

The Perceived Intensity of Caffeine Aftertaste: Tasters Versus Nontasters

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Abstract

The length and intensity of the aftertaste of caffeine was measured in groups of tasters and nontasters in order to determine if any differential information could be provided by aftertaste perception. Results indicate that a period of 4 min is sufficient to see differences between tasters and nontasters, and that nontasters' aftertaste of the saturated solution is equal in intensity with tasters perception immediately after stimulus presentation, but then after ~1 min fade faster. Nontaster ratings for the weaker solution were lower throughout the entire time period.

Introduction

Traditionally, diagnostic research has to a large extent been restricted to threshold determination. Often an absolute threshold is carefully measured and then compared with a normal population's threshold, as is typically the case with hearing or sight problems. Although in many modalities high intensity stimulation can be dangerous and is therefore usually avoided, occasionally a maximal threshold is determined. For example, heat and cold maximal thresholds are sometimes used in diagnosing central nervous system damage.

Threshold determinations, however, do not always provide a complete picture of perceptual functioning. An example of this is recruitment effects, where the perceived intensity for two persons (or groups) can differ at low physical intensity levels but then converge at higher physical intensity levels (Scharf, 1978; Stevens and Guirao, 1967). It is for this reason that scaling methods have come into use in diagnostics and have proven to give important differential information.

A problem with traditional scaling techniques is that over a large variation range there is no single unit available for interindividual comparisons. Individual functions can easily be determined with ratio scaling techniques such as magnitude estimation, but these methods do not allow the level comparisons that one needs in differential studies. New methods which utilize man's ability to make comparisons of perceptual magnitudes and to refer to other modalities, such as magnitude matching (Stevens and Marks, 1980), the Master Scale (Berglund, 1991), Labeled Magnitude Scaling (Green *et al.*, 1996) and the Category-Ratio Scale (Borg, 1982), have been developed to allow for interindividual level comparison.

A predisposition to having either relatively high (non-

tasters) or low (supertasters) thresholds for a class of bitter compounds that include PTC (phenylthiourea) and PROP (6-*n*-propylthiouracil) have been observed and linked both genetically (Fisher, 1967; Reed *et al.*, 1995) and pathologically (Bartoshuk *et al.*, 1996). Additionally, research has shown that nontasters have reduced sensitivity to other chemical classes such as caffeine (Hall *et al.*, 1975), sucrose and saccharine (Bartoshuk, 1979). Scaling methods have revealed that it is not always just a simple case of nontasters having a diminished ability to taste certain substances, as is indicated by threshold measurement, but that they in fact have what resembles a recruitment effect.

An area of taste perception which has not received much attention but which may provide us with additional information is aftertaste. Aftertaste is the stimulus intensity perceived in the moments immediately following removal of the stimulus (to differentiate with adaptation, in which the stimulus is constantly present). In many areas of perception, such as visual and auditory stimulation, this type of information might not be significant because the perception of the stimulus after presentation declines very rapidly. In taste perception, however, there is a clear after effect that can vary strongly over time.

From everyday experience we know that certain taste perceptions stay rather long while others disappear rather quickly. In wine tasting, simple wines are thought of as having a 'short tail', i.e. the taste disappears quickly, whereas other wines are regarded as having a 'long tail', the taste lingering and maturing in the mouth (see also Noble, 1994). Mushroom experts sometimes speak of certain tastes, particularly bitter, as having an obvious aftertaste. If a taste is particularly strong and lingers on for several minutes, it can be a sign that the mushroom in question is inedible.

The length of the aftertaste can also be used to help aide in identification of the species.

While there have been many studies of the time course of adaptation to taste stimuli, there have been few controlled studies of aftertastes. The psychophysical 'after-function' can be of obvious interest. In the case of tasters and nontasters, it could be that the time course of the aftertaste for a stimulus is different in nontasters, e.g. shorter in duration and possibly steeper in slope.

To test whether or not this hypothesis would be worth pursuing, we asked two subsets of subjects from another taste study (Marks *et al.*, 1992) to participate in an additional task. The first group of tasters/nontasters received a saturated caffeine solution and were asked to rate the intensity of the aftertaste over a long period of time in order to determine the general time course of taste intensity. The second, larger group received two suprathreshold concentrations of caffeine and rated the aftertaste intensity for 4 min in order to more closely investigate the shape of the aftertaste curve.

Methods, results and discussion

Taster/nontaster status for PROP was determined by a suprathreshold measure (filter-paper method). In the first study, four tasters and three nontasters tasted 10 ml of a highly concentrated solution of caffeine (0.056 M) delivered at room temperature (21°C) using a sip-and-spit method. A metronome aided subjects in keeping the solution in the mouth for 5 s. Ratings were made on the CR-10 scale. The CR-10 consists of a category scale ranging from 'nothing at all' to 'maximal' anchored to a numerical range, with the 'maximal' position outside of the listed numerical range. Subjects are told to first determine the position of their experience on the verbal side of the scale and then to report the corresponding numerical position (including decimals). Subjects were instructed that, if necessary, they may rate above 10, the high end of the numerical range on the scale.

A copy of the CR-10 scale was in front of subjects during the entire experiment. Immediately after spitting the solution the subject rated the intensity of the solution when it was in the mouth. Thereafter, ratings for the perceived intensity of the aftertaste were recorded every 30 s. Subjects were instructed not to spit during this time and to keep talking to a minimum. The experiment was stopped after either the subject had given three '0' ratings in a row or 15 min had passed; subjects were not informed prior to the experiment as to how long they would continue rating.

The mean time for nontasters to give their first 0 rating was 10 min and 30 s; the mean time for tasters was 12 min and 45 s, with two subjects still rating at the end of the 15 min time limit. At the 4 min mark, both nontaster and taster ratings began to level out and their approach to zero slowed. Ratings at this level become more susceptible to response bias; the subject becomes uncertain as to how 'tasteless' the

sensation is and how best to utilize the rapidly diminishing space on the bottom portion of the scale. Given the goal of investigating the differential possibilities and not the general time-intensity relationship of the aftertaste, 4 min was chosen as the time limit for the next experiment.

For the second experiment, another group consisting of 11 tasters and seven nontasters rated the intensity of aftertaste for a high concentration caffeine solution (0.056 M) and a weaker (0.018 M) caffeine solution for 4 min. The procedure was the same as that in the first experiment with the exception that ratings were stopped after 4 min, there was a thorough rinsing and 15 min recovery period before the second solution was administered, and the order of presentation of the weak and strong solutions was randomized and balanced between the subjects.

The taste stimulus was presented by the sip-and-spit method. A metronome aided subjects to ensure that each solution was kept in the mouth for 5 s. For the subjects from the second study the experiment was stopped after 4 min, and subjects were not informed beforehand as to how long they would continue rating.

Data collected from the subjects in the second experiment are shown in Figure 1. A clear difference between tasters and nontasters at both concentration levels is seen. Particularly interesting is how the ratings for both tasters and nontasters at the higher concentration level begin at the same level, but then the nontaster ratings drop faster with time. A repeated measures ANOVA using Concentration (high, low) and Time (0, 30, 60, 90, 120, 150, 180, 210, 240 s) as within-group factors and Taste Status (taster, nontaster) as a between-groups factor revealed a significant three-way interaction effect [$F(8, 128) = 2.31, P = 0.024$] supporting these observations. Subsequent *t*-tests revealed significant differences between taster and nontaster ratings at time 0 for the lower concentration of caffeine ($t = 2.19, P = 0.0434$) but not at the higher concentration ($t = -0.312, n.s.$). None of the ratings at time 240 were significantly different.

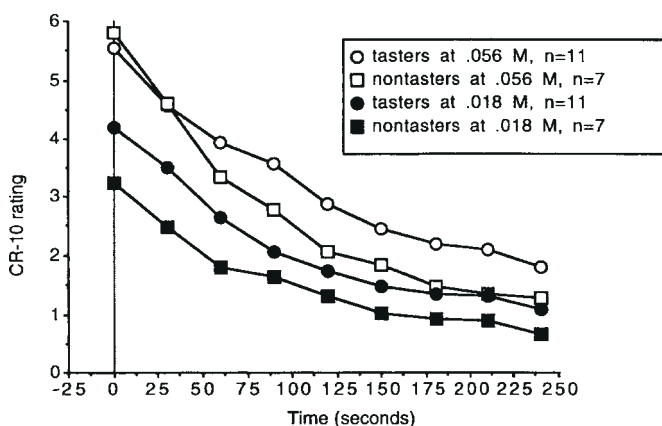


Figure 1 Mean aftertaste intensity ratings over time for nontasters and tasters at both concentrations.

Time-intensity (TI) procedures have been well developed and used extensively (e.g. Larson-Powers and Pangborn, 1978; Guinard *et al.*, 1985; Yoshida, 1986; Nakagawa *et al.*, 1996), and from the two experiments presented here, there appears to be enough evidence to support further development of the differential diagnostic possibilities of TI measurement. Aftertaste tests are simple to conduct and could compliment existing threshold determination methods for the taster/nontaster distinction.

Acknowledgements

This work was supported by a grant to G.B. from the Swedish Council for Research in the Humanities and Social Sciences (F 520/90).

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Accepted October 2, 1998