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Can children use temporal sensory methods to describe visual and food stimuli?

Ana Laura Velázquez[a*], Leticia Vidal[a], Paula Varela[b], Gastón Ares[a]

[a] Sensometrics & Consumer Science, Instituto Polo Tecnológico de Pando, Facultad de Química, Universidad de la República, By Pass de Rutas 8 y 101 s/n, CP 91000. Pando, Canelones, Uruguay

[b] Nofima AS, P.O. Box 210, 1431 Ås, Norway

*Corresponding author: Ana Laura Velázquez (alvelazquez@fq.edu.uy)

Abstract

Sensory scientists have adapted several sensory methods to fit children's cognitive abilities according to the different developmental stages. Although children have been reported to be able to use sensory methods to describe foods and beverages, published applications are limited to static characterizations. In this context, the objective of the study was to evaluate the feasibility of using two dynamic methods (temporal check-all-that-apply -TCATA- and Temporal dominance of sensations -TDS-) for sensory characterization with children. A video featuring colored circles (varying in size, appearing and disappearing) was used to convey the idea of temporal perception and to familiarize children with the methods. A series of six vanilla milk desserts was used in the tasting session. A total of 102 children (8 to 12 years old) recruited from two Uruguayan schools participated in the study. They were randomly divided in two groups, each of which used one of the methods. Results showed that TCATA and TDS allowed capturing the dynamics in the video. However, TCATA provided a more detailed description of how the colored circles evolved with time than TDS. In the case of the milk desserts samples, both methodologies showed similar results regarding the most relevant sensory characteristics. However, children mostly used them as static methods. In the TDS task, children dithered for long before selecting a new attribute, which points towards difficulties in evaluating dominance. Results from the present work suggest that refinements are needed to make TCATA and TDS methods applicable with children for characterizing food stimuli.

Keywords: *sensory characterization; Temporal Check-All-That-Apply; TCATA; Temporal Dominance of Sensations; TDS.*

Highlights

- Children were able to use TCATA and TDS to describe visual stimuli.
- TCATA provided a more detailed and accurate description of the video than TDS.
- Dominance may be conceptually complex for children.
- Children used TCATA and TDS methods as static when applied to food stimuli.
- Refinements are needed to use TCATA and TDS with children to characterize food.

1. Introduction

One of the strategies that can be implemented to promote healthier eating patterns among children is the development of healthy products that meet their sensory and hedonic expectations. Traditionally, product developers have used adults' feedback to develop food products targeted at children. However, their needs and wants differ from those of adults (Popper & Kroll, 2011). This difference has motivated sensory scientists to adapt several sensory methods to fit children's cognitive abilities according to the different developmental stages (Guinard, 2000).

Over the past decades multiple methods have been used to explore how children perceive food and beverages in sensory and consumer science (Laureati, Pagliarini, Toschi, & Monteleone, 2015; Popper & Kroll, 2011). Hedonic methods, such as paired comparison, ranking and hedonic scales, have been the most frequently applied methods with children to get insights during product development (Laureati, et al. 2015; Cordelle, Piper, & Schlich, 2005; Liem, Mars, & de Graaf, 2004; Pagliarini, Gabbiadini, & Ratti, 2005). Regarding analytical methods, the application of discriminative methods with children, such as paired comparison, ranking, triangle tests and tetrad tests, are well documented (Garcia, Ennis, & Prinyawiwatkul, 2012; Guinard, 2000; Liem et al., 2004). In contrast, there have been few attempts to use sensory descriptive methods due to their complexity. Recently, Laureati, et al. (2017) proposed the use of Check-All-That-Apply (CATA) to characterize food with children. They found that CATA allowed the identification of relevant attributes and enabled the discrimination of apple puree samples.

Food perception is a dynamic phenomenon due to the several changes foods undergo during oral processing. Sensory methods that consider this dynamic dimension have drawn increasing attention as a tool to better characterize the eating experience (Castura, 2018). However, temporal methods with children have been rarely reported in the literature. For instance, Temple, Laing, Hutchinson, and Jinks (2002) used time-

intensity measures with 8 to 9-year-old children and adults to study sweetness perception in different products. They showed that children gave higher sweetness ratings than adults, and that sweetness perception decreased faster in children as compared to adults. Recently, Lange et al. (2019) developed a discontinuous method to measure dynamic liking with children. The authors concluded that the method was suitable for children and highlighted several methodological challenges for its successful application. For instance, they stressed importance of the wording of the instructions and the usefulness of visual stimuli to help children to understand the concept of temporality.

Temporal Dominance of Sensations (TDS) and Temporal check-all-that-apply (TCATA) have become highly popular methods for dynamic sensory characterization. The two methods are conceptually different and may be suited for different purposes. TDS is based on the concept of dominance, and require assessors to select the attribute that catches their attention at each moment of the evaluation (Pineau et al., 2009). On the contrary, TCATA, an extension of Check-All-That-Apply (CATA) questions, is based on attribute applicability: assessors are asked to select all the terms they consider applicable to describe the sample at each moment of the evaluation and to uncheck them when they are no longer applicable (Castura, Antúnez, Giménez, & Ares, 2016). Both methods have been applied broadly in the food domain with adult populations (Ares et al., 2015; Ares et al., 2017; Di Monaco et al., 2014; Jaeger et al., 2017). TDS and TCATA have been reported to be suited for different purposes. TCATA has been reported to provide a more detailed description of how the sensory characteristics of products evolve over time (Esmerino et al., 2017; Ares et al., 2015; Kawasaki et al., 2019). On the contrary, TDS has been reported to be useful to identify the key attributes that catch consumers' attention throughout consumption (Alcaire et al., 2017b; Kawasaki et al., 2019).

Using Likert scales, Ares et al. (2015) showed that adult consumers perceive TDS and TCATA tasks as not tedious and easy. However, it is still not clear if they are applicable with younger populations due to some of their key features. Both methods are

based on the simultaneous evaluation of multiple sensory attributes, which requires sustained attention throughout the task. In addition, specific features of TDS and TCATA may be challenging for young consumers.

TDS relies on the concept of dominance, i.e. the sensation catching the attention of the assessor at a given time, not necessarily being the one with the highest intensity (Pineau et al., 2009). This concept may be difficult to understand for children. In this sense, one of the concerns raised for TDS is the high heterogeneity in how dominance is interpreted, which may hinder a detailed description of the dynamics of food perception, particularly when working with complex products (Di Monaco, Su, Masi, & Cavella, 2014; Ares et al., 2015). Moreover, Varela et al. (2018) reported dithering and dumping effects due to the need of only selecting one attribute and a limited availability of attributes on the list which may also hinder the accuracy of the temporal profiles. These features may be even more pronounced among children, but this has not been studied until now.

Meanwhile, TCATA is a highly demanding method that requires assessors to focus in two simultaneous tasks: checking applicable attributes and unchecking attributes that are no longer applicable. Participants may concentrate in checking the attributes that apply and sometimes forget to uncheck them, reducing the accuracy of the dynamic sensory profiles (Ares et al., 2016). The high cognitive demand of TCATA may be higher for children and could hinder their ability to use the method to accurately describe the dynamics of the sensory characteristics of products.

Regardless of the potential of both methods with adults, there is a lack of information regarding their use with children. In this context, the objective of this study was to evaluate the feasibility of using two dynamic methods, TCATA and TDS, for sensory characterization with children.

2. Materials and Methods

The study was divided into two main parts: the evaluation of a video and the dynamic sensory characterization of six vanilla milk dessert samples. The video was used to familiarize children with the methods and to check their ability to use them to describe a simple visual stimulus. Sample tasting focused on regular and sugar-reduced samples of vanilla milk desserts, a popular product usually targeted at children. Detailed results from the sensory characterization of the samples are presented in Velázquez, Vidal, Varela, & Ares (2020).

2.1 Participants

The study was focused on school-aged children and involved a convenience sample of 112 children (8–12 years old, 54% girls), recruited from two elementary schools in Montevideo (Uruguay). Only children over 8 years old were considered to assure reading fluency. In addition, from this age, children have been reported to be able to use different sensory tests on their own, without much assistance from an adult (Popper & Kroll, 2011).

In both schools, all children in the age range were invited to participate. One adult legally responsible for each child signed an informed consent form to allow their children participation in the study. The informed consent form stated that children with dietary restrictions or allergies could not participate in the study. Approximately 60% of the parents allowed their children to be involved in the study. Children provided informed assent to participate through the software used for data collection. They were informed that they were free to leave the test at any point in time. Ethical approval was obtained from the Ethics Committee of the School of Chemistry of Universidad de la República (Uruguay).

2.2. Experimental procedure

The main study comprised two tasks: video evaluation and sample tasting. Instructions for each of the tasks were given using explanatory videos featuring a cartoon

166 character (detective monkey). After each of the instruction videos, a researcher verbally
167 repeated the instructions and asked children if they had any question. A pilot study with
168 4 children (8-10 years old) was conducted to fine tune the video (e.g. the number of
169 colors that simultaneously appeared in the video and the speed at which colors
170 changed), the instructions, the sensory attributes and the number of samples to be
171 included in the study. Children were asked about their understanding of the task and the
172 sensory attributes. They were also asked about their perceived difficulty to complete the
173 task. Based on results from this pilot study, changes in the wording of the instructions
174 and sensory attributes were implemented.

175 The main study was conducted in a separate quiet room in each of the elementary
176 schools and lasted less than 20 minutes. Groups of 5-7 children performed the task at a
177 time with the assistance of 2 researchers. Two or three children were seated in a large
178 table with space in between them, but no physical divider was used. Data were collected
179 on Ipads (Apple Inc., Cupertino, California, USA) using Compusense Cloud
180 (Compusense Inc, Guelph, Canada).

181 Children were randomly divided into two groups, each of which used one of the
182 two sensory methods: TCATA (n=53) or TDS (n=59). No significant differences were
183 found in the age and gender distribution between the groups (p-values > 0.59).

184

185 *2.3.1. Video evaluation*

186 A visual test was designed to convey the idea of temporal evolution and to
187 familiarize children with the methods. The video lasted 40 seconds and included circles
188 of different colors. The circles appeared at different points in time and their sizes
189 gradually increased over time. After reaching a maximum of 8 or 14 cm in diameter, the
190 sizes gradually decreased until disappearing. Figure 1 shows two screenshots of the
191 video. Figure 2a shows the sequence of how the colors appeared on the screen, as well
192 as their size evolution. Children were asked to describe the video using either TCATA or
193 TDS. They had to use a list of 6 colors to describe all the colors they saw on the screen

194 at each point in time (TCATA) or the color that caught their attention (TDS) at each time.
195 The exact instructions of each task are provided in Figure 1.
196
197 Insert Figure 1 around here
198
199 *2.3.2 Sample tasting*
200 After children finished the evaluation of the video, written instructions providing a
201 link between the evaluation of the video and the evaluation of the sensory characteristics
202 of milk desserts were shown on the screen. Children were explained that they had
203 evaluated how colored circles changed over time and that in the following task they had
204 to use the same approach to say how the characteristics of milk desserts changed over
205 time. Then, explanations about how to conduct TDS or TCATA were provided using a
206 video. After children read the instructions on the screen, researchers verbally repeated
207 the key concepts and answered any doubt children might have.
208 Children received six milk vanilla dessert samples (custard type) and they were
209 asked to describe them using a TCATA or TDS task. The samples differed in their sugar
210 content, the type and concentration of vanilla flavoring and starch content (Table 1). Full
211 details of the samples are provided in Velázquez et al. (2020). According to results from
212 preliminary studies conducted with a trained panel of assessors, the samples showed
213 perceivable differences in their sweetness, vanilla flavor intensity and thickness (data not
214 shown). Differences among samples were also perceived by children in their sensory
215 characteristics and liking, as detailed in Velázquez et al. (2020). One of the samples was
216 considered a dummy sample (Warm-up) and was always presented first. The other five
217 samples (1 to 5 in Table 1) were presented following a Williams' Latin square
218 experimental design. Children received 20 g of each sample in black plastic cups coded
219 with 3-digit random numbers at 8°C. Still mineral water was used for rinsing between
220 samples.

A list of six words was used in TCATA and TDS: sweet, vanilla flavor, off-flavor, creamy, soft and hard. Attribute selection was based on previous studies (Alcaire et al., 2017a; Ares, Giménez, Barreiro, & Gámbaro, 2010; Bruzzone et al., 2015) and on the pilot study with children. Children were asked to read the list before starting the test. If they had any doubt about the meaning of the words, researchers provided verbal explanations. According to the evaluation protocol, children had to place a spoonful of sample in their mouths and immediately touch the “start” button to start the evaluation using either TCATA or TDS. Children did not receive any training related to the sensory attributes included in the study.

In TCATA, children had to check all the words that applied to describe what they perceived at each time of the evaluation, and to uncheck the words when they were no longer perceived. The specific written instructions provided to children were: *"Read the list of attributes. Click on the green button with a triangle and, at the same time, place a spoonful of dessert in your mouth. Check all the attributes you perceive at each moment. Remember to uncheck the attributes you no longer perceive".* In TDS, children had to select the word that described the sensation that caught their attention at each time of the evaluation (Pineau et al., 2009). The written instructions provided before the evaluation of each sample were: *"Read the list of attributes. Click on the green button with a triangle and, at the same time, place a spoonful of dessert in your mouth. Check the attribute that catches your attention the most".*

The duration of the evaluations was fixed at 40 s, and a stop button was not included for simplicity. Swallowing time was not recorded. After the dynamic sensory characterization task, children were asked to rate their overall liking (data not presented).

Insert Table 1 around here

2.4 Data analysis

All data analyses were performed using R software version 3.5.2 (R Core Team, 2018. Children who did not complete the whole task due to problems with internet connectivity were excluded from the analysis: TCATA (n=3) and TDS (n=8).

2.4.1. Video evaluation

The average starting time was computed for each method. The average time of selection was computed for each color and method. A t-test was used to compare the two methods.

Data were analyzed using unstandardized data to enable direct comparison with the video setting. The citation proportions for all attributes were calculated as the number of children that selected a color at each moment of the evaluation. Curves of citation proportions versus time were smoothed using a spline type polynomial.

2.4.2. Sample tasting

The average starting time was computed. A t-test was used to compare the two methods.

For each method, the number of selected and unselected (only for TCATA) attributes was analyzed using a mixed linear model, considering sample position as fixed effect and children as random effect. When significant differences were found, Fisher's test was used for post-hoc comparison of means. A significance level of 5% was considered.

Sample tasting data were evaluated using standardized times to account for participant noise (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009), considering the time from selection of the first attribute (time=0%) to the end of the evaluation (time=100%). Curves were constructed as previously mentioned for the video. For each term and each pair of products, a sign test was used at each time point to evaluate the existence of significant differences in the citation proportions of each term.

3. Results

3.1 Temporal evaluation of the visual stimuli (color circle video)

A significant difference ($p<0.05$) between TCATA and TDS was found in the time elapsed between the start of the test and the first selection of a color. The first color on the video appeared 3 s from the start. On average children selected the first color after 5.7 s using TCATA, whereas in TDS they selected the first color 11 s after the start of the video.

Visual comparison of the temporal evolution of circle size and color and the dynamic profiles indicated that TCATA provided a detailed description of the video (c.f. Figures 2a and 2b). The video featured a total of 6 colored circles during the 40 seconds and the children selected an average of 5.2 colors during the TCATA task. As shown in Figure 2b, the maximum proportion citations ranged between 0.82 and 0.92 for the five colors that appeared in the video, whereas the color that did not appear (white) was not selected. Citation proportions of the colors increased as circle size increased. The majority of the children unchecked colors as they disappeared from the screen: 84% unchecked all the colors and only 2 children failed to uncheck at least one color. On average, children unchecked 90% of the colors selected at some point of the evaluation.

Insert Figure 2 around here

In the TDS task children only selected an average of 2.8 colors during the task. The maximum citation proportions ranged between 0.22 and 0.53, even when only one color was shown on the screen. Gray color, which had the largest maximum circle diameter, showed the lowest citation proportion throughout the evaluation. However, as shown in Figure 2c, citation proportions tended to increase as circle size gradually increased. Nevertheless, 50% of the children tended to leave their selected dominant

color unchanged after it had disappeared from the screen. For instance, blue showed a citation proportion close to 0.4 at the end of the evaluation although it disappeared at 32s.

Although both tasks captured the dynamics of the video, TDS missed some details. For example, yellow circles were presented twice in the video, at the beginning and towards the end. As shown in Figure 3a, a high citation proportion (>0.8) was observed twice in the TCATA curves. However, in the TDS task (Figure 3b) it only showed citation proportions close to 0.4 towards the end of the video, whereas it was rarely selected at the beginning (citation proportions <0.2). Interestingly, the maximum citation proportion of yellow color was reached in TCATA after the color started to disappear from the screen.

In both methods, there was a gap between the appearance of the colors on the screen and children's selection of the respective color. As shown in Table 2, the gap between appearance and selection was larger at the beginning compared to the end of the video: i.e. color 1 (yellow) appeared at 3s and was selected in average at 6.8s for TCATA, while color 6 (yellow2) appeared at 29s and was selected at 30.2s. In addition, selection time tended to be larger for TDS than for TCATA, particularly for green and grey color (Table 2). Interestingly, when these colors appeared on the screen there were two other colors already displayed (Figure 1): i.e. when green color appeared, yellow and red were already on the screen. This suggests that the delay in selecting the color in TDS may be related to lack of dominance when circle size was small.

Insert Figure 3 around here

Insert Table 2 around here

3.2. Temporal evaluation of the food stimuli

The following section focuses on illustrating how children used TCATA and TDS to describe the evolution of the sensory properties of food stimuli. Most results are based on averages considering all the samples, complete dynamic sensory profiles are shown only for some selected samples for exemplification purposes. For the interested reader, details on the characterization of all samples are presented in Velázquez et al. (2020).

The time at which the first attribute was selected to describe the milk desserts significantly differed ($p<0.05$) between TCATA and TDS. Children who used TDS needed longer times to select the first attribute compared to those who used TCATA, both for the warm-up sample (9.2 vs 6.3 s) and for the remaining five milk dessert samples (11.8 vs 7.0 s).

The average number of selected attributes selected to describe the milk dessert samples using TCATA significantly increased ($p<0.001$) as the test progressed (Table 3) from 2.9 to 3.6. However, once an attribute was selected, children rarely unchecked it: the average number of attributes unchecked ranged between 0.9 and 1.2. No significant difference was found ($p=0.7254$) in the number of unchecked attributes with sample position.

In the case of TDS, children selected on average 1.3 – 1.6 attributes as dominant to describe each of the milk sample dessert samples. The number of selected attributes significantly differed among sample positions ($p<0.05$). However, in this case the number of selected attributes slightly decreased as the test progressed (Table 3).

Insert Table 3 around here

Figure 4 shows the dynamic profiles of two of the samples: the warm-up sample and Sample 3 for TCATA and TDS. Using TCATA, the warm-up sample was mainly characterized by the attributes *vanilla flavor*, *creamy* and *sweet* over the complete evaluation (Figure 4a). However, the curves were mostly flat for all the attributes. For

example, the citation proportion of *vanilla flavor* increased over the first 15 s, after which it reached a plateau (citation proportions ranged between 0.63 and 0.67). Children's ability to describe the temporal evolution of the desserts over time did not largely change after the warm-up sample. However, visual inspection of the curves of the subsequent samples showed that citation proportions tended to decrease towards the end of the evaluation for the majority of the attributes. As an example, Figure 4c shows that citation proportions of the attributes *creamy*, *sweet* and *soft* tend to decline towards the middle of the standardized time for Sample 3.

In the case of TDS, citation proportions for the warm-up sample were lower than 0.5 for all attributes (Figure 4b). Only *vanilla flavor* and *creamy* showed citation proportions higher than 0.25 over the evaluation time. TDS hardly captured the dynamics of the sensory perception of all the samples as children tended to select only one attribute to describe each sample. As shown in Figure 4b, the citation proportion of *vanilla flavor* for the warm-up sample varied within a very narrow range (0.39 – 0.49) over the whole evaluation time. No changes to this trend were observed in the following samples, as exemplified in Figure 4d for Sample 3.

Insert Figure 4 around here

Regarding sample discrimination minor differences were found between methods. The percentage of pairs of samples that were significant at some point of the evaluation was 20% of all possible comparisons for TCATA and 22% for TDS. In both methods, five attributes showed a significant difference for at least one pair of samples at some point of the evaluation. Two attributes were only significant in one of the methods: *creamy* in TCATA and *hard* in TDS. For individual attributes, a similar number of pairwise comparisons that showed significant differences among samples was found for TCATA (on average 1.8 pairs) and TDS (1.7 pairs). The average number of attributes with significant differences for every pairwise comparison was similar between TCATA

(1.1 attributes) and TDS (1.0 attributes). The differences among samples fitted expectations considering their formulation, as discussed in Velázquez et al. (2020).

Discussion

The present work evaluated the feasibility of using temporal methods for sensory characterization with children using two separate tasks: the evaluation of a video featuring colored circles and tasting of six vanilla milk desserts. The video evaluation was used to test children ability to use a list of terms to characterize the evolution of visual stimuli with time. Results showed that children were able to use both TCATA and TDS to describe how colors changed with time in the video.

In TCATA, the great majority of children selected the colors that corresponded to the circles displayed on the screen, which led to TCATA curves that almost perfectly matched the evolution of the circles with time. Although TCATA might be considered an arduous task since it requires to check and uncheck attributes, children reported no problem to use the method to describe the video.

Although children were also able to use TDS to describe how colors changed over time, they faced some challenges. First, children dithered for long before selecting an attribute to describe the video, which suggests that they faced difficulties to decide which color was catching their attention. This was observed even when only one circle was displayed on the screen (Figure 2), suggesting that dominance seemed to be conceptually complex for children. Varela et al. (2018) reported that dominance is a complex concept in a TDS test with trained assessors and adult consumers. In addition, these authors reported that dumping and dithering bias were widespread in TDS tests. It was proposed that the limited number of attributes available together with the need to select only one attribute under time pressure was closely related to the widespread of dithering and dumping bias in TDS.

TDS curves showed face validity as they matched the evolution of the colored circles. However, they missed relevant details due to the nature of the task. This result agrees with previous studies reporting that TCATA delivers a more detailed description of samples compared to TDS (Ares et al., 2015; Nguyen et al., 2018). In this sense, it should be highlighted that TCATA and TDS focus on different aspects of sensory perception. TCATA aims at describing changes over time in a group of sensory characteristics, whereas the focus of TDS is on describing changes in the attentional capture of the characteristics.

Children's ability to use TCATA and TDS as temporal methods to describe food stimuli was less clear. Results showed that children mainly used both as static methods. In the case of TCATA, children failed to actively uncheck the attributes when they were no longer applicable to describe samples and to select new attributes throughout the evaluation. Interestingly, this trend was only observed when children evaluated the desserts, as they were able to uncheck attributes when they evaluated the video. Selecting and deselecting attributes while tasting samples might have been too demanding for children. Another reason underlying the inability to unselect attributes in food samples, could be that sensory sensations rarely disappear completely during consumption, which is a clear difference with the video evaluation, where appearance and disappearance of the circles is clear. The tendency to refrain from unchecking attributes has also been reported with adults (Castura et al., 2016; Ares et al., 2015; Ares et al., 2016). One possible alternative to improve the accuracy of TCATA is the use fading variant where the selected attributes are gradually unselected after a pre-defined period (Ares et al., 2016).

In the case of TDS, children tended to select only one attribute during the evaluation period, which led to flat TDS curves for all samples (Figure 4). In this case, they did not select new attributes after they dithered for some time to select one attribute as dominant to describe a sample.

The samples used in the present work could have contributed to lack of temporality in the TCATA and TDS curves. Varela et al. (2018) reported that attributes transitions in TDS, both with trained panel and consumers, were mainly driven by big changes in the sample. Milk desserts experienced moderate changes during consumption and had a short manipulation period in the mouth. Further research should be conducted to evaluate children's ability to use TCATA and TDS for describing the evolution of the sensory characteristics of solid foods during consumption.

Despite of the lack of temporality, it is interesting to highlight that TCATA and TDS curves showed face validity, as the attributes with the highest citation proportions have been reported to be the most relevant for describing this product category (Ares et al., 2010; Bruzzone et al., 2015; de Wijk et al., 2003; Vidal, Barreiro, Gómez, Ares, & Giménez, 2013). As in the video evaluation, the temporal profiles obtained with TDS showed fewer details compared to those obtained with TCATA, in agreement with previous studies (Ares et al., 2017; Ares et al., 2015; Nguyen et al., 2018). This matches expectations given the existing conceptual differences between methods.

However, comparable sample discrimination was found between both methods. This contrast with the results reported by Ares et al. (2015) who found a higher sample discriminability with TCATA than TDS tests with trained panel and consumers. This discrepancy may be mainly related to the lack of temporality observed in both methods. Still, both methods were able to provide additional information regarding the sensory perception of the samples since no differences were found when the data were analyzed as static data -CATA (data not shown).Familiarization with the method seemed to influence children's performance. In TCATA, there was a slight increase in children's tendency to uncheck attributes from the warm-up sample to the subsequent samples, which suggests that familiarization with the task had some effect on their ability to use the method. This agrees with the work of Jaeger et al. (2017), who showed that familiarization improved the performance of participants in terms of product

discriminability when a familiarization step was introduced in three TCATA consumer tests. However, no changes in children's performance was observed in TDS.

Some of the results from the present work regarding the comparison between TCATA and TDS have been reported in studies involving adult consumers (Ares et al., 2017; Ares et al., 2015; Nguyen et al., 2018; Varela et al., 2018). However, a direct comparison between children and adults is not possible in the present work as it is beyond the project objectives. In this sense, further research could be conducted to compare children and adult's performance in TDS and TCATA task with different type of stimuli and complexity.

Conclusions

Results from the present work showed that children are able to understand and use TCATA and TDS for characterizing a dynamic visual stimulus. However, TCATA provided a more detailed and accurate temporal description than TDS. When the methods were used to characterize milk desserts, children mainly used them as static methods. Despite the lack of temporality captured by the data, it is important to highlight that results from both methods showed faced validity and enabled the discrimination of samples with subtle differences in their sensory characteristics. Results from the present work suggest that refinements are needed to make TCATA and TDS methods applicable with children for characterizing the dynamics of the sensory characteristics of food stimuli.

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615

616 **Figure captions**

617

618 **Figure 1.** Example of a screen captures from the video displaying colored circles to
619 familiarize children with Temporal Dominance of Sensations (TDS) and Temporal Check-
620 all-that-apply (TCATA).

621

622 **Figure 2.** Temporal evolution of the colored circles in the video: (a) Evolution of circle
623 size in the video, (b) Citation proportions of the colors using Temporal check-all-that-
624 apply (TCATA), and (c) Citation proportion of the colors using Temporal dominance of
625 sensations (TDS).

626

627 **Figure 3.** Comparison of temporal evolution of the size of yellow circles in the video
628 against children characterization using: (a) temporal check-all-that apply (TCATA) and
629 b) temporal dominance sensations (TDS).

630

631 **Figure 4** Dynamic profiles of selected samples using temporal check-all-that-apply
632 (TCATA) (left) and temporal dominance of sensations (TDS) (right): (a) and (b) Warm-
633 up sample, (c) and (d) Sample 3.

Table 1. Sugar, starch and vanilla concentration of the samples included in the study.

Sample	Added sugar (%)	Starch (%)	Vanilla (%)
Warm-up*	7	4.3	0.6
Sample 1	12	4.3	0.4
Sample 2	7	4.3	0.4
Sample 3	7	4.3	0.6
Sample 4	7	4.7	0.4
Sample 5	7	4.7	0.6

(*) The vanilla flavoring had a different aroma profile to the rest of the samples to avoid familiarization with any of the samples included in the main study.

Table 2. Average selection time (and standard error) of colors in the video evaluation for children who used temporal-check-that-apply (TCATA, n=50) and Temporal Dominance of Sensations (TDS, n=51).

Order of appearance	Color	Appearance of the color on the screen (s)	TCATA	TDS
1	Yellow	3	6.8 ± 0.6	8.4 ± 1.0
2	Red	5	7.5 ± 0.5	8.6 ± 0.8
3	Green*	9	10.8 ± 0.5	15.1 ± 1.6
4	Blue	18	20.1 ± 0.7	22.0 ± 1.0
5	Gray*	23	24.5 ± 0.7	28.1 ± 1.4
6	Yellow2*	29	30.2 ± 0.4	32.7 ± 0.6

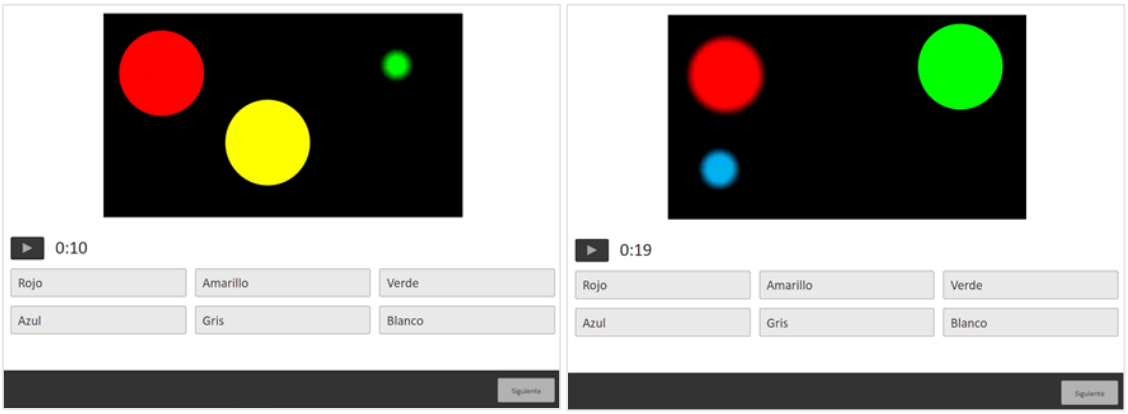
(*) Average values are significantly different according to t- test ($p < 0.05$).

Table 3. Number of attributes selected to describe the milk dessert samples by sample position, for children who used temporal-check-that-apply (TCATA, n=50) and Temporal Dominance of Sensations (TDS, n=51).

Sample position	Average number of attributes	
	TCATA	TDS
1 (warm-up sample)	2.9a	1.6a
2	3.5bc	1.4ab
3	3.5c	1.4b
4	3.3b	1.3b
5	3.6c	1.4b
6	3.6c	1.3b

Note: Average values with different superscripts letters are significantly different ($p<0.05$) according to Fisher's test.

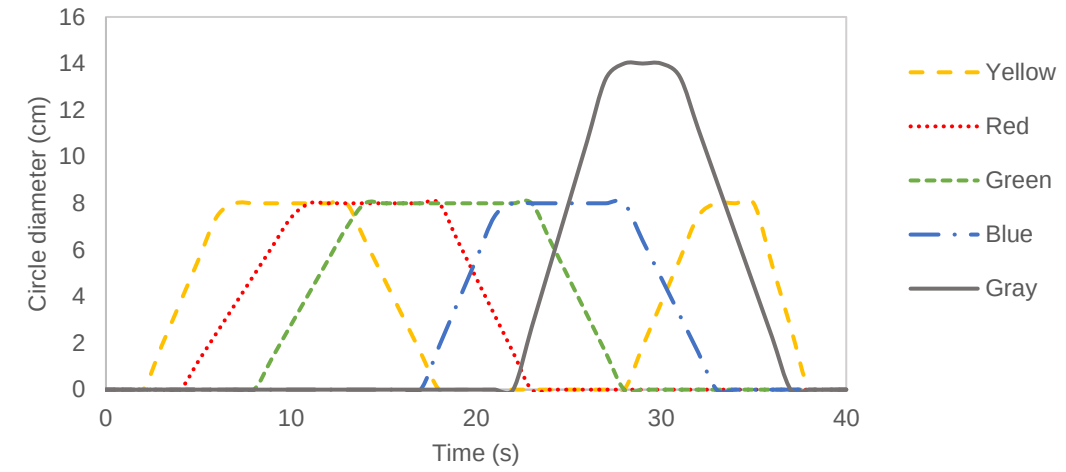
Figure 1.



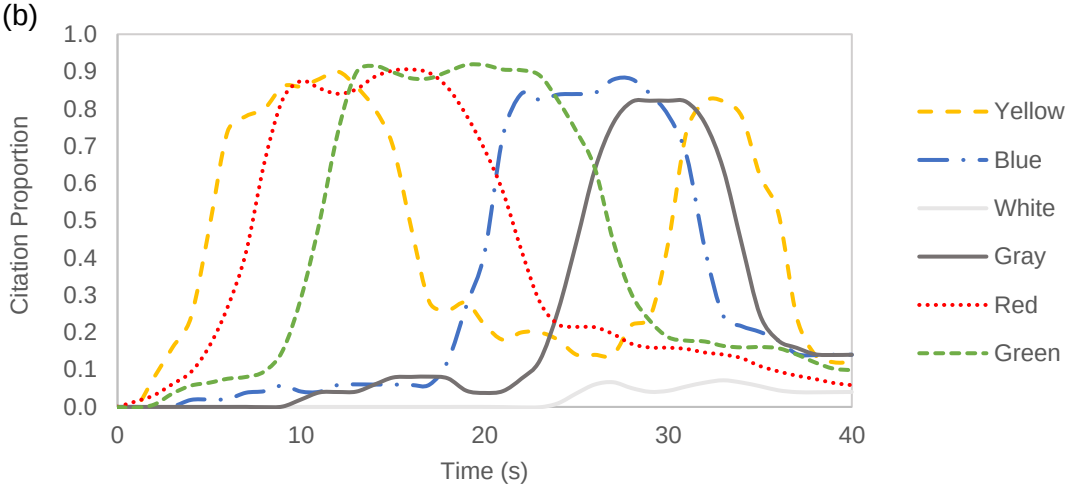
Note: The instructions provided to children for the TCATA were: "Read the words on the list. When you are ready to start, make a click on the video. Remember that you have to check the colors you see on the screen. Remember to uncheck the colors when you no longer see them". For the TDS the last sentence was modified to: "Remember that you have to check the color that catches your attention the most". The list included the following colors (from left to right and top to bottom): red, yellow, green, blue, grey, white.

Figure 2

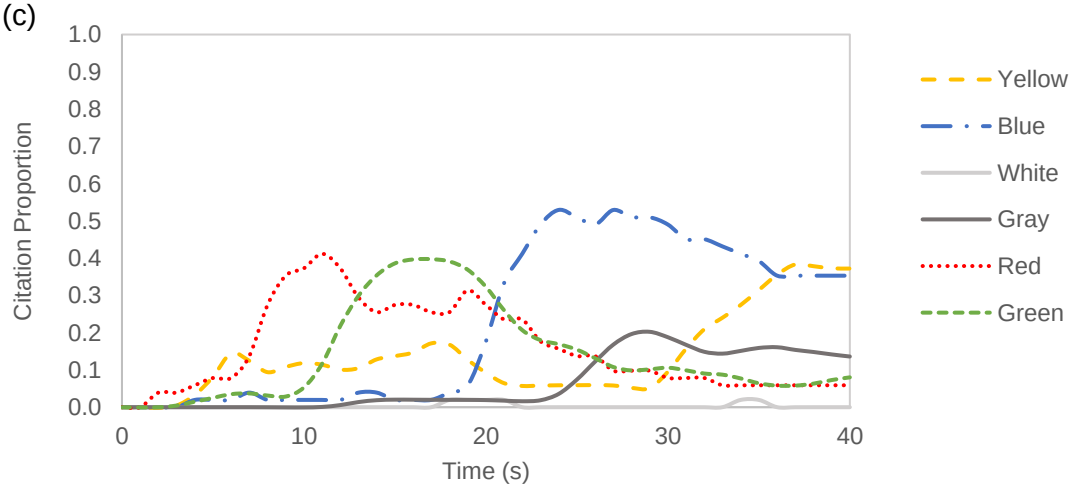
(a)



(b)



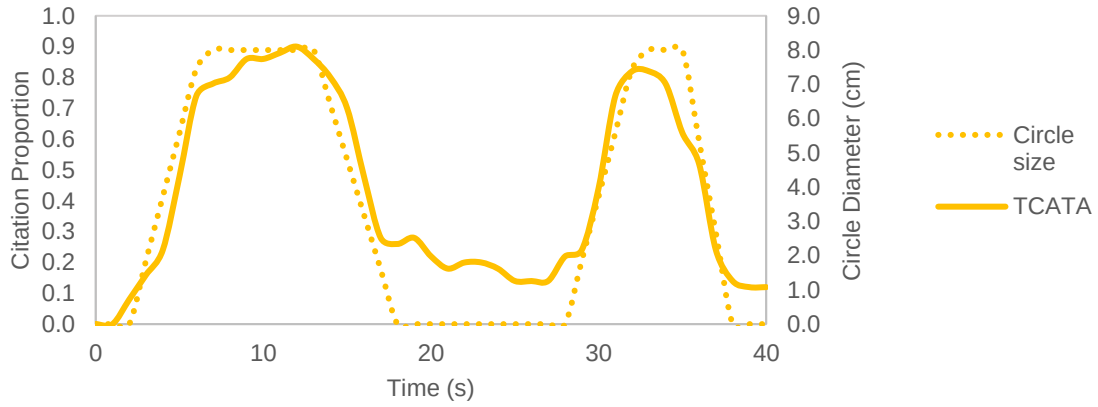
(c)



Note: Readers are referred to the online version of the manuscript for the colored version of the Figure.

Figure 3.

(a)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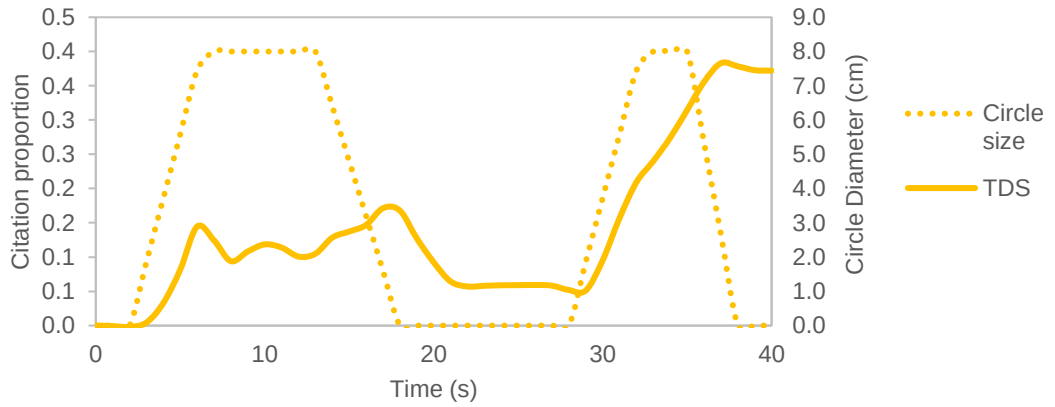
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
10
20
30
40
Time (s)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Circle Diameter (cm)
Circle size
TCATA

(b)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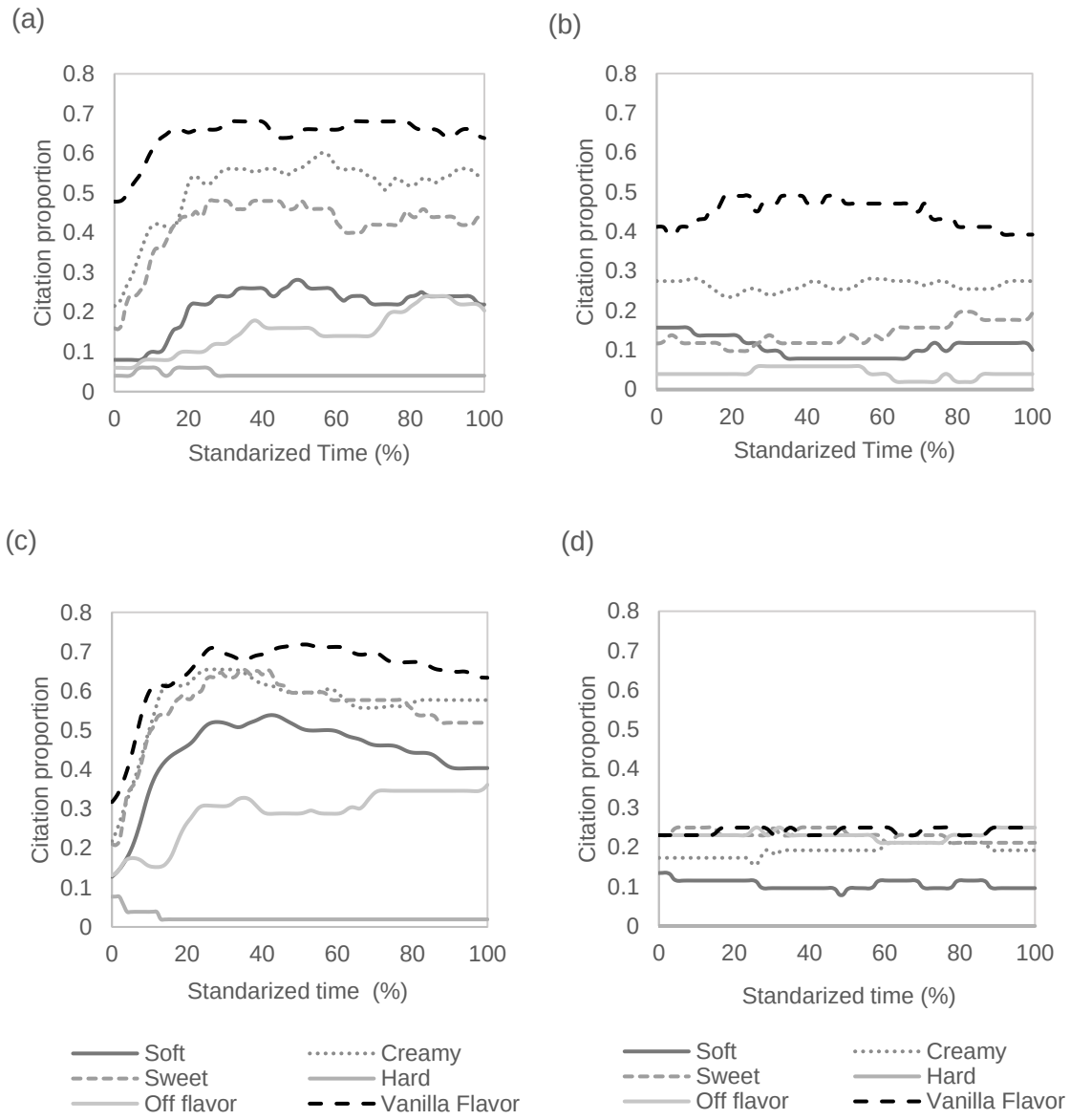
0.3
0.3
0.2
0.2
0.1
0.1
0.0
0
10
20
30
40
Time (s)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Circle Diameter (cm)
Circle size
TDS

Figure 4.


(a)
(b)
(c)
(d)
Citation proportion
Standarized Time (%)
Standarized time (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
20
40
60
80
100
Soft
Creamy
Sweet
Hard
Off flavor
Vanilla Flavor