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Dual-attribute Time-intensity Measurement of Sweetness and Peppermint Perception of Chewing Gum

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ABSTRACT

The relationship between duration and maximum intensity of sweetness and peppermint flavor of chewing gum was explored using dual-attribute time-intensity sensory evaluation. Four chewing gum samples, varying in rate of release of sweetness and peppermint flavor were evaluated by 10 trained time-intensity panelists. Chewing gum with a fast release of sweetness and peppermint flavor provided the highest maximum intensity and longest duration of sweetness and peppermint perception. The rate of release of sweetness was more important than rate of release of peppermint flavor in affecting duration of attributes.

Key Words: dual-attribute, time-intensity, chewing gum, sweetness, peppermint

INTRODUCTION

SWEETNESS AND PEPPERMINT FLAVOR are characteristics of gum that contribute to duration and intensity of taste. In the production of peppermint flavored gum, sensations of sweetness and peppermint can be controlled, in part, by varying release times. How such release times affect duration and maximum intensity of taste is not understood. Patents have been issued for techniques that produce gums with different rates of release of sweetness (Cherukuri et al., 1990; Yatka et al., 1991) and flavor (Cherukuri et al., 1990; Reed and Hook, 1992); and extended sweet release (Yatka et al., 1991; Cherukuri et al., 1990).

Very little research has been published on relationships between sweetness and flavor of chewing gum. Interactions between sweetness and flavor have been studied in aqueous solutions. Valdes et al. (1956) found that more flavorful solutions were assessed as sweeter than those containing less flavor. Cliff and Noble (1990) evaluated interactions between sweetness and flavor of peach extract aqueous solutions and found that sweetness intensity increased as amount of peach essence increased. With regard to chewing gum, De Roos (1990) showed that rate of flavor release was dependent on two factors: solubility of the flavor and chewing efficiency of the panelists. During chewing, flavors which were soluble in the sugar phase were released first, followed by those soluble in the gum phase. How these two interact was not demonstrated.

The dual-attribute method for time-intensity evaluations (Duizer et al., 1994) provides a way of determining the simultaneous impact of release times of sweetness and peppermint on duration and maximum intensity of taste. Using this technique, sweetness and peppermint flavor perception are recorded simultaneously while the gum is chewed. Parameters extracted from time-intensity curves can be analyzed to evaluate relationships between sweetness and peppermint flavor. By measuring the reliability of time-intensity curves (Bloom et al., 1994) the stability of effects of release times can also be determined. We used four specially designed gums, developed by Warner Lambert Canada Inc., representing slow and fast release of sweetness for each condition of slow and fast release of peppermint. Our objective was to determine the release time characteristics that produced the longest duration and maximum intensity of both tastes, with greatest reliability.

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METHOD

Samples

Four peppermint flavored chewing gums were prepared by Warner Lambert (Toronto, Canada). The samples varied in rate of release of sweetness and peppermint as follows: fast sweet-fast peppermint (FSFP); slow sweet-fast peppermint (SSFP); fast sweet-slow peppermint (FSSP); slow sweet-slow peppermint (SSSP). Slow release gums were composed of encapsulated flavor and sweetener, while fast release gums were formulated from liquid flavor and free sweetener.

Dual-attribute time-intensity procedure

All training and testing sessions were conducted at the Compusense Sensory Research Centre (Guelph, Canada). Ten panelists, experienced in time-intensity sensory evaluation participated. During training and testing, panelists were provided with 1g of each sample of chewing gum for evaluation. All samples were presented in cups labeled with a random three-digit code.

During training panelists were presented with samples of gum individually displaying slow sweet release, slow peppermint release, fast sweet release and fast peppermint release to familiarize them with the range of attributes to be evaluated. Following this, the panelists were introduced to the dual-attribute time-intensity procedure. The dual-attribute software (CSA^{TM}_{TPA}) developed by Compusense Inc. (Guelph, Canada) was used to collect information about sweetness and peppermint flavor perception of the chewing gum. The test consisted of a horizontal scale and a vertical scale originating at the zero point in the bottom left hand corner of the computer monitor. Both lines were 60 pixels in length. Anchors on the lines were "not sweet" and "very sweet" for the vertical axis and "no peppermint flavor" and "strong peppermint flavor" for the horizontal axis. Sweetness responses were collected on the vertical scale, while peppermint responses were collected on the horizontal scale.

To record responses, panelists could move a cursor along each of the two lines simultaneously. To do this, they were trained to move a mouse diagonally across a mouse pad. Panelists were instructed to begin recording perceptions of taste at the first chew and to continue until the perception of sweetness and peppermint flavor disappeared, or 15 min elapsed. For each sample, the gum was placed between the back molars in preparation for chewing. Recording was initiated during the first chew. Rate of chewing was not prescribed. At the start of each trial, panelists used the mouse to move the cursor from zero along each time-intensity line and when sweetness and peppermint perception disappeared, the cursor was moved back to the zero point at the end of each line.

Data were collected in variable time intervals over 15 min. From the start of the test to the 3 min point, data were collected every 3 sec to ensure refined analysis of fastest changes in flavor perception. From 3 min to 7 min, data were collected every 9 sec and from 7 min to 15 min data were collected every 15 sec. In total, 120 points of data were collected during the 15 min test. Panelists were presented with the same gum preparations as those used for dual-attribute testing and these samples were then used to practice the dual-attribute time-intensity technique.

The task of testing was to evaluate the sweetness and peppermint flavor perception of four gum samples (FSFP, SSFP, FSSP, SSSP), three times each, for a total of 12 evaluations. Six sessions of testing were conducted, with panelists evaluating two randomly selected samples on each day. Within each session, presentation of samples was randomized.

Analysis of time-intensity data

Using the CSA$^{TM}_{IFA}$ analysis program (CSA Version 4.3), three parameters were extracted from individual time-intensity curves; maximum intensity (IMAX) of sweet and peppermint perception, duration (DUR) of the two perceptions and panelist reliability scores (T-IR). A typical dual-attribute curve was labeled with parameters of IMAX and DUR (Fig. 1). T-IR is the absolute mean of a set of standard deviations. These standard deviations represent the variability of time-intensity scores at each sampling point in a set of time-intensity curves. Individual reliability scores are inverse measures with lower scores indicating more reliable panelists (Bloom et al., 1994).

Individually for perceptions of sweetness and peppermint flavor, 1-way repeated-measures analyses of variance were conducted to compare among the four samples for dependent variables duration (DUR), maximum intensity (IMAX) and reliability (T-IR). Contingent on significant differences among samples, we asked whether release times of sweetness and peppermint acted independently or whether release times interacted in affecting perception of sweetness and peppermint. Thus, four repeated-measures t-tests were conducted: slow- vs fast-release of sweetness for slow- and for fast-release peppermint flavor, and slow- vs fast-release of peppermint flavor for slow- and for fast-release sweetness.

RESULTS

THE MAXIMUM INTENSITY of both sweetness and peppermint perceptions differed among the 4 samples for both sweetness and peppermint (Fig. 2). Maximum intensity of sweetness was greatest with a fast-release of sweetness, independent of time release of peppermint (Table 1—sweet column, slow mint and fast mint). The fast release of peppermint enhanced the perception of sweetness only with the sample that contained a fast release of sweetness (Table 1—sweet column, fast sweet). Maximum intensity of peppermint did not depend upon rate of release of sweetness, and fast release of peppermint enhanced the perception of peppermint only when rate of sweetness was slow (Table 1—peppermint column, slow sweet).

Duration differed among the four samples in both sweetness perception and peppermint perception (Fig. 3). Sweetness was perceived longer in the fast-sweet vs the slow-sweet samples, whether the peppermint release was fast (Table 2—sweet column, fast mint) or slow (Table 2—sweet column, slow mint). The duration of sweetness was enhanced by fast vs slow release of peppermint, only when the gum sample had a slow release of sweetness (Table 2—sweet column, slow sweet). With fast release of sweetness, the release rate of peppermint was unimportant to duration of the perception of sweetness. The duration of perception of peppermint was enhanced by a fast-release of peppermint, only for the sample of slow-release sweetness (Table 2—peppermint column, slow sweet). The duration of perception of peppermint was enhanced by a fast-release of sweetness, only when the sample contained a slow release of peppermint (Table 2—peppermint column, slow mint). The fast release of sweetness masked any difference between slow and fast release of peppermint in enhancing duration of peppermint flavor.

Thus, for greatest maximum intensity of sweetness and longest duration of sweetness, gum should exhibit a fast release of sweetness. The maximum intensity of peppermint depends only upon the fast release of peppermint and only when release of sweetness is slow. Longest duration of peppermint would occur with any combination of release times of sweetness and peppermint, except slow sweet-slow peppermint. Also, to provide the longest duration of both sweetness and peppermint flavor, gum should contain a fast release of sweetness.

No research has been published evaluating interactions between sweetness and flavor in chewing gum using time-intensity sensory evaluation. De Roos (1990) evaluated rate of release of flavor from gums while chewing, however, the interaction between the sweetness and peppermint flavor was not reported. In a time-intensity study of interactions of sweetness and flavor in aqueous solutions, Cliff and Noble (1990) reported that maximum sweetness intensity increased with an increase in peach

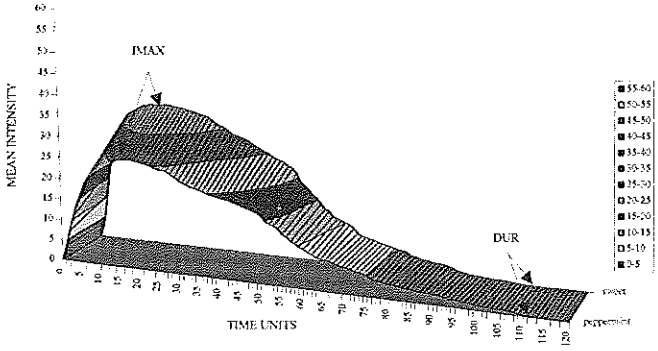

Fig. 1—Typical dual-attribute time-intensity curve.

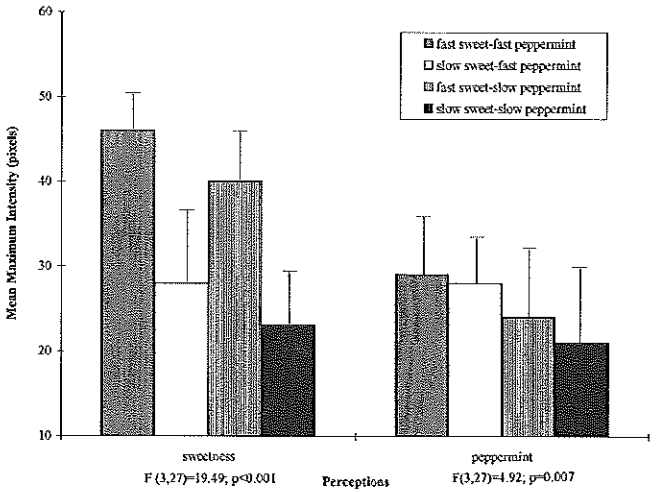

Fig. 2—Mean maximum sweetness and peppermint intensity for the four gum samples.

Table 1—T-test and probabilities for IMAX of slow vs fast peppermint and sweetness as related to levels of sweetness and peppermint

	Sweet		Peppermint	
	t-value	probability	t-value	probability
		slow mint		
Slow vs fast sweet	5.23	0.001	1.68	0.127
		fast mint		
Slow vs fast sweet	4.37	0.002	0.82	0.431
		slow sweet		
Slow vs fast mint	1.85	0.097	2.79	0.021
		fast sweet		
Slow vs fast mint	2.86	0.019	2.15	0.06

concentration and glucose concentration. However, maximum fruitiness intensity increased only with an increase in peach flavor concentration, not with an increase in sweetness. Our results demonstrated that duration of peppermint was affected by rate of release of sweetness, with a fast sweet release increasing the duration of peppermint perception. There was no effect of sweetness release on maximum peppermint intensity.

There were no differences in reliability of perceptions of peppermint across the four samples. The reliability of perception of sweetness differed across samples ($F(3,27) = 3.29$; $p = 0.036$). Perceptions of sweetness were more reliable when release of sweetness was fast, and this was particularly notable for samples in which the release of peppermint was slow (Table 3—sweet column, slow mint). All perceptions of sweetness and peppermint were highly reliable, with T-IR values from 0.77 to 0.86.

These results indicate that a chewing gum which contained fast release of both sweet and peppermint (FSFP) should prove most favorable to manufacturers marketing long lasting sweetness and flavor products. The sweetness and peppermint per-

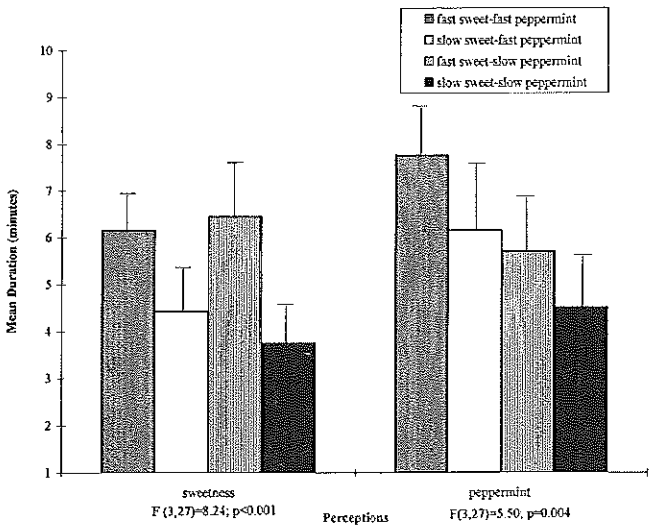

Fig. 3—Mean duration of sweetness and peppermint perception for the four gum samples.

Table 2—T-test and probabilities for DUR of slow vs fast peppermint and sweetness as related to levels of sweetness and peppermint

	Sweet		Peppermint	
	t-value	probability	t-value	probability
		slow mint		
Slow vs fast sweet	3.66	0.005	2.29	0.048
		fast mint		
Slow vs fast sweet	2.63	0.027	1.92	0.088
		slow sweet		
Slow vs fast mint	2.68	0.025	3.88	0.004
		fast sweet		
Slow vs fast mint	0.25	0.809	1.5	0.168

Table 3—T-test and probabilities for T-IR of slow vs fast peppermint and sweetness as related to levels of sweetness and peppermint

	Sweet		Peppermint	
	t-value	probability	t-value	probability
		slow mint		
Slow vs fast sweet	5.4	0.001	1.63	0.138
		fast mint		
Slow vs fast sweet	1.71	0.122	0.56	0.588
		slow sweet		
Slow vs fast mint	0.64	0.539	1.05	0.321
		fast sweet		
Slow vs fast mint	0.6	0.565	0.51	0.622

ceptions of such samples, in comparison with others, were most reliable. They also provided the maximum intensity and longest lasting intensity of sweetness and peppermint perception.

Our results demonstrate the application of the dual-attribute time-intensity test for tracking changes in multiple perceptions during chewing. There are many benefits to a dual-attribute test for measurement of attributes in a product. Using the dual-attribute time-intensity method, the information collected would be double that collected by single-attribute time-intensity. This is beneficial for products, such as chewing gum, which may increase panelist vulnerability to fatigue during testing. In addition, interactions between sweetness and flavor perception could be identified to produce optimal blends.

The dual-attribute time-intensity procedure may be used to study sensory characteristics of other products. Upon consumption, some foods produce sensations other than taste, such as the pain which may be produced by highly carbonated beverages. Using dual-attribute time-intensity, the relationship for example, between sharp and dull sensations could be measured. Also, the dual-attribute test could easily measure tenderness and juiciness of beef, where sample to sample variability may be a concern.

CONCLUSION

USING THE DUAL-ATTRIBUTE time-intensity technique, relationships between two attributes in chewing gum could be assessed. A fast release of sweetness enhanced the duration and intensity of sweet perception, as well as the duration of peppermint flavor in chewing gum. For a gum with a long lasting flavor and sweetness, a fast release of sweetness would be required. This would also produce a gum with a sweetness intensity greater than that of a gum with slow sweetness release. The fast release of sweetness would also increase intensity of taste of sweetness. The release time of peppermint was not important for long lasting flavor.

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