swallowing in individuals with oropharyngeal dysphagia (Bulow *et al* 2003) but the overall influence of chemesthesis during swallowing is still unknown. Moreover, in a systematic review of the effects of therapy by SLTs vis-à-vis oropharyngeal dysphagia, Speyer *et al* (2010) asserted that many questions remain unanswered.

Much of what we taste is perceived not just through taste but through smell (Kremer *et al* 2007). Indeed, a decrease in taste sensitivity, associated with aging is partly attributed to the loss of smell (Boyce and Shone, 2006). Interestingly, Kremer et al. (2007) found that the elderly can have decreased sensitivity to salty and sour tastes, but not sweet and bitter taste. Easterling *et al* (2008) note that one early sign of Alzheimer's disease is a diminished sense of smell, and so those with early stage Alzheimer's disease find highly seasoned, spicy, and sweet foods more satisfying. A better understanding of perceived strengths, agreeability and variability of tastes in a healthy population may help clinicians diagnose and treat these patient groups.

Using videofluorography Logemann *et al* (1995) significantly advanced the mounting evidence suggesting that taste can modulate the swallow reflex. Logemann and colleagues used sour bolus (lemon juice mixed with barium) to examine its effect on swallowing in patients with neurogenic dysphagia and reported enhanced swallow reflex and reduced aspiration due to the stimulant.

Since then, much of the research on the effect of tastes on modulating swallow reflex have aligned with the inclusion of sour bolus as a key component in various blends of taste stimulants. Palmer *et al* (2005) reported improved swallow reflex with healthy adults when swallowing a sour bolus (lemon) and suggested that taste stimuli or other strongly flavoured boluses may be useful in the management of dysphagia. Using healthy adults, Sciortino *et al* (2003), conversely found no changes in swallowing following sour bolus stimulation but reported a significant decrease in swallowing response time when cold, mechanical, and taste stimuli were combined. Ding *et al* (2003) and Leow *et al* (2007) evaluated the effects of taste on swallowing muscles in healthy participants using sweet, salty, sour tastants and found modulation affects, in particular when tastes were combined. Participant's perception of the stimuli was not reported in these studies and may have yielded additional useful information.

1.3 The inclusion of perception as a marker for swallow modulation

Using tastants saline, glucose and citrus (cooled to 4°C), Chee et al. (2005) reported a decrease in the volume of ingested bolus per second and increased inter swallow interval in healthy participants. Interestingly, the majority of the participants rated the tastants as intense. These results were similar to Hamdy *et al's* (2003) evaluation of cold and citrus stimulation on swallowing. Chee and colleagues suggested that the unfamiliar high intensity stimulus activated the participant's protective system against noxious stimuli, resulting in the decreased rate of ingested bolus. The swallow modulating effect of noxious stimuli has also been observed by other research in the field of dysphagia. Supplementing an elderly population with capsaicin troche Ebihara *et al* (2005) attributed cough and swallow reflex improvements to an increased release of 'substance P' involved in nociception (processing noxious stimuli). The researchers suggest that elevated levels of substance P results in an increased reaction towards any mechanical, thermal, or chemical change, thus improving swallowing and cough reflexes. Moreover, a study by Kajii *et al* (2002) using sour bolus with rats proposed that sensory stimuli could still have an effect after a taste stimulus was discontinued due to substance P, indicating the possible usefulness of gustatory stimulation not just in compensation but for the rehabilitation of patients with dysphagia. This physiological reaction may somewhat explain why a study by Pelletier and Lawless (2003) using citric acid and citric acid-sucrose mixtures on patients with dysphagia found no significant difference while participants with dementia exhibited less aspiration and penetration when high citric acid bolus concentrations were used. In addition to the tastes discussed in other studies (Miyaoka *et al* 2006; Uneyama and Yamada 2009) explored the influence of umami on the swallow reflex, however, no evidence that umami had a direct effect on swallowing function was presented.

1.4 Perception and the effects of genetics on taste

Pelletier *et al* (2006) explored the possibility that different concentration, qualities and likability of tastes may change lingual swallowing pressure in healthy adults. Results showed that moderate sucrose, high salt, and high citric acid elicited increased lingual swallowing pressures. Although palatability did not significantly affect lingual swallowing pressure the authors suggested that chemesthesis may have played an important role. Interestingly, some participants showed consistently high, medium or low lingual pressures across all tastants. Pelletier *et al* (2006) suggests that there may be a link between differences in swallowing pressures across individuals and the genetic variation in taste perception of a bitter compound called 6-n-propylthiouracil (PROP). Moreover, the density of specific taste receptors on the tongue (fungiform papillae) which are innervated by the trigeminal and facial nerves, correlate significantly with perceived bitterness of PROP and other tastes (Bartoshuk *at al* 1994). This supports the concept of non-tasters who have very few fungiform papillae, medium tasters, and supertasters who have an increased density of fungiform papillae. Individual variability arising from genetics, age and gender may therefore lead to a varied perception of the stimulus (Bartoshuk *at al* 1994). Moreover, deterioration of taste with medications or neural damage is accompanied by a decrease in the number of papillae (Zhang *et al* 2008). A better understanding of individual perception and physiological swallowing reactions to tastes may in the future enhance our ability to recommend safe and palatable dysphagia diets.

1.5 Conclusion

It is clear that there is evidence to support the theory that taste, chemesthesis, thermal and other sensory stimuli affect swallow. We have evidence that sour taste on its own modulates swallowing. There is evidence also that other tastants, for example capsaisin (Ebihara *et al* 2005) can improve swallowing and cough reflexes. With a few exceptions (Pelletier *et al* 2006; Ebihara *et al* 2005) many researchers did not take account of additional factors such as perception. While the inclusion of other stimuli such as thermal tactile make it difficult to directly compare results, there is an argument for the use of combined stimulus approaches to research as used by Sciortino *et al* (2003) and Chee *et al* (2005).

It is imperative to establish the gaps in our knowledge base so we can improve our care of dysphagic patients. A better understanding of perceived strengths, agreeability and variability of tastes in a healthy population may help broaden our knowledge. More research on individual perception and liking may well improve our understanding of physiological swallowing reactions to tastes and help establish an evidence based practice vis-à-vis the use of taste modification to food or liquid with patients with dysphagia.

1.6 Aims & Objectives

The objectives of this study were fourfold; to identify intense and/or agreeable sensory and chemesthetic stimuli, as a basis for further research into the treatments for dysphagia; to ascertain whether identified super-medium and non-taster differ in relation to their perception of tastes; to Identify groups of perceived tastes signified by common or opposing factors and to determine if correlations between taste intensity and agreeability existed in a selected non-dysphasic population.

2. Methods

2.1 Participants

One hundred and eight non-dysphagic, healthy females aged between 18 and 50 years were enrolled following an email sent via the University of Limerick events email which is received by all students and staff on the college campus and recruitment posters that were placed on campus (Appendix 1). According to Lawless and Heymann (2010), discrimination tests, examining if a perceptible difference exists between products, can be conducted with 25-40 participants. 108 participants were enroled to account for the three categories of tasters. They also hold that a study using a hedonic test should involve 75-150 participants. Recruited participants could voluntarily withdraw from the study at any stage. This study gained ethical approved from the Faculty of Education and Health Sciences research committee at the University of Limerick.

2.2 Inclusion and Exclusion criteria

A cut-off of 50 years was selected as taste perception declines with age (Methven *et al* 2012). The sample was confined to female participants in order to exclude a gender variable in this sample, as some studies have shown that females had more fungiform papillae than males (Bartoshuk *et al* 1994; Duffy *et al* 2010). To ensure participants did not have conditions that might impact on taste perception, the following additional exclusion criteria applied; smoked in the previous 6 months; history of ear nose and throat problems; allergy propensity; current cold or flu; recent surgery; oral problems including gum disease, xerostomia, oral cancer or nerve damage and endentulous; recent or unresolved cerebrovascular accident or head trauma effecting the sensory pathways of cranial nerve V and VII; on medication known to affect taste; sensory difficulties relating to taste and smell.

2.3 Data collection and Confidentiality

After prospective participants were given a study information sheet (Appendix 2), willing participants signed a consent form (Appendix 3) on the day of data collection. Participants were numerically coded and the only data collected were their name

A blue dye test was performed and representative images of the tongue taken for a fungiform papillae count. Subsequently participants completed a paper format nine point hedonic scale questionnaire (Sample, Appendix 4) rate individual tastes and stimuli for perceived intensity and agreeability. The scale ranged from ‘absolutely hate it’ to ‘absolutely love it’ for agreeability and ‘extremely weak and insubstantial’ to ‘extremely strong and powerful’ for perceived intensity Hedonic scales are commonly used for rating tastes (Lawless and Heymann 2010). Raw data from the digital camera and questionnaire were transferred to the researcher’s security restricted laptop. Access was restricted to the Principal Investigator along with the four Speech and Language Therapy Masters of Science student researchers who undertook the study. Paper format questionnaires were securely held with the Principal Investigator.

2.4 Fungiform papillae count

The materials used to count the fungiform papillae included blue food dye (royal blue icing colour Wilton Industries), cotton buds, disposable latex gloves, disposable aprons, standard 6 mm diameter hole-punch re-enforcers (Premier depot essentials) , digital camera(Cannon Power Shot SX30, SI-PC1560), tissues, water, disposable cups.

2.5 Blue Dye Test and Imaging Procedure

Like Shahbake *et al* (2005) and Zhang *et* al (2009) the researchers selected a small region of the anterior tongue that provides reliable measurements of fungiform papillae density (Figure 1). Digital images of the participants tongue and fungiform papillae were obtained by asking the participant to stick out her tongue and using a cotton bud, the left anterior third of their tongue was stained with blue food dye. The researcher removed any excessive amounts of dye present, until the desired contrast was achieved. Fungiform papillae on the tongue remained pink while the remaining dyed area of the tongue stained dark blue. Then the hole-punch re-enforcer was placed directly on the left anterior third of the tongue. Each hole-punch re-enforcer was marked with a number that represented a code for the anonymised client which corresponded with the participant’s number (code) on the questionnaire.

The digital camera was then held within 3-4cm from the tongue by the second student researcher before focusing the lens and capturing two successive images of each participants tongue. These images were immediately viewed on the camera's digital screen to determine usability and additional images were captured when necessary before removing the hole-punch re-enforcer. Using the camera's digital screen a preliminary count of the participants fungiform papillae was established. Participants were subsequently informed whether they were categorised as a non-taster, medium-taster or super-taster using cut-off points (Table 2.1).

During the process of refining the protocol for capturing images of participants fungiform papillae count the researchers conducted experimental trials among student colleagues. In preparation for the actual study, issues in relation to glare were rectified by taking the pictures beside the building's window thus using natural light. The optimal amount of blue dye needed in order to get the desired contrast of colours on the tongue was ascertained during these trial runs also.

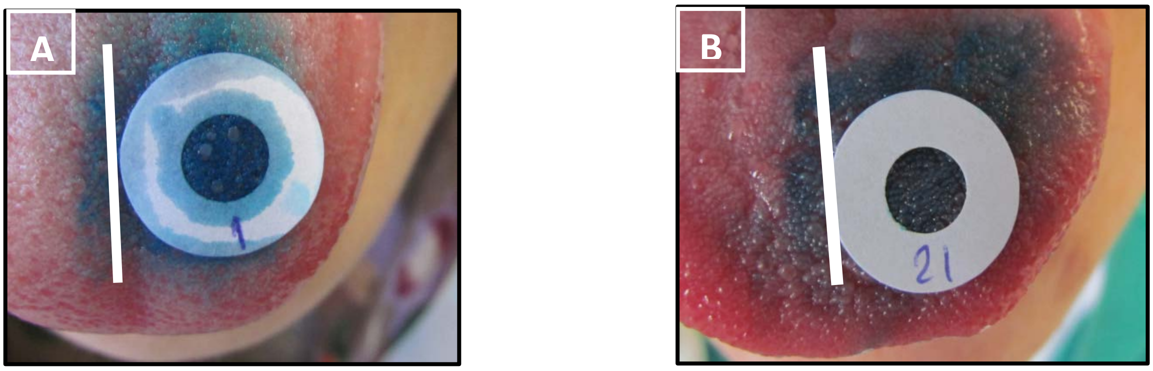

Figure 1. Fungiform papillae in a human tongue. 'A' nontaster and 'B' supertaster. The midline is highlighted with a white line showing the 6-mm-diameter stained area where papilla counts were conducted.

2.6 Grading fungiform papillae density

Digital tongue images were later transferred to Microsoft, Windows Photo Viewer for categorisation on the researcher's laptop. The best image of each tongue available was used for categorisation. Criteria for inclusion of tongue images for categorisation included; the entire measurement area should be visible, in focus, and free of glare, bubbles or foreign bodies. Fungiform papillae which were >50% inside the circle were counted as an entire unit. For staining quality, the pink circles should be visible on a blue background. Images were analysed and qualifying images were jointly graded by two researchers who agreed on the taster type categorisation. Borderline or discrepancy categorisations were subsequently categorised independently by two other researchers blind to the original results. A category was subsequently agreed by majority opinion between all four student researchers.

2.7 Allocation to study groups

Participants were categorised based on fungiform papillae density used in a similar studies such as Essick *et al* (2003) who categorised female tasters based on the PROP test and subsequently analysed mean fungiform papillae density for each taster group. In this study taster groups were categorised based on the number of fungiform papillae /cm^2 as outlined in Table 2.1 below. The diameter of the area of the tongue used to count the papillae was 6mm. As the area of a circle is the radius squared multiplied by pi, (r^2 X π), the area examined was $(0.3cm)^2$ X 3.14, or $0.28cm^2$.

Table 2.1. Fungiform Papillae density

Group	Papillae/$0.28cm^2$	Papillae/cm^2
Non-tasters	<15	<54
Medium-tasters	16-35	55-125
Super-tasters	≥36	≥125

2.8 Tastes and Variables

Fifty four stimuli representing the main five tastes (sweet, sour, salty, bitter and umami) in addition to chemesthetic stimuli were selected. Chemesthetic stimuli include tart (piquancy), menthol, fat, kokumi, menthol, kokumi, calcium, alcohol, spicy and CO_2. These sensory stimuli were chosen based on dysphasic literature of sensory stimuli and also to represent a spectrum of stimuli across the five main tastes and chemesthetic areas. Additional taste categories included smoked flavour, perfumed flavour and regular strong tasting foods. Control items were represented by plain porridge, plain pasta and water. While it was endeavoured to choose tastes participants would be familiar with, in some instances it was necessary to include unusual tastes to represent a spectrum of stimuli across all the tastes (Appendix 5).

Independent variables were the participants and participant taster groups while dependent variables were the perceived taste intensity and perceived taste agreeability of the various 54 taste stimuli.

2.9 Data reduction and statistical analyses

Participant's codes were entered into an SPSS Statistics 21.0 (IBM Corp. 2012) file in line with their corresponding taste category and ratings of agreeability and perceived intensity and the data summarised as medians, range, and minimum and maximum values. The following statistical analyses were undertaken; Shapiro-Wilk and Kormogorov-Smirnov tests of normality, Mann Whitney U tests to determine if differences existed between the non-tasters and medium-tasters in relation to taste perception; Factor Analysis to identify taste groupings signified by common factors (e.g. spiciness) and Spearman's rank correlation coefficient to explore associations between taste intensity and agreeability. A critical alpha probability (p) value of less than 0.05 was considered significant.

Where participants did not answer all questions only the unanswered questions were taken as missing values and omitted from analysis, the remaining data from the participant were included. As participants may not have been familiar with all of the 54 stimuli it was not practical to exclude a participant based on some unanswered questions.

3. Results

3.1. Participant data; taster group categorisation

Participants were allocated into groups based on the number of left anterior tongue fungiform papillae per cm^2, (see Figure 3.1.1.).

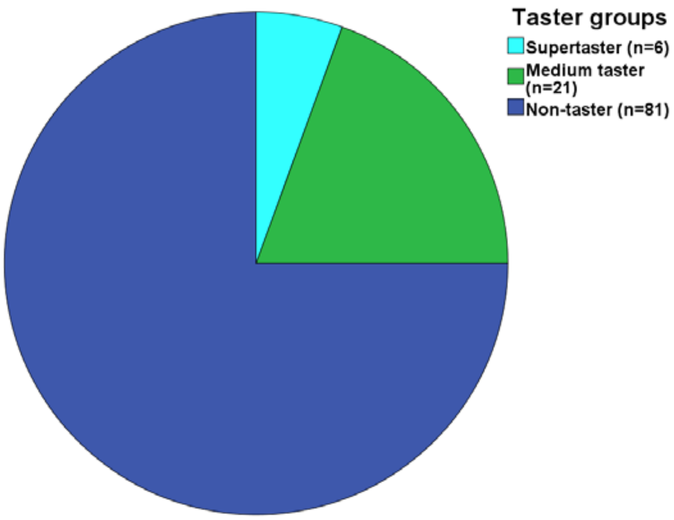

Figure 3.1.1. Number of participants allocated to each taster group based on FP density.

3.2. Questionnaire data

Respondent data was measured on an ordinal scale (1-9), and was determined to be abnormally distributed using both Shapiro-Wilk and Kormogorov-Smirnov tests of normality (Kolmogorov-Smirnov, P<0.05 for all datasets; Shapiro-Wilk, P<0.05 for all datasets; (Appendix 6) making the subsequent use of non-parametric statistics appropriate. Selected data (two highest and two lowest medians) for taste intensity and taste agreeability is described in terms of median, variance, range, n, and minimum and maximum values and percentiles in Table 3.2.1 and Table 3.2.2, respectively. For the remainder of the data see Appendix 7.

Table 3.2.1. The two highest and lowest median scores are presented for taste intensity

Intensity	N		Median	Variance	Range	Min.	Max.	Percentiles		
	Valid	**Missing**						**25**	**50**	**75**
Pure lemon juice	108	0	9	0.7	3	6	9	8	9	9
Raw garlic	107	1	9	1.1	6	3	9	8	9	9
Raw jalepeno pepper	94	14	9	1	5	4	9	8	9	9
Vinegar	107	1	9	0.9	4	5	9	8	9	9
Vodka	102	6	9	2.5	8	1	9	8	9	9
Whiskey	107	1	9	0.6	4	5	9	8	9	9
Black pepper	106	2	8	1.3	5	4	9	7	8	8
Chilli powder	107	1	8	1.1	6	3	9	8	8	9
Coffee granules	102	6	8	1.1	4	5	9	7	8	9
Dark chocolate	108	0	8	1.4	6	3	9	7	8	8
Liver	65	43	8	2.1	5	4	9	6	8	9
Mints	108	0	8	1.1	4	5	9	7	8	8
Minty chewing gum	108	0	8	1.5	5	4	9	7	8	9
Raw ginger	96	12	8	1.4	6	3	9	7	8	9
Raw onion	105	3	8	0.7	3	6	9	8	8	9
Seawater	103	5	8	1.6	6	3	9	7	8	9
Strong goats cheese	94	14	8	1	4	5	9	8	8	9
Plain pasta	106	2	3	2.8	7	1	8	2	3	5
Water	107	1	1	3.7	7	1	8	1	1	5

Table 3.2.2. The two highest and lowest median scores are presented for taste agreeability

Agreeability	N		Median	Variance	Range	Min.	Max.	Percentiles		
	Valid	Missing						25	50	75
Mints	108	0	8	2.3	8	1	9	6	8	9
Parmesan cheese	106	2	8	5	8	1	9	5	8	9
Smokey bacon	102	6	8	3.2	8	1	9	6	8	9
Water	107	1	8	2.9	7	2	9	6	8	9
Dark chocolate	105	3	7	6.6	8	1	9	5	7	9
Fudge	108	0	7	2.9	7	2	9	5	7	8
Hard meringue	91	17	7	4.4	8	1	9	5	7	9
Maple syrup	105	3	7	4.4	8	1	9	5	7	8
Mint herb	100	8	7	4.6	8	1	9	5	7	9
Minty chewing gum	108	0	7	2.9	6	3	9	6	7	9
Smoked salmon	101	7	7	7.2	8	1	9	5	7	9
Soy sauce	104	4	7	3.5	8	1	9	6	7	8
Strong goats cheese	94	14	7	10.5	8	1	9	2	7	9
Sugar	108	0	7	3.7	7	2	9	6	7	9
Vanilla	107	1	7	3.2	8	1	9	6	7	9
Liver	65	43	3	7.5	8	1	9	1	3	6
Seawater	103	5	2	4.8	8	1	9	1	2	4

3.3. Differences in perceived taste intensity and agreeability between taster groups

In order to determine whether the perceived intensity or agreeability of individual tastes differed between the Medium and Non-taster groups a Mann Whitney U test was performed. The supertaster group was omitted from this type of analysis as the numbers obtained were low (n=6) questioning the ability of the group to adequately represent the supertaster population.

3.3.1. Perceived Taste Intensity

No significant differences in perceived taste intensity between medium and non-tasters were observed for 53 of the 54 tastes analysed. A significant difference ($P<0.05$) between medium and non-tasters was observed for the perceived taste intensity of fennel (see Figure 3.3.1.).

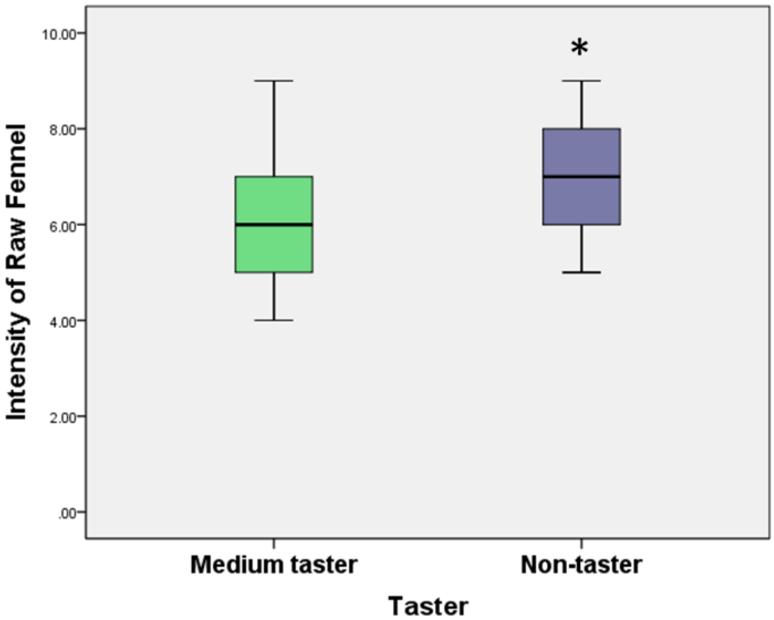

Figure 3.3.1. The perceived intensity of Raw Fennel is different between Medium and Non-Tasters

A Mann Whitney U test revealed a significant difference in the taste intensity of Fennel between Medium (Median=6, n=13) and Non-Tasters (Median=7, n=38), U=155.5, z=-2.017, * $P<0.05$, two-tailed).

3.3.2. Perceived Taste Agreeability

No difference in perceived taste agreeability between medium and non-tasters was observed for 52 of the 54 tastes analysed. A significant difference between medium and non-tasters was observed for the perceived taste agreeability of fudge ($P<0.01$) and black pepper ($P<0.05$) (see Figure 3.3.2. and 3.3.3)

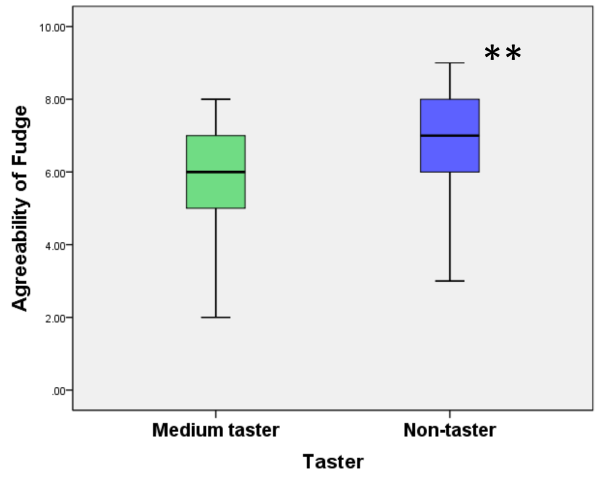

Figure 3.3.2. The perceived agreeability of Fudge is different between Medium and Non-Tasters

A Mann Whitney U test revealed a significant difference in the taste agreeability of Fudge between Medium (Median=6, n=21) and Non-Tasters (Median=7, n=81), U=496.5, z=-2.99, **P<0.01, two-tailed).

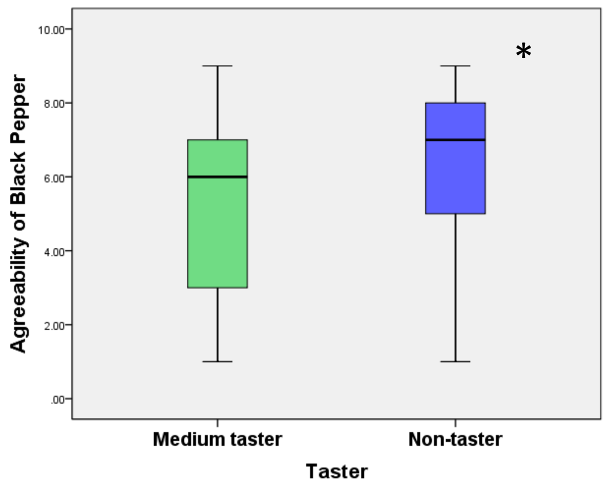

Figure 3.3.3. The perceived agreeability of Black Pepper is different between Medium and Non-Tasters

A Mann Whitney U test revealed a significant difference in the taste agreeability of Black Pepper between Medium (Md=5.5, n=20) and Non-Tasters (Md=7, n=79), U=542, z=-2.188, *P<0.05, two-tailed).

3.4. Correlations between Taste Intensity and Taste Agreeability

The relationship between perceived taste intensity and taste agreeability across all categories of taster (Super; Medium and Non-Taster) was investigated using Spearmans Rank Order Correlation. The strength of the relationship between intensity and agreeability was determined using guidelines from Cohen 1988 (cited in Pallant 2013), as shown in Table 3.4.1. One-tailed Spearmans Rank Order correlations were performed as if the taste was agreeable it was considered that the correlation would be positive, and if less agreeable that the correlation would be negative. Significant weak to moderate positive correlations were observed for 12 of the tastes (see Table 3.4.2.), and significant weak to moderate negative correlations were observed for 11 of the tastes (see Table 3.4.3.). No correlations were found to exist between intensity and agreeability of taste for the remaining 31 tastes.

Table 3.4.1. Strength of Relationship between Intensity and Agreeability

Strength of Correlation	Correlation Coefficient (r)
Small (weak)	0.1-0.29
Medium (moderate)	0.3-0.49
Large (strong)	0.5-1.0

Table 3.4.2. Positive Correlations between Perceived Taste Intensity and Agreeability (1-tailed test)

Taste	Significance level	Correlation Coefficient	N
Fudge	P<0.01	0.307	108
Porridge	P<0.01	0.303	107
Mints	P<0.01	0.295	108
Minty Chewing gum	P<0.01	0.267	108
Unsalted Margarine	P<0.01	0.266	95
Vanilla	P<0.01	0.265	107
Hard Meringue	P<0.05	0.241	91
Plain Pasta	P<0.05	0.212	106
Lavender oil	P<0.05	0.206	72
Cumin	P<0.05	0.193	80
Cream	P<0.05	0.17	108
Maple syrup	P<0.05	0.167	105

Table 3.4.3. Negative Correlations between Perceived Taste Intensity and Agreeability (1-tailed test)

Taste	Significance level	Correlation Coefficient	N
Seawater	P<0.01	-0.434	103
Liver	P<0.01	-0.356	65
Whiskey	P<0.01	-0.309	107
Beer	P<0.01	-0.297	108
Strong Goats Cheese	P<0.01	-0.233	94
Seaweed	P<0.05	-0.231	55
Black Pepper	P<0.01	-0.229	105
Raw Jalepeno Pepper	P<0.05	-0.211	94
Sparkling Water	P<0.05	-0.192	97
Chilli Powder	P<0.05	-0.181	107
Vodka	P<0.05	-0.177	102

3.5 Factor Analysis

3.5.1. Factor analysis of taste intensity

The suitability of the data for factor analysis was unable to be tested using Barlett's test of sphericity and a Kaiser-Meyer Olkin (KMO) test as the resulting matrix was 'non-positive definite'. This is likely to result from a number of missing values that reduces the case to variable ratio, as not all respondents answered every question. While the missing data may influence the power of the factor analysis, it remains the most appropriate tool to obtain summarised taste groupings from the data.

Principal component analysis with a varimax (orthogonal) rotation of 54 hedonic scale questions on taste intensity was conducted on data from 108 participants. Exploratory factor analysis of taste intensity showed a flattening of the scree plot after 6 factors (Appendix 8). As 6 factors explained 59.4% of variance, a confirmatory principal component analysis used Eigenvalues over 2.7 followed by a varimax rotation with Kaiser normalisation that converged in 11 iterations. Tastes were considered to load on a factor if the factor score was above 0.6 (Field 2013) The six factors extracted were named and are shown in Figure 3.5.2. and representative boxplots of the tastes signified by the first three factors are shown in Figures 3.5.3 to 3.5.5.

Factor scores were assigned to each participant and a Mann Whitney U test was performed to determine if taster groups differed in relation to factor scores. No significant differences between the groups was found based on the factor scores.

Table 3.5.1. Factor loading scores for intensity

Factor 1 Strong	Factor 2 Spicy/tangy	Factor 3 Aromatic Herb	Factor 4 Rich	Factor 5 Herb	Factor 6
Lemon Juice Vodka Coffee granules Vinegar Raw onion Raw garlic Tablesalt Maple syrup	Chilli Powder Raw ginger Dark chocolate Mackerel Seawater Tonic Water	Soy sauce Plain porridge Raw thyme Lavender oil Raw fennel	Hard meringue Walnuts Cream Red meat cooked rare	Raw parsley (Not soda water Not sparkling water)	Not plain pasta

Figure 3.5.2. A six factor solution of taste intensity. Tastes with a factor score above 0.6 are included.

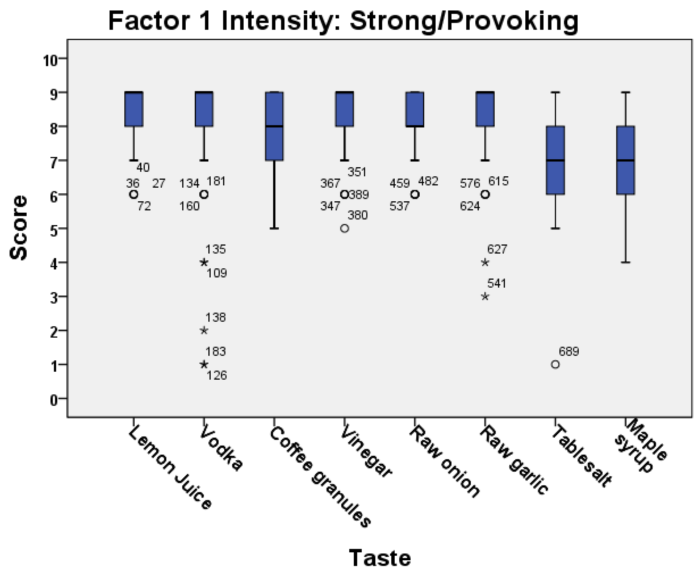

Figure 3.5.3. Boxplot of taste intensities signified by factor 1, strong/provoking.

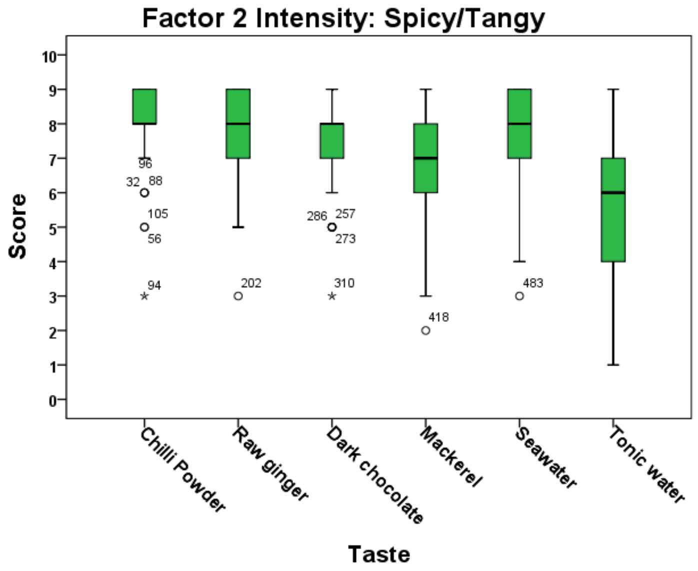

Figure 3.5.4. Boxplot of taste intensities signified by factor 2, spicy/tangy.

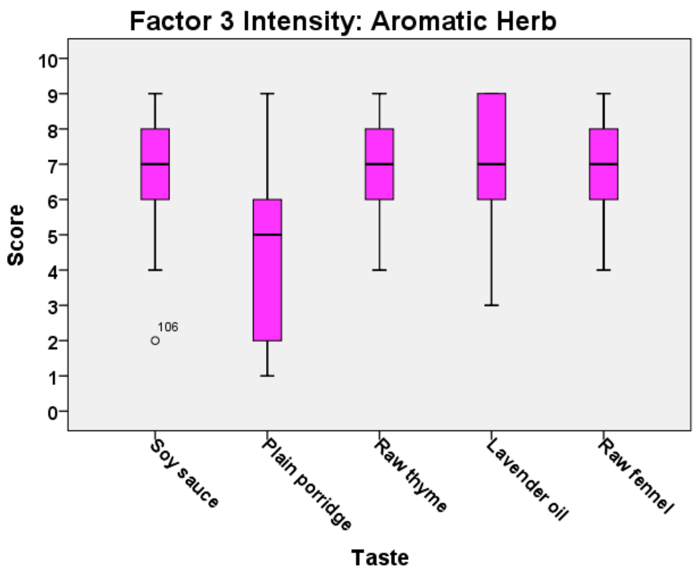

Figure 3.5.5. Boxplot of taste intensities signified by factor 3, aromatic herb.

3.5.2. Factor analysis of taste Agreeability

As per factor analysis of taste intensity, the suitability of the data for factor analysis was unable to be tested using Barlett's test of sphericity and a Kaiser-Meyer Olkin (KMO) test as the resulting matrix was 'non-positive definite'. This is likely to result from a number of missing values that reduces the case to variable ratio, as not all respondents answered every question. While the missing data may influence the power of the factor analysis, it remains the most appropriate tool to obtain summarised taste groupings from the data.

Principal component analysis with a varimax (orthogonal) rotation of 54 hedonic scale questions on taste intensity was conducted on data from 108 participants. Exploratory factor analysis of taste intensity showed a flattening of the scree plot after 6 factors (Appendix 8). As 6 factors explained 57.1% of variance, a confirmatory principal component analysis used Eigenvalues over 3.1 followed by a varimax rotation with Kaiser normalisation that converged in 15 iterations. Tastes were considered to load on a factor if the factor score was above 0.6 (Appendix 9).The six factors extracted were named and are shown in Figure 3.6.2. and representative boxplots of the tastes signified by the first three factors are shown in Figures 3.6.3 to 3.6.5.

Factor scores were assigned to each participant and a Mann Whitney U test was performed to determine if taster groups differed in relation to factor scores. There was no significant difference between the groups based on factor scores.

Agreeability data

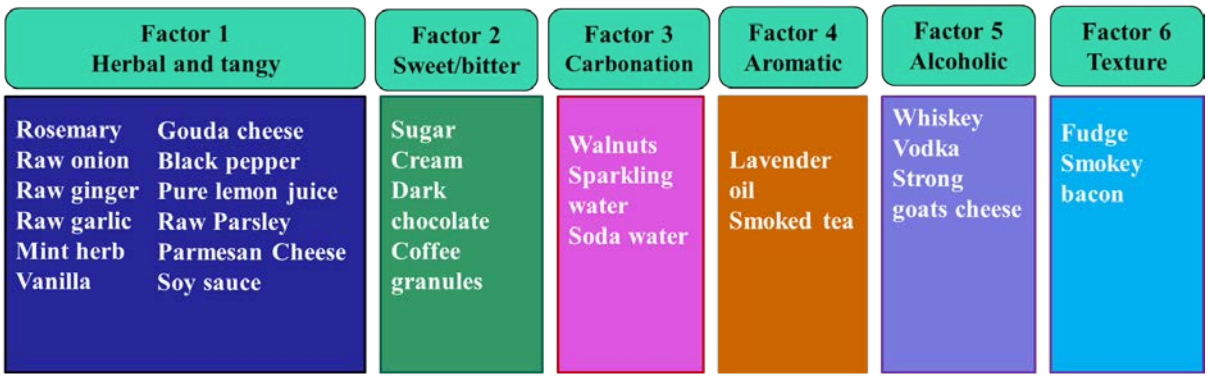

Figure 3.6.2. A six factor solution of taste intensity. Tastes with a factor score above 0.6 are included.

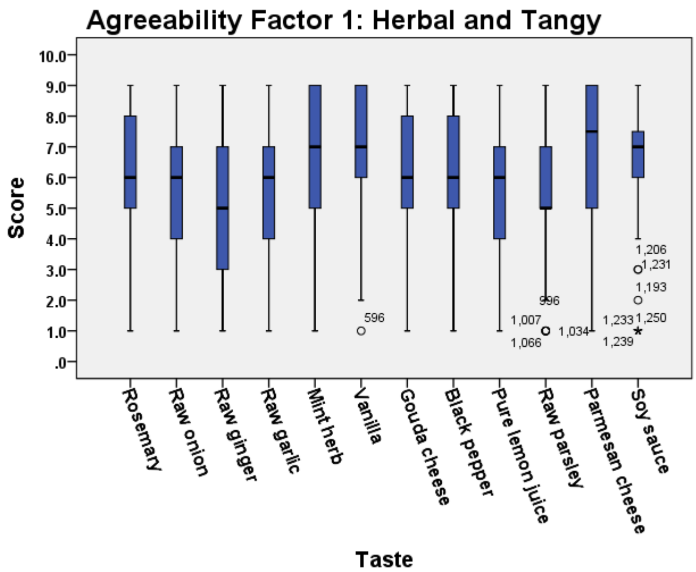

Figure 3.6.3. Boxplot of taste agreeability’s signified by factor 1, herbal and tangy

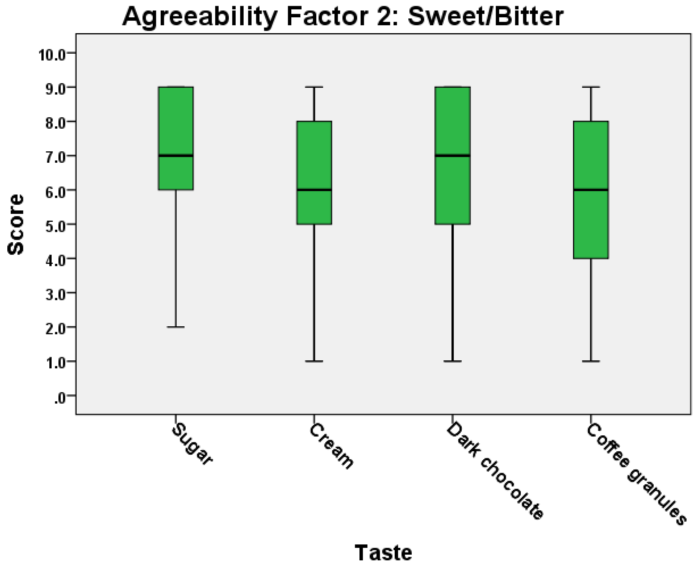

Figure 3.6.4. Boxplot of taste agreeabilities signified by factor 2, sweet/bitter

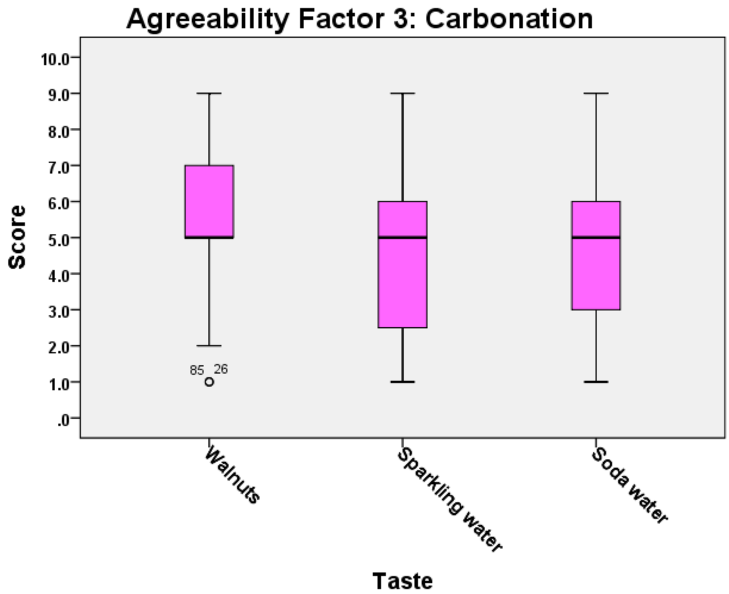

Figure 3.6.5. Boxplot of taste agreeability's signified by factor 3, carbonation

4. Discussion

This study identified a number of intense and agreeable sensory and chemesthetic stimuli, which may be useful in the development of treatments for dysphagia. It also identified 6 groups of perceived intense and 6 perceived agreeable tastes signified by common or opposing factors, and identified a number of weak to modest correlations between taste intensity and agreeability. The study also determined that while medium and non-tasters showed no difference in their perception of taste for the majority of tastes tested, there was a difference between these groups in relation to perceived intensity of fennel and the perceived agreeability of both fudge and black pepper.

4.1 Participants

In contrast to other studies using only female participants (Essicke *et al* 2003) the number of medium tasters and in particular, the number of supertasters was low in this female population. While cut-offs for papillae count between groups were in line with results from previous studies (Essicke *et al* 2003; Bakke et al. 2011) the study design or the sample population chosen may have influenced the result. In respect of study design the use of PROP as a predictor was deemed unwarranted as the method used here was based on Cruickshans *et al* (2009) and Fischer *et al* (2013). Using PROP or reviewing the protocol employed in this study may test the validity of the groupings allocated in this study.

Furthermore this sample may be unrepresentative of the female population, or indeed the Irish population may have lower numbers of super and medium tasters relative to other populations. Few studies have assessed the number of taster categories within the Irish adult female population and as an island with traditionally low immigration a more homogenous population may exist (Heutink and Oostra 2002), with respect to papillae density. This cannot be casually assumed however as a study by Feeney (2014) on Irish children using PROP had 27.5% classified of participants as nontasters, 49.1% as medium tasters and 22.4% as supertasters which is broadly in line with other studies internationally. Segovia *et al* (2002), on the other hand, found a significantly higher density of fungiform papillae in children than in adults, which shows fungiform papillae atrophy with age. In the absence of evidence vis-à-vis fungiform papillae density of a comparative group this research suggests that the participants in this study were different to other populations.

4.2 Identification of intense or agreeable stimuli

This study identified a number of particularly intense stimuli and agreeable stimuli. Intense tastes were identified as having a high median, small range, high minimum score and least variance (table 3.2.1). Raw onion, pure lemon juice had the highest intensity (min. score of 6), followed by strong goats cheese, vinegar, whiskey, coffee granules and mints (min. score of 5). These tastes had low variance indicating a good consensus among participants in relation to their perceived intensity. It is interesting that of the strong tastes identified, four, raw onion, pure lemon juice, coffee granules and vinegar were signified by the factor strong/provoking by factor analysis. It is possible that there may be additional reasons why not all of these intense tastes were identified by factor analysis.

More variance was observed among the tastes in relation to perceived agreeability indicating lower consensus regarding agreeability among participants. Tastes considered most agreeable (minimum score of 2/3) and high median (7/8) were minty chewing gum (min. 3), fudge, sugar and water. Other tastes with a high median (8) included mints and smoky bacon. Sweet tastes such as sugar, hard meringue, maple syrup, vanilla and dark chocolate were also considered agreeable with a median of 7, while more savoury tastes such as parmesan cheese, smoked salmon, goats cheese and soy sauce were also rated as agreeable (7/8).

Factor Analysis was undertaken to determine whether the tastes would group or summarise together on the basis of underlying indicators or factors (Pallant, 2013). This analysis has the potential to reduce a large number of variables to a smaller group that are related to one factor, for instance in this study a number of very intense tastes previously identified could be summarised into a group based on strong or provoking tastes.

It is worth noting that the data obtained from the taste questionnaire was deemed unsuitable for factor analysis based on results of the Bartlett's test of sphericity and a Kaiser-Meyer-Olkin (KMO) test. This may be due to the smaller than optimal ratio of cases (number of respondents) to each variable (taste intensity / agreeability) which was 2:1. It has been suggested that the ideal sample size should be >150 with a ratio of 5 cases to each variable (Pallent, 2013), in this respect, it is noteworthy that not all respondents answered all questions, which reduces the case to variable ratio further. While the missing data may influence the power of the factor analysis, it remains the most appropriate tool to obtain summarised taste groupings from the data. Furthermore, the ideal sample size may depend on the strength of the factors signifying the data, *Beavers et al* (2013) suggest that if the factors have 4 or more variable loadings of 0.6, as is the case for many of the factors obtained in this study then the sample size is irrelevant. It is noteworthy that this is a pilot study and subsequent studies will verify the factors obtained here.

Eight strong/provoking tastes factored strongly together in terms of taste intensity (see Figures 3.5.2 and 3.5.3). Previous research has examined two of these chemesthetic stimuli, pure lemon juice and salt (Pelletier *et al* 2006; Todd *et al* 2012). Lemon juice demonstrated the highest factor score in this group. This corresponds well with the literature on the swallow modulating effects of as previous studies examined the effect of sour bolus on swallowing pressure (Pelletier et al. (2006), and efficiency of oropharyngeal swallowing (Logemann *et al* 1995). This may indicate that other tastes that are identified here as being strong/provoking may evoke similar effects on swallowing. Some intense tastes are not palatable, which may make their use in treating dysphagia more difficult. In this respect the four tastes that were identified as spicy/tangy or herbal by factor analysis of intensity may prove to be more useful in that they may be more palatable. This is particularly interesting as factor analysis of agreeability scales indicate a similar grouping of tangy or bitter tastes in addition to herbal tastes (agreeability, factor 1: herbal and tangy), the median score for these taste was 5 indicating that they were perceived as neither agreeable nor disagreeable to many of the participants. It is notable that exposure to spicy foods enhances liking (Stevenson and Yeomans 1995). This may aid patient compliance if used for therapeutic purposes. Recent research into capsaicin, a component of chilli peppers that activates the trigeminal nerve demonstrates an ability to modulate cough and swallow reflex (Ebihara *et al* 2005). To date there is a dearth of studies into the usefulness of other spicy/tangy and herbal stimuli in dysphagia research, despite indications that cohorts vulnerable to dysphagia, people with Alzheimer's disease find highly seasoned, spicy, and sweet foods more satisfying (Easterling *et al* 2008).

Studies which observed swallow modulating effects of salt were confined to its use in conjunction with other tastes such as citric acid. There may be an unknown synergy factor between these tastes, for example lemon Juice, vodka, vinegar, raw onion, raw garlic and table salt all activate chemesthesis (Silver 1999). Hyperadditive relationships or enhancement or synergism can occur whereby there is a greater taste intensity in a mixture of tastes than would be expected (Lawless and Heymann 2010). Indeed, an addition of even small amounts in mixtures can produce strong taste sensations. The most well-known of these trace tastes are umami and various salts (Lawless and Heymann 2010). In contrast there can also be inhibitory or masking interactions between tastes as observed by Pelletier and Lawless (2003) using sucrose and salt.

Carbonation, also a chemesthetic stimulus, is a factor identified by both intensity and agreeability and has been reported to improve swallowing in individuals with oropharyngeal dysphagia (Bulow *et al* 2003). The reason for the inclusion of walnuts by this factor is unclear. The identification by factor analysis of other stimuli already under investigation such as strong tastes and carbonation is interesting and perhaps validates the use of this analysis. The broad range of stimuli identified by the factor analysis is an encouraging outcome as this creates the potential for a large number of tastes or combinations to test further and may also be useful when catering for individual tastes. Finally, in relation to taste intensity it may be of interest to investigate rich tastes which comprised of fat and sweet in addition to walnuts.

The results of this study concur with current literature in identifying and grouping strong and/or provoking tastes, carbonation, and chilli (capsaicin) but also suggest new stimuli that may be useful in future dysphagic research. In this regard, herbs and rich stimuli warrant further investigation. Indeed it is known that aroma compounds responsible for citrus, herbal, mint, and pine-like aromas are usually potent in the parts-per million range while food flavours such as methoxy pyrazine compounds that occur in bell peppers are so potent that they are detectable in the parts per billion range (Lawless and Heymann 2010). Should a handful of the vast array of taste and aroma stimuli available to the food industry be recognised to have positive swallow modulating effects there would be numerous combinations available. Indeed, it is possible that combination stimuli may be more effective in activating a physiological reaction such as the release of substance P' (Kajii *et al* 2002; Ebihara *et al* 2005) thereby modulating nociception to achieve improved swallow reflex.

In relation to group differences regarding perception of taste, this study focused on distinctions which existed between medium and non-tasters. Supertasters were excluded due to low number in the sample (n-6) as the ability of this number of participants to represent the super-taster population was a questionable. There were very few differences between the groups in terms of taste intensity or agreeability. If these results are reflected when participants are asked to rate actual tastes, it may indicate that prospective patients may not need to be tested for either PROP or fungiform papillae count as it will be unlikely to impact on the suitability of a taste stimulus treatment. Finally, when participants were credited with separate scores (z-scores) in relation to each factor, no difference between medium and non-taster groups was observed for any factor in relation to intensity or agreeability.

Fennel showed a difference in perceived intensity between medium and non-tasters, many of the participants did not answer this question (53), but of those who did non-tasters perceived it to be more intense than medium tasters. This is in contrast to the results of other studies whereby intensity of taste increases in relation to the number of fungiform papillae (Bartoshuk 2000). When compared to non-tasters, supertasters reportedly experience greater subjective burn and irritancy from capsaicin and other spicy substances (Karrer and Bartoshuk 1991) greater perception of fattiness of fat-containing foods (Duffy *et al* 1996) and sweetness of sweet food (Schonhof 2004). As aforementioned, aromatic herbal tastes are identified as a factor for intensity (Factor 3; aromatic herbs), with the inclusion of fennel. As this is a potentially useful and unexplored group of tastes (herbs) it will be important to research any differences between taster groups in more detail, particularly with the inclusion of supertasters.

In terms of agreeability non-tasters rate fudge and black pepper as more agreeable than medium tasters. This finding is not surprising as non-tasters have a higher taste threshold for both sweet and spicy food than medium and super-tasters (Miller and Reedy 1990). Indeed previous studies (Tourila 1996) have observed an inversed U- shape correlation between palatability and intensity for sweet tastes such as sucrose. Consequently it is suggested that there is a hedonic optimum or best concentration.

Black pepper is perceived to be more agreeable to non-tasters than medium tasters. This relates well to the weak negative correlation (r=-.23) between perceived agreeability and intensity for this taste. This again correlates well with previous research. Karrer and Bartoshuk (1991) showed that in comparison to non-tasters, medium and supertasters reportedly experience greater subjective burn and irritancy from capsaicin and other spicy substances.

A limited number of correlations between intensity and agreeability were observed in this study, suggesting that for this female group perceived palatability is not an issue for many of the tastes of interest identified by factor analysis.

The limited number of moderate/weak correlations creates a potential for useful palatable tastes given that intensity can be increased without altering palatability, assuming that it is palatable to begin with. The usefulness of tastes that display strong negative correlations in dysphagic treatment is debatable due to the potential for un-palatability and non-compliance (Chee *et al* 2005). Future studies need to look at palatability in detail using actual tastes rather than perceived taste.

4.3 Conclusions and future directions

Overall this pilot study identifies a number of tastes that are perceived to be very intense and also those that are deemed most agreeable to the majority of participants. There is a relatively broad range of tastes determined to be agreeable, these include a number of savoury as well as sweet tastes. Tastes that are deemed intense are of interest in future research as a number of strong and provoking tastes grouped together in factor analysis, indicateing an underlying factor which links these tastes. The identification of strong/provoking tastes and carbonation correlates well with current research into sensory stimuli for use in dysphagia. Perhaps of greater interest is the identification of new tastes that warrant future investigation such as herbal, aromatic and spicy tastes. To date these are unexplored stimuli and present a new avenue for dysphagic research. It is important to note that the results of this study need to be further explored using actual rather than perceived tastes. While no differences between medium and non-tasters were identified in terms of their perceived taste intensity or agreeability a limitation of this study is the exclusion of a supertaster group. It may be that this group does show different taste perception which may require further exploration. Finally, the limited number of weak and modest ($r<0.5$) correlations observed between taste agreeability and intensity are advantageous in terms of dysphagic research given the identification of intense and spicy/tangy and herbal tastes coupled with concerns relating to palatability of intense tastes.

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Appendices

Appendix 1 **Recruitment Email and Poster**

UNIVERSITY of LIMERICK

OLLSCOIL LUIMNIGH

We are MSc students who are looking for participants for a taste study.

Would you like to know if you are you a supertaster or maybe a non-taster?
We can tell you if you are willing to give us 10 minutes of your time!
And you can help us by telling us what you think about different tastes.

If you are female, aged between 18-50 years, a non-smoker of at least 6 months duration, don't have allergies or a history of ear, nose, mouth and throat problems, including diagnosed sensory problems related to smell and taste, are not on medications which affect your sense of taste and smell, and don't have a cough, cold or any respiratory infection on the day of in question, we would appreciate your help in our study on taste….

Interested? Please come to the Speech & Language Therapy Clinic in the Health Sciences Building (across the Living Bridge) anytime on ______day, the _th of January.

This research study has received Ethics approval from the Education and Health Sciences Research Ethics Committee (2013_10_08_ EHS). If you have any concerns about this study and wish to contact someone independent you may contact: Chairman, Education and Health Sciences Research Ethics Committee, EHS Faculty Office, University of Limerick, Tel 00 353 (061) 234101

WANTED!

FEMALE VOLUNTEERS!

ARE YOU A SUPERTASTER OR A NON-TASTER?

If you are female, aged between 18-50 years, a non-smoker of at least 6 months duration, don't have allergies or a history of ear nose and throat problems, don't have diagnosed sensory problems related to smell and taste, are not on medications which affect your sense of taste and smell, don't have gum disease and don't have a cough, cold or any respiratory infection on the day of in question, we would appreciate your help in our study on taste….

Interested? Please come to the Speech & Language Therapy Clinic in the Health Sciences Building (across the Living Bridge)

Anytime between 10am and 5pm on Monday 3rd/Tuesday 4th of February.

Just give us 10 minutes of your time, answer questions about your taste preferences.

We'll put blue food dye on your tongue and you can find out!

REWARD

TEA, COFFEE AND BISCUITS

This research study has received Ethics approval from the Education and Health Sciences Research Ethics Committee (2013_10_08_ EHS). If you have any concerns about this study and wish to contact someone independent you may contact: Chairman, Education and Health Sciences Research Ethics Committee, EHS Faculty Office, University of Limerick, Tel 00 353 (061) 234101

DEPARTMENT OF CLINICAL THERAPIES

INFORMATION SHEET

The name of this study is…..

'The identification of perceived intensity and agreeability of sensory and chemesthetic properties of selected taste stimuli among a selected non-dysphagic population'.

The purpose of this information sheet is to give you the information about our study so you can make an informed choice to participate or not.

To participate you must be……………

Female	**Aged between 18-50 years**
A non-smoker of at least 6 months duration	

You must not…………….

Have allergies	**Have a history of ear nose and throat problems including oral surgery**
Have diagnosed sensory problems related to smell and taste	**Have gum disease**
Be on medications which affect your sense of taste and smell	**Have a cough, cold or any respiratory infection today**

We want to find out about what you think about various tastes. We also want to count the number of fungiform papillae on the tip of your tongue to see if you are a supertaster, average taste or what's called a non-taster. This will help us understand if your tastes preferences are related to the number of papillae on your tongue. We will ask you to rate a number of tastes in one room, and then we will take you to another room to place some blue food dye on the tip of your tongue. We will take a photo so we can count the papillae. Then you can wipe your tongue or take a drink of water to cleanse your tongue. Have a cup of coffee if you want and while you do that we can count your papillae and tell you which taste category you are in.

If you are happy to participate in our study, please sign the consent form, and then we can start.

This study has received ethical approval from the University of Limerick Research Ethics Committee. If you have concerns regarding this study, please contact: Chairman, Education and Health Sciences, Research Ethics Committee, EHS Faculty Office, University of Limerick, Tel (061) 234101 Email : hsresearchethics@ul.ie

DEPARTMENT OF CLINICAL THERAPIES

Taste study

'The identification of perceived intensity and agreeability of sensory and chemesthetic properties of selected taste stimuli among a selected non-dysphagic population'.

Consent Form

I ______________________________(*please print name)*
hereby give my consent to take part in the above study.
I understand my data will be anonymised.
I do not have any known allergies
I am aware of the potential risks and understand I can opt of the study at any stage.

Signed:_________________________________

Date:__________________________________

This survey has received ethical approval from the University of Limerick Research Ethics Committee. If you have concerns regarding this study, please contact: Chairman, Education and Health Sciences, Research Ethics Committee, EHS Faculty Office, University of Limerick, Tel (061) 234101 Email : hsresearchethics@ul.ie

Appendix 4 Questionnaire sample page

DEPARTMENT OF CLINICAL THERAPIES

'The identification of perceived intensity and agreeability of sensory and chemesthetic properties of selected taste stimuli among a selected non-dysphagic population'.

Participant code:

Item	**Ratings**
1 **Fudge**	**How would you describe the intensity or strength of this taste? Tick one box to indicate your opinion on the overall intensity of this taste.** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely weak Neither strong & powerful Extremely strong & insubstantial nor weak & insubstantial & powerful **How much do you like/dislike this taste? Tick one box which best reflects your overall liking of this taste?** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Absolutely hate it Neither hate it Absolutely love it nor love it
2 **Raw garlic**	**How would you describe the intensity or strength of this taste? Tick one box to indicate your opinion on the overall intensity of this taste.** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely weak Neither strong & powerful Extremely strong & insubstantial nor weak & insubstantial & powerful **How much do you like/dislike this taste? Tick one box which best reflects your overall liking of this taste?** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Absolutely hate it Neither hate it Absolutely love it nor love it
3 **Black pepper**	**How would you describe the intensity or strength of this taste? Tick one box to indicate your opinion on the overall intensity of this taste.** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely weak Neither strong & powerful Extremely strong & insubstantial nor weak & insubstantial & powerful **How much do you like/dislike this taste? Tick one box which best reflects your overall liking of this taste?** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Absolutely hate it Neither hate it Absolutely love it nor love it
4 **Cooking oil**	**How would you describe the intensity or strength of this taste? Tick one box to indicate your opinion on the overall intensity of this taste.** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Extremely weak Neither strong & powerful Extremely strong & insubstantial nor weak & insubstantial & powerful **How much do you like/dislike this taste? Tick one box which best reflects your overall liking of this taste?** ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ Absolutely hate it Neither hate it Absolutely love it nor love it

Appendix 5 **List of Tastes**

Beer	Black pepper	Chilli powder	Coffee granules	Cooking oil
Cream	Cumin	Dark chocolate	Fudge	Gouda cheese
Hard meringue	Kidney beans	Lavender oil	Liver	Mackerel
Maple syrup	Mint herb	Mints	Minty chewing gum	Natural yoghurt
Non-flavoured antacids	Parmesan cheese	Plain pasta	Plain porridge	Pure lemon juice
Raw fennel	Raw garlic	Raw ginger	Raw jalepeno pepper	Raw onion
Raw parsley	Raw thyme	Red meat cooked rare	Rosemary	Rosewater
Seawater	Seaweed	Smoked salmon	Smoked teas	Smokey bacon
Sodawater	Soy sauce	Sparkling water	Strong goats cheese	Sugar
Table salt	Tonic water	Unsalted margarine	Vanilla	Vinegar
Vodka	Walnuts	Water	Whiskey	

Appendix 6 **Tables of Normality: Intensity and agreeability**

Table of Normality: Intensity

Intensity	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Beer	0.187	108	0.000	0.907	108	0.000
Black Pepper	0.181	106	0.000	0.898	106	0.000
Chilli Powder	0.256	107	0.000	0.755	107	0.000
Coffee Granules	0.228	102	0.000	0.845	102	0.000
Cooking Oil	0.211	104	0.000	0.935	104	0.000
Cream	0.179	108	0.000	0.956	108	0.001
Cumin	0.172	80	0.000	0.905	80	0.000
Dark Chocolate	0.193	108	0.000	0.892	108	0.000
Fudge	0.166	108	0.000	0.946	108	0.000
Gouda Cheese	0.166	77	0.000	0.942	77	0.002
Hard Meringue	0.177	91	0.000	0.945	91	0.001
Kidney Beans	0.257	99	0.000	0.915	99	0.000
Lavender Oil	0.158	71	0.000	0.908	71	0.000
Liver	0.191	65	0.000	0.889	65	0.000
Mackerel	0.171	89	0.000	0.893	89	0.000
Maple Syrup	0.175	105	0.000	0.93	105	0.000
Mint Herb	0.198	100	0.000	0.905	100	0.000
Mints	0.198	108	0.000	0.889	108	0.000
Minty Chewing Gum	0.204	108	0.000	0.865	108	0.000
Natural Yoghurt	0.197	106	0.000	0.927	106	0.000
Non Flavoured Antacids	0.154	85	0.000	0.952	85	0.003
Parmesan Cheese	0.18	106	0.000	0.908	106	0.000
Plain Pasta	0.194	106	0.000	0.899	106	0.000
Plain Porridge	0.201	107	0.000	0.927	107	0.000
Pure Lemon Juice	0.353	108	0.000	0.71	108	0.000
Raw Fennel	0.147	55	0.005	0.911	55	0.001
Raw Garlic	0.285	107	0.000	0.708	107	0.000
Raw Ginger	0.213	96	0.000	0.843	96	0.000
Raw Jalepeno Pepper	0.368	94	0.000	0.637	94	0.000
Raw Onion	0.273	105	0.000	0.791	105	0.000
Raw Parsley	0.156	100	0.000	0.926	100	0.000
Raw Thyme	0.195	82	0.000	0.925	82	0.000
Red Meat Cooked Rare	0.14	94	0.000	0.943	94	0.000
Rosemary	0.196	90	0.000	0.923	90	0.000
Rosewater	0.171	60	0.000	0.956	60	0.029
Seawater	0.233	103	0.000	0.809	103	0.000
Seaweed	0.225	55	0.000	0.916	55	0.001
Smoked Salmon	0.142	99	0.000	0.912	99	0.000
Smoked Teas	0.197	44	0.000	0.921	44	0.005
Smokey Bacon	0.213	102	0.000	0.914	102	0.000
Sodawater	0.21	98	0.000	0.937	98	0.000
Soy Sauce	0.201	105	0.000	0.916	105	0.000
Sparkling Water	0.186	107	0.000	0.946	107	0.000
Strong Goats Cheese	0.278	94	0.000	0.789	94	0.000
Sugar	0.176	108	0.000	0.904	108	0.000
Tablesalt	0.142	108	0.000	0.89	108	0.000
Tonic Water	0.177	99	0.000	0.93	99	0.000
Unsalted Margarine	0.182	95	0.000	0.948	95	0.001
Vanilla	0.165	106	0.000	0.931	106	0.000
Vinegar	0.307	107	0.000	0.775	107	0.000
Vodka	0.271	102	0.000	0.632	102	0.000
Walnuts	0.214	98	0.000	0.904	98	0.000
Water	0.308	107	0.000	0.746	107	0.000
Whiskey	0.403	107	0.000	0.607	107	0.000

Table of Normality: Agreeability

Agreeability	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Beer	0.151	108	0.000	0.913	108	0.000
Black Pepper	0.165	105	0.000	0.917	105	0.000
Chilli Powder	0.185	107	0.000	0.897	107	0.000
Coffee Granules	0.159	102	0.000	0.889	102	0.000
Cooking Oil	0.321	101	0.000	0.845	101	0.000
Cream	0.159	108	0.000	0.915	108	0.000
Cumin	0.148	80	0.000	0.927	80	0.000
Dark Chocolate	0.16	105	0.000	0.881	105	0.000
Fudge	0.162	108	0.000	0.924	108	0.000
Gouda Cheese	0.143	76	0.001	0.909	76	0.000
Hard Meringue	0.145	91	0.000	0.89	91	0.000
Kidney Beans	0.158	99	0.000	0.951	99	0.001
Lavender Oil	0.175	72	0.000	0.932	72	0.001
Liver	0.212	65	0.000	0.835	65	0.000
Mackerel	0.173	90	0.000	0.906	90	0.000
Maple Syrup	0.142	105	0.000	0.924	105	0.000
Mint Herb	0.155	100	0.000	0.9	100	0.000
Mints	0.184	108	0.000	0.867	108	0.000
Minty Chewing Gum	0.167	108	0.000	0.895	108	0.000
Natural Yoghurt	0.14	106	0.000	0.933	106	0.000
Non Flavoured Antacids	0.315	83	0.000	0.841	83	0.000
Parmesan Cheese	0.2	106	0.000	0.857	106	0.000
Plain Pasta	0.209	106	0.000	0.927	106	0.000
Plain Porridge	0.14	107	0.000	0.934	107	0.000
Pure Lemon Juice	0.135	108	0.000	0.938	108	0.000
Raw Fennel	0.153	55	0.002	0.955	55	0.038
Raw Garlic	0.185	107	0.000	0.921	107	0.000
Raw Ginger	0.137	95	0.000	0.931	95	0.000
Raw Jalepeno Pepper	0.137	94	0.000	0.904	94	0.000
Raw Onion	0.2	105	0.000	0.912	105	0.000
Raw Parsley	0.191	100	0.000	0.938	100	0.000
Raw Thyme	0.175	82	0.000	0.944	82	0.001
Red Meat Cooked Rare	0.147	95	0.000	0.896	95	0.000
Rosemary	0.143	90	0.000	0.931	90	0.000
Rosewater	0.286	60	0.000	0.9	60	0.000
Seawater	0.27	103	0.000	0.801	103	0.000
Seaweed	0.172	55	0.000	0.927	55	0.002
Smoked Salmon	0.181	101	0.000	0.86	101	0.000
Smoked Teas	0.189	45	0.000	0.943	45	0.029
Smokey Bacon	0.192	102	0.000	0.837	102	0.000
Sodawater	0.245	97	0.000	0.917	97	0.000
Soy Sauce	0.201	104	0.000	0.879	104	0.000
Sparkling Water	0.144	108	0.000	0.93	108	0.000
Strong Goats Cheese	0.216	94	0.000	0.807	94	0.000
Sugar	0.15	108	0.000	0.903	108	0.000
Tablesalt	0.153	108	0.000	0.948	108	0.000
Tonic Water	0.112	99	0.004	0.947	99	0.001
Unsalted Margarine	0.223	95	0.000	0.88	95	0.000
Vanilla	0.192	107	0.000	0.882	107	0.000
Vinegar	0.115	106	0.001	0.931	106	0.000
Vodka	0.136	103	0.000	0.937	103	0.000
Walnuts	0.159	100	0.000	0.948	100	0.001
Water	0.252	107	0.000	0.801	107	0.000
Whiskey	0.17	107	0.000	0.882	107	0.000

Appendix 7 Tables of descriptive statistics for intensity and agreeability

Table of descriptive statistics for intensity

Intensity	N		Median	Variance	Range	Min.	Max.	Percentiles		
	Valid	Missing						25	50	75
Pure lemon juice	108	0	9	0.7	3	6	9	8	9	9
Raw garlic	107	1	9	1.1	6	3	9	8	9	9
Raw jalepeno pepper	94	14	9	1	5	4	9	8	9	9
Vinegar	107	1	9	0.9	4	5	9	8	9	9
Vodka	102	6	9	2.5	8	1	9	8	9	9
Whiskey	107	1	9	0.6	4	5	9	8	9	9
Black pepper	106	2	8	1.3	5	4	9	7	8	8
Chilli powder	107	1	8	1.1	6	3	9	8	8	9
Coffee granules	102	6	8	1.1	4	5	9	7	8	9
Dark chocolate	108	0	8	1.4	6	3	9	7	8	8
Liver	65	43	8	2.1	5	4	9	6	8	9
Mints	108	0	8	1.1	4	5	9	7	8	8
Minty chewing gum	108	0	8	1.5	5	4	9	7	8	9
Raw ginger	96	12	8	1.4	6	3	9	7	8	9
Raw onion	105	3	8	0.7	3	6	9	8	8	9
Seawater	103	5	8	1.6	6	3	9	7	8	9
Strong goats cheese	94	14	8	1	4	5	9	8	8	9
Beer	108	0	7	1.8	6	3	9	6	7	8
Cumin	80	28	7	1.6	5	4	9	7	7	8
Gouda cheese	77	31	7	3.2	8	1	9	5	7	7
Lavender oil	71	37	7	2.4	6	3	9	6	7	9
Mackerel	89	19	7	2.2	7	2	9	6	7	8
Maple syrup	105	3	7	1.3	5	4	9	6	7	8
Mint herb	100	8	7	1.8	6	3	9	7	7	8
Parmesan cheese	106	2	7	2.3	7	2	9	6	7	8
Raw fennel	55	53	7	2.1	5	4	9	6	7	8
Raw thyme	82	26	7	1.5	5	4	9	6	7	8
Rosemary	90	18	7	2.2	7	2	9	6	7	8
Seaweed	55	53	7	2.7	6	3	9	5	7	8
Smoked salmon	99	9	7	2.3	6	3	9	6	7	8
Smoked teas	44	64	7	1.8	5	4	9	6	7	8
Smokey bacon	102	6	7	1.3	5	4	9	7	7	8
Soy sauce	105	3	7	1.6	7	2	9	6	7	8
Sugar	108	0	7	1.8	8	1	9	6	7	8
Table salt	108	0	7	2	8	1	9	6	7	8
Vanilla	106	2	7	3.2	7	2	9	6	7	8
Fudge	108	0	6	2.6	8	1	9	5	6	7
Natural yoghurt	106	2	6	4.6	8	1	9	4	6	7
Raw parsley	100	8	6	3.6	8	1	9	5	6	7
Red meat cooked rare	94	14	6	1.9	7	2	9	5	6	7
Tonic water	99	9	6	4.5	8	1	9	4	6	7
Walnuts	98	10	6	2.2	7	2	9	5	6	7
Cooking oil	104	4	5	3.3	8	1	9	3	5	5

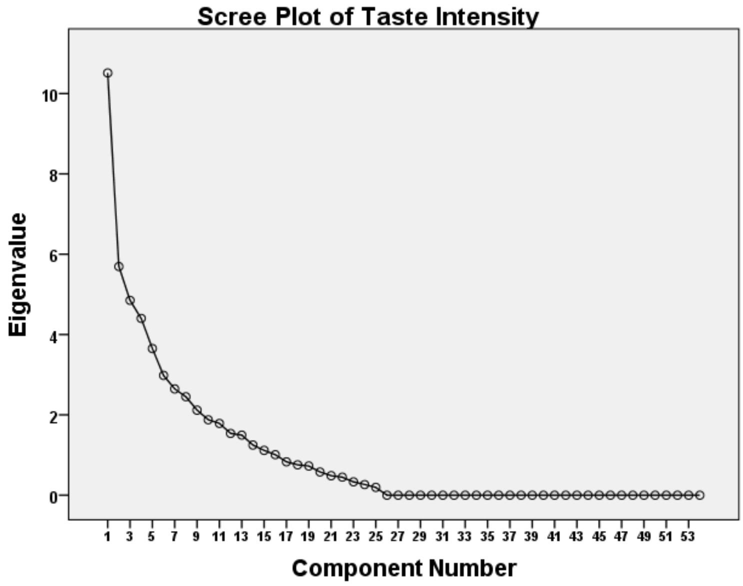
Cream	108	0	5	3.5	8	1	9	3	5	6
Hard meringue	91	17	5	3.6	8	1	9	4	5	7
Kidney beans	99	9	5	2.5	8	1	9	3	5	5
Non-flavoured antacids	85	23	5	4.3	8	1	9	4	5	7
Plain porridge	107	1	5	3.6	8	1	9	2	5	6
Rosewater	60	48	5	3.7	8	1	9	3	5	6
Sodawater	98	10	5	3.8	8	1	9	4	5	7
Sparkling water	107	1	5	4.3	8	1	9	3	5	6
Unsalted margarine	95	13	5	4.1	8	1	9	3	5	6
Plain pasta	106	2	3	2.8	7	1	8	2	3	5
Water	107	1	1	3.7	7	1	8	1	1	5

Table of descriptive statistics for agreeability

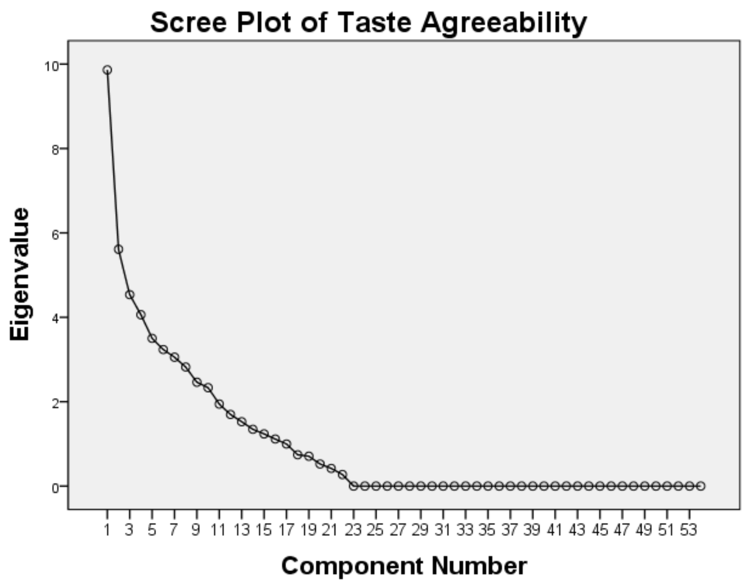
Agreeability	N Valid	N Missing	Median	Variance	Range	Min.	Max.	Percentiles 25	Percentiles 50	Percentiles 75
Mints	108	0	8	2.3	8	1	9	6	8	9
Parmesan cheese	106	2	8	5	8	1	9	5	8	9
Smokey bacon	102	6	8	3.2	8	1	9	6	8	9
Water	107	1	8	2.9	7	2	9	6	8	9
Dark chocolate	105	3	7	6.6	8	1	9	5	7	9
Fudge	108	0	7	2.9	7	2	9	5	7	8
Hard meringue	91	17	7	4.4	8	1	9	5	7	9
Maple syrup	105	3	7	4.4	8	1	9	5	7	8
Mint herb	100	8	7	4.6	8	1	9	5	7	9
Minty chewing gum	108	0	7	2.9	6	3	9	6	7	9
Smoked salmon	101	7	7	7.2	8	1	9	5	7	9
Soy sauce	104	4	7	3.5	8	1	9	6	7	8
Strong goats cheese	94	14	7	10.5	8	1	9	2	7	9
Sugar	108	0	7	3.7	7	2	9	6	7	9
Vanilla	107	1	7	3.2	8	1	9	6	7	9
Beer	108	0	6	7	8	1	9	3	6	7
Black pepper	105	3	6	5.3	8	1	9	5	6	8
Chilli powder	107	1	6	6	8	1	9	5	6	8
Coffee granules	102	6	6	7.2	8	1	9	4	6	8
Cream	108	0	6	5.2	8	1	9	5	6	8
Cumin	80	28	6	4	8	1	9	5	6	8
Gouda cheese	76	32	6	4.7	8	1	9	5	6	8
Mackerel	90	18	6	5.5	8	1	9	5	6	7
Natural yoghurt	106	2	6	4.9	8	1	9	5	6	7
Plain porridge	107	1	6	5.1	8	1	9	5	6	8
Pure lemon juice	108	0	6	5.6	8	1	9	4	6	7
Raw garlic	107	1	6	4.8	8	1	9	4	6	7
Raw onion	105	3	6	5.8	8	1	9	4	6	7
Raw thyme	82	26	6	4.2	8	1	9	4	6	7
Rosemary	90	18	6	3.6	8	1	9	5	6	8
Table salt	108	0	6	4.5	8	1	9	5	6	7
Vinegar	106	2	6	5.2	8	1	9	5	6	8
Cooking oil	101	7	5	2.4	7	1	8	3	5	5
Kidney beans	99	9	5	4.1	8	1	9	5	5	7
Lavender oil	72	36	5	5.5	8	1	9	4	5	7
Non-flavoured antacids	83	25	5	2.8	8	1	9	4	5	5
Plain pasta	106	2	5	2.3	8	1	9	5	5	6
Raw fennel	55	53	5	4.6	8	1	9	4	5	7

Raw ginger	95	13	5	6.2	8	1	9	3	5	7
Raw jalepeno pepper	94	14	5	7.4	8	1	9	2	5	7
Raw parsley	100	8	5	4.2	8	1	9	5	5	7
Red meat cooked rare	95	13	5	8.2	8	1	9	2	5	8
Rosewater	60	48	5	3.3	8	1	9	4	5	6
Seaweed	55	53	5	5.8	8	1	9	3	5	6
Smoked teas	45	63	5	4.5	8	1	9	4	5	6
Sodawater	97	11	5	4.4	8	1	9	3	5	6
Sparkling water	108	0	5	6.2	8	1	9	2	5	6
Tonic water	99	9	5	5.3	8	1	9	3	5	7
Vodka	103	5	5	5.2	8	1	9	2	5	6
Walnuts	100	8	5	4.2	8	1	9	5	5	7
Unsalted margarine	95	13	4	3.4	8	1	9	2	4	5
Whiskey	107	1	4	7.1	8	1	9	1	4	7
Liver	65	43	3	7.5	8	1	9	1	3	6
Seawater	103	5	2	4.8	8	1	9	1	2	4

Appendix 8 Scree plot of exploratory factor analysis showing a levelling of the plot after 6 factors



Scree plot of exploratory factor analysis showing a levelling of the plot after 6 factors



Appendix 9 Factor loading scores for intensity and agreeability

Factor loading scores for Intensity

Intensity	Component					
	1	2	3	4	5	6
Pure lemon juice	.821	.027	.184	.022	.055	.172
Vodka	.749	.021	-.045	.031	.132	-.045
Coffee granules	.737	.145	.124	.205	.194	-.085
Vinegar	.702	.379	-.027	-.087	-.103	.074
Raw onion	.693	-.154	.087	.093	.046	.177
Raw garlic	.638	.050	.182	-.269	-.280	.247
Tablesalt	.630	.224	.114	.132	.088	-.203
Maple syrup	.622	.409	.250	.299	-.187	-.168
Non-flavoured antacids	.579	-.043	.092	-.210	-.036	-.307
Whiskey	.485	-.034	.049	.220	-.013	.373
Fudge	.354	.165	-.005	.171	.153	.019
Chilli powder	.114	.807	-.007	-.147	-.055	-.120
Raw ginger	.095	.756	.112	.282	-.005	.248
Dark chocolate	.241	.722	.295	.034	.035	-.131
Mackerel	-.150	.670	.348	.211	.079	.313
Seawater	.335	.644	-.064	.007	-.090	.177
Tonic water	-.052	.608	-.031	-.061	.098	-.151
Mint herb	.306	.570	.483	-.036	.075	.206
Smoked salmon	-.028	.570	.092	.455	.190	.271
Sugar	.344	.501	-.351	.277	.324	.220
Cooking oil	.025	.469	.081	-.019	-.230	-.115
Soy sauce	.325	.100	.791	-.160	.004	-.058
Plain porridge	-.102	.111	.690	.193	-.202	-.173
Raw thyme	.189	.284	.682	-.088	-.064	.104
Lavender oil	.088	-.096	.618	.063	.196	.408
Raw fennel	.281	-.202	.605	.257	.107	-.088
Cumin	-.051	.270	.591	.473	.190	.123
Parmesan cheese	.260	.413	.505	.218	.200	.194
Smoked teas	-.086	.239	.494	.282	.436	.063
Black pepper	.354	-.260	-.488	-.364	.186	.311
Strong goats cheese	.184	-.280	.432	.420	.108	-.068
Hard meringue	-.043	.225	.032	.748	-.315	.019
Walnuts	.003	-.147	.121	.655	.051	-.066
Cream	.198	.304	.008	.645	-.249	-.192
Red meat cooked rare	.119	-.171	.184	.606	.321	.049
Smokey bacon	.230	-.290	-.103	.589	.022	.228
Gouda cheese	-.007	.124	.048	.543	-.067	.030
Natural yoghurt	.125	.114	.093	.450	-.024	-.432
Kidney beans	.034	.352	.298	.383	-.053	-.220
Vanilla	.270	.347	.279	.375	.236	.289
Sparkling water	-.131	-.049	.058	.107	-.809	.108
Soda water	-.134	.249	.117	.016	-.786	-.056
Rawparsley	-.116	.104	.252	-.033	.736	-.097
Mints	.398	.173	-.104	-.166	.575	.334
Seaweed	.130	-.242	.459	-.118	.575	-.143
Rosemary	.168	.207	.409	.168	.506	.475
Liver	-.235	.043	.014	.395	.503	.426
Unsalted margarine	-.022	.369	-.124	.412	-.426	-.252
Plain pasta	.287	-.316	.154	.213	.038	-.630
Raw jalepeno pepper	.407	.060	.163	.024	.186	.560
Rosewater	.376	.110	.044	.202	.402	-.553
Minty chewing gum	.361	.373	-.010	-.315	.259	.466
Beer	.244	-.128	.104	.143	-.290	.434
Water	-.271	.220	.338	-.317	.121	-.376
Eigenvalues	*10.5*	*5.7*	*4.9*	*4.4*	*3.7*	*3*
Variance explained (%)	*19.5*	*10.5*	*9*	*8.2*	*6.8*	*5.5*
No. of test measures	*8*	*6*	*5*	*4*	*3*	*1*

Factor loading scores for Agreeability

Agreeability	Component					
	1	2	3	4	5	6
Rosemary	.801	-.045	-.191	-.213	.003	.135
Raw onion	.790	.058	.138	.085	.140	.249
Raw ginger	.767	-.056	-.137	.410	.240	.009
Raw thyme	.767	.190	.026	.070	.321	.021
Raw garlic	.759	.212	-.083	-.070	-.244	-.105
Mint herb	.738	-.050	-.122	-.022	.163	-.278
Vanilla	.694	.156	-.054	-.140	.222	-.269
Gouda cheese	.673	.371	-.221	.069	-.296	.336
Black pepper	.669	-.046	.163	-.187	-.069	.306
Pure lemon juice	.660	-.163	.098	-.171	-.190	-.069
Raw parsley	.652	-.265	.062	.475	.120	.143
Parmesan cheese	.625	.506	.047	.383	.042	.061
Soy sauce	.622	.025	-.034	.309	-.115	-.130
Cumin	.589	.036	.183	.271	-.244	.109
Vinegar	.573	-.062	.040	-.066	-.300	.236
Table salt	.551	-.047	.075	.041	.078	.252
Mackerel	.367	-.318	.155	.241	.175	.152
Sugar	-.115	.785	-.112	.110	-.086	.313
Cream	-.084	.740	.276	-.021	.022	.123
Dark chocolate	.378	.687	.032	-.114	.110	-.170
Raw fennel	.262	-.660	-.053	.204	.321	.100
Coffee granules	.262	.648	.066	.101	.229	.057
Seawater	.333	-.577	-.051	.057	.066	-.094
Minty chewing gum	.044	.567	.137	.165	-.247	-.231
ChillI powder	.433	.460	.345	-.091	-.169	-.057
Natural yoghurt	.121	.410	-.083	-.239	.127	-.101
Mints	.033	.366	-.044	-.019	.025	.178
Walnuts	.167	-.059	.853	.211	.062	-.093
Sparkling water	.036	.375	.744	-.019	.030	-.017
Sodawater	-.228	-.203	.706	-.306	.222	.198
Tonic water	-.008	.242	.512	.017	.351	-.379
Unsalted margarine	-.390	.047	.493	.239	-.162	.361
Cooking oil	.324	.255	.449	-.097	-.082	.356
Rosewater	.091	-.311	.438	.382	.186	-.001
Raw jalapeno pepper	.265	.261	.436	.005	-.346	-.079
Liver	-.198	-.131	.333	.037	.250	.193
Water	.072	-.056	-.149	.031	-.148	.045
Lavender oil	.250	-.073	-.190	.778	-.058	-.109
Smoked tea	.159	.009	.440	.724	-.193	.177
Plain porridge	.197	-.155	-.074	-.673	.280	-.358
Maple syrup	-.413	.226	-.231	.497	.370	-.048
Beer	.192	-.084	.128	-.481	-.083	.272
Plain pasta	.117	.318	.328	-.465	.036	-.113
Kidney beans	-.048	.056	-.094	-.247	.047	-.002
Whiskey	.125	-.033	.128	-.202	.746	.065
Vodka	.148	-.015	.211	-.301	.744	.182
Strong goats cheese	.194	-.006	-.461	.140	.631	-.173
Seaweed	.392	.023	-.097	-.004	-.557	-.125
Fudge	-.235	.224	-.127	-.204	.080	.648
Smokey bacon	.342	.176	-.020	-.204	-.149	.601
Hard meringue	.074	.269	-.305	-.025	.131	.585
Smoked salmon	.057	-.173	.040	.279	.489	.528
Non-flavoured antacids	.176	.036	.191	.138	.044	.525
Red meat cooked rare	.063	-.208	.110	.161	.132	.465
Eigenvalues	*9.9*	*5.6*	*4.5*	*4.1*	*3.5*	*3.2*
Variance explained (%)	*18.3*	*10.4*	*8.4*	*7.5*	*6.4*	*6*
No. of test measres	*12*	*4*	*3*	*3*	*3*	*2*