Food Quality and Preference 6 (1995) 121–126

0950-3293/95/$9.50+.00
0950-3293(94)00021-2

THE EFFECT OF LINE ORIENTATION ON THE RECORDING OF TIME–INTENSITY PERCEPTION OF SWEETENER SOLUTIONS

L. M. Duizer,[a] K. Bloom[b] & C. J. Findlay[a]

[a]Compusense Inc., 150 Research Lane, Guelph, Ontario, Canada, N1G 4T2
[b]Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1

(*Accepted* 11 *October* 1994)

ABSTRACT

A trained time–intensity panel was used to evaluate the effect of scale orientation on time–intensity responses. Equi-sweet samples of aspartame, acesulfame k, sucralose and 9% sucrose were presented to 10 panelists for evaluation on both horizontal and vertical scales. For the most part, horizontal and vertical scales yielded similar results. However, Maximum Intensity responses on the vertical scale were approximately 13% greater than Maximum Intensity responses on the horizontal scale. The parameters of Decrease Angle, Decrease Area and Area Under the Curve were also significantly larger when vertical scales were used than when horizontal scales were used. We suggest that differences can be minimized by anchoring reference samples to the scales and by counterbalancing the presentation of the scales within and amongst panelists. These results demonstrate the use of time-intensity scales on two dimensions and suggest the possibility of multi-attribute evaluations of taste.

Keywords: time–intensity; sweetness; sweeteners; scale orientation.

INTRODUCTION

Time–intensity sensory evaluation is a method which allows for the measurement of the temporal changes in the texture and the flavour of food. Devices for recording time–intensity responses have undergone methodological improvement since their inception. Time–intensity data were originally collected by timing panelists with a stop watch as they recorded their responses to intensity on graph paper (Neilson, 1957). Since then, researchers have developed both automated and computerized time–intensity procedures. These procedures have employed different instruments and different visual representations of time–intensity scales.

Initially, automated procedures required panelists to indicate their time–intensity perceptions by moving a pen horizontally (Larson-Powers & Pangborn, 1978; Schmitt *et al.*, 1984) or vertically (Schwartz, 1980; DuBois & Lee, 1983) on moving strip chart paper. To eliminate the possible distraction to the panelists of the movement of chart paper, Birch & Munton (1981) developed the SMURF, an instrument containing a taste 'dial box' and 'taste dial'. The panelists moved the dial clockwise in response to changes in sensory perception, and a concealed strip chart recorder provided time–intensity curves of all responses. Although the automated approaches collected time–intensity data efficiently, the transformation of the data into a useable form was cumbersome. The curves were measured manually, and the results were then entered into a computer for statistical analysis. This procedure required a large time commitment and increased the potential for errors.

With the advent of personal computers in the early 1980s, computerized time–intensity software programs were developed. These programs were used to collect data in a form which could be easily analysed. Programs have differed in the type of instrument used to record responses. For example, Guinard *et al.*, (1985) introduced the use of a joystick which could be moved within a vertical slot, while Lee (1985) attached a game paddle to a computer. With the latter instrument, panelists turned a dial on a 'game paddle' to move an 'x' along a horizontal line shown on the computer monitor.

At present, there are two commercially available software packages for the measurement of time–intensity taste perceptions. Both computer packages are used to collect data over a programmed period of time. However, they differ in the visual orientation of the scale on which the panelists indicate the intensity of their perception. The PSA-system provides a vertical scale on which the panelists indicate their perceptions of the attribute (Cliff & Heymann, 1993). In contrast, the CSA_{TPA}™ temporal profile analysis module developed by

Compusense, provides a horizontal scale (equivalent to 60 pixels) on which the panelists indicate their perception.

Compusense is currently developing a system to simultaneously measure two time dependent sensory attributes. This requires both horizontal and vertical scales displayed on the computer monitor. The effect of scale orientation on the resultant time–intensity data has not been reported in the literature. In the present study we compared judgements of sweetness using a horizontal scale with the judgement of sweetness using a vertical scale to determine whether scale orientation affects response to taste perception.

MATERIALS AND METHODS

Sample preparation

Four model solutions (sucrose, aspartame, acesulfame k and sucralose) were prepared using food grade sweeteners in distilled water. All concentrations were isosweet to 9% sucrose, as determined through earlier paired comparison testing. The concentrations of each sweetener were: 9% sucrose; 0·05% aspartame; 0·08% acesulfame k; 0·018% sucralose. Twenty millilitres of each sweetener were poured into a 50 ml cup labelled with a random 3-digit blinding code. Each cup was covered with a lid and a straw was inserted through a hole in the lid. All sweeteners were served at room temperature.

Time–intensity evaluations

All training and testing sessions were conducted at the Compusense Sensory Research Centre (Guelph, Canada). Ten trained panelists, experienced in time–intensity testing of sweeteners participated in this study. Prior to testing, the panelists attended eight 1-h training sessions to familiarize themselves with the use of horizontal and vertical line scales. During training, samples of sweetener similar to those used in testing were presented to the panelists for evaluation. The Computerized Sensory Analysis Temporal Profile Analysis software (CSA_{TPA}™) (CSA V4.3; Compusense Inc, Guelph, Canada) was modified to make the presentation of either a vertical line scale or the existing horizontal line scale possible. Both the vertical and horizontal lines were 60 pixels long and were labelled with the anchors 'not sweet' and 'very sweet'. The time–intensity software (CSA_{TPA}™) was programmed to collect responses every 0·5 s for a total of 60 s (120 records). The panelists were instructed to drink the sample through the straw, hold it in their mouths for 3 s and then swallow. Time–intensity evaluations were started immediately upon ingestion to capture the time course of maximum intensity. The panelists used a mouse to move a cursor along the time–intensity line, reflecting the changes in sweetness perception. Testing of each sample ended when the panelists moved the cursor back to zero on the time–intensity line, indicating that sweetness perception was no longer present.

During testing, the panelists evaluated the four sweeteners on both the horizontal and vertical scales. Four replications of testing were conducted. During each testing session, eight samples were evaluated with a 5-min break between samples. The rating scale appeared on the monitor as a horizontal line for four samples and as a vertical line for the remaining four samples in a randomized and balanced order. During the 5-min break between the samples, the panelists cleansed their palate with unsalted crackers and distilled water.

Analysis of the time–intensity data

Eight time–intensity parameters were extracted from individual time–intensity curves using the CSA_{TPA}™ analysis program (CSA V4.3). Figure 1 provides a diagram of the time–intensity parameters and each parameter is defined in Table 1.

Each of the eight parameters of the time–intensity curve were analysed to determine whether panelists rated the four sweeteners differently when the scale was presented horizontally or vertically. Orientation (2) × Sweeteners (4) repeated-measures analyses of variance were conducted for each parameter. When significant differences between or amongst orientations and sweeteners occurred, multiple comparisons with repeated measures *t*-tests were conducted.

RESULTS AND DISCUSSION

When averaged across the four sweeteners, horizontal ratings differed from vertical ratings for four of the eight time-intensity parameters: *IMAX* ($F(1,9) = 16{\cdot}57$, $p = 0{\cdot}003$); *AUC* ($F(1,9) = 12{\cdot}24$, $p = 0{\cdot}007$); *DEC ANGLE* ($F(1,9) = 5{\cdot}59$, $p = 0{\cdot}042$); *DEC AREA* ($F(1,9) = 6{\cdot}17$, $p = 0{\cdot}035$); see Fig. 2. When averaged across orientation, there were significant differences amongst the four sweeteners for three of the eight time–intensity parameters: *AUC*($F(3,27) = 3{\cdot}88$, $p = 0{\cdot}020$); *INC ANGLE* $(3,27) = 4{\cdot}45$, $p = 0{\cdot}011$); *DEC AREA* ($F(3,27) = 4{\cdot}09$, $p = 0{\cdot}016$); see Fig. 3.

Representative time–intensity curves for horizontal and vertical orientation for each sweetener are shown in Fig. 4. Average curves produced by simple arithmetic averaging are skewed toward the panelist with the longest duration and do not provide an accurate illustration of the individual parameters. For this reason, the curves in Fig. 4 are the time–intensity curves from one panelist who is in the middle of the range. These curves graphically illustrate the individual time–intensity parameters.

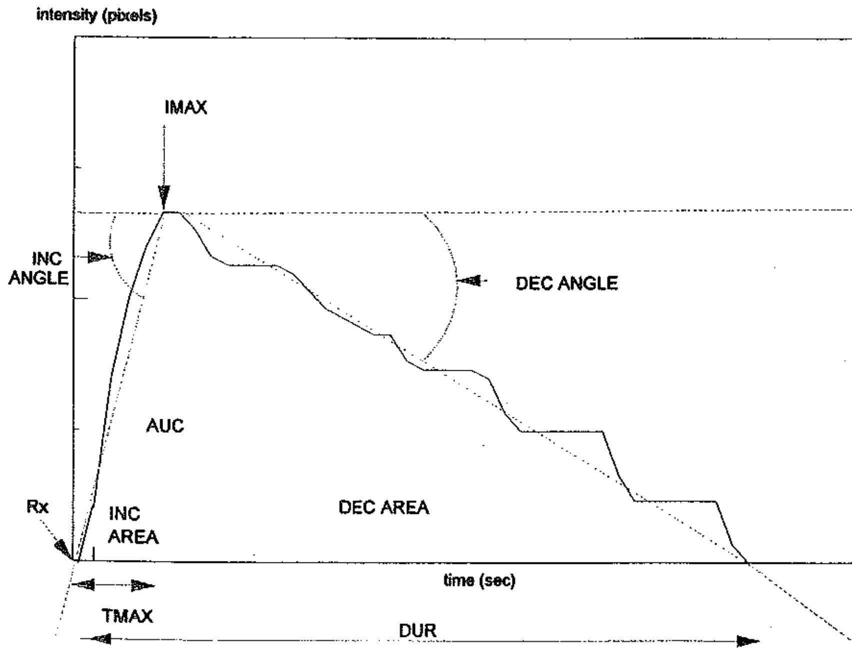

FIG. 1. Time–intensity curve and parameters.

TABLE 1. Time–intensity Parameters and their Definitions

Parameter	Abbreviation	Definition
Maximum intensity	*IMAX*	The maximum sweetness intensity (up to 60 pixels) of each sample.
Time to maximum intensity	*TMAX*	The time (in seconds) at maximum intensity.
Duration	*DUR*	The time (in seconds) for sweetness perception (from first perception to the end of the perception).
Increase angle	*INC ANGLE*	The angle of increase to maximum intensity. This can be interpreted to be the rate of onset of sweetness of the sample.
Increase area	*INC AREA*	The area under the increasing portion of the curve.
Decrease angle	*DEC ANGLE*	The angle of decrease from maximum intensity. This can be interpreted to be the rate of decrease of sweetness perception.
Decrease area	*DEC AREA*	The area under the decreasing portion of the curve.
Area Under the Curve	*AUC*	The total area under the time–intensity curve.

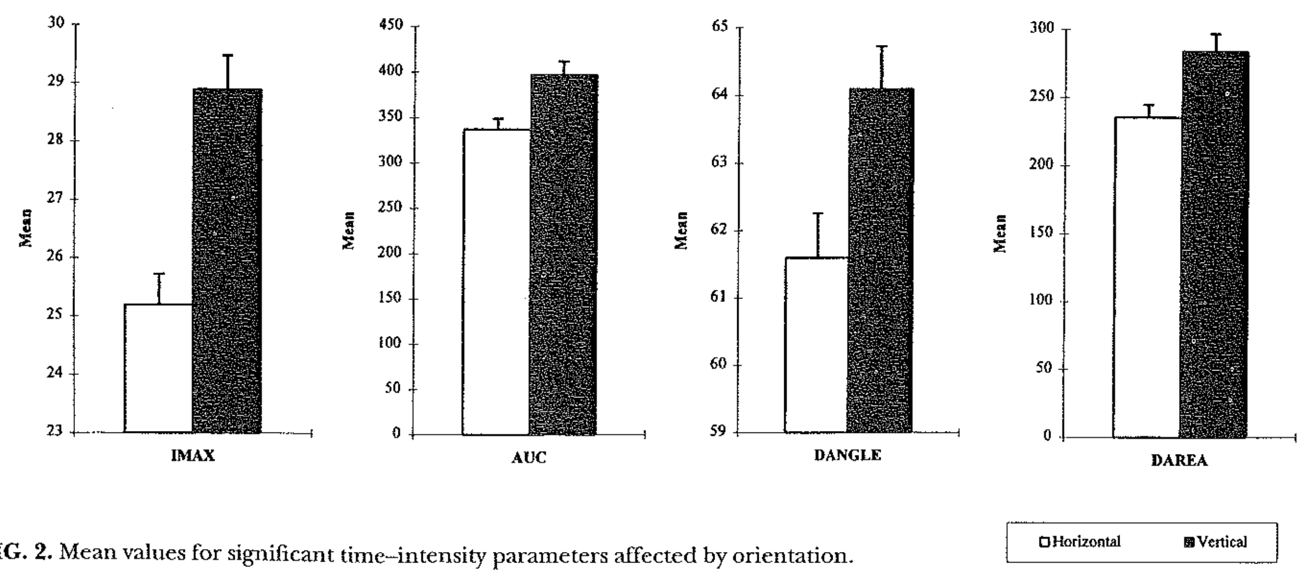

FIG. 2. Mean values for significant time–intensity parameters affected by orientation.

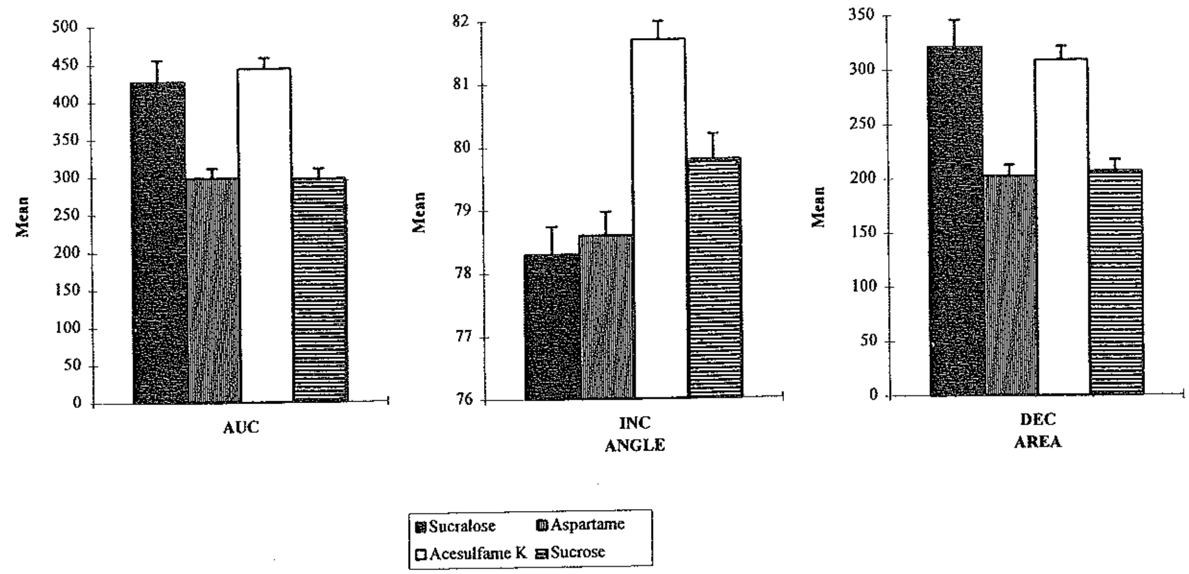

FIG. 3. Mean values for significant time–intensity parameters affected by sweetener.

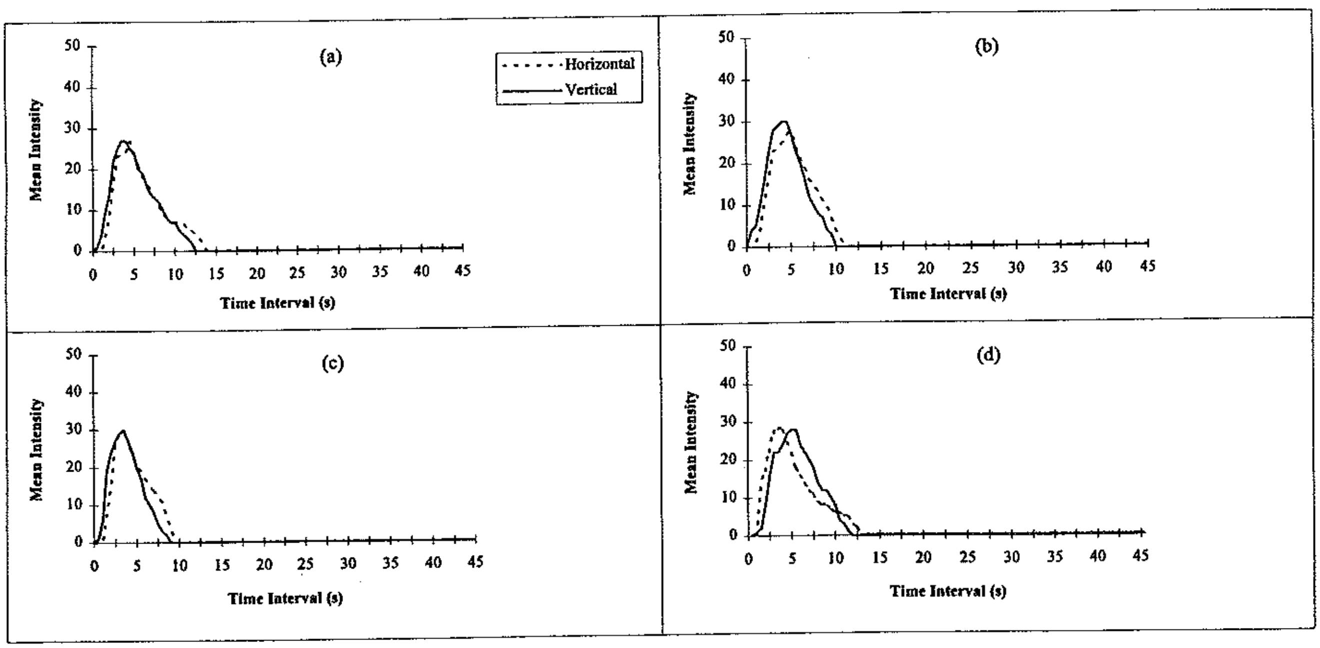

FIG. 4. Time–intensity curves from one individual for each sweetener: (a) sucralose; (b) aspartame; (c) acesulfame k; (d) sucrose.

Multiple comparisons with repeated-measures *t*-tests were conducted to isolate the differences between sweeteners for the three significant parameters. The results indicated that the area under the curve was significantly greater for sucralose as compared with aspartame ($t(9) = 2{\cdot}61$, $p = 0{\cdot}028$), and with sucrose ($t(9) = 2{\cdot}32$, $p = 0{\cdot}046$). Likewise, the area under the curve was significantly greater for acesulfame k compared with aspartame ($t(9) = 2{\cdot}80$, $p = 0{\cdot}021$), and with sucrose ($t(9) = 2{\cdot}31$, $p = 0{\cdot}046$). The angle of increasing intensity was significantly greater for acesulfame k as compared with sucralose ($t(9) = 3{\cdot}31$, $p = 0{\cdot}009$), and with aspartame ($t(9) = 4{\cdot}01$, $p = 0{\cdot}003$). Finally, the area under the decreasing portion of the curve was significantly greater for sucralose as compared with aspartame ($t(9) = 3{\cdot}04$, $p = 0{\cdot}014$), and with sucrose ($t(9) = 2{\cdot}51$, $p = 0{\cdot}033$), and greater for acesulfame k as compared with aspartame ($t(9) = 2{\cdot}64$, $p = 0{\cdot}027$). There were no significant Orientation × Sweetener interaction effects for any of the eight parameters (Table 2). This means that differences in perceptions of the four sweeteners (sucralose, acesulfame k, aspartame, and sucrose) were not affected by the orientation of the time–intensity scale. These results provide evidence that both horizontal and vertical scales can be used to assess time–intensity sweetness responses. In addition, the lack of significant differences between horizontal and vertical scales for the parameters of *TMAX*, *INC ANGLE*, *INC AREA* and *DUR* provide support for the use of either horizontal or vertical time–intensity scales.

It has been demonstrated that maximum intensity affects the area under the curve, as indicated by significantly high correlations between the *IMAX* and the *AUC* and *DEC AREA* (Duizer, 1992). In this study the significant *AUC*, *DEC AREA* and *DEC ANGLE* results observed between the two orientations are concomitant with the significant *IMAX* values (Table 2, Fig. 2).

Lawless & Clark (1992) have defined a bias in sensory evaluation as something which causes a response to be an inaccurate reflection of intensities. The results from this study suggests that for certain parameters line orientation could be a potential bias. Panelists' responses were affected by the orientation of the time–intensity line. Maximum sweetness intensity (*IMAX*) rated on the vertical scale was approximately 13% higher than that rated on the horizontal time–intensity scale (Fig. 2). Perhaps this is due to the different muscle groups involved in moving the mouse vertically versus horizontally. A vertical movement of the arm requires the use of the biceps, brachialis and triceps muscles which are the larger muscles in the arm. These larger muscles are used for strength and not for fine motor control, hence, reducing the precision in the movement of the mouse along the vertical line. This lack of precision results in a larger excursion of the mouse along the vertical line. In contrast, less strength is required to move the arm horizontally. The shoulder and wrist are rotated to accommodate the left to right movement (Chaffin, 1991). This movement produces a smaller, better controlled excursion of the mouse on the horizontal line.

The differences observed between the two orientations may be minimized to reduce possible bias due to orientation of the line. For example, the presentation of reference samples to anchor responses in the same position on the vertical and horizontal lines may increase the precision of the panel (O'Mahony & Wong, 1989). Further training with reference samples might allow the panelists to become more familiar with both orientations. Finally, scale orientation can be counterbalanced within and among panelists to homogenize orientation effects.

TABLE 2. Summary of *p*-values for Sweetener and Orientation

Parameter	Orientation	Sweetener	Orientation × Sweetener
IMAX	0·003	N.S.	N.S.
TMAX	N.S.	N.S.	N.S.
DUR	N.S.	N.S.	N.S.
AUC	0·007	0·016	N.S.
INC ANGLE	N.S.	0·011	N.S.
INC AREA	N.S.	N.S.	N.S.
DEC ANGLE	0·042	N.S.	N.S.
DEC AREA	0·035	0·018	N.S.

(N.S. = $p > 0{\cdot}05$)

Results from this study, regardless of orientation, were similar to those obtained by other researchers. Independent of orientation, there were no significant differences in maximum intensity for the four sweeteners, because the samples were equisweet to 9% sucrose. Noble *et al.* (1991) have stated that for the purpose of temporal perception measurement, sweeteners must be equisweet, as sweetener concentration affects time–intensity parameters. Differences in *INC ANGLE* amongst sweeteners reflects the rate of onset of the sweeteners. This measure is similar to the 'rate max' reported by Ott & Palmer (1990) which was obtained by dividing the height to reach maximum intensity by the time to maximum intensity. The significantly greater *INC ANGLE* observed for acesulfame k indicates that the rate of onset of sweetness perception of acesulfame k is quicker than that of aspartame and sucralose. These results were similar to those observed by Ott *et al.*, (1991) who concluded that acesulfame k had a faster rate of onset than sucrose, aspartame and alitame.

CONCLUSIONS

Time–intensity evaluations may be performed in both horizontal and vertical orientations. Although most of the time–intensity parameters are not significantly different, the value for maximum intensity is greater vertically than horizontally. This difference may be due to the muscle groups required to move the mouse horizontally compared to vertically.

These findings support the use of both horizontal and vertical scales to collect time–intensity responses for two different attributes simultaneously. This development will provide a new tool to investigate time dependent changes in foods and consumer products.

ACKNOWLEDGEMENTS

Financial support for this study was provided in part by the Industrial Research Assistance Program of the National Research Council Canada. This research could not have been completed without the generous cooperation of our panelists.

REFERENCES

Birch, G. G. & Munton, S. L. (1981). Use of the 'Smurf' in taste analysis. *Chem. Senses*, **6**, 45–52.

Chaffin, D. B. (1991). *Occupational Biomechanics*. John Wiley & Sons, Inc., Toronto, p. 397.

Cliff, M. & Heymann, H. (1993). Development and use of time–intensity methodology for sensory evaluation: A review. *Food Research International*, **26**, 375–385.

Dubois, G. E. & Lee, J. F. (1983). A simple technique for the evaluation of temporal taste properties. *Chem. Senses*, **7**, 237–247.

Duizer, L. M. (1992). An assessment of sensory time–intensity and instrumental methods for bovine muscle tenderness measurements. M.Sc. Thesis. University of Guelph, Guelph, ON.

Guinard, J-X., Pangborn, R. M. and Shoemaker, C. F. (1985). Computerized procedure for time–intensity sensory measurements. *Journal of Food Science*, **50**, 543–546.

Larson-Powers, N. & Pangborn, R. M. (1978). Paired comparison and time–intensity measurements of the sensory properties of beverages and gelatins containing sucrose or synthetic sweeteners. *Journal of Food Science*, **43**, 41–46.

Lawless, H. T. & Clark, C. C. (1991). Psychological Biases in time–intensity scaling. *Food Technology*, **46**, 81, 84–86, 90.

Lee, W. E. (1985). Evaluation of time–intensity sensory responses using a personal computer. *Journal of Food Science*, **50**, 1750–1753.

Neilson, A. J. (1957). Time–intensity studies. *Drug and Cosm. Industry*, **80**, 88–93.

Noble, A. C., Matysiak, N. L. & Bonnans, S. (1991). Factors affecting the time–intensity parameters of sweetness. *Food Technology*, **45**, 121–126.

O'Mahony, M. & Wong, S-Y. (1989). Time–intensity scaling with judges trained to use a calibrated scale: Adaptation, salty and umami tastes. *Journal of Sensory Studies*, **3**, 217–236.

Ott, D. B., Edwards, C. L. & Palmer, S. J. (1991). Perceived taste intensity and duration of nutritive and non-nutritive sweeteners in water using time–intensity evaluations. *Journal of Food Science*, **56**, 535–542.

Ott, D. B. & Palmer, S. J. (1990). Ingestion and expectoration sampling methods of four tastes in a model system using time–intensity evaluations. *Journal of Sensory Studies*, **13**, 53–70.

Schmitt, D. J., Thompson, L. J., Malek, D. M. & Munroe, J. H. (1984). An improved method for evaluating time–intensity data. *Journal of Sensory Studies*, **49**, 539–542, 580.

Schwartz, M. (1980). Sensory screening of synthetic sweeteners using time–intensity evaluation. *Journal of Food Science*, **45**, 577–581.