Dutch consumers do not hesitate: Capturing implicit ‘no dominance’ durations using Hold-down Temporal Dominance methodologies for Sensations (TDS) and Emotions (TDE)

Roelien van Bommeletal., Markus Stiegera,b, Pascal Schlichc, Gerry Jagera,b

1. Introduction

Sensory perception of foods and beverages changes dynamically during consumption (Lenfant, Loret, Pineau, Hartmann, & Martin, 2009; Panouille, Saint-Eve, DeLeris, LeBleis, & Souchon, 2014; Saint-Eve, Panouille, Capitaine, DeLeris, & Souchon, 2015; Young, Cheong, Hedderley, Morgenstern, & James, 2013). Over the years several methodologies have been proposed to measure the temporal evolution of sensory perception of food products, such as the Time-Intensity (TI) technique (Lee & Pangborn, 1986), Dual-Attribute Time-Intensity (DATI) (Duizer, Bloom, & Findlay, 1997), Temporal Dominance of Sensations (TDS) (Pineau et al., 2009), and the Temporal Check-All-That-Apply (T-CATA) method (Castura, Antúnez, Giménez, & Ares, 2016). Temporal Dominance of Sensations (TDS) is one of the most commonly used methodologies to measure temporal dynamics in sensory perception during consumption (Pineau et al., 2009). More recently, Temporal Dominance of Emotions (TDE) was introduced to measure the sequence of dominant food-evoked emotions perceived during consumption (Jager et al., 2014). Combining the TDS and TDE method allows to investigate relationships between dynamic sensory perception and food-evoked emotions.

In the early stages of the TDS development, trained panellists were instructed to select a dominant attribute, which remains dominant until another attribute is selected. This procedure does not allow recording ‘no dominance’ (ND) periods. ND periods can occur because of indecisive selection behaviour due to hesitation or uncertainty about attribute selection and time needed to switch from one attribute to another. ND periods may create noise in TD data. ND can be recorded implicitly using a ‘hold-down’ procedure, where panellists actively hold down the attribute button that is perceived dominant, but release it when no longer dominant. The ‘Hold-down’ procedure allows subjects to report indecisive behaviour simply by not holding down a button. This study compared the ‘classic’ and ‘Hold-down’ TD methodologies. One hundred and thirty-seven participants evaluated four dark chocolates in two sessions, one for sensory (TDS) and one for emotion (TDE) evaluations. Participants employed either classic (n = 68) or Hold-down (n = 69) TD following a between subjects design. Similar dominance rates and dynamic evolutions of attributes during consumption were observed for both methods. ND durations between attribute selections were shorter than 1 s during sensory and emotion evaluations. Such short ND durations unlikely reflect periods of true hesitation, but rather reflect the time needed to switch between dominant attributes. No evidence is found for Hold-down TD outperforming classic TD in terms of sensitivity and discrimination ability. In conclusion, irrespective of the conceptual likelihood regarding the occurrence of ‘no dominance’ periods, the present study failed to demonstrate moments of hesitation using the ‘Hold-down’ procedure.
studies and products. In the default TD protocol, from now on here referred to as ‘classic’ TD, the assessors select the perceived dominant attribute, and dominance recording of this attribute starts from then and remains until a new attribute is selected (Pineau et al., 2009).

Varela et al. (2018) investigated the reasoning of assessors behind changing and selecting dominant attributes using TDS. They observed that assessors reported indecisive selection behaviour on dominance between two attributes (e.g. texture or flavour) and hesitations due to dumping effects (e.g. response restrictions), using a retrospective verbalization task. To engage assessors and to stimulate attribute selection, Thomas, Visalli, Cordelle, and Schlich (2015) used a TDS protocol that highlighted the dominant attribute for 3 s after selection. After 3 s the visual highlight disappeared, but dominance duration of that attribute was recorded until the next attribute was selected. Castura and Li (2016) investigated the effect of these ‘dominance gaps’ (i.e. the moment where nothing is visually highlighted as dominant), and suggested there is a need for better task instruction to actively involve assessors during TDS evaluations. Only 10% of the assessors selected a subsequent dominant attribute within 6 s after the selection highlight disappeared, and 58% of the assessors took longer than 10 s to select a subsequent dominant attribute after the selection highlight disappeared (Castura & Li, 2016). Hence, it is plausible that moments of ‘no dominance (ND)’ occur, defined here as the time gap between the selection of two subsequent dominant attributes. ND periods can occur because of a delayed response time, indecisive selection behaviour due to hesitation or uncertainty about attribute selection, the cognitive effort to choose a dominant attribute or time needed to select a new attribute, which may create noise in the TD data. Capturing periods of ND could reduce noise and improve sensitivity, consequently leading to better product discrimination and better reproducibility of TDS and TDE.

Recently, Rodrigues, de Souza, Lima, da Cruz, and Pinheiro (2018) included a ‘no perception’ button for TDS evaluations by trained panelists using a predefined consumption time protocol. They observed that ‘no perception’ gradually increased towards the end of the predefined consumption time. ‘No perception’ was defined as the absence of a sensation (Rodrigues et al., 2018), while the present study defines ‘no dominance’ as the absence of dominance for any of the sensations. Including a ‘no dominance’ button in TDS evaluations assumes to record ND explicitly. However, it seems counterintuitive and contradictory to the concept and definition of ‘dominance’ to include a no dominance’ button in TD evaluations. Hence, the introduction of a ‘Hold-down’ TD method, where panelists actively hold down the button of the attribute that is perceived dominant, but release it when they no longer perceive it as dominant, allows to record ND duration implicitly (Schlich, 2017). ND is recorded when the active selection of an attribute ends until a new dominant attribute is selected. To better understand the concept of dominance, the occurrence of implicit ND duration periods in TD methods has to be explored.

To date, the question remains how dynamic sensory and emotion evaluations of foods are influenced by ND periods that occur between the selection of two subsequent dominant attributes. In addition, from a methodological perspective, it is unclear how to best capture or measure ‘no dominance’ or indecisive behaviour as part of panelist behaviour. Finally, it is unclear how ND periods affect sensitivity and product discrimination capability in TD methods. The aims of this study are to shed further light on the questions raised above by (i) comparing the performance of the Hold-down TD with the classic TD methodology for dynamic sensory and emotion profiling, and (ii) identification of ND duration periods in TD evaluations in an example product category (dark chocolates). This study evaluated four varieties of dark chocolates in two sessions, one for sensory (TDS) and one for emotions (TDE). Participants employed either classic TD (n = 68) or Hold-down TD (n = 69) in a between subjects design. We hypothesized that the Hold-down TD method allows to implicitly capture periods of hesitation and indecisive behaviour which leads to reduced noise in the data, resulting in higher sensitivity and better product discrimination.

Table 1

<table>
<thead>
<tr>
<th>Participant characteristics.</th>
<th>Classic TD (n = 68)</th>
<th>Hold-down TD (n = 69)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) Mean ± SD</td>
<td>27.0 ± 12.1</td>
<td>24.2 ± 9.1</td>
</tr>
<tr>
<td>Gender [% (n)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>27.9 (19)</td>
<td>27.5 (19)</td>
</tr>
<tr>
<td>Female</td>
<td>72.1 (49)</td>
<td>72.5 (50)</td>
</tr>
<tr>
<td>BMI (kg/m²) Mean ± SD</td>
<td>22.0 ± 2.0</td>
<td>21.8 ± 1.8</td>
</tr>
</tbody>
</table>

2. Materials and methods

2.1. Participants

One hundred thirty-seven healthy (self-reported) Dutch participants, aged 18–65 years, were recruited for this study from a database with volunteers to participate in research of the Division of Human Nutrition of Wageningen University, the Netherlands. All participants were consumers of dark chocolate, without allergies or intolerances for milk, lactose or nuts, with normal abilities to taste and smell (self-reported), and without chocolate cravings (self-reported). None of the participants was familiar with TD methodology or had any previous training in sensory evaluation of chocolates. After inclusion, participants were randomly divided in two groups, employing either classic TD (n = 68) or Hold-down TD (n = 69) for sensory and emotion evaluation in a between subjects design. Table 1 shows participant demographics per group. No significant differences were observed for age, gender and BMI between the two participant groups (p > 0.05). Participants received a monetary incentive for their participation, and gave written informed consent before the start of the study. The study protocol was submitted to and exempted from ethical approval by the Medical Ethical Committee of Wageningen University.

2.2. Products

Four varieties of commercially available dark chocolates from the Lindt Excellence series (70% cocoa, Intense Orange, Grilled Sesame and Intense Cranberry) were chosen because of previously reported emotional associations with chocolate products (Cardello et al., 2012; den Uijl, Jager, de Graaf, Meiselman, & Kremer, 2016; den Uijl, Jager, Zandstra, de Graaf, & Kremer, 2016; Jager et al., 2014; Thomson, Crocker, & Marketo, 2010). Clear differences in sensory characteristics between products (e.g. plain dark chocolate vs. flavoured dark chocolate with small pieces of nuts or dried fruit) were chosen to evoke different emotion responses between the dark chocolates. Participants received unbranded pieces of chocolate of approximately 3 g per sample, presented in small transparent plastic bags coded with 3-digits. Products were presented in sequential monadic order according to a Williams Latin Square design (Williams, 1949).

2.3. Attribute selection

For comparative reasons, the sensory and emotion attributes included in this study were based on the attributes and definitions used by Jager et al. (2014). Ten sensory attributes describing texture and flavour (bitter, cocoa, crunchy, dry, fruity, melting, nutty, sour, sticky and sweet) and ten emotion attributes describing valence and arousal (aggressive, bored, calm, energetic, guilty, happy, interested, loving, nostalgic and whole) were used in this study. Emotion and sensory attributes and descriptions were translated from English to Dutch and checked using back translation.

2.4. Temporal dominance methodologies

TimeSens (version 1.1.601.0, ChemoSens, Dijon, France) was used to collect the data for the classic TD and Hold-down TD methodologies. Participants who evaluated the four chocolates
Participants were instructed to consume the whole sample at once (3 g of chocolate) for the product evaluation. After each product evaluation participants had to indicate their liking of the product on a 9-point hedonic scale with end anchors ‘dislike extremely’ to ‘like extremely’. A neutralisation time of 1 min was included between samples, and participants were instructed to eat a piece of cracker and rinse their mouth with water.

2.6. Data analysis

All figures were plotted using TimeSens software (version 1.1.601.0, ChemoSens, Dijon, France). Statistical analyses were performed using R-studio (R version 3.4.2, RStudio team, 2016). Analyses were performed separately for classic TD and Hold-down TD. Data was pre-processed by standardizing time between 0 (first attribute selection) and 1 (click on the stop button) (Lenfant et al., 2009). Results of this study were considered significant at an alpha level of 0.05. TDS and TDE curves by product were generated for the classic TD and the Hold-down TD method. TD curves represent the proportion (%) of participants that cited an attribute as dominant at that moment in time (Lenfant et al., 2009; Pineau et al., 2009). A significance line at p = 0.05 was calculated according to the equation proposed by Pineau et al. (2009). The significance line in Hold-down TD is slightly lower compared to the classic TD as ND citations are considered as elicitations of an additional attribute in the analysis. For each product that was evaluated by Hold-down TD, proportions of ND duration rates in the TDS and TDE curves were compared to the significance line to determine the moments during consumption when ND duration became significantly dominant. In addition, bandplots by product were generated separately for TDS and TDE for the classic TD and Hold-down TD method. Bandplots are depicted above each TD curve, and represent the sequence and duration of dominant attributes as time-bands (Galmarini, Visalli, & Schlich, 2017).

2.6.1. No dominance duration and test behaviour

Means and standard errors of the mean were calculated for total duration, latency before first citation, and total number of citations for each product for classic and Hold-down TDS and TDE. Additionally, means and standard errors of the mean were calculated for total ND duration, latency after last citation, and ND durations between citations for each product for Hold-down TDS and Hold-down TDE. To establish mean values for ND periods between attribute selections, ND periods that occurred after the first attribute selection were coded ‘ND 1st switch’, the ND periods after
the second attribute selection were coded ‘ND 2nd switch’ and so forth. The switch from the last attribute selection to the stop button was coded ‘ND last switch’. When assessors only had one ND period during their evaluation, this ND period was categorized in ‘ND last switch’. Mean ND durations were calculated for each ND switch based on the number of assessors for each ND switch. To check if test behaviour parameters differed between methods within protocol (TDS and TDE), a three-way analysis of variance (ANOVA) was performed on each test behaviour, with product and method (classic TD and Hold-down TD) as fixed factors and subject as random factor. A three-way ANOVA was used to check for differences between TDS and TDE within method, with product and protocol (TDS and TDE) as fixed factors and subject as random factor. Differences on test behaviour parameters between products within method were tested using a two-way ANOVA, with product as fixed factor and subject as random factor. Upon significance of the ANOVA, Tukey HSD pairwise comparison was performed to indicate differences in test behaviour parameters between the four chocolate products.

2.6.2. Comparison of performance of classic TD and Hold-down TD

TDS and TDE curves and bandplots were visually inspected to identify differences and similarities in dominance sequences and dominance rates between classic TD and Hold-down TD. A two-way ANOVA was performed on the dominance duration by attribute for classic TD and Hold-down TD separately, with product as fixed factor and subject as a random factor (Galmarini et al., 2017). Product discrimination by method was evaluated with the F-product statistic. Canonical Variate Analysis (CVA) (Peltier, Visalli, & Schlich, 2015b) was performed on dominance durations for classic TD and Hold-down TD separately. Attributes included in the CVA maps are significant at p < 0.15. CVA maps were generated separately for sensations and emotions. CVA maps included ellipses representing 90% confidence intervals (CI) for each product. Hotelling-Lawley MANOVA tests were performed for pairwise product comparison for classic TD and Hold-down TD separately (Peltier, Visalli, & Schlich, 2015a). The CVA maps were visually compared on differences and similarities in product representation between classic TD and Hold-down TD.

2.6.3. Liking

Liking was evaluated immediately after the TDS and TDE evaluation. For each product, mean liking scores and standard errors were calculated for classic TD and Hold-down TD separately. To test how liking scores differed between methods, a three-way ANOVA was performed on liking, with product and method (classic TD and Hold-down TD) as fixed factors and subject as random factor. To test how liking scores observed in classic TD and Hold-down TD differed between products, a two-way ANOVA was performed on liking by method, with product as fixed factor and subject as random effect. Due to an experimental mistake, only the liking scores for the products in the last session were saved. Because a balanced design was used, half of the liking scores were saved after TDS evaluation and half after the TDE evaluation. Results based on differences in liking are therefore to be interpreted with caution due to the low sample size (n ~ 34).

3. Results

TDS and TDE curves and bandplots for the four chocolates evaluated with the classic TD (left column) and Hold-down TD methodology (right column) are depicted in Figs. 2 and 3. The significance line for the classic TD is represented at a dominance rate of 16.0% and for the Hold-down TD at a dominance rate of 14.7%. The TD curves for the Hold-down TD methodology represent an attribute line characterizing the ND duration time during product evaluation. TDS and TDE curves and bandplots for the Hold-down TD methodology show that during each product evaluation ND duration time becomes significantly dominant at the last 10% of standardized consumption time. ND rates increase to approximately 100% towards the end of consumption time. Significant ND duration times in TDS for Hold-down TD methodology were observed only for the Orange-flavoured chocolate between 70 and 75% of standardized time. ND duration times in TDE for the Hold-down TD methodology touched significance only between 72 and 78% of standardized time for the 70% cocoa chocolate, and between 60 and 65% of standardized time for the Sesame chocolate.

3.1. No dominance duration and test behaviour

Table 2 shows the test behaviour at panel level by product observed with the classic and the Hold-down TD method. The number of ND periods per evaluation in the Hold-down TD is equal to the number of clicks on an attribute. The TDS protocol of the Hold-down TD had significantly more clicks, and consequently more ND periods, compared to the TDE protocol (F(1,68) = 41.8, p < 0.001). The averaged ND periods between attribute selections observed in Hold-down TD were significantly shorter for TDS compared to TDE (F(1,68) = 11.1, p = 0.001). However, the ND period between the last attribute selection and the stop button did not differ between TDS and TDE protocols in the Hold-down TD (F(1,68) = 0.83, p = 0.37). The ND period between the last attribute selection and the stop button was significantly shorter compared to the latency before first attribute selection (F(1,68) = 74.0, p < 0.001). However, the latency between start and first attribute selection was significantly shorter in the Hold-down TD method (F(1,65) = 17.1, p < 0.001) compared to the classic TD method. Furthermore, participants needed significantly longer time to select the first dominant attribute in TDE compared to TDS in both methods (F(1,65) = 19.2, p < 0.001). No significant differences were observed on the overall duration of consumption for the classic and Hold-down TD in TDS and TDE (F(3,655) = 0.7, p = 0.55).

3.2. Comparison of performance of classic TD and Hold-down TD

Visual inspection of the TDS curves and bandplots (Fig. 2) show overall very similar dominance rates and dominance durations as well as very similar sequences of dominant attributes per product for classic TD and Hold-down TD. Some minor differences, however, were observed. Compared to the Hold-down TD, dry was observed to be significantly dominant at the beginning of consumption in the classic TD for the 70% cocoa chocolate. For the Orange-flavoured chocolate, melting touched significance in the middle of consumption with the classic TD method, but not with the Hold-down TD method. In contrast to the classic TD method, cocoa and sweet were observed to be significantly dominant for the Sesame chocolate at the end of consumption with the Hold-down TD method. For the Cranberry chocolate only in the classic TD method sticky was observed to be significantly dominant at the middle of consumption.

TDE curves and bandplots (Fig. 3) per chocolate evaluated with classic TD (left column) and Hold-down TD (right column) show
overall similar dominance rates for the TDE evaluations, but display
different dominance sequences per product. From the middle to the
end of consumption lower dominance rates were observed for calm
and bored for 70% cocoa chocolate in the Hold-down TD compared
to the classic TD. For the Orange-flavoured chocolate longer and
higher dominant rates for nostalgic were observed in the Hold-down
TD. Happy only touched significance for Sesame chocolate in the
classic TD, however, happy was observed to be significantly

Fig. 2. Graphic representation of the sequence of dominant sensations (TDS curves) for classic TD method (left column) and Hold-down TD method (right column) for all four chocolate products. Areas under the significance line are coloured grey.
dominant throughout consumption in the Hold-down TD. Higher dominance rates for calm and energetic were observed in the classic TD method for the Cranberry chocolate in the beginning and middle of consumption, respectively, whereas the Hold-down TD depicted higher dominance rates for happy throughout consumption.

3.3. Product discrimination

Table 3 shows the product discrimination for each attribute for the classic TD and the Hold-down TD method for the sensory and emotion evaluations. The classic TD and the Hold-down TD both discriminated...
the products on bitter, cocoa, crunchy, dry, fruity, nutty and sweet sensations. The classic TD additionally discriminated the products on sour and sticky. The classic TD and the Hold-down TD both discriminated the products on the emotions bored, interested, nostalgic and whole. The classic TD additionally discriminated the products on calm, energetic, happy and loving, whereas the Hold-down TD additionally discriminated the products on aggressive.

CVA maps on dominance duration of sensations for classic TD (left map) and Hold-down TD (right map) are depicted in Fig. 4. Each of those maps account for 98% of the explained variance. The MANOVA F-statistics are of the same magnitude (52–55) indicating the same level of discrimination of the two methods. Hotelling-Lawley test showed that all products were evaluated significantly different from each other on sensory characteristics (p < 0.05) in the Hold-down CVA map. In contrast, product differences observed with the classic TD method show that the Cranberry chocolate and Orange chocolate are perceived similar in terms of their sensory characteristics (p = 0.19). All other pairwise comparisons between products by Hotelling-Lawley test were significant (p < 0.05) in both methods.

Interestingly, both methods show similar product differentiation for sensations and emotions, whereas dimension 1 differentiates the fruity-flavoured chocolates from the non-fruity flavoured chocolates. Dimension 2 further distinguishes between the Sesame (nutty) chocolate and the other chocolates.

3.4. Liking

Mean liking scores and standard errors for the four chocolates assessed on a 9-point hedonic scale after TDS and TDE evaluations with classic TD and Hold-down TD are represented in Table 4. Liking results should be interpreted with caution due to the low sample size (n ∼ 34).

Table 2
Comparison of test behaviour between products (mean values ± standard error of the mean).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
<th>70% cocoa</th>
<th>Orange</th>
<th>Sesame</th>
<th>Cranberry</th>
<th>F-Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDS Overall duration (s)</td>
<td>Classic</td>
<td>49.7 ± 3.19^C</td>
<td>43.2 ± 2.61^A</td>
<td>41.5 ± 2.29^A</td>
<td>46.0 ± 2.73^BC</td>
<td>11.2***</td>
</tr>
<tr>
<td></td>
<td>Hold-down</td>
<td>51.3 ± 2.60^B</td>
<td>46.4 ± 2.62^A</td>
<td>44.8 ± 2.30^A</td>
<td>48.7 ± 2.81^A</td>
<td>8.8***</td>
</tr>
<tr>
<td>Latency between start and first attribute selection (s)</td>
<td>Classic</td>
<td>5.26 ± 0.56</td>
<td>4.03 ± 0.34</td>
<td>4.19 ± 0.36</td>
<td>5.06 ± 0.44</td>
<td>2.65</td>
</tr>
<tr>
<td></td>
<td>Hold-down</td>
<td>3.32 ± 0.26^B</td>
<td>2.97 ± 0.29^B</td>
<td>3.16 ± 0.27^A</td>
<td>4.17 ± 0.51^B</td>
<td>3.64*</td>
</tr>
<tr>
<td>Total number of attribute selections</td>
<td>Classic</td>
<td>6.63 ± 0.48</td>
<td>6.13 ± 0.46</td>
<td>5.85 ± 0.49</td>
<td>6.47 ± 0.46</td>
<td>2.29</td>
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<tr>
<td></td>
<td>Hold-down</td>
<td>6.55 ± 0.38^B</td>
<td>5.49 ± 0.31^B</td>
<td>6.10 ± 0.38^A</td>
<td>6.41 ± 0.43^B</td>
<td>5.17***</td>
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<tr>
<td>Total no dominance duration per evaluation (s)</td>
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<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
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<tr>
<td></td>
<td>Hold-down</td>
<td>4.63 ± 0.32</td>
<td>4.90 ± 0.57</td>
<td>5.17 ± 0.57</td>
<td>5.16 ± 0.51</td>
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<td>Latency between last attribute selection and stop (s)</td>
<td>Classic</td>
<td>1.43 ± 0.12</td>
<td>1.45 ± 0.31</td>
<td>1.43 ± 0.14</td>
<td>1.17 ± 0.09</td>
<td>0.54</td>
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<tr>
<td></td>
<td>Hold-down</td>
<td>0.58 ± 0.04</td>
<td>0.77 ± 0.08</td>
<td>0.73 ± 0.11</td>
<td>0.74 ± 0.07</td>
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<td>No dominance duration between attribute selections (s)</td>
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<td>na</td>
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<td>na</td>
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<tr>
<td></td>
<td>Hold-down</td>
<td>5.08 ± 0.04</td>
<td>0.77 ± 0.08</td>
<td>0.73 ± 0.11</td>
<td>0.74 ± 0.07</td>
<td>1.63</td>
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</table>

TDE Overall duration (s)

<table>
<thead>
<tr>
<th>Dimension 1</th>
<th>Classic</th>
<th>48.2 ± 3.05^B</th>
<th>42.1 ± 2.60^A</th>
<th>42.4 ± 2.51^A</th>
<th>44.2 ± 2.76^A</th>
<th>7.15***</th>
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</thead>
<tbody>
<tr>
<td>Latency between start and first attribute selection (s)</td>
<td>Classic</td>
<td>6.23 ± 0.46</td>
<td>5.88 ± 0.65</td>
<td>5.42 ± 0.42</td>
<td>6.10 ± 0.65</td>
<td>0.65</td>
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<tr>
<td>Total number of attribute selections</td>
<td>Classic</td>
<td>4.12 ± 0.29</td>
<td>3.99 ± 0.25</td>
<td>3.88 ± 0.29</td>
<td>3.87 ± 0.28</td>
<td>0.41</td>
</tr>
<tr>
<td>Latency between last attribute selection and stop (s)</td>
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<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>No dominance duration between attribute selections (s)</td>
<td>Classic</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>TDE Overall duration (s)</td>
<td>Hold-down</td>
<td>51.6 ± 2.72^B</td>
<td>44.6 ± 2.71^B</td>
<td>43.1 ± 2.39^A</td>
<td>46.0 ± 2.53^A</td>
<td>13.3***</td>
</tr>
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<td>Latency between start and first attribute selection (s)</td>
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<td>6.23 ± 0.46</td>
<td>5.88 ± 0.65</td>
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<td>3.87 ± 0.28</td>
<td>0.41</td>
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<tr>
<td>Latency between last attribute selection and stop (s)</td>
<td>Classic</td>
<td>5.49 ± 0.59</td>
<td>4.08 ± 0.47</td>
<td>4.90 ± 0.61</td>
<td>4.53 ± 0.47</td>
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<td>na</td>
<td>na</td>
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<td>TDE Overall duration (s)</td>
<td>Hold-down</td>
<td>51.3 ± 2.60</td>
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<td>4.90 ± 0.61</td>
<td>4.53 ± 0.47</td>
<td>2.25</td>
</tr>
<tr>
<td>No dominance duration between attribute selections (s)</td>
<td>Classic</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
</tbody>
</table>

Significant at (*) 0.05, (**) 0.01, (***) 0.001.

abDifferent letters in a row indicate significant differences (p < 0.05) between products according to Tukey’s HSD at 95% confidence.

Table 3
ANOVA of dominance durations of sensation and emotion attributes for the classic TD and the Hold-down TD methodologies.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Classic TD</th>
<th>Hold-down TD</th>
<th>Attribute</th>
<th>Classic TD</th>
<th>Hold-down TD</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-value</td>
<td></td>
<td>F-value</td>
<td>F-value</td>
<td></td>
<td>F-value</td>
</tr>
<tr>
<td>Sensations</td>
<td>Bitter</td>
<td>37.30***</td>
<td>59.94***</td>
<td>Emotions</td>
<td>Aggressive</td>
</tr>
<tr>
<td></td>
<td>Cocoa</td>
<td>56.61***</td>
<td>83.10***</td>
<td></td>
<td>Bored</td>
</tr>
<tr>
<td></td>
<td>Crunchy</td>
<td>50.50***</td>
<td>28.40***</td>
<td></td>
<td>Calm</td>
</tr>
<tr>
<td></td>
<td>Dry</td>
<td>26.84***</td>
<td>8.04***</td>
<td></td>
<td>Energetic</td>
</tr>
<tr>
<td></td>
<td>Fruity</td>
<td>118.99***</td>
<td>149.65***</td>
<td></td>
<td>Guilty</td>
</tr>
<tr>
<td></td>
<td>Melting</td>
<td>0.45</td>
<td>2.52</td>
<td></td>
<td>Happy</td>
</tr>
<tr>
<td></td>
<td>Nutty</td>
<td>84.11***</td>
<td>91.95***</td>
<td></td>
<td>Interested</td>
</tr>
<tr>
<td></td>
<td>Sour</td>
<td>4.31**</td>
<td>1.86</td>
<td></td>
<td>Loving</td>
</tr>
<tr>
<td></td>
<td>Sticky</td>
<td>10.64***</td>
<td>1.38</td>
<td></td>
<td>Nostalgic</td>
</tr>
<tr>
<td></td>
<td>Sweet</td>
<td>27.71***</td>
<td>26.04***</td>
<td></td>
<td>Whole</td>
</tr>
<tr>
<td>No dominance</td>
<td>na</td>
<td>2.44</td>
<td></td>
<td></td>
<td>No dominance</td>
</tr>
</tbody>
</table>

Significant at (*) 0.05, (**) 0.01, (***) 0.001.
No interactions for product by method (F(3, 405) = 0.20, p = 0.90) and protocol (TDS and TDE) by method (F(1, 405) = 0.01, p = 0.93) were observed. That suggests that the method (classic TD and Hold-down TD) did not influence how products were liked and that liking scores were similar between methods by protocol. However, a significant interaction for product by protocol (F(3, 405) = 5.56, p < 0.001) indicates that products were scored significantly different on liking after TDS and TDE evaluations. No clear direction of difference was observed as the 70% cocoa and Sesame chocolate were less liked and the Orange flavoured and Cranberry chocolate were more liked after TDE evaluations compared to TDS evaluations. Liking scores obtained after TDE evaluations did not significantly differ among the four chocolate varieties (p > 0.05). Liking scores observed after TDS evaluations with classic TD and Hold-down TD report that the Sesame chocolate was most liked and Cranberry chocolate least liked.

4. Discussion

The aims of this study were (i) to compare the performance of the Hold-down TD with the classic TD methodology for dynamic sensory and emotion profiling, and (ii) to identify ND duration periods in TD evaluations in an example product category (dark chocolates). We hypothesized that the Hold-down TD method allows to implicitly capture periods of hesitation and indecisive behaviour which leads to reduced noise in the data, resulting in higher sensitivity and better product discrimination. Our findings indicate similar performance in terms of sensitivity of the classic TD method and the Hold-down TD method. No evidence was found for the Hold-down TD method outperforming the classic TD method with regard to product discrimination ability. ND duration periods observed between the selection of two subsequent dominant attributes in the Hold-down TD method were on average less than 1 s. It seemed plausible that periods of ND would have occurred because of a delayed response time, uncertainty about

Fig. 4. CVA maps of dominance durations of sensations by classic TD (left column) and Hold-down TD (right column) methodology. Confidence ellipses at 90% and F-values significant at p < 0.001. NDIMSIG represents the number of significant dimensions.

Fig. 5. CVA maps of dominance duration of emotions by classic TD (left column) and Hold-down TD (right column). Confidence ellipses at 90% and F-values significant at p < 0.001. NDIMSIG represents the number of significant dimensions.
attribute selection or indecisive selection behaviour due to hesitation. In contrast, the short ND duration periods between the selection of dominant attributes observed in TDS and TDE in the Hold-down method could indicate that subjects continuously perceive dominant attributes. One could speculate that consumers already think about the next dominant attribute before letting go of the currently dominant attribute. The observed time between subsequent dominant attributes is considered too short to represent moments of ‘true’ hesitation and indecisive behaviour, such as mentally weighing the dominance of more than one attribute. Consequently, it seems far more likely the ND duration periods represent the time needed to switch between dominant attributes. Hence, despite subjects were offered the possibility to implicitly indicate indecisive behaviour, and for example think about the next attribute to select for some time, simply by not holding down any attribute button, this behaviour was not observed in this study. The question is whether this was in part related to the task paradigm at hand. We deliberately chose not to include a ND button and/or to highlight the occurrence of ND periods to participants, as this seems to be incompatible with the very nature of ND (i.e. the absence of something). Still, panellists might need clearer and more explicit instruction on the option of ND periods.

As a result of time standardization, implicit ND captured with Hold-down TD will always reach a dominance rate of 100% at the end of consumption. A dominance rate of 100% represents 100% panel agreement since all subjects release the selection of the last dominant attribute and press the stop button at the end of the TD task. ND becomes significantly dominant only in the last 10% of product evaluation, meaning that there are individual differences on the latency between last attribute selection and pressing the stop button. Consequently, panel consensus about dominance of any of the sensory and emotion attributes dropped below significance. Hence, the Hold-down TD method might possibly correcting an overestimation of significant dominance rates in the last 10% of standardized consumption time in classic TD. The present results on ND duration time in TDS evaluations were in line with previous observations from a pilot study (presented by Schlich et al., at the 2nd Asian Sensory and Consumer Research Symposium, Shanghai, May 2016). In this pilot study ND duration time was observed in TDS evaluations of dark chocolate. The results of the pilot study showed that ND duration time became significantly dominant in the last 10% of standardized consumption time. Most studies on TDS correct for the latency before first attribute selection to reduce noise in the data. However, the current study did not find indications to correct for the latency after the last attribute selection as this duration was observed to be short (approx. 1.4 s) and was significantly lower compared to the latency before first attribute selection. One could speculate that the increase in ND duration towards the end of consumption time could have been due to ambiguity on the definition ‘when perception ends’.

ND represents the absence of dominance for any of the sensations instead of an ‘active’ perception. Due to the nature of the concept ‘no dominance’ participants were not informed that periods of ND were recorded, nor were they given the option to explicitly choose for a ND period during their evaluations (e.g. by providing a button coded “no dominance”). Instead, the Hold-down TD measured ND periods in TDS and TDE implicitly, where ND reflected the period between the selection of two subsequent dominant attributes. A previous study included a ‘no perception’ button in TDS evaluations with predefined consumption times. They observed that dominance rates of ‘no perception’ gradually increase towards the end of the predefined consumption time and even reach significance at the end of consumption time in 2 out of 5 product profiles when texture and taste attributes are assessed simultaneously (Rodrigues et al., 2018). Although the concept and design of the current study was different, it seems plausible that at the end of consumption time it becomes more difficult to perceive and report dominant sensations. However, one could debate whether the inclusion of a ‘no dominance’ or ‘no perception’ button does justice to the conceptual nature and definition of dominance and the absence of it.

The classic and Hold-down TD method differed on the selection procedure of a dominant attribute. In the classic TD only the moment of dominance of an attribute has to be weighted by the assessors, whereas in the Hold-down TD the assessors also have to decide when dominance of an attribute ends. Although the Hold-down TD is based on the concept of dominance, the selection procedure of a dominant attribute comes closer to the selection procedure in the TCATA method, where assessors have to select and deselect attributes that are applicable at a given moment in time (Castura et al., 2016). Comparable to the aim of our study, TCATA Fading was introduced to reduce noise and to eliminate an overestimation of applicable attributes at moments of consumption in the TCATA method (Ares et al., 2016). In TCATA Fading, assessors select applicable attributes at a given moment in time and the attribute selection is gradually unselected over a period of 8 s. Similar dynamic profiles were observed between TCATA and TCATA Fading, but TCATA Fading resulted in lower citation proportions. Ares et al. (2016) suggested that selecting and un-selecting attributes might require different cognitive processes that possibly underlie differences in dynamic profiles.

As sensory characteristics of foods are thought to be related to food-evoked emotions (Gutjar et al., 2015), one would expect that with similar dynamic sensory profiles observed between classic TD and Hold-down TD, the dominance sequences for emotions would also be similar for the different methods. However, this was not what was found in the present study. Although the type of emotions that characterized each product were similar between methods, the dynamic sequences of emotions by product deviated between classic TD and Hold-down TD. This suggests that not only the sensory characteristics of food but other factors, such as context or the task paradigm at hand, may influence food-evoked emotion profiles. It is still unknown to what extent food-evoked emotion profiles are solely elicited by the evaluated food and to which degree context and task characteristics influence the reproducibility of food-evoked emotion evaluations.

Lower dominance rates were observed for the emotion attributes compared to the sensory attributes in classic and Hold-down TD method. Consequently, better product discrimination was observed in TDS compared to TDE. The difference in dominance rates and product discrimination supports the idea that consumers show less agreement on self-reported food-evoked emotions compared to sensory characteristics (Jager et al., 2014). The evaluation of food-evoked emotions might include recalled believes and experiences of the food product, rather than the actual food-evoked emotion the product communicates during the evaluation moment (Köster & Mojet, 2015; Thomson et al.,

<table>
<thead>
<tr>
<th>Method</th>
<th>Protocol</th>
<th>n</th>
<th>70% cocoa</th>
<th>Orange</th>
<th>Sesame</th>
<th>Cranberry</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classic</td>
<td>TDS</td>
<td>35</td>
<td>6.0 ± 0.3*</td>
<td>5.8 ± 0.4*</td>
<td>6.9 ± 0.3*</td>
<td>5.8 ± 0.3*</td>
<td>2.8</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td>TDE</td>
<td>33</td>
<td>5.8 ± 0.4</td>
<td>6.3 ± 0.3</td>
<td>5.9 ± 0.3</td>
<td>5.9 ± 0.3</td>
<td>0.5</td>
<td>0.66</td>
</tr>
<tr>
<td>Hold-down</td>
<td>TDS</td>
<td>33</td>
<td>6.4 ± 0.3*</td>
<td>6.0 ± 0.4*</td>
<td>7.2 ± 0.3*</td>
<td>5.8 ± 0.3*</td>
<td>4.0</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>TDE</td>
<td>36</td>
<td>5.4 ± 0.4</td>
<td>6.6 ± 0.3</td>
<td>6.2 ± 0.4</td>
<td>6.5 ± 0.3</td>
<td>2.6</td>
<td>0.06</td>
</tr>
</tbody>
</table>

*Similar letters within one row refer to statistically comparable liking scores (p < 0.05).
Furthermore, it could be that emotion responses evoked by food are not as strong as sensory characteristics, are more intuitive, and therefore more difficult to recognize and report compared to the sensory characteristics of food. Emotions are perceived rather unconscious, but direct self-reported emotion measurements demand consumers to verbalize these unconscious emotions (Thomson, 2016). Consequently, reporting food-evoked emotions might be a more demanding task compared to the identification of sensory characteristics which requires a more analytical mind-set.

When discussing the results of the hedonic assessment, caution should be taken with interpretation due to the low sample size (n ~ 34). Hence, these findings should be considered as explorative and need replication. No differences in liking of products were observed between liking scores obtained after classic TD and Hold-down TD, meaning that the selection task of the different methods does not seem to influence the liking scores. However, significant differences in liking of products were observed when liking was evaluated after TDS and TDE evaluations, suggesting that reporting dominant sensations or emotions might have an effect on hedonic evaluations. The cognitive process prior to the hedonic evaluations might have influenced the liking scores. Traditionally, hedonic evaluations are decoupled from analytical assessments to put consumers more in an integrated state of mind to evaluate the product as a whole instead of breaking it down in sensory characteristics (Lawless & Heymann, 2010). Liking scores observed after TDS, which has a more analytical nature, discriminated more between products (significant differences in liking assessed after TDS between products were observed) compared to liking scores after TDE, which has a more intuitive nature (no significant differences in liking assessed after TDE between products were observed).

From a methodological point of view the Hold-down TD method has its strengths and limitations. The Hold-down TD method has the advantage that it actively involves assessors during the TD evaluations, as they have to monitor the start, duration, and the end of perceiving an attribute as dominant. The currently proposed Hold-down TD measured ND periods implicitly, that is, ND was not included as an attribute as dominant. The currently proposed Hold-down TD measured ND periods implicitly, that is, ND was not included as an attribute as dominant. The currently proposed Hold-down TD measured ND periods implicitly, that is, ND was not included as an attribute as dominant. The currently proposed Hold-down TD measured ND periods implicitly, that is, ND was not included as an attribute as dominant.

To in conclusion, using Hold-down TD revealed ND duration times between the selection of two subsequent attributes that were too short (less than 1 s on average) to be considered moments of true hesitation or indecisive behaviour by panellists. Consequently, no evidence was found for Hold-down TD outperforming classic TD in terms of sensitivity and discrimination ability in this study. Irrespective of the conceptual likelihood of panellists experiencing ‘no dominance’ periods, the present study failed to demonstrate moments of hesitation using the ‘Hold-down’ procedure. Capturing moments of indecisive selection behaviour (both at the individual and panel level) warrants further exploration and methodological developments to be able to identify this likely characteristic of panellist behaviour.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.foodqual.2018.08.008.

References


