



## Temporal dominance of sensations: A comparison between younger and older subjects for the perception of food texture



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### ABSTRACT

Temporal dominance of sensations (TDS) is a technique that can be used to assess the sensory perception of food texture. The use of TDS is becoming more popular; however its value in older subjects is unknown. The aim of this study was to compare the abilities of a young group and an older group to perform the TDS technique for the dynamic perception of texture. Twenty healthy subjects aged 55–70, and twenty healthy subjects aged 21–29, were selected according to strict criteria, where no subjects had dentures or had used the TDS technique before. Subjects were individually trained on the TDS technique with nine texture attributes. Both age groups generated TDS curves, where consensus on dominating attributes showed progression in the perception of food texture throughout the mastication sequence for both groups. Intra-subject variability in the TDS sequence was also similar between age groups. However, the older subjects took longer to select a first attribute, made fewer selections, and took longer to change attribute choice. Older subjects also showed higher dominance rates for the hard attribute, and lower dominance rates for the brittle, sticky and oily attributes.

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### 1. Introduction

With the recent development of the Temporal dominance of sensations (TDS) methodology (Pineau et al., 2004), an opportunity has emerged to assess texture perception dynamically as food is broken down, without the need to rate it on a numeric scale. This technique allows the dominant sensory sensations to be monitored throughout the mastication sequence. Subjects are required to select the most dominant texture that is perceived at any point in time from a choice of textures on which they have been trained on (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009). TDS shows the dominance, or agreement between subjects, of which textural terms are selected, and how dominance changes as food is broken down.

As the TDS technique becomes more popular there is an increased need to understand how different subjects will use it. One group of particular importance are the now ageing “baby boomer” generation. An understanding of food texture perception in this age group is of critical importance for those involved in preparing foods and for food manufacturers seeking to improve the textural properties of food (Fillion & Kilcast, 2001). However, given the active nature of the TDS technique, it is unknown if older

subjects can use the technique appropriately (the age range of subjects in previous TDS studies is typically 20–55 (Lenfant et al., 2009; Ng et al., 2012; Saint-Eve et al., 2011)). Furthermore, while significant research has investigated changes in the perception of odor and taste as people age, changes that take place in the perception of food texture are not as well understood, particularly in solid foods. Older people commonly have trouble consuming foods of difficult textures such as crunchy, dry, and stringy foods (Hildebrandt, Dominguez, Schork, & Loesche, 1997), which can reduce dietary intake of these foods (Walls & Steele, 2004).

At different stages of ageing there are changes in oral physiology affecting the perception of food texture. Disease and the use of medications are more prevalent in older age groups, and these also contribute to changes in texture perception. In general, there is a reduction in the number of functional teeth (Nagao, 1992), an increase in tooth wear (Mioche, 2004), increased masticatory muscle activity required to break food down to the swallow point (Mishellany-Dutour, Renaud, Peyron, Rimek, & Woda, 2008; Peyron, Blanc, Lund, & Woda, 2004a), reduced co-ordination of the oral devices (Baum & Bodner, 1983), and a reduction in saliva flow (Dodds, Johnson, & Yeh, 2005). The ability to recognize shapes inside the oral cavity also declines (Calhoun, Gibson, Hartley, Min-ton & Hokanson, 1992; Landt & Fransonn, 1975), and across the surface of the entire body there is a reduced ability to discriminate touch (Webb & Copeman, 1996). As a consequence older subjects

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tend to increase the number of chews and time applied to food products before swallowing (Feldman, Kapur, Alman, & Chauncey, 1980; Mishellany-Dutour et al., 2008), and the median particle size of the swallowed food bolus may also be larger in subjects of declining dental health (Fontijn-Tekamp, van der Bilt, Abbink, & Bosman, 2004; vanderBilt, Olthoff, Bosman, & Oosterhaven, 1993).

In semi-solid foods, the ability to discriminate thickness and coolness declines with age (Forde & Delahunty, 2002), as does the ability to discriminate changing particle size (Hatae et al., 2001). Only Mioche (2004) has investigated changes in texture perception of solid foods with age, showing that both healthy elderly and healthy young subjects have similar relationships between total muscle work and tenderness perception of meat (although weaker correlations were observed with the elderly).

The aim of this study was therefore to compare and validate the use of the TDS technique for food texture perception between a younger group and an older group, and therefore also to gain insight into how dynamic texture perception differs with age. In particular, to assess the performance, we aimed to characterize TDS behavior, intra-subject variability, the nature of the TDS curves, and the average dominance rates of textural attributes of the two age groups using almonds, cashews, macadamias, and peanuts as test foods.

## 2. Methodology

### 2.1. Subject selection

Forty subjects were selected for this study: twenty young subjects (21–29,  $25.5 \pm 2.5$ , mean  $\pm$  SD) and twenty older subjects (55–70,  $62.9 \pm 4.8$ , mean  $\pm$  SD). There were ten males and ten females in each group. Subjects were selected on the basis of having good oral and general health. Subjects had no dentures, no jaw problems, no active tooth decay or gum disease, did not suffer from dry mouth, were not receiving any orthodontic treatment, and were non-smokers. All subjects were regular users of computers (at least once per week) and no subjects had taken part in a TDS trial before this study. Subjects with some missing teeth, and subjects with a small number of artificial teeth were accepted (bridges or crowns), provided all other criteria were met. All subjects were fluent English speakers. This project was reviewed and approved by the Massey University Human Ethics Committee: Southern A (Application 12/02).

### 2.2. Test foods and serving size

Nuts are one type of food which can be difficult for older people to chew due to its texture (Sheiham & Steele, 2001). In this study four different types of nuts (blanched almonds, roasted cashews, raw macadamia nuts, and roasted peanuts) were used for the TDS analysis, and were served at a constant volume of  $3 \text{ cm}^3$ . All

nuts were unsalted and were sourced from Prolife Foods Ltd, Hamilton, New Zealand. Fresh samples were sourced weekly, and were stored in foil bags at  $20^\circ\text{C}$ .

### 2.3. Texture attributes

The vocabulary used to describe food texture can vary slightly with age (Roininen, Fillion, Kilcast, & Lahteenmaki, 2004), and consequently the generation of texture terms to describe the four nuts was undertaken with separate sessions for each age group with a small number of subjects who were selected according to the same criteria as the TDS study. Group 1 involved six subjects aged 53–64 (two male, four female,  $59.0 \pm 4.3$ , mean  $\pm$  SD), and Group 2 involved seven subjects aged 24–31 (two male, five female,  $27.4 \pm 2.4$ , mean  $\pm$  SD). Subjects were asked to chew a sample of each nut and describe its texture. Four of the younger subjects and three of the older subjects who participated in the texture generation returned to participate in the main study. Following the generation sessions, all terms from both sessions were combined, and nine texture attributes were selected by the scientists involved (Table 1). This required selecting the most frequently quoted terms and eliminating confounding terms that described the same sensation. The nine terms were clear and simple words that both age groups would understand. Of the nine attributes selected, eight were generated independently from both groups (hard, crunchy, chewy, gritty/grainy, dry, soft, sticky, and oily). Brittle was the exception, only generated by the older group, but was fused with the word shatter produced by the younger group. Definitions for all texture attributes were derived from those presented by Jowitt (1974), with the exception of the definition for crunchy, which was derived from Dijksterhuis, Luyten, de Wijk, and Mojet (2005). A reference product was then selected for each attribute for use in the training session (Table 1). References were also selected by the scientists involved. To do this a range of useful reference options for each attribute were chewed (alongside the definitions), and the most appropriate references were selected.

### 2.4. Training procedure

For each subject a 60-min training session for TDS was conducted at least one day before each TDS session (maximum 4 days before the TDS session). Subjects were instructed not to eat any closer than 2 h before the training session. Training sessions were identical for subjects of either age group, and were all conducted one-on-one, with each individual subject and the researcher. The session was used to explain the concept of TDS, to train subjects on the textures to be used in the study (using the reference foods), and to practice the TDS procedure four times by serving samples of blanched peanuts (not used in the main study). To be as thorough as possible and to ensure consistency across all trainings, the researcher used a script throughout the trainings. Subjects were able

**Table 1**

Final sensory terms, and their definition, used in the Temporal Dominance of Sensations (TDS) procedure.

Texture attribute	Definition	Reference food
Hard	A high resistance to deformation by applied force of the teeth.	Ginger nuts, Griffins™. (Griffins Foods Ltd, New Zealand).
Crunchy	The sensation of a loud sound during biting and chewing.	ETA™ Kettles, Ready Salted (ETA Foods, New Zealand).
Brittle	A tendency to crack, fracture, or shatter without substantial force of the teeth.	Huntley and Palmers™ Cream Crackers™ Original (Huntley and Palmers, New Zealand).
Dry	The sensation of a reduction in the free fluids in the mouth.	Weetbix (Sanitarium, Australia).
Chewy	A persistent resistance to breakdown on chewing.	Wine Gums (Pascall®, Australia).
Gritty/Grainy	The presence of small, hard particles.	All-Bran® (Kelloggs®, Australia).
Soft	A low resistance to deformation by applied force of the teeth.	Mr. Mallow® Marshmallows. (Funtastic Limited Group, Australia).
Sticky	A tendency to stick/adhere to contacting surfaces, especially the palate, teeth and tongue during mastication.	Delish Smooth Peanut Butter (MOI Agencies Ltd., China).
Oily	A thin immiscible liquid in the mouth.	Extra Light Olive Oil, Pams® (Pams Products Limited, New Zealand).

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