Food Quality and Preference 52 (2016) 153–159

Contents lists available at ScienceDirect

Food Quality and Preference

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

Application of hedonic dynamics using multiple-sip temporal-liking and facial expression for evaluation of a new beverage

Diego Rocha-Parra [a,b], David García-Burgos [c], Simone Munsch [c], Jorge Chirife [a], María Clara Zamora [a,b,*]

[a] Facultad de Ciencias Agrarias, Pontificia Universidad Católica Argentina (UCA), R. Freire 183, Ciudad de Buenos Aires (1426AVC), Argentina
[b] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina
[c] Department of Psychology, Clinical Psychology and Psychotherapy, University of Fribourg, 2 Rue de Faucigny, CH-1700 Fribourg, Switzerland

ARTICLE INFO

Article history:
Received 12 January 2016
Received in revised form 27 April 2016
Accepted 28 April 2016
Available online 29 April 2016

Keywords:
Facial expression
Healthy beverage
Multiple-sip modality
Temporal acceptance
Hedonic

ABSTRACT

Drinking and eating are not a matter of a single sip or bite. Dynamic data gathered from multiple sip or bite, seem to be more reliable than simple sip/bite evaluation. However, methodologies and analyses based on multiple sips/bites have received little attention until recently. The present study tested an innovative approach to measure the temporal changes in acceptance. It combines multiple-sip temporal-liking measurements (MSTL) with implicit taste reactivity using facial pattern expressions at different time points, for evaluation of a new beverage. Seventy-three consumers (35 females and 38 males) evaluated acceptance during 60 s, drinking three sips, with each sip every 20 s. The consumers' faces were filmed by a camera during the test session in order to analyze facial affective reactions. The results of the present paper show that MSTL modality allows seeing temporal changes in the acceptance of the beverage. Parameters analyzed maximum intensity (I_{max}) and area under the curve (AUC) in self-reported response curves presented variation through successive sips. The self-rated liking increased from the first sip to the third. In the same way facial expressions also showed a change over time during successive sips. In this case, the basic emotion of disgust, unpleasantness-related Action Units (AUs; AU 26 and AU 15) and negative valence showed a decrease from the first sip to the third one. It was observed that negative facial reactions are greater than the positive facial reactions in intensity.

1. Introduction

In this paper temporal aspects of consumer acceptance during consumption are examined. Temporal consumer acceptance is an issue that has recently gained interest (Delarue & Blumenthal, 2015). There are different ways to measure consumers' hedonic response to food in a dynamic perspective during a one bite/sip consumption event that have been suggested. Hedonic Time-Intensity (TI) and Multi-Attribute Time-Intensity methods have been used to provide information about the onset and decay of the hedonic attributes, its duration and its maximal intensity (e.g., Delarue & Loescher, 2004; Kuesten, Bi, & Feng, 2013; Methven et al., 2010). The Temporal Dominance of Sensations (TDS), Temporal Dominance of Emotions (TDE) and Temporal Drivers of Liking (TDL) approaches, consist of identifying dominant sensations/emotions which are responsible for the liking or disliking of a product, until the perception ends (e.g., Jager et al., 2014; Sudre, Pineau, Loret, & Martin, 2012; Thomas, Visalli, Cordelle, & Schlich, 2015).

Sudre et al. (2012) adapted TDS approach to investigate the temporal aspects of hedonic assessment, replacing the attributes by a 7-point liking scale. Consumers recorded temporal changes in their liking by clicking on a button corresponding to the above 7-point liking scale. With this procedure, consumers were not asked to constantly manipulate a cursor as for Time-Intensity, but just to focus on their liking change. However, the consumer decision to change the liking level during test is more an interval measure than a continuous quantification. Thomas et al. (2015) applied TDS to measure temporal liking, but they introduced a change in order to encourage the subjects to re-evaluate their liking. The blackened box corresponding to their liking score is turned back to white after 3 s. Subjects were instructed to re-evaluate their liking at these moments, and clicking the same box as before if they do not perceive any change in liking. The modification to the TDS scale brings it closer to the Time-Intensity register.

* Corresponding author at: Facultad de Ciencias Agrarias, Pontificia Universidad Católica Argentina (UCA), R. Freire 183, Ciudad de Buenos Aires (1426AVC), Argentina.
E-mail address: zamoramariacl@gmail.com (M.C. Zamora).

http://dx.doi.org/10.1016/j.foodqual.2016.04.013
0950-3293/

These approaches take into account one sip of the product. However, consuming a beverage is not a matter of a single sip as it implies dynamic physical, sensory, physiological and psychological phenomena with time (Delarue & Blumenthal, 2015; Galmarini, Symoneaux, Visalli, Zamora, & Schlich, 2015; Sudre et al., 2012). In order to get a more realistic description of the products' sensory and hedonic experience, dynamic changes over several sips in perception and acceptance of the drink should be considered. In this sense, previous studies have reported that small differences in the sensory profiles of products only become noticeable after repeated tasting; and changes in acceptance may be associated with small variations in the sensory properties over time (Köster, 2009; Köster, Couronne, Léon, Lévy, & Marcelino, 2002; Stein, Nagai, Nakagawa, & Beauchamp, 2003; Zandstra, Weegels, Van Spronsen, & Klerk, 2004). For instance, the use of multiple-sip Temporal Dominance of Sensations have been able to identify differences among sweeteners which had not been detected using classic sensory measurements averaged across time (Zorn, Alcaire, Vidal, Giménez, & Ares, 2014). To our best knowledge, no previous studies have applied multiple-sip methodology to the temporal liking assessment of beverages.

The focus of the present study was to test an improved method of TI, called multiple-sip temporal-liking (MSTL), based on scoring liking at predefined time-points during several sips (using computerized time-intensity method) to evaluate a new healthy beverage.

In recent years, there has been a growing interest in developing new functional beverages with special characteristics and health properties. Fortification of drinks offers a convenient alternative to contribute to a better nutritional quality of the population and a better balance in the daily diet. In particular, fortified drinks elaborated with wine polyphenols have received considerable interest for their presumed beneficial effects including antioxidant, anticarcinogenic, anti-inflammatory, hypotensive or even anticoagulant properties (see Arranz et al., 2012, for a review). It has been shown that small daily intakes of wine can reduce the risk of coronary heart disease and atherosclerosis, this benefit is ascribed to the antioxidants properties of the phenolic compounds (Diaz et al., 2012; Mazza, Fukumoto, Delaquis, Girard, & Ewert, 1999; Radovanovic & Radovanovic, 2010; Renaud & de Lorgeril, 1992) which differ from those found in grapes.

However, there are some drawbacks in wine consumption associated with the ingestion of alcohol: a) consumption must be moderate (i.e. 1–2 glasses per day) in order to avoid alcohol related diseases, and b), many people, either by ethnical, social or religious reasons do not consume wine. Recently a new dealcoholized powder was obtained from freeze-drying red wine which contained the polyphenols but without the alcohol (Galmarini et al., 2013; Rocha Parra, Galmarini, Chirife, & Zamora, 2015; Sánchez, Baeza, Galmarini, Zamora, & Chirife, 2013). It is to be noted that 400 mL of this reconstituted beverage contains about the same amount of wine polyphenols that a glass (100 mL) of red wine.

In order to complete our assessment of the temporal changes in acceptance of this beverage, repeated liking measurements were combined with implicit taste reactivity methodology using facial expression patterns. It is believed that facial expression analysis may aid in finding rapid, uncontrollable micro-expression responses that influence acceptance and preferences (Leitch, Duncan, O'Keefe, Rudd & Gallagher, 2015). Furthermore, facial expressions appear to reveal more accurate hedonic response to beverages as they reflect the affective core process without contamination from higher-order appraisal processes (e.g., Berridge, 2000; Havermans, 2011; Pham, Cohen, Pracejus, & Hughes, 2001).

The aim of present study was to measure the temporal changes in acceptance with repeated liking measurements (explicit measures), combined with taste reactivity methodology using facial expressions (implicit measures) during consumption of a new healthy red wine-based powder beverage. Besides the two modes (explicit and implicit) in multiple-sip methodology were also used for exploring whether gender differences affected temporary acceptance.

2. Materials and methods

2.1. Participants

The study was carried out with 73 consumers, recruited from the Pontificia Universidad Católica Argentina, based on their frequency of consumption of fruit juices (at least 2–3 times a week) and red wine (at least once a week). The whole population was homogeneous, consisting of 35 females and 38 males; aged 18–41 years old (22.3 ± 3.2, mean ± standard deviation). The procedure was conducted in individual computerized booths and the participants' faces were filmed. Participants were informed about the purpose of the study and that the experimental procedure would be video recorded. All the subjects performed the tests in one session, signed an informed consent form and they were not compensated for their participation. The study was approved by the Ethics Committee of the Pontificia Catholic University of Argentina.

2.2. Samples

The two formulations used for the present work, called 35-4 and 40-5, were selected from a previous study (Rocha Parra et al., 2015) considering their different but highest acceptance ratings (6.1 ± 1.7 and 6.6 ± 1.3; $p < 0.05$) measured with a 9-point category scale in 144 consumers of both sexes, but without previous significant gender divergences using the simple-sip methodology. The formulation 35-4 was obtained by the combination (for one liter of reconstituted drink powder) of the 35 g of wine powder + 4 g of commercial sweetener (cyclamate 5700 mg/100 g; saccharin 2000 mg/100 g), and 40 g of wine powder + 5 g of commercial sweetener for the formulation 40-5. The formulations had the same concentration of raspberry aroma (0.01%, Symrise, Argentina) and thickeners (0.20%, Guar gum, Gelfix, Argentina) in both samples. The wine powder was obtained by freeze drying the wine according to a method previously described by Sánchez et al. (2013). The wine used was *Cabernet Sauvignon*, "Postales del Fin del Mundo" (*Bodega Fin del Mundo*) from a cold climate wine growing region (Neuquén province, Patagonia region, Argentina) with an original alcohol content of 13.7% in average and a pH of 3.8 (vintage 2013, aged in oak). Carbohydrates used as drying aids for encapsulation were a mixture of Maltodextrin (Dextrose Equivalent 10 (MD10) provided by Productos de Maíz S.A., Argentina) and Arabic gum (provided by Gelfix, Argentina). The solution of wine + carbohydrate was freeze-dried at room temperature in a FIC Ll-I-E300-CRT freeze dryer (Rificor, Argentina). The powder obtained had 3% moisture content and about 1400 mg polyphenols/100 g.

The samples provided to consumers were rehydrated the day of tasting and served in 10-ml transparent plastic cups at 15 °C and encoded with three-digit random numbers to record the sample.

2.3. Preliminary testing

In order to design the timing between sip, a preliminary test was made with 16 participants (13 women and 3 men) who evaluated one sip of both samples during 30 s by Time-Intensity (T-I) methodology taking into account the Taylor and Pangborn's (1990) results, in which the maximum levels of liking were observed at 20–30 s after the placement of the sample in the mouth. The results showed that the sample 35-4 presented a maximum intensity (I_{max}) at 9 s approx. and then slowly decreased. The sample 40-5 presented I_{max} at 13 s, maintained this value approx. until 20 s and then decreased. Consequently, a time of 20 s between sips was selected, providing time enough to maintain the liking level and prevent that the evaluator's acceptance dropping below the neutral level and to obtain more homogeneous curves among participants.

2.4. Self-reported like/dislike intensity-time response curves (explicit measures)

The panel of 73 consumers evaluated the acceptance level through time using T-I data acquisition module of the software SensoMaker v1.8 (Federal University of Lavras, Brazil). On intensity scale (range 0–10, with 0 = dislike and 10 = like extremely), the software provided the T–I curve as well as the maximum intensity (I_{max}) and area under the curve (AUC).

Before starting the test, the participants were instructed in the evaluation software use. Each participant consumed three sips of the same sample (10 mL each), taking one sip every 20 s, and making a continuous rating for 60 s. The time axis was standardized in order to avoid that the total time differs from one participant to another, ruling out potential time-based differences. The timing of sample sips was managed by the timer on the software screen. The cursor was always visible during the continuous rating on the scale, which was anchored between 0 and 10. The specific instructions given at the subjects regarding the temporal liking task were as follow: "You will receive three cups of sample and the task is to evaluate liking through a 60 s time period responding to the question: How do you like this beverage now? Put the entire content of the first cup of the sample in your mouth, quickly press the start button and, evaluates the level of liking using the mouse to move the cursor along line scale on the screen. When the timer indicates 20 s, put the seconds cup of the sample in your mouth and continue the evaluation. At 40 s, put the third cup of the sample in your mouth and continues the evaluation of liking until 60 s".

Mineral water was used for rinsing between formulations which were served in transparent plastic containers at 15 °C; however, in the 20 s interval sip of the same sample the subjects did not rinse their mouths with mineral water. The participants evaluated the two formulations in one session. The order of formulation presentation was balanced among 73 consumers.

2.5. Facial expressions: basic emotions and action units (implicit measures)

A behavioral measure of formulation-elicited affective reactions was provided by the analysis of the facial patterns following the procedure of Garcia-Burgos and Zamora (2013). Facial reactions were videotaped with a digital video camera (JVC GZ-MS150SU), which was located in a hole of the booth wall, directly above the computer screen and in front of the subject at a distance of 1.5 m. The illumination of the participant's face was optimized by using daylight lamps (6500 k), in addition to the ceiling lights. The participants sat on a wooden school chair and were kept from turning their head by rating the liking of the beverages by time-intensity registers on a computer screen. The cups used were transparent so that they did not interfere with the recording. In addition, the camera had face detection technology which identified people's faces following their movements and made adjustments to achieve the optimum focus, exposure and white balance. The experimenter followed the facial expressions in real time watching the camera screen without being seen by the subjects.

The video files were run through the FACET™ SDK (iMotions Inc., Cambridge Innovation Center, US). The automatic facial expression recognition software tracked and analyzed frame-by-frame (1/25 s) the intensity (as estimated by expert human coders from 0 [=absent] to 1 [=very high intensity]) of positive/negative valence (as measure of overall affection) and joy/disgust emotion (as measure most likely based on solely flavor pleasantness/unpleasantness, respectively), as well as the probability for the presence of facial Action Units (AUs) related to specific pleasant/unpleasant reactions (as the levels of the evidence for the specific facial muscle activations [between 0 = absent and 1 = strongly present] described in the Facial Action Coding System; Ekman & Friesen, 1978). On the basis of previous findings (Ekman & Friesen, 1978; Ekman, Friesen, & O'Sullivan, 1988; Weiland, Ellgring, & Macht, 2010), cheek raising (AU6), lip corner pulling (AU12) and lip sucking (AU28) were taken as facial movements displayed in response to a pleasant stimulus; while nose wrinkling (AU9), upper lip raising (AU10), lip corner depressing (AU15) and jaw dropping (AU26) as index of unpleasant reactions. Negative valence and disgust emotion were included in order to get a complete view of the overall hedonic reactions. Thus, the intensity of valence and basic emotions and the probability of AUs during the 1-, 5- and 10-s intervals after the first sip, seconds sip and third sip were calculated and transformed into mean values. The ten seconds before the first sip were used as a baseline for all the analysis. After excluding frames without facial tracking due to head movements (e.g., shaking and turning the head, head-down motions) and occlusions of the face (e.g., when hand gestures occluded parts of the face); approximately 80% of the video frames were analyzable by the software.

2.6. Data analysis

Following the same analysis of T-I measurements that Taylor and Pangborn (1990), individual curves with $I_{max} > 5$ (sample liked) and $I_{max} \leqslant 5$ (sample disliked or neutral) were separately explored. 2 Gender × 2 Samples × 3 Sip mixed-factorial ANOVAs were performed on T-I parameters, I_{max} and AUC. On the other hand, 2 Gender × 2 Sample × 3 Sip ANOVAs were performed on the intensity output of valence (positive/negative), basic emotions (joy/disgust) and the probability of AUs being present for 1-, 5- and 10-s periods. Gender (male vs. female) condition was considered as the between-subjects factor, and Sample (40-5 vs. 35-4) and Sip (first vs. seconds vs. third) as the within-subject factors. We used the same statistical strategy (General Linear Model procedure of PASW Statistics 18; SPSS Inc., Chicago, IL) as Rocha Parra et al. (2015) in order to reduce alternative explanations in terms of statistical bias, although the present study included more within-measurements (2 formulations × 3 sips vs. 4 formulations × 1 sip) but lower sample size (73 vs. 144 participants). The post hoc comparisons were carried out by Tukey test. For all analyses, $p \leqslant 0.05$ was considered significant.

3. Results

3.1. Self-reported like/dislike intensity-time response curves (explicit measures)

The visual analysis of individual curves with $I_{max} > 5$ (sample liked) and $I_{max} \leqslant 5$ (neutral or disliked) for the sample 40-5 showed that 32 females (91.4%) and 34 males (89.5%) presented $I_{max} > 5$. Consequently, the curves of subjects with the range of $I_{max} \leqslant 5$ (three females and four males), who also demonstrated the lowest values in the dislike range for the sample 35-4, were discarded. This selection of the curves reduces the variability and increases the consensus among participants, since only those consumers who like the drink will be considered for the analysis. In the case of the sample 35-4, visual analysis of individual curves did not show such unanimous acceptance consensus, being most of the curves close to neutral point. The average acceptance T-I curves for males and females of the two samples, during three sips, over the time course of 60 s are shown in Fig. 1 and mean values of I_{max} and AUC for the three sips according to gender and samples are shown in Table 1. The differences in acceptance between samples were evident from the first to the third sip. These visual observations were statistically confirmed through ANOVA analysis of the curve parameters.

The ANOVA analysis on I_{max} showed a significant main effect of Sample ($F [1, 386] = 101.39$, $p < 0.001$, $\eta p2 = 0.21$), and Sip ($F [2, 386] = 11.07$, $p < 0.001$, $\eta p2 = 0.06$). No other effects or interactions were significant. The analysis of Sip showed lesser liking scores in the first sip compared with the others two sips ($ps < 0.05$; see Table 1); as well as the higher scores for the sample 40-5 compared to 35-4. The analysis of AUC presented a significant main effect of Gender ($F [1, 386] = 12.33$, $p < 0.001$, $\eta p2 = 0.03$), Sample ($F [1, 386] = 113.66$, $p < 0.001$, $\eta p2 = 0.23$) and Sip ($F [2, 386] = 109.86$, $p < 0.001$, $\eta p2 = 0.37$). No other effects or interactions were significant. The significant effect of Gender demonstrated higher scores of self-rated liking in male compared with female participants; the analysis of Sample showed higher scores for the sample 40-5 compared to 35-4; as well as differences among the three sips, with an increasing of liking scores from the first to the last sip ($ps < 0.05$).

3.2. Facial expressions: valence, basic emotions and action units (implicit measures)

In terms of positive valence (see Fig. 2, A), unlike the 1-s (highest $F[2, 144] = 2.22$, $p = 0.11$) interval, the analysis of 5-s and 10-s periods after tasting the wine samples showed a main effect of Sip ($F [2, 144] = 13.32$, $p < 0.001$, $\eta p2 = 0.16$) with higher intensity in the first sip compared to third one ($ps < 0.05$) and a Gender × Sip interaction (lower $F [2, 144] = 3.06$, $p = 0.05$, $\eta p2 = 0.04$). The analysis of the interaction showed that positive valence decreased in female from the first sip to the third one, as well as a lower score in the third sip compared to males ($ps < 0.05$). The analysis of negative valence (see Fig. 2, B) only showed a main effect of Gender ($F [1, 72] = 5.01$, $p < 0.05$, $\eta p2 = 0.06$) during the 1-s interval, with greater negative valence score in females compared with males, and Sip ($F [2, 144] = 3.06$, $p = 0.05$, $\eta p2 = 0.04$) in the 5-s period, with a reduction from the first and seconds sips to third one. No other effects or interactions were significant in positive/negative valence (highest $F[2, 144] = 2.62$, $p = 0.08$).

Table 1
Maximum intensity (I_{max}) and area under the curve (AUC) parameters of the T-I curves for the degree of liking of two different powder beverage samples (40-5 and 35-4) across the three sips and split by Gender.

Sample	Gender	Sip	I_{max}	AUC
40-5	Male	1	6.0 ± 1.1	92.3 ± 19.3
		2	6.8 ± 1.1	125.3 ± 21.4
		3	7.3 ± 1.1	143.8 ± 19.8
	Female	1	6.1 ± 1.1	79.1 ± 17.8
		2	6.7 ± 1.3	119.2 ± 27.5
		3	6.5 ± 1.2	121.7 ± 21.3
35-4	Male	1	5.1 ± 1.0	66.7 ± 17.1
		2	5.5 ± 0.5	96.5 ± 15.2
		3	5.8 ± 0.9	105.2 ± 19.3
	Female	1	5.1 ± 1.3	60.3 ± 15.1
		2	5.3 ± 1.2	90.1 ± 20.7
		3	5.8 ± 1.6	104.3 ± 21.5

Note. The data are presented as mean (±standard deviation).
Significant main Gender effect is only presented in AUC.

Concerning basic emotions (see Table 2), the analysis of joy did not reveal any significant main effects or interaction (highest $F [2, 144] = 2.64$, $p = 0.08$). The analysis of disgust revealed a significant main effect of Gender during the 1-s interval ($F[1, 72] = 3.70$, $p = 0.05$, $\eta p2 = 0.05$), with a higher intensity in females than males, and Sip during the 1-s, 5-s and 10-s intervals (lowest $F [2, 144] = 3.09$, $p < 0.05$, $\eta p2 = 0.04$), with higher intensity in the first sip compared to third one ($ps < 0.05$). No other effects or interactions were significant.

In terms of pleasantness-related AUs (see Table 3), the analysis of AU6 revealed a significant main effect of Sip in 1-, 5- and 10-s periods (lowest $F [2, 144] = 3.52$, $p < 0.05$, $\eta p2 = 0.05$), showing a lower level of cheek raising during the last sip compared to

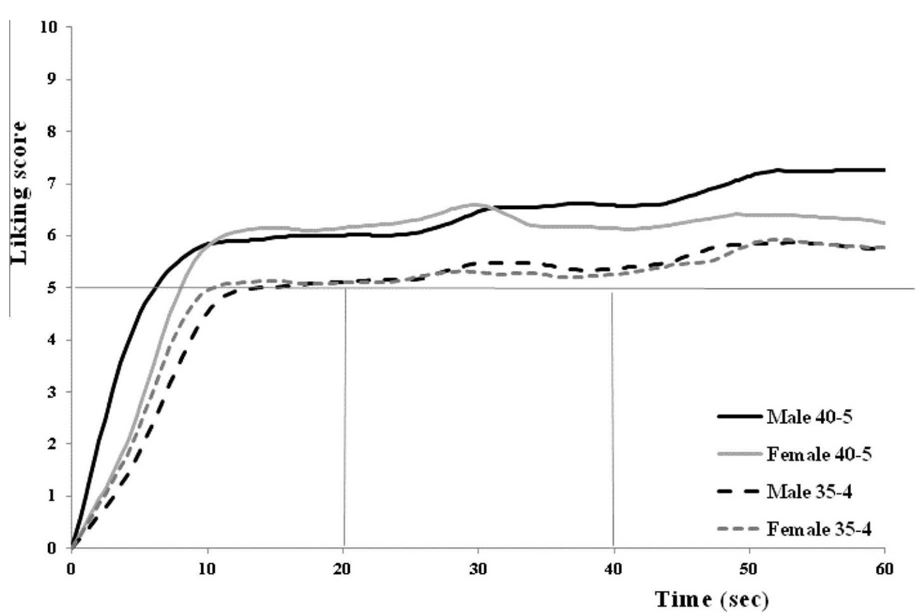

Fig. 1. Time-Intensity curves for the degree of liking of two different powder beverage samples (40-5 and 35-4) during 60 s after the first (0 s), second (20 s) and third (40 s) sip. The averaged data are split by gender groups.

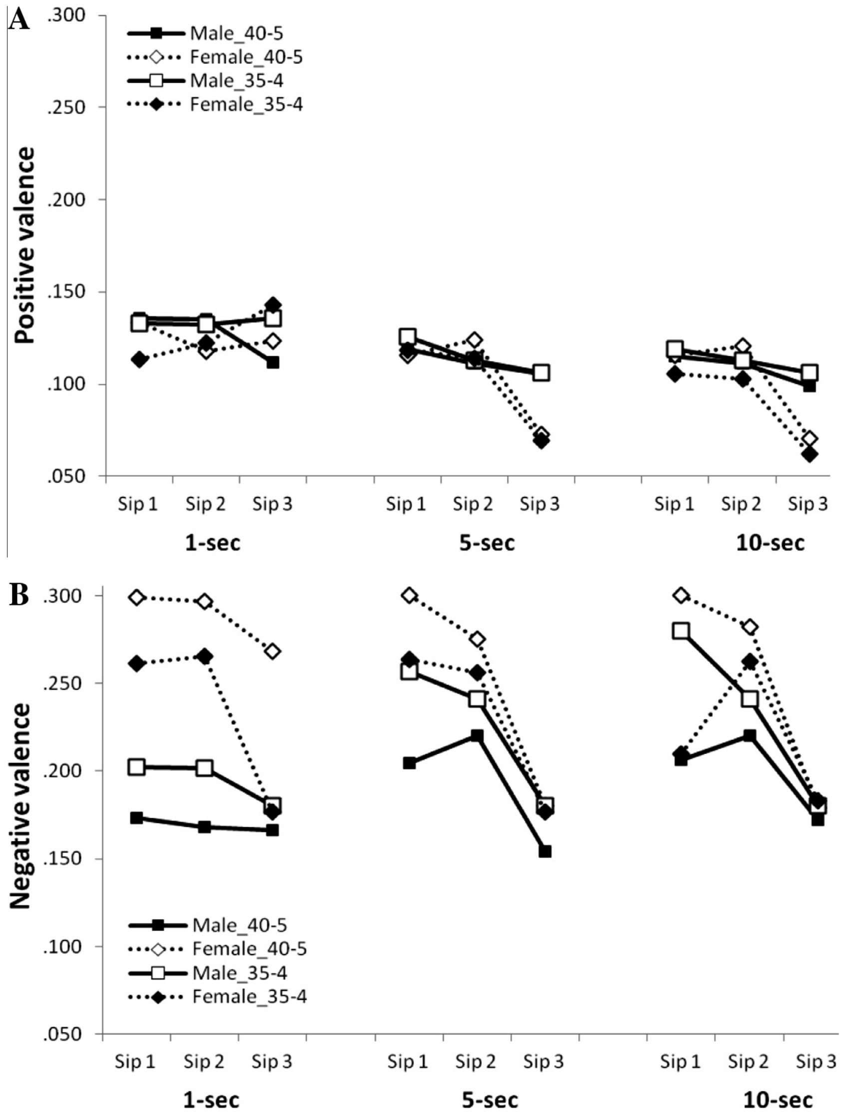

Fig. 2. Effect of the first, second and third sip on intensity of positive (A; pleasant) and negative (B; unpleasant) valence for males and females during the 1-, 5- and 10-s intervals for two different powder beverage samples (40-5 and 35-4).

Table 2
The intensity of the emotional states of "joy" and "disgust" for males and females during the 1-, 5- and 10-s intervals after the first sip, second sip and third sip.

Basic emotions and AUs	Gender	1-s period			5-s period			10-s period		
		Sip 1	Sip 2	Sip 3	Sip 1	Sip 2	Sip 3	Sip 1	Sip 2	Sip 3
Joy	Male	0.014 (0.02)	0.022 (0.02)	0.019 (0.05)	0.020 (0.05)	0.018 (0.04)	0.023 (0.05)	0.021 (0.05)	0.025 (0.04)	0.019 (0.03)
	Female	0.020 (0.02)	0.018 (0.03)	0.021 (0.07)	0.021 (0.03)	0.022 (0.04)	0.016 (0.03)	0.021 (0.04)	0.023 (0.03)	0.017 (0.03)
Disgust	Male	0.032 (0.03)	0.037 (0.04)	0.061 (0.09)	0.055 (0.08)	0.069 (0.10)	0.052 (0.09)	0.062 (0.10)	0.069 (0.11)	0.055 (0.09)
	Female	0.066 (0.06)	0.072 (0.10)	0.067 (0.13)	0.093 (0.12)	0.075 (0.10)	0.058 (0.11)	0.093 (0.12)	0.084 (0.11)	0.061 (0.11)

Note. The data are presented as mean (±standard deviation). Interpretation: between 0 = absent and to 1 = very high intensity. Since analyses revealed no effect or interaction on any measure, the data were collapsed across Sample factor.

seconds one ($ps < 0.05$). The analysis of AU12 showed a significant main effect of Sip in 5- and 10-s periods (F [2, 144] = 4.71, $p < 0.05$, $\eta p2 = 0.06$), with a decrease of lip corner pulling in the third sip compared to the first and seconds ones ($ps < 0.05$). No other effects or interactions involving pleasantness-related AUs were significant (highest F [2, 144] = 3.18, $p = 0.09$, $\eta p2 = 0.08$).

In terms of unpleasantness-related AUs (see Table 3), the analysis of AU9 and AU10 across 1-, 5- and 10-s periods revealed no significant effects or interactions (highest F [2, 144] = 3.20, $p = 0.08$, $\eta p2 = 0.03$). By contrast, the analysis of AU26 revealed a significant main effect of Sip in the 1-s period (F [2, 144] = 5.58, $p < 0.01$, $\eta p2 = 0.07$), showing an increment of jaw dropping from the first to the third sip; whereas the analysis of AU26 and AU15 in the 5- and 10-s periods revealed a significant main effect of Sip (lowest F [2, 144] = 10.33, $p < 0.001$, $\eta p2 = 0.12$) and interaction of Gender × Sip (lowest F [2, 144] = 3.60, $p = 0.05$, $\eta p2 = 0.05$),

Table 3
The probability of action units (AUs) presumed to be associated with pleasant and unpleasant stimuli being present, for males and females during the 1-, 5- and 10-s intervals after the first sip, second sip and third sip.

Basic emotions and AUs	Gender	1-s period			5-s period			10-s period		
		Sip 1	Sip 2	Sip 3	Sip 1	Sip 2	Sip 3	Sip 1	Sip 2	Sip 3
AU6 +	Male	0.102 (0.05)	0.090 (0.05)	0.101 (0.06)	0.115 (0.08)	0.123 (0.09)	0.101 (0.07)	0.115 (0.08)	0.123 (0.07)	0.098 (0.06)
	Female	0.161 (0.09)	0.140 (0.14)	0.139 (0.13)	0.167 (0.12)	0.169 (0.14)	0.117 (0.13)	0.167 (0.10)	0.166 (0.14)	0.123 (0.14)
AU12 +	Male	0.142 (0.15)	0.134 (0.18)	0.144 (0.20)	0.135 (0.15)	0.132 (0.16)	0.117 (0.17)	0.115 (0.12)	0.118 (0.14)	0.101 (0.16)
	Female	0.184 (0.22)	0.155 (0.20)	0.160 (0.17)	0.156 (0.18)	0.154 (0.20)	0.106 (0.16)	0.155 (0.18)	0.155 (0.19)	0.114 (0.19)
AU28 +	Male	0.248 (0.21)	0.264 (0.22)	0.240 (0.20)	0.258 (0.20)	0.242 (0.21)	0.237 (0.20)	0.264 (0.20)	0.259 (0.24)	0.320 (0.29)
	Female	0.218 (0.16)	0.216 (0.19)	0.226 (0.22)	0.221 (0.21)	0.227 (0.20)	0.167 (0.25)	0.217 (0.21)	0.222 (0.21)	0.172 (0.16)
AU9 −	Male	0.259 (0.23)	0.281 (0.25)	0.292 (0.26)	0.280 (0.27)	0.274 (0.27)	0.240 (0.23)	0.276 (0.27)	0.260 (0.27)	0.229 (0.22)
	Female	0.252 (0.26)	0.270 (0.28)	0.275 (0.29)	0.247 (0.25)	0.266 (0.27)	0.142 (0.14)	0.250 (0.24)	0.277 (0.27)	0.145 (0.14)
AU10 −	Male	0.293 (0.27)	0.276 (0.27)	0.277 (0.27)	0.278 (0.27)	0.295 (0.18)	0.256 (0.18)	0.275 (0.17)	0.294 (0.18)	0.255 (0.18)
	Female	0.248 (0.25)	0.241 (0.24)	0.209 (0.20)	0.268 (0.15)	0.252 (0.15)	0.258 (0.20)	0.276 (0.16)	0.256 (0.15)	0.216 (0.19)
AU15 −	Male	0.393 (0.22)	0.413 (0.24)	0.457 (0.25)	0.385 (20)	0.401 (0.21)	0.359 (0.23)	0.382 (0.19)	0.401 (0.20)	0.358 (23)
	Female	0.385 (0.21)	0.401 (0.21)	0.401 (0.22)	0.342 (0.18)	0.375 (0.19)	0.223 (0.24)	0.343 (0.18)	0.374 (0.18)	0.218 (0.21)
AU26 −	Male	0.442 (0.14)	0.441 (0.14)	0.447 (0.16)	0.417 (0.12)	0.426 (0.12)	0.401 (0.16)	0.428 (0.13)	0.438 (0.12)	0.406 (0.18)
	Female	0.438 (0.17)	0.446 (0.17)	0.482 (0.16)	0.437 (0.17)	0.453 (0.16)	0.274 (0.23)	0.437 (0.17)	0.460 (0.17)	0.276 (0.26)

Note. The data are presented as mean (±standard deviation). Interpretation: between 0 = absent and 1 = strongly present. Since analyses revealed no effect or interaction on any measure, the data were collapsed across Sample factor. +: facial action units associated to pleasant stimuli; −: facial action units associated to unpleasant stimuli.

showing a lower lip corner depressing in females compared to males during the third sip and a higher intensity in the seconds sip compared to third one. No other effects or interactions involving unpleasantness-related AUs were significant (highest $F [2, 144] = 2.94$, $p = 0.09$, $\eta p2 = 0.04$).

4. Discussion

The modality of multiple-sip temporal-liking (MSTL) using computerized time-intensity methods to produce like/dislike intensity-time response curves was used. This modality was combined with implicit taste reactivity methodology using facial pattern expressions. Both methodologies, explicit (i.e., self-rated liking via MSTL) and implicit measure (i.e., taste reactivity via facial pattern expressions) hedonic response. These hedonic responses were examined during consumption of a new red wine-based powder beverage.

The results of the present paper show that MSTL modality allows seeing temporal changes in the acceptance of the beverage. Parameters analyzed (I_{max} and AUC) in self-reported response curves presented variation through successive sips. The self-rated liking increased from the first sip to the third.

In the same way, the implicit measures via facial expressions also showed a change over time during successive sips. In this case negative valence, basic emotion of disgust and unpleasantness-related AUs (AU 26 and AU 15) showed a decrease from the first sip to the third one. In addition, the same behavior (but with less intensity) was presented in positive valence and pleasantness-related AUs (AU6 and AU12). This is supported by the findings of Horio (2003), Weiland et al. (2010), de Wijk, Kooijman, Verhoeven, Holthuysen, and de Graaf (2012), and Danner, Sidorkina, Joechl, and Duerrschmid (2014) who also found that negative facial reactions were significantly more intense than positive ones.

On the other hand, the present wine-based beverage reproduced the gender differences in sensory perception of regular red wine as it has been previously reported (Atkin, Nowak, & Garcia, 2007; Bruwer, 2007). Interesting changes were observed in women's liking patterns, those who showed greater negative valence score and higher intensity of disgust during the very first contact with the beverage (in the first sip and 1-s interval), and greater reduction in positive valence over time (in the third sip and 10-s period) this can be seen in Fig. 2. Therefore, our findings support that acceptability varies during the consumption experience, and multiple-sip methodology allows to identify at what time the consumer acceptance changes in a more realistic way.

Rocha Parra et al. (2015) examined the acceptance of the same red wine-based powder beverage, but using a simple-sip and single-point measurements. They found divergence in acceptance by gender only after using a double scale "confirmation" strategy. It consisted of using a second scale to double check consumer evaluations, in which first a 9-point category scale and then a Visual Analogue Scale (VAS) were applied in order to confirm the participants' perceptions about this new beverage. By contrast, clear gender differences in acceptance appeared when the hedonic reaction was monitored dynamically using cumulative measurements (such as the area under the liking time curve), after multiples sips (as in the case of positive valence), and with measurements at different durations (5- and 10-s periods in the case of AU15 and AU26). These changes in acceptance may be associated with small differences in the sensory profiles of different products and they only become noticeable after repeated tasting (Köster et al., 2002; Stein et al., 2003; Zandstra et al., 2004; Zorn et al., 2014).

Different methodologies have been adapted to measure linking over time. Kuesten et al. (2013) applied multi-attribute time–intensity (MATI) to evaluate both intensity and linking attributes. Delarue and Loescher (2004) studied the dynamics of food preferences by means of hedonic tests with imposed duration (linking evaluation every 1, 5 and 30 min), and Sudre et al. (2012) adapted TDS-methodology to investigate the temporal aspects of hedonic response. However, these methodological adaptations lack the continuous nature of time-intensity registers; and they were made using a unique event each measure (one sip). Thomas et al. (2015) made some modifications to capture the continuous nature of the hedonic response, but also used a single sip analysis to make the evaluation. Regarding multiple sip methodology, Methven et al. (2010) adapted boredom test to investigate linking over the time. The inherent nature of this method made it possible to investigate the ONS (Oral nutrition supplements) evaluated during successive sips.

The present paper is the first work that addresses the specific issue of multiple sips applied to food related facial analysis. Multiple-sip assessment offers much more information than one sip because each sip constitutes an independent event. Moreover, the use of the two approaches (explicit and implicit measures) allows observing different dynamic responses as three successive stimuli were evaluated.

Limitations of the analysis of temporal liking scores should be also considered in order to provide more accurate information about hedonic processes underlying product acceptance and preferences. For example, cumulative measurements as area under the curve of liking ratings or of the automated facial expression output, offers a global picture view of affective state and temporal changes (several sips), but they do not recognize the temporal dominance of emotions and the time course or dynamics of emotion. Also, rating liking continuously during and following taste-related emotion elicitation could interfere with emotion experience.

Furthermore, it will be necessary to extend the present study to other products in order to confirm whether the observed gender differences are really related to the product, or could be a more general 'gender-related' difference in dynamics of acceptance. The overall mean in each basic emotions and action units over 1, 5 or 10 s duration allows the simultaneous evaluation of multiple emotions of positive or negative valence. It will be important to develop methodology to assess acceptability trends and affective responses in a more time sensitive manner; such as using time series analysis of emotions from facial expression (Leitch, Duncan, O'Keefe, Rudd, & Gallagher, 2015). Another improvement could be the use of a higher number of sips, larger amounts, and a larger duration of the liking evaluation.

5. Conclusions

The present work revealed that the multiple sip methodology allowed observing changes in acceptance of the studied beverage, through successive sips using explicit and implicit measures. Moreover, multiple-sip offers more information than one sip because each sip constitutes an independent event. Both measures (explicit and implicit) show differences between genders, as shown by a greater area under the liking-time curve as well as lesser score of negative valence and disgust emotion in male participants. The overall mean in each basic emotions and action units over 1, 5 or 10 s durations allows the simultaneous evaluation of multiple emotions of positive or negative valence. However, negative facial reactions are greater than the positive facial reactions in intensity.

Acknowledgements

The present work was financed by Premio Nacional Arcor a la Innovación en Alimentos-Edition 2013. We are grateful to all the volunteers who participated in this study.

References

Arranz, S., Chiva-Blanch, G., Valderas-Martínez, P., Medina-Remón, A., Lamuela-Raventós, R. M., & Estruch, R. (2012). Wine, beer, alcohol and polyphenols on cardiovascular disease and cancer. *Nutrients, 4*(7), 759–781.

Atkin, T., Nowak, L., & Garcia, R. (2007). Women wine consumers: Information search and retailing implications. *International Journal of Wine Business Research, 19*(4), 327–339.

Berridge, K. C. (2000). Measuring hedonic impact in animals and infants. Microstructure of affective taste reactivity patterns. *Neuroscience and Biobehavioral Reviews, 24*, 173–198.

Bruwer, R. J. (2007). Regional brand image and perceived wine quality: The consumer perspective. *International Journal of Wine Business Research, 19*(4), 276–297.

Danner, L., Sidorkina, L., Joechl, M., & Duerrschmid, K. (2014). Make a face! Implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. *Food Quality and Preference, 32*, 167–172.

de Wijk, R. A., Kooijman, V., Verhoeven, R. H. G., Holthuysen, N. T. E., & de Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. *Food Quality and Preference, 26*(2), 196–203.

Delarue, J., & Blumenthal, D. (2015). Temporal aspects of consumer preferences. *Current Opinion in Food Science, 3*, 41–46.

Delarue, J., & Loescher, E. (2004). Dynamics of food preferences: A case study with chewing gums. *Food Quality and Preference, 15*(7-8 SPEC.ISS.), 771–779.

Diaz, B., Gomes, A., Freitas, M., Fernandes, E., Nogueira, D. R., Gonzalez, J., & Parajo, J. C. (2012). Valuable polyphenolic antioxidants from wine vinasses. *Food and Bioprocess Technology, 5*(7), 2708–2716.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: A technique for measurement of facial movement*.Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., Friesen, W. V., & O'Sullivan, M. (1988). Smiles when lying. *Journal of Personality and Social Psychology, 54*, 414–420.

Galmarini, M. V., Maury, C., Mehinagic, E., Sánchez, V., Baeza, R. I., Mignot, S., ... Chirife, J. (2013). Stability of individual phenolic compounds and antioxidant activity during storage of a red wine powder. *Food and Bioprocess Technology, 6*(2), 3585–3595.

Galmarini, M. V., Symoneaux, R., Visalli, M., Zamora, M. C., & Schlich, P. (2015). Static vs. dynamic liking in chewing gum: A new approach using a background task and a natural setting. *Food Quality and Preference, 40*, 381–386.

Garcia-Burgos, D., & Zamora, M. C. (2013). Facial affective reactions to bitter-tasting foods and body mass index in adults. *Appetite, 71*(1), 178–186.

Havermans, R. C. (2011). "You Say it's Liking, I Say it's Wanting ...". On the difficulty of disentangling food reward in man. *Appetite, 57*(1), 286–294.

Horio, T. (2003). EMG activities of facial and chewing muscles of human adults in response to taste stimuli. *Perceptual and Motor Skills, 97*(1), 289–298.

Jager, G., Schlich, P., Tijssen, I., Yao, J., Visalli, M., de Graaf, C., & Stieger, M. (2014). Temporal dominance of emotions: Measuring dynamics of food-related emotions during consumption. *Food Quality and Preference, 37*, 87–99.

Köster, E. P. (2009). Diversity in the determinants of food choice: A psychological perspective. *Food Quality and Preference, 20*(2), 70–82.

Köster, E. P., Couronne, T., Léon, F., Lévy, C., & Marcelino, A. S. (2002). Repeatability in hedonic sensory measurement: A conceptual exploration. *Food Quality and Preference, 14*(2), 165–176.

Kuesten, C., Bi, J., & Feng, Y. (2013). Exploring taffy product consumption experiences using a multi-attribute time–intensity (MATI) method. *Food Quality and Preference, 30*, 260–273.

Leitch, K. A., Duncan, S. E., O'Keefe, S., Rudd, R., & Gallagher, D. L. (2015). Characterizing consumer emotional response to sweeteners using an emotion terminology questionnaire and facial expression analysis. *Food Research International, 76*, 283–292.

Mazza, G., Fukumoto, L., Delaquis, P., Girard, B., & Ewert, B. (1999). Anthocyanins, phenolics, and color of Cabernet Franc, Merlot, and Pinot Noir wines from British Columbia. *Journal of Agricultural and Food Chemistry, 47*(10), 4009–4017.

Methven, L., Rahelu, K., Economou, N., Kinneavy, L., Ladbrooke-Davis, L., Kennedy, O. B., ... Gosney, M. A. (2010). The effect of consumption volume on profile and liking of oral nutritional supplements of varied sweetness: Sequential profiling and boredom tests. *Food Quality and Preference, 21*(8), 948–955.

Pham, M. T., Cohen, J. B., Pracejus, J. W., & Hughes, G. D. (2001). Affect monitoring and the primacy of feelings in judgment. *Journal of Consumer Research, 28*(2), 167–188.

Radovanovic, B., & Radovanovic, A. (2010). Free radical scavenging activity and anthocyanin profile of Cabernet Sauvignon wines from the Balkan region. *Molecules, 15*(6), 4213–4226.

Renaud, S., & de Lorgeril, M. (1992). Wine, alcohol, platelets, and the French paradox for coronary heart disease. *The Lancet, 339*(8808), 1523–1526.

Rocha Parra, D., Galmarini, M., Chirife, J., & Zamora, M. C. (2015). Influence of information, gender and emotional status for detecting small differences in the acceptance of a new healthy beverage. *Food Research International, 76*, 269–276.

Sánchez, V., Baeza, R., Galmarini, M. V., Zamora, M. C., & Chirife, J. (2013). Freeze-drying encapsulation of red wine polyphenols in an amorphous matrix of maltodextrin. *Food and Bioprocess Technology, 6*(5), 1350–1354.

Stein, L. J., Nagai, H., Nakagawa, M., & Beauchamp, G. K. (2003). Effects of repeated exposure and health-related information on hedonic evaluation and acceptance of a bitter beverage. *Appetite, 40*(2), 119–129.

Sudre, J., Pineau, N., Loret, C., & Martin, N. (2012). Comparison of methods to monitor liking of food during consumption. *Food Quality and Preference, 24*(1), 179–189.

Taylor, D. E., & Pangborn, R. M. (1990). Temporal aspects of hedonics responses. *Journal of Sensory Studies, 4*, 241–247.

Thomas, A., Visalli, M., Cordelle, S., & Schlich, P. (2015). Temporal drivers of liking. *Food Quality and Preference, 40*(PB), 365–375.

Weiland, R., Ellgring, H., & Macht, M. (2010). Gustofacial and olfactofacial responses in human adults. *Chemical Senses, 35*(9), 841–853.

Zandstra, E. H., Weegels, M. F., Van Spronsen, A. A., & Klerk, M. (2004). Scoring or boring? Predicting boredom through repeated in-home consumption. *Food Quality and Preference, 15*(6), 549–557.

Zorn, S., Alcaire, F., Vidal, L., Giménez, A., & Ares, G. (2014). Application of multiple-sip temporal dominance of sensations to the evaluation of sweeteners. *Food Quality and Preference, 36*, 135–143.