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Temporal Check-All-That-Apply (TCATA): A novel dynamic method for characterizing products

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ABSTRACT

Temporal Check-All-That-Apply (TCATA) is introduced as a new dynamic method for describing multidimensional sensory properties of products as they evolve over time. TCATA extends the Check-All-That-Apply (CATA) method. Selection and deselection of attributes are tracked continuously over time, permitting assessors to characterize the evolution of sensory changes in products. TCATA is presented using results from trained panel evaluations of yogurt products. Data are also used to illustrate approaches for exploratory data analysis. Raw data from each assessor are represented using indicator charts. Panel data are aggregated into TCATA product plots. Reference lines are added to provide additional guidance. Product pairwise comparisons are made in TCATA difference plots, emphasizing differences that are less likely to have arisen from chance. Correspondence analysis (CA) is used to visualize product trajectories over time in a sensory space, providing a summary multivariate understanding of the dynamic sensory properties. CA conducted on the TCATA yogurt data highlight the importance of the dynamic profile, and suggest that understanding the complexity of products requires investigation of temporal changes. Results indicate that the TCATA method has potential for evaluating temporal aspects of sensory perception but further research is required to identify methodological issues and to refine the methodology.

1. Introduction

One of the challenges in sensory evaluation is characterizing the rapidly evolving sensations that comprise the dynamic properties of products. Temporal sensory evaluation of foods and beverages is a complex endeavour, but also one that is relevant for understanding how products are perceived in the mouth during consumption. It comprises the evaluation of many in-mouth sensations (olfactory, gustatory, and trigeminal, as well as sound, texture, and temperature) that are not static but rather evolve over time (see Lawless & Heymann, 2010, Ch. 8). Various temporal sensory methods are available for characterization of dynamic product properties. In this manuscript, the Temporal Check-All-That-Apply (TCATA) method is introduced as a novel temporal sensory method, which could be used by assessors to characterize products.

Historically, temporal sensory evaluations have focused on attribute intensities, and have been conducted within the framework of analytical sensory evaluation. The best example is continuous time intensity (TI), which enables intensity measurement of one relevant attribute at a time. TI data are usually represented using curves, which show changes in attribute intensity between onset and extinction times (ASTM, 2013). Although Dual-Attribute Time Intensity (Duizer, Bloom, & Findlay, 1996) has been proposed for evaluation of two attributes simultaneously, continuous measurement is not possible for three or more attributes.

The traditional approach for measurement of three or more attributes involves descriptive analysis at specific, discrete time points during consumption (Lawless & Heymann, 2010, Ch. 8). Various methods have been proposed which pre-establish time windows for responses, e.g., Time-Scanning Descriptive Analysis (Seo, Lee, Jung, & Hwang, 2009), Multi-Attribute Time Intensity (MATI; Kuesten, Bi, & Feng, 2013), Time Related Profiling (Kostyra, Baryłko-Pikielna, Dąbrowska, & Wasiak-Zys, 2008), and Sequential profiling (Methven et al., 2010). Other methods involve determination of sensory properties at points of consumption, such as the intensity variation descriptive method (Gordin, 1987), or in sync with chew strokes, such as Progressive Profiling (Jack, Piggott, & Paterson, 1994).

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The Flavour Profile method (Caul, 1957) captures several product concepts, one being the order of elicitation of flavour characteristics. In a food product, the early development of appropriate sensations is closely tied to the emergence of a few attributes at the beginning of the evaluation. The Temporal Order of Sensations (TOS; Pecore, Rathjen-Nowak, & Tamminen, 2011) method captures the order in which the first few (e.g. 3) attributes emerge with each bite (or sip) of a multi-bite evaluation. TOS data are strictly ordinal, allowing the possibility of paper-based data collection.

Temporal Dominance of Sensations (TDS; Pineau, Cordelle, & Schlich, 2003; Pineau et al., 2009) was originally proposed as a multi-attribute temporal sensory method that scaled the intensities of a sequence of *dominant* attributes. Pineau et al. (2012, p. 164) propose a variant of TDS in which the dominant attribute is selected, without scaling its intensity, an approach often followed by other researchers (e.g., Thomas, Visalli, Cordelle, & Schlich, 2015; Zorn, Alcaire, Vidal, Giménez, & Ares, 2014). Time-Quality Tracking (Halpern, 1991; Zwillinger & Halpern, 1991) is an earlier method that also captures a sequence of attributes without intensities.

Adams, Williams, Lancaster, and Foley (2007) proposed using Check-All-That-Apply (CATA) questions to allow consumers to indicate their sensory perception of the samples that were also being evaluated hedonically. CATA questions provide multivariate binary data which properly indicate the applicability of provided descriptors to the samples. CATA questions do not directly capture intensities. If an attribute is present in one product, and also occurs in another product at a different intensity level, it is possible that an assessor will check the attribute for both samples. There is no scale to permit an assessor to characterize the level difference. Nonetheless, evidence presented so far in the literature has shown good correlation between CATA frequencies and attribute intensities (Bruzzone, Ares, & Giménez, 2012; Reinbach, Giacalone, Ribeiro, Bredie, & Frøst, 2014). CATA questions are being used increasingly in consumer questionnaires, and have been the subject of numerous methodological investigations published in this journal (Ares & Jaeger, 2013; Ares et al., 2013, 2014; Jaeger et al., 2014). Methods for evaluating reproducibility and repeatability of CATA assessors have been proposed (Jaeger et al., 2013; Worch & Piqueras-Fiszman, 2015). Meyners and Castura (2014) provide a review of methodological considerations and Meyners, Castura, and Carr (2013) give statistical approaches for CATA questions.

This manuscript presents TCATA as a temporal extension of CATA. TCATA extends the use of CATA questions by allowing continuous selection and deselection of attributes based on applicability of the attribute to describe the sample. The layout of the TCATA question is much like a CATA question. The assessors' task is to indicate and continually update the attributes that apply to the sample moment to moment, that is, to track the sensations in the sample as it changes over time. Assessors are permitted to check attributes at times whenever applicable, and to uncheck attributes (or leave attributes not checked) whenever not applicable. Multiple attributes can be selected simultaneously, which may permit description of sensations that arise either sequentially or concurrently.

In the present work the TCATA method is presented, along with results from a TCATA study involving a trained panel.

2. Materials and methods

2.1. Temporal Check-All-That-Apply (TCATA)

In a TCATA evaluation of a single sample by an assessor in a particular session, the computerized data collection system displays the entire list of attributes on the screen. The layout of a TCATA question is much like a CATA question (cf. Meyners & Castura, 2014). Fixed order of attributes is avoided to reduce confounding effects related to attribute order and position; in the study presented herein, attributes were presented according to an experimental design to balance biases associated with attribute position. The number of attributes was kept to a maximum of 10, consistent with TDS methodological recommendations (Pineau et al., 2012), which seems tentatively appropriate for TCATA.

Assessors were instructed to review the attributes to facilitate the task of locating attributes during the TCATA evaluation. They were instructed to click a Start button concurrently with putting the sample into the mouth, and to immediately commence tracking changes in the sample by checking and unchecking words, such that the words that were selected described the sample in that moment. At any time between clicking Start and the end of the evaluation time, assessors were free to check any unselected attribute, or to uncheck any selected attribute. In a TCATA evaluation, it is possible that some attributes are never checked, that other attributes are checked but never unchecked, and that other attributes are checked and unchecked one or more times, ending in either the checked or the not checked state. Note that checking, unchecking, or not checking one attribute does not affect the possibility of checking, unchecking, or not checking any other attribute. Multiple attributes can be selected simultaneously according to when the attribute is considered applicable to describe the sample. It is important to stress that TCATA does not rely on the concept of dominance: assessors select attributes that are deemed applicable for describing each sample at each time slice.

Computer records are maintained and indicate each change in the checked status of each attribute, e.g., when an assessor checks a not-selected attribute or unchecks a selected attribute. The attribute and all time(s) that the attribute was checked and/or unchecked are recorded. Compusense at-hand 5.6 (Compusense Inc., Guelph, Ontario, Canada) used the JavaScript `Date` object method `getTime()` to obtain timestamps for the evaluation start and for each event, which are subsequently reported in the software at 10 ms (0.01 s) intervals. Data form a multivariate binary time series.

Data in this TCATA study are considered to be a time series of applicability data because assessors are instructed to describe samples in a manner similar to CATA. For this type of data, no explicit assumptions are made regarding the type attentional process that might result in selection (or deselection) of attributes. For example, it is possible that a sensation (or the lack of a sensation) will capture the assessor's attention, leading the assessor to update or maintain the current checked state of the corresponding attribute, as applicable. It is also possible that seeing an attribute on the screen, thinking of an attribute, or other process might direct the attention of the assessor to consider the applicability of that particular attribute for describing the sample being evaluated, and that the assessor subsequently updates or maintains the checked state of that attribute in response.

2.2. Stirred yogurt study

2.2.1. Yogurt products

Six commercial strawberry yogurt products, available in supermarkets in Montevideo, Uruguay were selected for inclusion in the test. All products were stirred yogurts with blended fruit (Greek yogurts were not included). Products differed in fat content (0% and 3.2%) and sugar content (9–17%). Some of the products were formulated with sweeteners. Samples were purchased and maintained in storage under refrigeration temperatures (4 °C ± 1 °C), and removed from the refrigerator as needed immediately prior