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Exploring how age influences sensory perception, thirst and hunger during the consumption of oral nutritional supplements using the check-all-that-apply methodology

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1. Introduction

The population aged 60 years or older is growing by 3% annually and is predicted to reach 2 billion by 2050 (United Nations, 2017). Meeting the nutritional requirements of this older cohort is essential, to maintain their health and quality of life (Leslie & Hankey, 2015; Doets & Kremer, 2016; Ruark *et al.,* 2016). However, food and caloric intake of the older adult ~~elderly~~ is often insufficient (Field & Duizer, 2016) with up to 10% of community dwelling older adults suffering from undernutrition (Doets & Kremer, 2016).

There are numerous factors contributing to undernutrition in older adults including loss of appetite (Donini, Savina & Cannella, 2003; Leslie & Hankey, 2015). The impairment of sensory perception in relation to taste and smell with increasing age reduces food interest (Doets & Kremer, 2016; Methven, Jiménez-Pranteda & Lawlor, 2016). As a result of the impairments in sensory function with age, there is a growing requirement for the development of food products with optimum sensory properties for older adults. It is therefore essential to conduct sensory evaluations with older adults to improve our understanding of their sensory perception and preferences (Maitre, Symoneaux & Sulmont-Rossé, 2015; Methven, Jiménez-Pranteda & Lawlor, 2016). This remains a largely under researched area of sensory science due to the challenges associated with this age group (Methven, Jiménez-Pranteda & Lawlor, 2016). There is a need to determine which sensory methods can be deemed affective for use with older adults.

The Check-all-that-apply (CATA) method has been used increasingly to assess the sensory properties of food and beverages (Adams *et al.,* 2007; Methven, Jiménez-Pranteda & Lawlor, 2016; Grasso *et al.,* 2017). This method comprises a multiple-choice questionnaire whereby panellists are asked to select from a list of descriptive attributes which best describe the product (Ares & Jaeger, 2015; Methven, Jiménez-

Pranteda & Lawlor, 2016). Although CATA has had widespread use for the sensory characterisation of many foods including desserts (Dooley, Lee & Meullenet, 2010; Bruzzone, Ares & Giménez, 2012; Vidal *et al.,* 2013; Bruzzone *et al.,* 2015), meat (Henrique, Deliza & Rosenthal, 2015; Jorge *et al.,* 2015; Grasso *et al.,* 2017), and beverages (Ares *et al.,* 2011; Plaehn, 2012; Cardinal *et al.,* 2015), it has been rarely used with older adults ~~elderly individuals~~ with the exception of a study by Ruark *et al.* (2016). Therefore, further work is required to understand and assess the suitability of CATA for older adults (Piqueras-Fiszman, Ares & Varela, 2011; Ruark *et al.,* 2016).

Traditional sensory methods are predominantly conducted using one bite or one sip of product not reflecting normal food consumption patterns (Thomas *et al.,* 2016). Recent studies have evaluated products over increasing bites and sips (Schlich *et al.,* 2013; Zorn *et al.,* 2014; Thomas *et al.,* 2016; Galmarini, Visalli & Schlich, 2017; Thomas *et al.,* 2018). However, to date this approach has predominantly utilised methods such as TDS and TCATA (Thomas *et al.,* 2016) with no previous studies to the best of the authors' knowledge applying a CATA evaluation over multiple bites or sips. The need for such an approach was highlighted by Ruark *et al.* (2016).

Oral nutritional supplements (ONS) combined with dietary counselling is successful in improving dietary uptake and alleviating undernutrition in older adults (Agarwal *et al.,* 2013; den Boer, Boesveldt & Lawlor 2019). However, these supplements are only successful in improving nutritional status if the full portion is consumed (Thomas *et al.* 2016). This is not always achieved due to their undesirable sensory profiles and adherence to ONS has been reported to be as low as 37% in some cases (Gosney, 2003). To date, other research groups have explored the sensory profiles of ONS with increasing consumption volume (Methven *et al.,* 2010; Thomas *et al.,* 2016; Thomas *et al.,* 2018). Methven *et al.* (2010) used a sequential profile method to evaluate the sensory perception of ONS over repeat consumption (8 x 5 ml aliquots) and showed that mouth-drying, metallic, and mouthcoating attributes built up with increasing consumption of ONS. Thomas *et al.* (2016) assessed the sensory perception of two ONS over the course of consumption of the full volume using a TDS method followed by a hedonic scale (A-TDL) and showed a decrease in liking and an increase in thirst with increasing sips due to the build-up of a mouthcoating. Furthering this research Thomas *et al.* (2018) assessed two ONS with older adults, in a mode to replicate full daily consumption and reported that both ONS increased thirst.

Although previous studies have explored the sensory profiles of ONS using a range of different sensory techniques (Methven *et al.,* 2010; Thomas *et al.,* 2016; Thomas *et al.,* 2018), no study has applied the CATA methodology with ONS. The CATA method offers the benefit that a greater number of sensory attributes can be made available for selection.

The main aim of this study was ~~is~~ to advance sensory science methodology for older cohorts. The research sought ~~seeks~~ to apply the CATA methodology to investigate the differences in sensory perception of ONS, when a full volume, over multiple sips is consumed. Both younger and older adults were ~~are~~ included in the study to assess if indeed CATA is an appropriate methodology, for the older cohort and deepen our knowledge of how perceptions differ with age. In addition to investigating taste, texture and liking preferences, the study also considered~~s~~, thirst, hunger and fullness as these influence ONS adherence. In addition to the methodology development, the study was ~~is~~ designed to deepen our understanding of how an older population experience ONS and to identify factors likely to improve ONS adherence and ultimately enhance the nutritional status of older people.

2. Materials and Methods

2.1 Samples

Thirty ONS from a range of different companies were evaluated for their apparent viscosity (Section 2.2), these included semi-solid/dessert style, thickened, compact/shot style and beverage style supplements. The thirty products were formulated for a range of different conditions, however the grounds on which they were selected for this study was to ensure a representation of a broad range of ~~textures and~~ viscosities.

Based on the results for apparent viscosity two ready to drink beverage style ONS were selected for use. Of the beverage style supplements analysed the lowest and highest apparent viscosity values obtained at a shear rate of 0.1 s^{-1} were 0.016 and 4.56 Pa.s. The two ONS selected for this study represent the upper and lower ends of this range. Throughout this manuscript these two supplements are referred to as ONS 1 (low viscosity) and ONS 2 (high viscosity). ONS 1 and 2 were vanilla flavoured ready to drink beverage style supplements consisting of milk proteins, vegetable oils, maltodextrin and sucrose as well as many essential vitamins and minerals. Both supplements differed significantly in energy density and protein content with ONS 1 presenting as a moderate energy and protein beverage style ONS and ONS 2 presenting as a high energy and protein pre-thickened beverage style ONS. As this study was predominantly focused on the sensory perception of the ONS, the protein and energy content were not standardised between the two supplements.

2.2 Rheological Analyses

The rheology of 30 commercial ONS was measured using a Physica MCR 301 Rheometer (Anton Paar, Graz, Austria). The rheometer was fitted with a cone-and-plate geometry (diameter: 50 mm, cone angle: 2 °) and the temperature was set and maintained at room temperature (21 °C) throughout the analysis. All measurements were conducted in triplicate. Prior to analysis the samples were stirred at 200 rpm at 21 °C for 10 minutes using a laboratory stirrer (IKA RCT basic, IKA® Werke, GmbH & Co. KG, Germany). The sample was loaded on to the plate and allowed to equilibrate 2 minutes prior to analysis. Shear stress values were measured at shear rates from 0.1 to 1000 s^{-1} with a ramp of 120 seconds.

2.3 Participants

A total of 160 panellists were recruited for this sensory study. This group was divided into a test group which consisted of 80 panellists (untrained, 35 men and 45 women, aged over 65, mean age 73.7 ± 7.9) and a control group (untrained, 35 men and 45 women, aged 18-35, mean age 25.3 ± 3.8). Panellists were recruited through word of mouth and poster advertisements and were non-vanilla rejectors and regular consumers of dairy based drinks. Each panellist signed a written informed consent agreement before participating in the experiment. For the purpose of this study the test group consisted of healthy older adults as opposed to undernourished older adults as the recruitment of 80 undernourished older adults is very challenging and this population cohort are considered vulnerable. Therefore, this study will act solely as a pilot CATA study and future work should be conducted with undernourished older adults. This sensory project was approved by the UCD Human Research Ethics Committee (Ref. No. LS-17-50).

2.4 Term generation

A list of thirty different sensory attributes (Table 1) was created based on a lexicon previously used in similar sensory studies (Ruark *et al.*, 2016; Thomas *et al.*, 2016), along with two focus group sessions performed by (1): a panel of eight researchers from the UCD Institute of Food and Health (2 men and 6 women, mean age 24.2 ± 2.5), and then (2): 6 over 65 year olds (3 men and 3 women, mean age 68.8 ± 3.5). The panellists were instructed to taste both ONS and list all of the vocabulary relating to the products. After tasting the supplements, the recorded vocabulary was discussed among the panellists in the focus group and a final list of terms was selected based on the general consensus of agreement. The order of terms on the CATA questionnaire were randomised between subjects according to Williams Latin Square Design (Williams, 1949), which removed any possibility of biased responses to questions.

2.5 Experimental session

The experimental trials took place over two twenty-minute sessions in a sensory laboratory at room temperature (21 °C) under white lighting in accordance with ISO 8589 (ISO-Standard, 2007). Given that one of the aims of this study was to evaluate the changes in hunger and fullness levels with increasing consumption volume, subjects were instructed not to eat for two hours prior to the sensory sessions. Panellists were also not allowed to consume water at any stage during the sensory session in order to replicate a real consumption experience. Prior to beginning the sensory evaluation baseline measurements for hunger, fullness, and thirst were measured using Visual Analogue Scales 100 mm (VAS) (Flint *et al.,* 2000).

Over the course of both sensory sessions five samples (40 ml each) of the ONS were ~~monadically~~ presented in a monadic sequential order (at room temperature) to the panellists in a balanced rotation order (Williams, 1949). Panellists were provided with the 40 ml of ONS in 60 ml clear plastic cups labelled with randomised three-digit sample codes. The panellists were allocated 3 minutes to consume the full 40 ml sample and complete the sensory questionnaire. On the questionnaire they were instructed to record their overall liking using a 9-point structured hedonic scale ranging from “dislike extremely” to “like extremely”. They were then instructed to check all of the sensory terms which they believed best described the supplement which they had just consumed from the list of CATA attributes. Finally, they were asked to evaluate their hunger, fullness, thirst, and desire to drink more of the sample on 100 mm VAS (Flint *et al.,* 2000) anchored on the left-hand side with “not at all” and the right-hand side with “extremely”. This evaluation process was repeated following each 40 ml serving. By the end of both sensory sessions the panellists had consumed one bottle (200 ml) of each ONS.

2.6 Data Analysis

Overall liking, hunger, thirst, fullness and desire to eat were analysed using a mixed model ANOVA with age as the between subject factor, and sip and ONS as the within subject repeated measures, to determine the significant differences between age and ONS and furthermore age and sips.

Frequency of selection of each CATA attribute were determined by calculating the number of individuals who selected each attribute for both age cohorts with both samples. A Fishers exact test (Chi squared) was performed to determine the significant differences between age and attribute selection frequency for both samples. To determine the significant differences in attribute selection frequency between each sip within both age groups, a Cochran’s Q test was used. All statistical analysis was conducted using IBM®SPSS® (version 24.0 for Windows) (IBM Corp., USA).

The penalty-lift analysis for the CATA data was completed by determining the differences between the mean liking scores when an attribute was selected, versus the mean liking scores when an attribute was not selected (Meyners *et al.,* 2013).

3. Results

3.1 Sample Selection

As previously mentioned, the two supplements selected for use in the sensory evaluation were chosen based on rheological data (as discussed below). The study sought to compare
a high and low viscosity product as high viscosity products are associated with mouthcoating which is reported to contribute to ONS dislike (Methven *et al.,* 2010), which may subsequently affect adherence.

As the nutritional profiles of the two supplements differs, no comparisons are made on the hunger or fullness ratings between the two supplements.

3.2 Rheology

Figure 1 shows the flow curves for both ONS. There were significant differences in viscosity of the two ONS in line with the study design. ONS 2 had a syrup like consistency with viscosity ranging from 4.56 to 0.06 Pa.s over a shear rate of 0.1 to 1000 s^{-1}. The flow behaviour of this supplement is evidently pseudoplastic with a decrease in viscosity on shearing. ONS 1 on the other hand had low viscosity levels ranging from 0.02 to 0.01 Pa.s over a shear rate of 0.1 to 1000 s^{-1} and exhibited Newtonian flow behaviour.

3.3 Subject data

Table 2 summarises the differences between the younger and older cohorts. The number of subjects taking medications where dry mouth is reported (The Royal Pharmaceutical Society, 2019) was greater in the older adult cohort. Likewise, the number of subjects with at least one missing tooth, one artificial tooth and suffering from dry mouth was also significantly higher in the older cohort. This reflects the different oral status between the two age cohorts.

3.4 Liking

Average liking scores for both age cohorts and ONS are shown in Figures 2A and B. ONS 1 and 2 both scored between 5 and 7 (neither like nor dislike - like moderately) on a 9-point hedonic scale for liking. On average the overall liking scores declined by less than 1 scale point with increasing consumption volume from sip 1 to sip 5. The overall liking scores did not differ significantly between the two age cohorts nor the two ONS. The mixed model ANOVA showed a significant effect ($p \leq 0.001$) for liking with sip number, however, there were no significant interactions for liking.

3.5 Hunger

Average hunger ratings after each sip for both age cohorts and ONS are shown in Figure 3. The hunger profiles declined significantly ($p \leq 0.001$) with increasing volume of consumption for both age cohorts and ONS. Hunger ratings were significantly different between the two age cohorts ($p \leq 0.05$) with the younger cohort on average hungrier than the older cohort both before and after consumption. The mixed model ANOVA showed a significant effect for hunger with sip number ($p \leq 0.001$) and also a significant sip by age interaction ($p \leq 0.001$). However, there were no significant ONS by sip or ONS by age interactions.

3.6 Fullness

The VAS ratings for fullness at each sip for both age categories and ONS were assessed (Figure 4). There is a clear trend of increasing fullness with each successive sip for both age cohorts and ONS with the exception of ONS 1 in the older cohort which had a less pronounced increase between sips 1 and 4. There were significant effects for sip number ($p \leq 0.001$) and for ONS ($p \leq 0.05$), however, there were no significant differences in fullness profiles between the two age cohorts. A significant interaction existed for sip by age, but no other significant interactions were recorded.

3.7 Desire

The desire to consume more of the ONS declined gradually with each 40 ml volume consumed in both age cohorts (Figure 5). There was a significant effect for sip number and a significant sip by ONS interaction ($p \leq 0.001$). There were, however, no significant differences in desire between the two ONS or the two age cohorts.

3.8 Thirst

Average thirst ratings with each sip for both age groups and ONS are shown in Figure 6. Overall thirst scores of the younger cohort increased by less than 1 scale point for ONS 1 and by 6.5 scale points for ONS 2 between sips 1 and 5. In contrast, the older cohort's thirst ratings increased by 14.5 scale points for ONS 1 and 8.6 scale points for ONS 2 over the 5 sips.

The thirst profiles were significantly different ($p \leq 0.001$) between the two age cohorts with the younger cohort on average thirstier than the older cohort. The mixed model ANOVA showed a significant difference in thirst profiles between the two supplements ($p \leq 0.05$) with ONS 2 contributing to higher thirst ratings in both age cohorts. There was also a significant effect ($p \leq 0.001$) for thirst with sip number.

3.9 CATA

3.9.1 Number of attributes selected

The average number of attributes selected by both age cohorts across the five different sips for both ONS differed (Table 3). The older cohort selected less attributes on average to describe the two ONS than the younger cohort. However, based on the results of the mixed model ANOVA these differences were not significant ($p=0.055$).

3.9.2 Attribute selection frequency

The attribute selection frequency for both age groups at each sip level for ONS 1 and ONS 2 are illustrated in Tables 4 and 5 respectively. The most frequently selected attributes chosen by both age cohorts to describe ONS 1 were 'Milky', 'Smooth', 'Sweet' and 'Vanilla' while for ONS 2 the terms 'Creamy', 'Smooth', 'Sweet', 'Thick' and 'Vanilla' were chosen most frequently.

The Fishers exact test (Chi squared) revealed significant differences ($p \leq 0.01$) between the two age cohorts in the selection of 5 of the 30 attributes for ONS 1; 'Hazelnut', 'Metallic', 'Milky', 'Vanilla' and 'Watery' and 4 of the 30 attributes for ONS 2; 'Chocolate', 'Mouthcoating', 'Thick' and 'Viscous'. For ONS 1 these 5 terms were selected significantly more by the younger cohort, whereas, for ONS 2 the term 'Chocolate' (sip 2) was selected significantly more by the older cohort with the remaining attributes ('Mouthcoating', 'Thick' and 'Viscous') selected more by the younger cohort (at different sip levels).

A Cochran's Q test revealed significant differences ($p \leq 0.01$) in the frequency of selection of a number of attributes with increasing consumption in both age cohorts. For the younger cohort the selection of the attributes 'Metallic' and 'Runny' decreased significantly with increasing consumption volume for ONS 1. Whereas, for ONS 2 the selection of 'Caramel' decreased. In contrast, for the older cohort no significant differences existed in the attribute selection frequency during ONS 1 consumption, however, for ONS 2 the selection of 'Chocolate' increased significantly with sip number.

3.9.3 Number of discriminating attributes

Significant differences ($p \leq 0.05$) in the selection of 10 of the 30 sensory attributes between the two ONS were observed for the younger age cohort. With this cohort selecting the attributes 'Milky', 'Runny' and 'Watery' significantly more to describe ONS 1 than ONS 2 and the attributes 'Creamy', 'Custard-Like', 'Gloopy', 'Mouthcoating', 'Soft', 'Thick' and 'Viscous' significantly more to describe ONS 2 than ONS 1. Similar results were observed in the older cohort with significant differences ($p \leq 0.05$) existing in the selection of 10 of the 30 attributes between the two ONS. This cohort selected the attributes 'Artificial', 'Runny' and 'Watery' significantly more to describe ONS 1 than ONS 2 and the attributes 'Creamy', 'Custard-Like', 'Gloopy', 'Mouthcoating', 'Thick' and 'Viscous' significantly more to describe ONS 2 than ONS 1.

3.10 Penalty-lift Analysis

Penalty-lift analysis was conducted on ONS 1 and ONS 2 in both age cohorts at sip 5 (Fig. 7). The purpose of the penalty-lift analysis was to determine which attributes drove liking and disliking in the two age cohorts. To improve the accuracy of the results, attributes which were selected by 20% of participants or less were removed from the penalty-lift analysis (Popper, 2014).

The penalty-lift analysis revealed that the two main drivers for ONS 1 liking in the younger cohort were 'Soft' and 'Silky' which caused an increase in liking by 1.3 and 0.9 scale points respectively. The two main drivers for ONS 1 dislike in this cohort were 'Artificial' and 'Aftertaste' which caused a decrease in liking of 1.7 and 1.4 points. In the older cohort the most important drivers for ONS 1 liking were 'Vanilla', 'Silky' and 'Creamy' all of which caused an increase in liking of 1 scale point, while the most notable drivers of dislike were 'Watery' and 'Runny'.

In ONS 2 'Sweet' was the main driver of liking in the younger cohort and increased liking by 0.5 points. Similar to ONS 1, 'Aftertaste' was an important driver of dislike for ONS 2 in the younger cohort and decreased liking by 1.6 scale points on average. 'Creamy' and 'Milky' were the main promotors of ONS 2 liking in the older cohort causing an increase of 1.3 and 1 points respectively, while 'Vanilla' was the predominant driver of ONS 2 dislike in this cohort causing an average decline in liking score of 0.5 points. Noteworthy is the fact that more drivers of disliking are apparent in the younger cohort for both ONS than in the older cohort.

4. Discussion

This study used CATA methodology to investigate the differences in sensory perception of ONS between younger and community dwelling older adults over successive sips of a full volume of two ONS where the volume served during consumption is controlled. In addition to assessing taste perceptions and liking profiles, hunger, fullness and thirst were quantified as these may influence ONS adherence.

The study selected two ONS with contrasting flow behaviours. The high viscosity product was selected as mouthcoating has been reported to be positively correlated with apparent viscosity, therefore this product would be expected to provide more mouthcoating than the low viscosity product (Aime *et al.,* 2001). A build-up of mouthcoating with increased ONS consumption has been previously reported as being disliked (Methven *et al.,* 2010), and may therefore have a subsequent effect on ONS adherence. For this reason, both high and low viscosity supplements were selected in order to determine whether lower viscosity ONS exhibit more desirable sensory profiles therefore contributing to higher liking.

It has also been reported that low intake and adherence of ONS is due in part to their unpleasant satiating properties (den Uijl *et al.,* 2015; den Boer, Boesveldt & Lawlor 2019), a factor which may be influenced somewhat by the texture aspects of the ONS such as their thickness (den Boer, Boesveldt & Lawlor 2019). Previous studies have reported that food intake increases with decreasing viscosity (Zijlstra *et al.,* 2008) due in part to the fact that thicker products have a greater tendency to be consumed at a slower rate (Viskaal-van Dongen, Kok & de Graaf, 2011 ; den Boer, Boesveldt & Lawlor 2019) which leads to higher/longer orosensory stimulation and higher/longer transit time through the oral cavity (Zijlstra *et al.,* 2008; den Boer, Boesveldt & Lawlor 2019), both of which trigger a satiety response (Chambers, 2016). It is therefore expected that the higher viscosity supplement may contribute to increased satiety and lower intake. However, the authors recognise that the nutritional profiles of the two supplements in this study differ, therefore, no comparisons are made on the hunger or fullness ratings between the two supplements. The authors therefore recommend that future research should adopt the approach taken by den Boer, Boesveldt & Lawlor (2019) who adjusted the texture of the same ONS using thickeners in order to adjust the thickness without modifying the energy content.

4.1 Sensory perception (CATA profiling)

With regards to the sensory perception of the ONS it was evident that consumption volume only had a slight effect on the sensory profiles of the ONS in both age cohorts. The younger cohort selected the attributes ‘Metallic’ and ‘Runny’ significantly less with increasing sips for ONS 1. Whereas, for ONS 2 within the younger cohort the selection of the attribute ‘Caramel’ decreased significantly with increasing consumption volume. This result is in agreement with Thomas *et al.* (2018), who showed that the selection of ‘Caramel’ became more infrequent with increasing sips. However, the work of Thomas *et al.* (2018) was conducted with participants aged between 60 and 75 years and therefore these results are not directly comparable with those obtained from the younger cohort in this study. In contrast, for the older cohort no significant differences existed in the attribute selection frequency during ONS 1 consumption. This suggests that the older adults were less aware of any changes in flavour profiles with increasing consumption volume. These findings were somewhat surprising as other studies (Methven *et al.,* 2010; Thomas *et al.,* 2016) have reported an increase in off-notes during the consumption of ONS such as 'metallic' which is often due to the presence of certain minerals such as iron sulphate (Lim & Lawless, 2006). This difference between the studies may be due in part to the differences in the type of sensory method used. It is plausible that the CATA sensory method was not as sensitive as the sequential profiling and A-TDL methods employed by Methven *et al.* (2010) and Thomas *et al.* (2016) respectively. Therefore, the CATA method may lack the sensitivity to measure changes in perception as consumption of ONS progresses. However, this study did not include a control sensory method to compare this. Therefore, it would be of interest if future research studies could compare the use of the CATA methodology over multi-sip intake alongside a control method such as descriptive analysis in order to draw more effective conclusions on this matter.

In relation to attribute selection frequency the younger cohort selected more flavour/taste attributes than the older cohort as they selected the attributes 'Hazelnut', 'Metallic', 'Milky' and 'Vanilla' significantly more than the older cohort to describe ONS 1. For ONS 2 the older cohort selected the attribute 'Chocolate' significantly more than the younger cohort, however, ONS 2 was a 'Vanilla' flavoured supplement, therefore the selection of this attribute may perhaps be explained by the declining taste perception which occurs with age (Methven *et al.,* 2012). This age-related decline in taste perception may be as a result of numerous age related physiological factors such as, reduction in taste bud density and the replacement of acini in the salivary glands with fibrous connective tissue (Imoscopi *et al.*, 2012) as well as increased incidences of oral and systemic diseases (Field & Duizer, 2016; Imoscopi *et al.,* 2012) and frequent use of prescription drugs (Fukasawa *et al.,* 2005; Boyce & Shone, 2006). It was evident from the subject screenings in this study that not unsurprisingly, the number of individuals taking prescription drugs on a weekly basis was significantly higher in the older cohort than the younger cohort. It was also apparent that the number of older adults taking medications, where altered taste is reported as a common or very common side effect (The Royal Pharmaceutical Society, 2019) was significantly higher in the older adult cohort. This possibly impacted on the older cohort selection of the attribute 'Chocolate' significantly more than the younger cohort.

Interestingly, texture perception of the ONS appeared to differ between the two age cohorts which was reflected in the attribute selection with the younger cohort selecting 'Watery' significantly more than the older cohort for ONS 1 and 'Thick' and 'Viscous' significantly more for ONS 2. This suggests that the older cohort were less aware of the textural changes between the two supplements than the younger cohort. This finding may be attributed to the age-related alterations to oral hygiene, dental health, saliva flow and composition, and palate covering all of which have a direct influence on texture perception (Roininen *et al.,* 2003; Doets & Kremer, 2016). The oral status of the two age cohorts in this present study directly reflects these age-related changes with the number of older subjects with at least one missing tooth, one artificial tooth and suffering from dry mouth significantly higher in the older cohort than the younger cohort. In addition to this the number of older adults taking medications where dry mouth is reported (The Royal Pharmaceutical Society, 2019) was greater in the older cohort. Therefore, it is likely that the differences in oral status between the two cohorts contribute in part to the differences in the selection of texture attributes to describe the two

ONS. The present results are consistent with the findings of Roininen *et al.* (2004) who suggested that larger numbers of textural attributes are identified by younger population groups to describe the texture of foods, Hutchings *et al.* (2014) who showed younger consumers select more texture attributes than older consumers when using TDS, and Smith *et al.* (2006) who reported that viscosity perception deteriorates with age.

Although the texture perception of the ONS appeared to differ between the two age cohorts, this study also showed that the older cohort were capable of discriminating between the two ONS, with the subjects selecting the attributes ‘Runny’ and ‘Watery’ significantly more to describe ONS 1 than ONS 2 and the attributes ‘Gloopy’, ‘Mouthcoating’, ‘Thick’ and ‘Viscous’ significantly more to describe ONS 2 than ONS 1. A finding which corroborates with those of Withers, Gosney & Methven (2013) that suggested both younger and older adults are capable of perceiving differences in the thickness of milk samples. Taking this into consideration it is evident that community dwelling older adults were capable of perceiving differences in texture between the two ONS however the younger cohort were able to discriminate between the two ONS more effectively than the older cohort as illustrated in the differences in attribute selection frequency.

Although this study was conducted solely in community dwelling older adults, it is likely that the above findings will also be mimicked in patient groups of undernourished older adults and dependent living older adults. Therefore, further research should extend this work to include an undernourished patient cohort.

4.2 The implications for the use of older adults in CATA studies

Overall 25 out of 30 attributes for ONS 1 and 26 out of 30 attributes for ONS 2 were statistically similar between the two age cohorts and there were no significant differences between the two age cohorts in the number of attributes selected. Both age cohorts were able to significantly discriminate between the two ONS products. Therefore, it is evident that older adults were very capable of using the CATA methodology and could discriminate between the two ONS using CATA. Taking this into account, this study suggests that the CATA methodology is an appropriate technique for community dwelling older subjects and therefore its use with this population cohort to evaluate ONS can be justified. However, the lack of change in the CATA profile from sip to sip in both age cohorts suggests that the CATA methodology may lack the sensitivity in assessing changes in perception as products are consumed.

The justification of the CATA method for use with older adults is highly beneficial as the CATA methodology is a relatively simple method for older adults ~~the elderly~~ compared to other sensory methods as the process of selecting a number of descriptive terms from a list is relatively straight forward and user-friendly making it particularly suitable for individuals suffering from a decline in cognitive function (Adams *et al.,* 2007; Ruark *et al.,* 2016). It is also quick to perform, which is important when working with an older adult ~~elderly~~ cohort due to their decreased attention capacity and their increased tendency to become fatigued (Methven, Jiménez-Pranteda & Lawlor, 2016). The ability to conduct a

CATA evaluation without using a computer is also preferable in older adult ~~elderly~~ populations. The CATA method unlike other sensory methods also offers the added benefit that a large number of sensory attributes can be made available for selection.

4.3 Liking

Previous studies have demonstrated a dislike of ONS due to their undesirable sensory properties (Gosney, 2003; Kennedy *et al.,* 2010). Other studies have also highlighted a decrease in liking of ONS with increased consumption volume (Methven *et al.,* 2010; Thomas *et al.,* 2016; Thomas *et al.,* 2018). Based on this knowledge, it was therefore expected that in this present study both age cohorts would rate the ONS low in terms of liking and that liking would decline in both age cohorts with repeat consumption. The findings from this study were however unable to support this position, as both age cohorts reported to ‘neither like nor dislike’ or ‘like moderately’ the ONS indicating that both age cohorts found the ONS tolerable. Our results also found that an increase in consumption volume of ONS had a minimal effect on liking reduction in both age cohorts.

Multiple factors may have contributed to these findings. Firstly, the panellists in this study were aware that the beverages which they were consuming were ‘medical nutrition’ which may have influenced their liking responses as they would have considered the supplements good for their health and therefore may have compromised on liking. Moreover, Thomas *et al.* (2018) previously highlighted that sensory booths are not the most appropriate environment for sensory evaluations of this nature. It is possible that when completing sensory evaluations within the environment of a sensory booth individuals may feel that any expression of product dislike will offend the researcher. As a result, they may feel compelled to give false results in order to please the researcher. Taking this into account evaluations conducted at home or in hospital or care home settings may potentially yield a better representation of real-life perception of ONS.

As mentioned above, previous research groups have found ONS liking to decline with increased consumption volume, which is thought to be due in part to the build-up of negative mouthfeel attributes such as mouth-drying and metallic, over consumption volume (Methven *et al.,* 2010; Thomas *et al.,* 2016; Thomas *et al.,* 2018). It was, therefore, surprising that no relationship was found between increasing consumption volume and liking decline in this present study. However, the supplements chosen in this study were different to those used in previous studies (Methven *et al.,* 2010; Thomas *et al.,* 2016; Thomas *et al.,* 2018). Therefore, it is possible that the two ONS in this study happen to have more desirable flavour profiles and less off-notes/better off-note masking.

There were similarities in liking responses between the two age cohorts, indicating that these test populations (who were not regular consumers of ONS) certainly found the product acceptable. As the study reflects a first tasting of ONS for the panellists, this is a possible source of bias in this study. Taking this into consideration this study acts solely as a pilot CATA study and future work should be extended to include an undernourished older adult group who are regular consumers of ONS.

4.4 Appetite

An increase in consumption volume of five sips led to a steady decline in hunger ratings of both age cohorts with both ONS. There was also a clear trend of increasing fullness with each successive sip for both age cohorts. These results are not surprising considering the participants consumed a total of 200 ml of ONS across the 5 sips which equates to a 200 kcal and 7.6 g protein intake following the consumption of ONS 1 and a 300 kcal and 20 g protein intake following the consumption of ONS 2. However, these results differ to insights from Hubbard *et al.* (2012) who noted that ONS had little suppressive effect on appetite and food intake and Thomas *et al.* (2018) who reported that the consumption of ten sips of ONS (protein intake of 15 g ± 0.5 g) only slightly reduced hunger status by 0.4 scale points. It is possible that the differences between this present study and that of Thomas *et al.* (2018) are due in part to the differences in the type of ONS evaluated. Whilst the total protein intake of the ONS in the study by Thomas *et al.* (2018) was 15 g ± 0.5 g, volume or energy density consumed is not known. Therefore, it is plausible that the differences in the two studies may be due to possible differences in total volume and energy density of the ONS served to panellists.

It was also apparent from this present study that the hunger profiles were significantly different between the two age cohorts with the younger cohort on average hungrier than the older cohort throughout the consumption of both ONS. These results may be explained by the diminished appetite in this age cohort which occurs due to a number of factors including lack of physical activity, psychological issues such as depression and physiological factors including age-related adjustments in body composition, reductions in total energy expenditure, the slowing of gastric emptying, and an increase in rapid satiety signals which lead to early satiation (Donini, Savina & Cannella, 2003; Leslie & Hankey, 2015; Doets & Kremer, 2016). The older cohort in this study comprised healthy community dwelling older adults, however, it is predominantly dependent living malnourished, older adults that are regular consumers of ONS, a population cohort that will suffer from even greater diminished appetite. As a result, some older individuals will not have the capacity to consume the full serving of ONS as it will be too filling, thus reducing adherence.

As the volume consumed in this study was controlled, panellists had no choice but to consume one full bottle (200 ml) of ONS in each sensory session. However, in real life situations, the decline in hunger that occurs with increased consumption volume, coupled with the reduced hunger profiles and diminished appetite in older adults may lead to individuals not finishing the full ONS. Taking this into consideration the results of this study support the current strategies which are focused on compacting beverage style ONS into lower volume concentrated ONS (den Boer, Boesveldt & Lawlor, 2019). Finally, it is also important to note that the portion size consumed in each of the CATA evaluations was 200 ml (1 bottle), however in some cases individuals may be recommended up to 8 bottles per day depending on whether the supplement is being used for complete nutrition or supplementary nutrition (Fresenius Kabi, 2019). Therefore, to capture real insights of ONS consumption future studies will need to take this into account.

Interestingly, the sensation of thirst increased significantly with increasing volume of consumption of ONS in both age cohorts. A finding which is in accordance with previous research by Thomas *et al.* (2018), who reported that the consumption of ten sips of ONS in an older adult population group strongly increased thirst ratings causing an increase of 2 points on the thirst scale. Thomas *et al.* (2018) also reported the attribute 'dry' as a temporal driver of thirst for ONS and Methven *et al.* (2010) reported a build-up of mouth-drying with increasing consumption volume of ONS. In the current study a significant increase in the selection of 'dry' was not observed in either age cohort for either ONS with increasing consumption volume. 'Mouthcoating' was however selected frequently throughout the tasting period in both age cohorts particularly with ONS 2 the thicker supplement, therefore it is possible that this contributed to an increase in thirst.

It has been reported that the presence of whey proteins may increase in-mouth dryness through their precipitation on the tongue contributing directly to an increase in thirst sensation (Sano *et al.,* 2005; Withers *et al.,* 2014; Bull *et al.,* 2017; Thomas *et al.,* 2018). The older cohort with a higher tendency for altered salivary composition and reduced muscle strength will also find it more difficult to clear any unpleasant 'mouthcoatings' causing an increase in thirst and making ONS consumption more challenging (Withers, Gosney & Methven, 2013).

The thirst profiles between the two age cohorts were significantly different with the younger cohort on average thirstier than the older cohort. It is possible that older adults experience less thirst, due to age related physiological changes (Kenney & Chiu, 2001; Schols *et al.,* 2009). The number of individuals in the present study reporting to suffer from dry mouth and taking medications where dry mouth is reported (The Royal Pharmaceutical Society, 2019) was significantly higher in the older cohort than the younger cohort. It is therefore likely that these differences in oral status may have played a role in the reduced thirst ratings in the older cohort. Lack of thirst in older adults has previously been reported as a possible driving factor for decreased ONS adherence (Gosney, 2003).

5. Conclusion

The findings demonstrate that the CATA methodology was effective in discriminating between the two ONS when used by community dwelling older adults. The older adults selected attributes for the ONS at similar rates to the younger adults. This suggests that the CATA sensory technique is appropriate for use with community dwelling older adults. However, the CATA methodology may lack the sensitivity to describe changes in perception of ONS as intake is progressed. Further research is warranted to compare the use of the CATA methodology over multi-sip intake alongside a control method such as descriptive analysis. The study provided greater insight into the differences in the drivers of liking and disliking of ONS between younger and older adults. Hunger and thirst profiles differed between the two age cohorts with the older adults remaining less hungry and thirsty throughout the consumption of ONS than the younger adults. While hunger sensations decreased with consumption volume, the thirst sensations increased significantly with increasing consumption volume of ONS in both age cohorts. Future work should be conducted with dependent living and hospitalised older adults to investigate the effectiveness of the CATA methodology to evaluate ONS in this population cohort.

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Declaration of Interest

None

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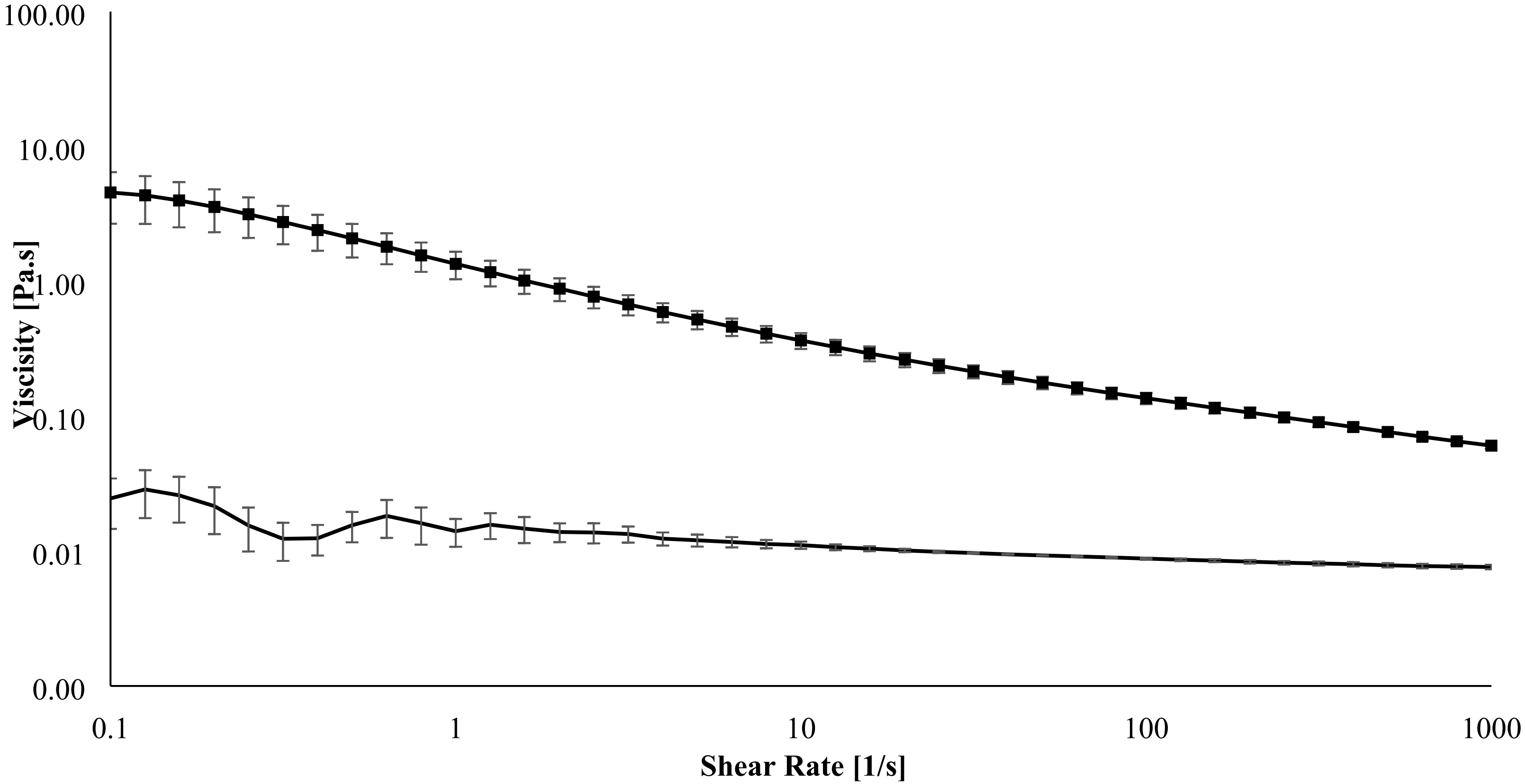


Figure 1. Flow curves of ONS 1 (▬) and ONS 2 (-■-) with error bars representing standard deviation.

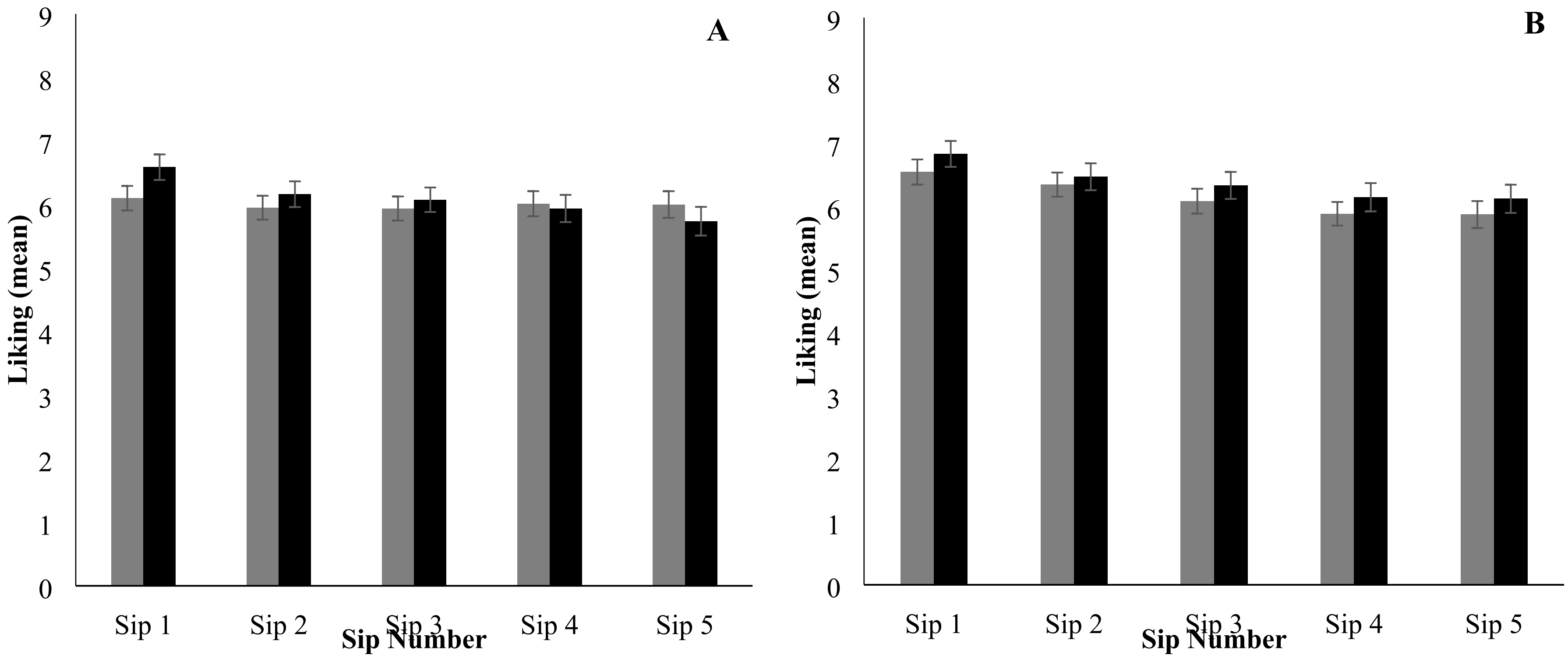


Figure 2. Mean ratings for liking at each sip for both younger (■)and older (■) adults for (A) ONS 1 and (B) ONS 2 with error bars representing the standard errors of the means.

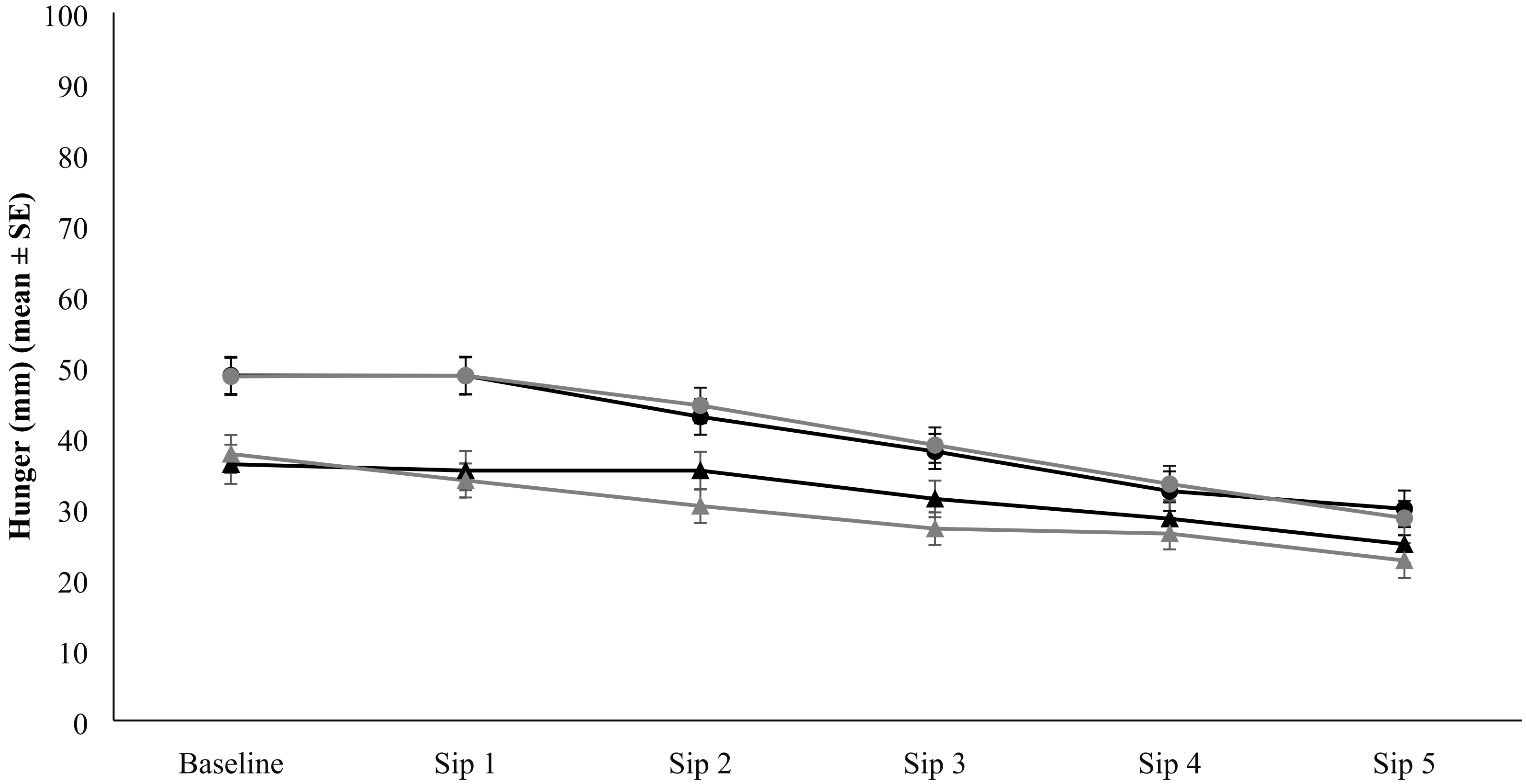


Figure 3. Mean ratings for hunger at each sip for ONS 1 in both younger (—●—) and older adults (—▲—) and ONS 2 in younger (—●—) and older adults (—▲—), with error bars representing the standard errors of the means.

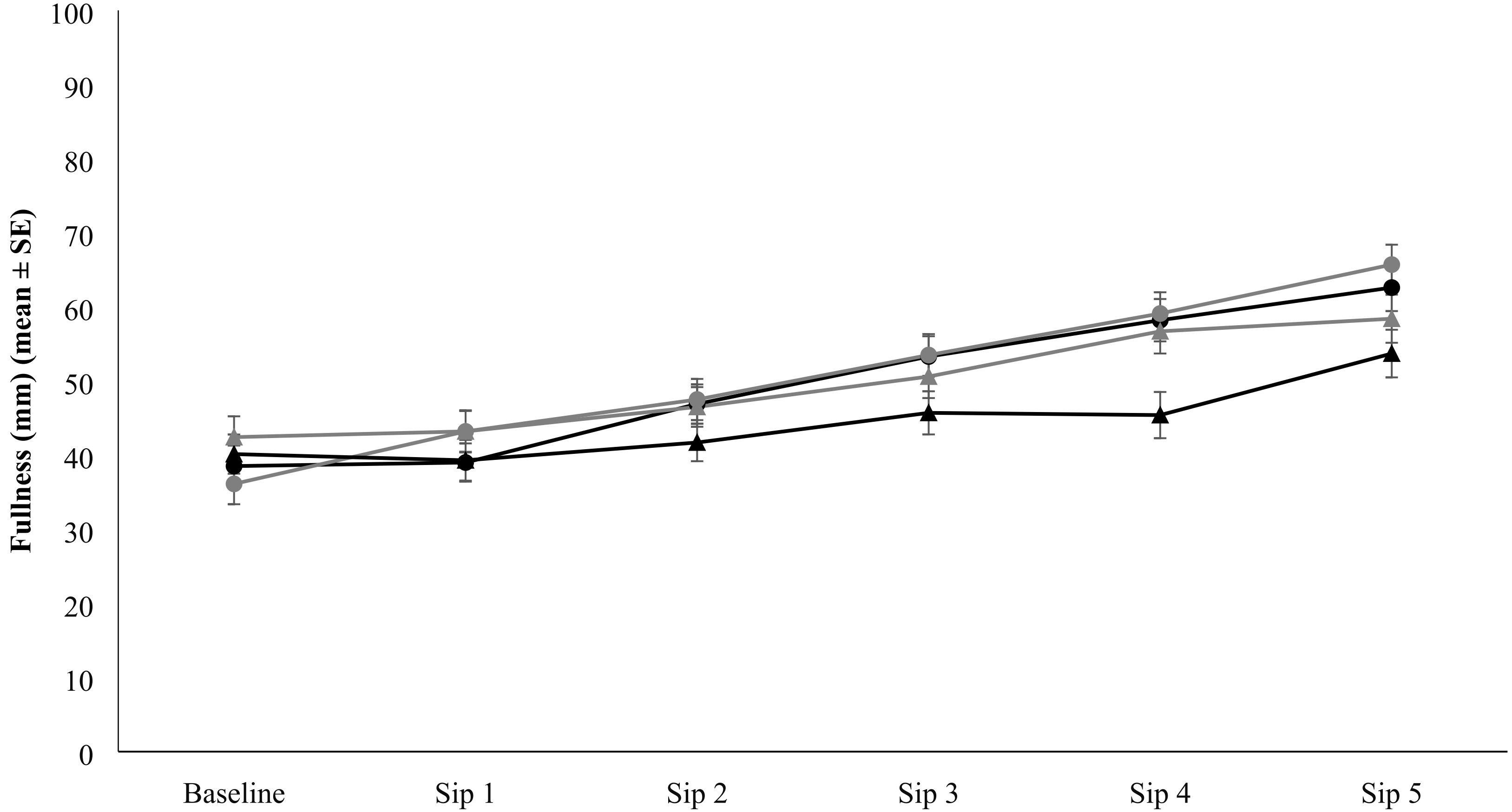


Figure 4. Mean ratings for fullness at each sip for ONS 1 in both younger (—●—) and older adults (—▲—) and ONS 2 in younger (—●—) and older adults (—▲—), with error bars representing the standard errors of the means.

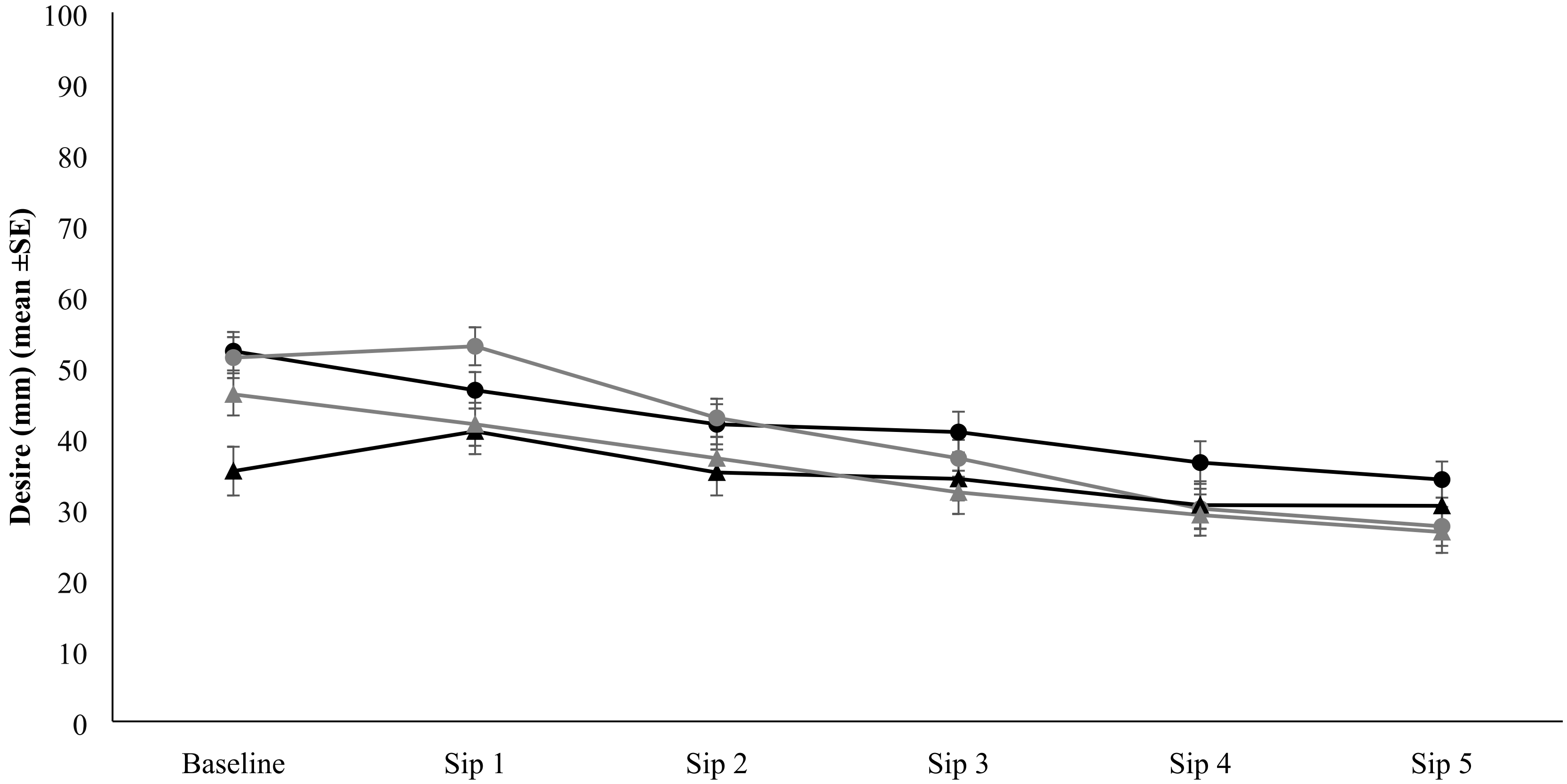


Figure 5. Mean ratings for desire at each sip for ONS 1 in both younger (—●—) and older adults (—▲—) and ONS 2 in younger (—●—) and older adults (—▲—), with error bars representing the standard errors of the means.

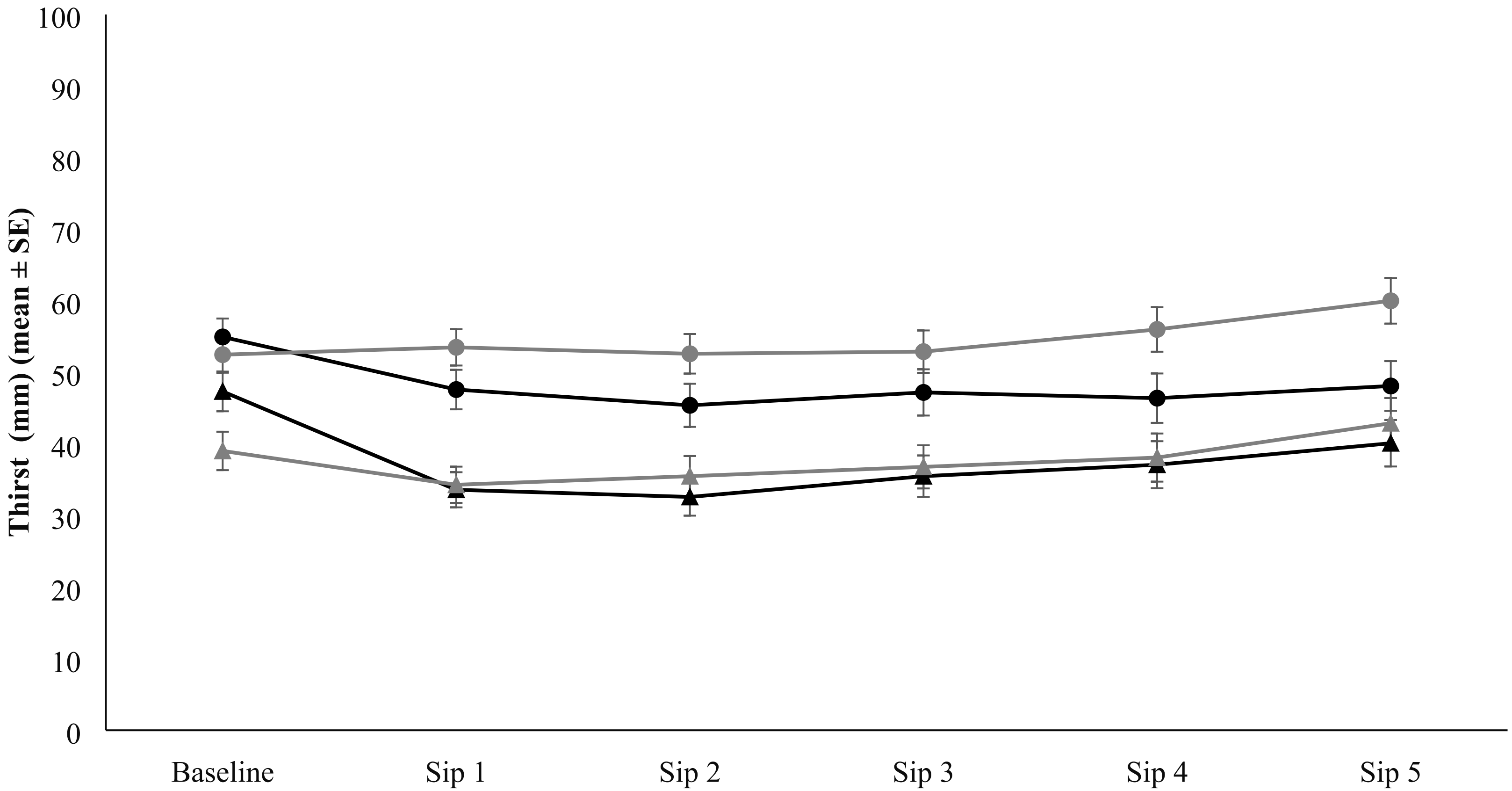
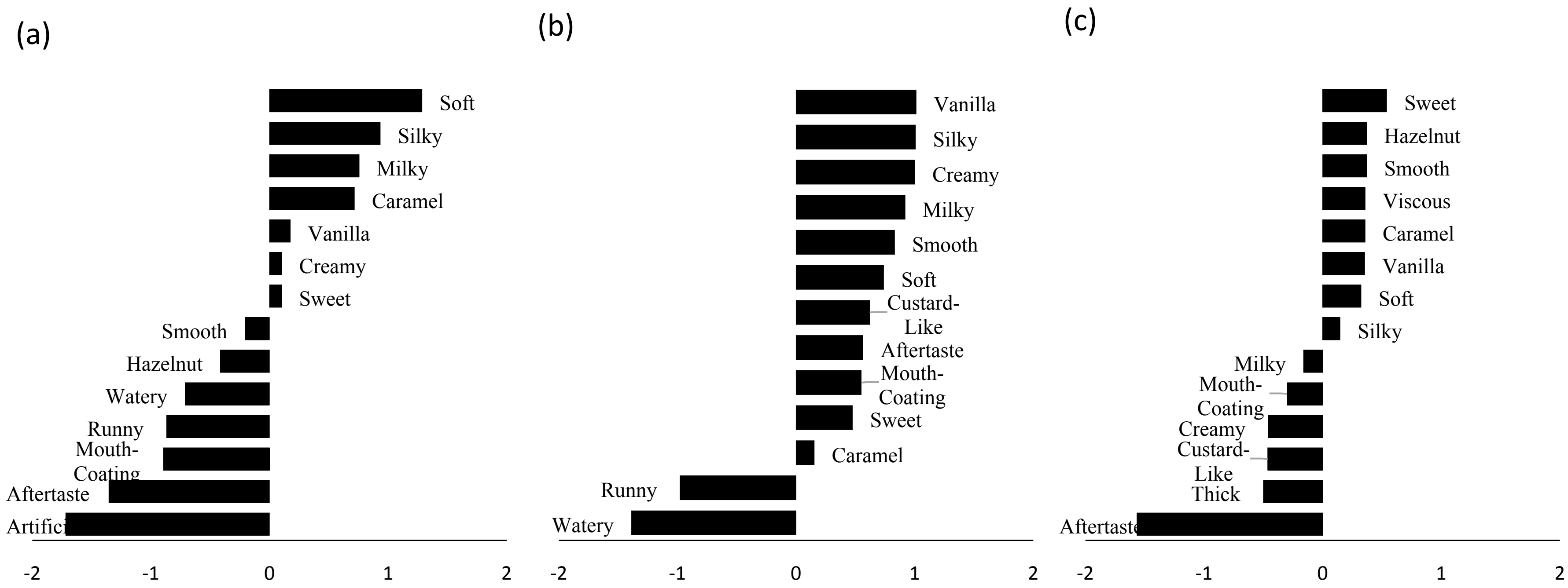


Figure 6. Mean ratings for thirst at each sip for ONS 1 in both younger (—●—) and older adults (—▲—) and ONS 2 in younger (—●—) and older adults (—▲—), with error bars representing the standard errors of the means.


(a)
Soft
Silky
Milky
Caramel
Vanilla
Creamy
Sweet
Smooth
Hazelnut
Watery
Runny
Mouth-
Coating
Aftertaste
Artifici
-2
-1
0
1
2
(b)
Vanilla
Silky
Creamy
Milky
Smooth
Soft
Custard-
Like
Aftertaste
Mouth-
Coating
Sweet
Caramel
Runny
Watery
-2
-1
0
1
2
(c)
Sweet
Hazelnut
Smooth
Viscous
Caramel
Vanilla
Soft
Silky
Milky
Mouth-
Coating
Creamy
Custard-
Like
Thick
Aftertaste
-2
-1
0
1
2

(d)

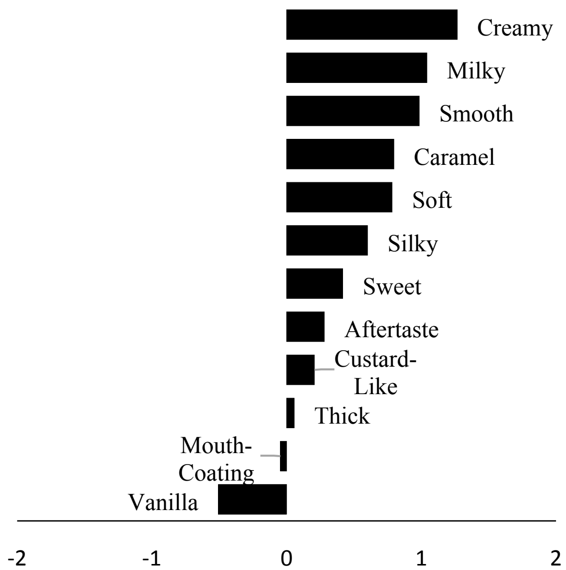


Figure 7. Results of the penalty-lift analysis for ONS 1 in (a) younger and (b) older adults and ONS 2 in (c) younger and (d) older adults. The values indicate a change in liking when an attribute was selected compared to when it was not selected by panellists at sip 5.

Table 1.
Sensory terms used in the check-all-that-apply (CATA) task.

Terms	
Texture/Mouthfeel	Taste/Flavour
Soft	Caramel
Viscous	Sweet
Smooth	Grassy
Dry	Metallic
Custard-like	Coffee
Mouthcoating	Vanilla
Gloopy	Artificial
Watery	Medicinal
Creamy	Milky
Astringent	Hazelnut
Airy	Bitter
Oily	Aftertaste
Thick	Chocolate
Grainy	
Silky	
Runny	
Jelly-like	

Table 2. Participants demographics for both the older and younger cohort.

	Older subjects (n=80)	Younger subjects (n=80)
Number of males/females	35/45	35/45
Age (mean ± SD, range)	73.7 ± 7.9 (65-97)	25.3 ± 3.8 (18-35)
Number of subjects taking medications (at least weekly)	52	7
Number of subjects taking medications where dry mouth is reported as a common/very common side effect (The Royal Pharmaceutical Society, 2019)	22	4
Number of subjects taking medications where altered taste is reported as a common/very common side effect (The Royal Pharmaceutical Society, 2019)	14	2
Number of subjects to report suffering from dry mouth	14	0
Number of subjects to report suffering from oral/gum disease	3	0
Number of subjects suffering from frequent colds	6	8

Number of smokers	4	10
Number of subjects with at least 1 missing tooth	54	7
Number of subjects with at least 1 artificial tooth	36	0

	Sip 1		Sip 2		Sip 3		Sip 4		Sip 5	
	ONS 1	ONS 2	ONS 1	ONS 2	ONS 1	ONS 2	ONS 1	ONS 2	ONS 1	ONS 2
18-35	6.6 ± 2.3	7.8 ± 2.6	6.7 ± 2.4	8.0 ± 2.6	6.8 ± 2.5	7.8 ± 2.7	7.0 ± 2.5	7.8 ± 2.7	7.2 ± 2.6	8.3 ± 3.0
Over 65	5.9 ± 3.6	6.6 ± 3.8	6.2 ± 3.9	6.6 ± 4.0	5.9 ± 4.1	7.0 ± 4.1	6.2 ± 4.1	7.1 ± 4.3	5.9 ± 4.0	7.3 ± 4.4

Table 3. Differences between the two age groups in the number of attributes selected across all five sips for both ONS (no significant differences were observed between the two age cohorts using a mixed model ANOVA)

Table 4. Frequency of selection of CATA terms for both age cohorts at each sip for ONS 1.

ONS 1										
	Sip 1		Sip 2		Sip 3		Sip 4		Sip 5	
	18-35 %	Over 65 %	18-35 %	Over 65 %	18-35 %	Over 65 %	18-35 %	Over 65 %	18-35 %	Over 65 %
Airy ^{ns}	7.5^{aq}	10^{dq}	10^{as}	10^{ds}	12.5^{au}	10^{du}	12.5^{aw}	10^{dw}	18.75^{ay}	12.5^{dy}

Aftertaste^{ns}	27.5^{aq}	31.25^{dq}	31.25^{as}	30^{ds}	32.5^{au}	42.5^{du}	37.5^{aw}	45^{dw}	40^{ay}	33.75^{dy}
Artificial^{ns}	20^{aq}	7.5^{dq}	25as	15^{ds}	22.5^{au}	11.25^{du}	17.5^{aw}	13.75^{dw}	21.25^{ay}	10^{dy}
Astringent^{ns}	6.25^{aq}	2.5^{dq}	6.25^{as}	1.25^{ds}	7.5^{au}	5^{du}	7.5^{aw}	6.25^{dw}	11.25^{ay}	5^{dy}
Bitter^{ns}	7.5^{aq}	1.25^{dq}	1.25^{as}	2.5^{ds}	3.75^{au}	2.5^{du}	2.5^{aw}	5^{dw}	5^{ay}	2.5^{dy}
Caramel^{ns}	47.5^{aq}	37.5^{dq}	40as	42.5^{ds}	43.75^{au}	37.5^{du}	45^{aw}	32.5^{dw}	42.5^{ay}	37.5^{dy}
Chocolate^{ns}	2.5^{aq}	6.25^{dq}	3.75^{as}	7.5^{ds}	2.5^{au}	10^{du}	5^{aw}	8.75^{dw}	6.25^{ay}	11.25^{dy}
Coffee^{ns}	5^{aq}	11.25^{dq}	5as	13.75^{ds}	5^{au}	10^{du}	3.75^{aw}	10^{dw}	5^{ay}	8.75^{dy}
Creamy^{ns}	31.25^{aq}	51.25^{dq}	37.5^{as}	42.5^{ds}	41.25^{au}	46.25^{du}	41.25^{aw}	48.75^{dw}	41.25^{ay}	47.5^{dy}
Custard-Like^{ns}	21.25^{aq}	23.75^{dq}	17.5^{as}	28.75^{ds}	18.75^{au}	31.25^{du}	20^{aw}	30^{dw}	17.5^{ay}	23.75^{dy}
Dry^{ns}	8.75^{aq}	5^{dq}	5as	5^{ds}	10^{au}	7.5^{du}	11.25^{aw}	5^{dw}	11.25^{ay}	6.25^{dy}
Gloopy^{ns}	1.25^{aq}	6.25^{dq}	2.5^{as}	3.75^{ds}	2.5^{au}	2.5^{du}	2.5^{aw}	3.75^{dw}	3.75^{ay}	6.25^{dy}
Grainy^{ns}	0^{aq}	2.5^{dq}	0as	0^{ds}	2.5^{au}	2.5^{du}	0^{aw}	2.5^{dw}	0^{ay}	1.25^{dy}
Grassy^{ns}	3.75^{aq}	0^{dq}	0as	1.25^{ds}	0^{au}	2.5^{du}	2.5^{aw}	2.5^{dw}	2.5^{ay}	1.25^{dy}
Hazelnut	26.25^{aq}	8.75^{dr}	22.5^{as}	13.75^{ds}	22.5^{au}	6.25^{dv}	23.75^{aw}	10^{dw}	23.75^{ay}	7.5^{dz}
Jelly-Like^{ns}	0^{aq}	0^{dq}	0as	2.5^{ds}	0^{au}	0^{du}	1.25^{aw}	1.25^{dw}	1.25^{ay}	2.5^{dy}
Medicinal^{ns}	7.5^{aq}	6.25^{dq}	10as	5^{ds}	8.75^{au}	6.25^{du}	8.75^{aw}	7.5^{dw}	10^{ay}	8.75^{dy}
Metallic	21.25^{aq}	3.75^{dr}	16.25^{abs}	3.75^{ds}	10^{abu}	3.75^{du}	13.75^{abw}	5^{dw}	8.75^{by}	2.5^{dy}
Milky	63.75^{aq}	53.75^{dq}	78.75^{as}	53.75^{dt}	72.5^{au}	48.75^{dv}	71.25^{aw}	47.5^{dx}	68.75^{ay}	53.75^{dy}
Mouthcoating^{ns}	17.5^{aq}	18.75^{dq}	21.25^{as}	23.75^{ds}	27.5^{au}	25^{du}	26.25^{aw}	33.75^{dw}	33.75^{ay}	26.25^{dy}
Oily^{ns}	5^{aq}	3.75^{dq}	12.5^{as}	8.75^{ds}	7.5^{au}	5^{du}	10^{aw}	2.5^{dw}	8.75^{ay}	5^{dy}
Runny	45^{aq}	37.5^{dq}	33.75^{abs}	31.25^{ds}	35^{abu}	35^{du}	30^{abw}	27.5^{dw}	25^{by}	32.5^{dy}
Silky^{ns}	27.5^{aq}	36.25^{dq}	32.5^{as}	30^{ds}	25^{au}	28.75^{du}	36.25^{aw}	31.25^{dw}	35^{ay}	37.5^{dy}
Soft^{ns}	21.25^{aq}	37.5^{dq}	23.75^{as}	40^{ds}	23.75^{au}	32.5^{du}	26.25^{aw}	42.5^{dw}	33.75^{ay}	27.5^{dy}
Smooth	52.5^{aq}	50^{dq}	58.75^{as}	53.75^{ds}	65^{au}	45^{du}	60^{aw}	46.25^{dw}	58.75^{ay}	45^{dy}
Sweet^{ns}	53.75^{aq}	47.5^{dq}	47.5^{as}	55^{ds}	52.5^{au}	50^{du}	56.25^{aw}	48.75^{dw}	55^{ay}	50^{dy}
Thick^{ns}	2.5^{aq}	6.25^{dq}	2.5^{as}	7.5^{ds}	6.25^{au}	8.75^{du}	8.75^{aw}	7.5^{dw}	12.5^{ay}	8.75^{dy}
Vanilla	68.75^{aq}	58.75^{dq}	65as	52.5^{ds}	68.75^{au}	46.25^{dv}	70^{aw}	46.25^{dx}	68.75^{ay}	48.75^{dy}
Viscous	2.5^{aq}	2.5^{dq}	6.25^{as}	1.25^{ds}	3.75^{au}	1.25^{du}	7.5^{aw}	5^{dw}	5^{ay}	3.75^{dy}
Watery	51.25^{aq}	26.25^{dr}	52.5^{as}	28.75^{dt}	47.5^{au}	30^{du}	46.25^{aw}	33.75^{dw}	43.75^{ay}	26.25^{dy}

Different superscript letters denote significant differences in attribute selection frequency for ONS 1:
(a,b,c) between each sip for 18-35's, (d,e,f) between each sip for over 65's, (q,r) between the two groups within sip 1, (s,t) between the two groups within sip 2, (u,v), between the two groups within sip 3, (w,x) between the two groups within sip 4, (y,z) between the two groups within sip 5, (ns) no significant difference.

Table 5. Frequency of selection of CATA terms for both age cohorts at each sip for ONS 2.

ONS 2										
	Sip 1		Sip 2		Sip 3		Sip 4		Sip 5	
	18-35 %	Over 65 %	18-35 %	Over 65 %	18-35 %	Over 65 %	18-35 %	Over 65 %	18-35 %	Over 65 %
Airy ^{ns}	2.5 ^{aq}	5 ^{dq}	11.25 ^{as}	3.75 ^{ds}	7.5 ^{au}	5 ^{du}	10 ^{aw}	3.75 ^{dw}	10 ^{ay}	6.25 ^{dy}
Aftertaste ^{ns}	35 ^{aq}	30 ^{dq}	35 ^{as}	32.5 ^{ds}	32.5 ^{au}	36.25 ^{du}	33.75 ^{aw}	28.75^{dw}	35 ^{ay}	37.5 ^{dy}
Artificial ^{ns}	10 ^{aq}	3.75 ^{dq}	13.75 ^{as}	3.75 ^{ds}	18.75 ^{au}	7.5 ^{du}	13.75 ^{aw}	6.25 ^{dw}	18.75 ^{ay}	13.75 ^{dy}
Astringent ^{ns}	7.5 ^{aq}	1.25 ^{dq}	6.25 ^{as}	2.5 ^{ds}	10 ^{au}	3.75 ^{du}	10 ^{aw}	5 ^{dw}	10 ^{ay}	8.75 ^{dy}
Bitter ^{ns}	1.25 ^{aq}	1.25 ^{dq}	7.5 ^{as}	0 ^{ds}	1.25 ^{au}	2.5 ^{du}	2.5 ^{aw}	1.25 ^{dw}	3.75 ^{ay}	2.5 ^{dy}
Caramel	53.75 ^{aq}	37.5 ^{dq}	36.25 ^{bs}	42.5 ^{ds}	43.75^{abu}	45 ^{du}	37.5 ^{bw}	41.25^{dw}	36.25 ^{by}	35 ^{dy}
Chocolate	1.25 ^{aq}	3.75 ^{dq}	1.25 ^{as}	13.75 ^{et}	2.5 ^{au}	8.75 ^{deu}	1.25 ^{aw}	7.5 ^{dew}	5 ^{ay}	7.5 ^{dey}
Coffee ^{ns}	7.5 ^{aq}	15 ^{dq}	7.5 ^{as}	13.75 ^{ds}	5 ^{au}	13.75 ^{du}	6.25 ^{aw}	11.25^{dw}	5 ^{ay}	12.5 ^{dy}
Creamy ^{ns}	81.25 ^{aq}	75 ^{dq}	80 ^{as}	80 ^{ds}	76.25 ^{au}	73.75 ^{du}	76.25 ^{aw}	76.25^{dw}	78.75 ^{ay}	73.75 ^{dy}
Custard-Like ^{ns}	41.25 ^{aq}	45 ^{dq}	48.75 ^{as}	46.25 ^{ds}	43.75 ^{au}	43.75 ^{du}	42.5 ^{aw}	53.75^{dw}	47.5 ^{ay}	48.75 ^{dy}
Dry ^{ns}	3.75 ^{aq}	6.25 ^{dq}	7.5 ^{as}	10 ^{ds}	5 ^{au}	13.75 ^{du}	11.25^{aw}	10 ^{dw}	15 ^{ay}	11.25 ^{dy}
Gloopy ^{ns}	21.25 ^{aq}	8.75 ^{dq}	18.75 ^{as}	11.25 ^{ds}	25 ^{au}	12.5 ^{du}	23.75 ^{aw}	10 ^{dw}	16.25 ^{ay}	12.5 ^{dy}
Grainy ^{ns}	0 ^{aq}	3.75 ^{dq}	0 ^{as}	1.25 ^{ds}	0 ^{au}	2.5 ^{du}	0 ^{aw}	1.25 ^{dw}	0 ^{ay}	2.5 ^{dy}
Grassy ^{ns}	0 ^{aq}	2.5 ^{dq}	0 ^{as}	1.25 ^{ds}	1.25 ^{au}	1.25 ^{du}	0 ^{aw}	3.75 ^{dw}	0 ^{ay}	2.5 ^{dy}
Hazelnut ^{ns}	17.5 ^{aq}	18.75 ^{dq}	20 ^{as}	15 ^{ds}	23.75 ^{au}	13.75 ^{du}	18.75 ^{aw}	13.75^{dw}	23.75 ^{ay}	16.25 ^{dy}
Jelly-Like ^{ns}	2.5 ^{aq}	3.75 ^{dq}	3.75 ^{as}	3.75 ^{ds}	2.5 ^{au}	6.25 ^{du}	7.5 ^{aw}	3.75 ^{dw}	5 ^{ay}	5 ^{dy}
Medicinal ^{ns}	5 ^{aq}	6.25 ^{dq}	5 ^{as}	10 ^{ds}	3.75 ^{au}	3.75 ^{du}	5 ^{aw}	8.75 ^{dw}	11.25 ^{ay}	8.75 ^{dy}

Metallic ^{ns}	10 ^{aq}	3.75 ^{dq}	13.75 ^{as}	2.5 ^{ds}	7.5 ^{au}	2.5 ^{du}	6.25 ^{aw}	6.25 ^{dw}	8.75 ^{ay}	2.5 ^{dy}
Milky ^{ns}	51.25 ^{aq}	41.25 ^{dq}	56.25 ^{as}	37.5 ^{ds}	52.5 ^{au}	32.5 ^{du}	47.5 ^{aw}	41.25^{dw}	58.75 ^{ay}	40 ^{dz}
Mouthcoating	56.25 ^{aq}	36.25 ^{dq}	53.75 ^{as}	32.5 ^{dt}	47.5 ^{au}	41.25 ^{du}	52.5 ^{aw}	46.25^{dw}	50 ^{ay}	38.75 ^{dy}
Oily ^{ns}	7.5 ^{aq}	6.25 ^{dq}	12.5 ^{as}	5 ^{ds}	8.75 ^{au}	7.5 ^{du}	10 ^{aw}	7.5 ^{dw}	10 ^{ay}	10 ^{dy}
Runny ^{ns}	3.75 ^{aq}	10 ^{dq}	7.5 ^{as}	10 ^{ds}	6.25 ^{au}	10 ^{du}	7.5 ^{aw}	10 ^{dw}	8.75 ^{ay}	10 ^{dy}
Silky ^{ns}	37.5 ^{aq}	37.5 ^{dq}	35 ^{as}	31.25 ^{ds}	32.5 ^{au}	32.5 ^{du}	28.75 ^{aw}	40 ^{dw}	37.5 ^{ay}	42.5 ^{dy}
Soft ^{ns}	38.75 ^{aq}	45 ^{dq}	32.5 ^{as}	45 ^{ds}	33.75 ^{au}	42.5 ^{du}	30 ^{aw}	45 ^{dw}	43.75 ^{ay}	45 ^{dy}
Smooth ^{ns}	67.5 ^{aq}	58.75 ^{dq}	62.5 ^{as}	48.75 ^{ds}	57.5 ^{au}	56.25 ^{du}	67.5 ^{aw}	58.75^{dw}	66.25 ^{ay}	55 ^{dy}
Sweet ^{ns}	52.5 ^{aq}	53.75^{dq}	55 ^{as}	46.25 ^{ds}	60 ^{au}	57.5 ^{du}	57.5 ^{aw}	47.5 ^{dw}	56.25 ^{ay}	60 ^{dy}
Thick	71.25 ^{aq}	40 ^{dr}	73.75 ^{as}	45 ^{dt}	71.25 ^{au}	51.25 ^{du}	72.5 ^{aw}	45 ^{dx}	75 ^{ay}	48.75 ^{dz}
Vanilla ^{ns}	63.75 ^{aq}	50 ^{dq}	67.5 ^{as}	51.25 ^{ds}	66.25 ^{au}	55 ^{du}	66.25 ^{aw}	56.25^{dw}	58.75 ^{ay}	51.25 ^{dy}
Viscous	30 ^{aq}	12.5 ^{dq}	26.25 ^{as}	15 ^{ds}	31.25 ^{au}	8.75 ^{dv}	23.75 ^{aw}	12.5 ^{dw}	28.75 ^{ay}	13.75 ^{dy}
Watery ^{ns}	1.25 ^{aq}	1.25 ^{dq}	2.5 ^{as}	2.5 ^{ds}	1.25 ^{au}	5 ^{du}	7.5 ^{aw}	8.75 ^{dw}	3.75 ^{ay}	6.25 ^{dy}

Different superscript letters denote significant differences in attribute selection frequency for ONS 2: (a, b, c) between each sip for 18-35-year olds, (d, e, f) between each sip for over 65 year olds, (q, r) between the two age groups within sip 1, (s, t) between the two age groups within sip 2, (u, v) between the two age groups within sip 3, (w, x) between the two age groups within sip 4, (y, z) between the two age groups within sip 5,(ns) no significant difference

Highlights

- Individuals aged 18-35 and over 65 evaluated full volumes of ONS using CATA.
- Older adults used CATA effectively to discriminate between two ONS.
- CATA may lack the sensitivity to describe perception changes as intake progressed.
- Older adults were less hungry and thirsty throughout the consumption of ONS.
- Attributes driving liking/disliking differed with age but ONS liking did not.