Food Quality and Preference 36 (2014) 104–110

Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

A new rapid detection threshold method for use with older adults: Reducing fatigue whilst maintaining accuracy

Victoria J. Allen [a,d,*], Caroline A. Withers [b], Guillermo Hough [c], Margot A. Gosney [a], Lisa Methven [b]

[a] Clinical Health Sciences, The University of Reading, UK
[b] Food and Nutritional Sciences, The University of Reading, UK
[c] Comisión de Investigaciones Científicas, Provincia Buenos Aires, Argentina
[d] College of Nursing, Midwifery and Healthcare, University of West London, UK

ARTICLE INFO

Article history:
Received 22 August 2013
Received in revised form 20 March 2014
Accepted 21 March 2014
Available online 30 March 2014

Keywords:
Threshold
Detection
Methodology
Age

ABSTRACT

Taste and smell detection threshold measurements are frequently time consuming especially when the method involves reversing the concentrations presented to replicate and improve accuracy of results. These multiple replications are likely to cause sensory and cognitive fatigue which may be more pronounced in elderly populations. A new rapid detection threshold methodology was developed that quickly located the likely position of each individuals sensory detection threshold then refined this by providing multiple concentrations around this point to determine their threshold. This study evaluates the reliability and validity of this method. Findings indicate that this new rapid detection threshold methodology was appropriate to identify differences in sensory detection thresholds between different populations and has positive benefits in providing a shorter assessment of detection thresholds. The results indicated that this method is appropriate at determining individual as well as group detection thresholds.

1. Introduction

Several methodologies have previously been used to determine taste and smell detection thresholds in older people. The majority of studies analysing taste detection thresholds reported in a recent systematic review (Methven, Allen, Withers, & Gosney, 2012) involved participants taking a sip of solutions (17 out of 24 studies, 70%). Similar methodologies are used within smell detection research, where two blank samples are typically presented alongside an odorant and the participant selects the sample containing the odour (Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997), commercially available as "Sniffin' Sticks™". The alternative forced choice (AFC) approach, where participants have to select the tastant or odorant against blank samples, is the most common approach. The utilisation of the AFC sip test methodology or sniffin' sticks™ method is inexpensive to set up and therefore could be used in most populations.

However, this method requires several samples to be presented in each set. The number of blank water samples usually ranges from one to three (2AFC to 4AFC). The greater the number of samples presented, the less the probability of the participant guessing correctly by chance (50–25%), but the more samples presented in each set the more information participants need to remember to make accurate comparisons. This is important to consider in older adult populations where memory starts to become a problem and is noticed in most healthy independently living people over 70 years of age (Sachdev et al., 2010).

To overcome the problems associated with correctly guessing without giving numerous samples to taste at a time, several studies have reversed the concentrations depending on participant answers, thereby replicating results. They either decreased the concentration when the correct answer was given and increased concentration if incorrect (Baker, Didcock, Kemm, & Patrick, 1983; Grzegorczyk, Jones, & Mistretta, 1979; Wayler, Perlmuter, Cardello, Jones, & Chauncey, 1990) or when correct, repeated the concentration until it had been selected twice correctly, then decreased concentration and if incorrect, increased concentration (Bales, Steinman, Freeland-Graves, Stone, & Young, 1986; Hummel et al., 1997; Mojet, Christ-Hazelhof, & Heidema, 2005; Stevens, Cruz, Hoffman, & Patterson, 1995) until a designated number of reversals were reached (between 5 and 8). This staircase method had a better test retest reliability than a single ascending series (Doty, McKeown, Lee, & Shaman, 1995). A typical staircase

Abbreviation: RDT, rapid detection threshold.

* Corresponding author at: University of West London, Paragon House, Brentford, Middlesex TW8 9GA, UK. Tel.: +44 020 8209 4563.
E-mail address: victoria.allen@uwl.ac.uk (V.J. Allen).

http://dx.doi.org/10.1016/j.foodqual.2014.03.007
0950-3293/

threshold method obtains seven reversals (Haehner et al., 2009). Depending on the consistency of results this equates to between 21 and 123 solutions being tasted for a 3-AFC. Therefore, undertaking such methodologies is likely to cause taste and cognitive fatigue because multiple tastings are required. This is an important consideration, especially in older adults, where reported fatigue in all activities increases as people age and is associated with functional decline (Avlund, 2010) and may therefore also have an impact on immediate quality of life and ability of participants to subsequently complete their required activities of daily living or other activities.

To avoid fatigue, some studies have used a forced-choice ascending concentration series method. All participants are given all sets of concentrations and blanks (single ascending series) as described within the ASTM standard E679-04, without repeating concentration steps (ASTM standard E679-04). Taste acuity threshold was usually determined as the geometric mean between the lowest concentration the tastant could be detected and the highest concentration that could not be detected (ASTM standard E679-04; Kennedy, Law, Methven, Mottram, & Gosney, 2010; Spitzer, 1988). However, other studies reported merely the lowest concentration the tastant could be detected as the detection threshold (Easterby-Smith, Besford, & Heath, 1994; Schiffman, Crumbliss, Warwick, & Graham, 1990). Although this ascending AFC method can be considered appropriate to determine group thresholds (ASTM standard E679-04), at an individual level it may result in inaccurate detection thresholds being assigned.

Therefore, the current methods available suggest a more appropriate method is required for older adults that can determine each individual's taste detection threshold yet also decrease the influence of a positive guess and prevent fatigue.

The rapid detection threshold (RDT) method is based on the ascending/descending staircase approach used in previous studies with some modifications. For the RDT method, three samples were presented in each set (1 tastant or odorant and 2 blanks). Participants had a 33% chance of guessing correctly by chance. However, as many older adults struggle with their memory (Sachdev et al., 2010) more samples would reduce the ability of participants to make accurate comparisons. The first set presented within our adapted methodology was not the lowest concentration rather it was concentration step two within the total range, this enabled the subsequent concentration given to be based on the initial response. This is similar to a previously validated rapid assessment method of an individual's preference choices (Conner, Haddon, & Booth, 1986). By adapting responses from a middle of the range sample enabled the subsequent sample to be closer to participant's personal threshold, thus, reducing the number of samples required and fatigue or frustration caused by several sets being presented significantly below threshold. Three reversal points were decided upon for this test from test–retest reliability for three reversal points based on previous work by Doty et al. (1995). Doty and colleagues analysed data (mean ± SD) from 14 repeated measures of a single staircase odour detection thresholds using phenyl ethyl alcohol (PEA) to determine a formula for test re-test reliability for this methodology. Undertaking three reversals had a test re-test reliability of 0.715 based on their model which significantly improved the repeatability over one or two reversals, however, test re-test reliability after this point, though increasing slightly, did not substantially improve (Doty et al., 1995). By limiting the test to three reversals, this also substantially reduced the number of odour or taste sets participants were exposed to compared to a typical staircase threshold method of seven reversals (Haehner et al., 2009). These factors are proposed within the RDT method to reduce the cognitive, taste and general fatigue experienced by participants when undertaking a detection threshold test without significantly impeding accuracy.

2. Material and methods

2.1.Study 1

Older adults ($n = 28$, 65+ years) were recruited from healthy independently living people in the local community (Reading, UK) and healthy younger adults ($n = 28$, 18–35 years) were recruited from the University of Reading campus. Written informed consent was obtained from each participant. The study procedures were given a favourable ethical opinion to proceed by the University of Reading (Reference 10/61) and the research was performed in accordance with the Helsinki Declaration.

Participants attended a central location on one occasion. They were informed that the study was to compare smell detection thresholds between younger and older adults. They were not aware that their answers would be used to validate a new methodology.

Participants were blindfolded so they could not see the colour codes on the sniffin' sticks™ denoting the control and odourant pens. Initially participants were given the highest concentration of n-butanol to smell (40 mM) 2 cm from the nose, for familiarisation with the odorant. Participants were informed that this was the odour they were trying to detect. The task was explained to participants; they would have three different sniffin' sticks™ held 2 cm below their nose. Out of these sniffin' sticks™ one would contain the n-butanol odour and two would be blank (odourless). The participants had to inform the researcher which of the three samples contained the odour even if they were not able to recognise it (forced choice).

The Sniffin' Sticks™ (Burghart-Messtechnik, Wedel, Germany) contained n-butanol and were in a geometric progression of 2 from 0.00122 to 40 mM. All participants received the lowest concentration (0.00122 mM n-butanol) with two blank samples within their first set. The concentration of n-butanol was increased until the participant provided a correct result, the concentration of n-butanol was then decreased (reversal) until they selected incorrectly, when the concentration was increased again (reversal). This occurred until seven reversals had occurred.

The data was used to determine odour detection thresholds for n-butanol using both the standard ascending/descending staircase and new rapid detection threshold methodology (RDT method).

2.2. Study 2

Older adults ($n = 34$, 65+ years) were recruited from healthy independent living people in the local community (Reading, UK) and older patients ($n = 34$, 65+ years) recruited from National Health Service general acute medical or surgical hospital wards (UK). Written informed consent was obtained from each participant. The study procedures were given a favourable ethical opinion to proceed by the UK's South Central Research Ethics Committee (reference: 09/H0603/23).

Tastant samples were prepared in mineral water and the control was the same mineral water (Harrogate Spa, UK). The salt solutions contained sodium chloride in a geometric progression of 3 from 0.41 to 98.4 mM. The sweet solutions contained sucrose in a geometric progression of 2 from 1.98 to 63.6 mM. These geometric progressions are greater than the exponent values of 1.4 mM for sodium chloride and 1.3 mM for sucrose identified by Stevens (1969), indicating that participants should be able to discriminate between the stimuli concentration steps. These larger geometric progression ratios were chosen to reduce the number of tastant samples presented. The concentration range for sucrose was 0.68 g/l (1.99 mM) to 21.8 g/l (63.6 mM) and for sodium these were 0.23 mg/l (0.41 mM) to 5.71 g/l (98.4 mM) These were based on the author's previous work on sensory detection thresholds in