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"See me, feel me": Effects of 3D-printed surface patterns on beverage evaluation

Thomas J.L. van Rompay [a,*], Friederike Finger [a], Daniel Saakes [b], Anna Fenko [a]

[a] Department of Communication Science, University of Twente, The Netherlands
[b] Department of Industrial Design, KAIST, Republic of Korea

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ABSTRACT

Research shows that packaging appearance can have a strong impact on taste experience and product evaluation. However, so far research has mainly focused on how visual appearances may steer sensory impressions including smell and taste. Taking into account new (technological) developments which allow for consideration of a wide range of previously unexplored packaging factors, the research presented here investigates the impact of 3D-printed surface patterns on taste evaluations as a function of product type (a bitter tasting coffee versus a sweet tasting chocolate drink) and verbal product claims (either stressing taste strength or taste softness). To this end, 3D-printed cups with angular and rounded surface patterns were manufactured and handed to shoppers participating in a taste session for a fictitious coffee or chocolate brand. Results show that an angular surface pattern increased perceived bitterness and taste intensity ratings, whereas a rounded surface pattern induced a sweeter taste evaluation and a less intense taste experience. Congruent pairings of drinks and tactile patterns resulted in more favorable outcomes. Finally, congruence was also found to be important with respect to taste descriptions, with verbal claims in line with surface pattern associations further enhancing product experience.

1. Introduction

When shopping at the supermarket, consumers face literally thousands of branded products screaming for attention. Packaging design is among the key means to secure consumer attention at the point of purchase, and later on, to sustain interest after consumption. Traditionally, visual elements such as shape, color, and size were the key candidates to do so, but recently manufacturers increasingly turn to other sensory elements such as smell and tactile elements in particular. For instance, Heineken recently reenergized one of its Mexican beer brands with a matte finish suggestive of a more masculine personality. But although researchers have looked into material influences on food and beverage evaluation (e.g., Biggs, Juravle, & Spence, 2016; Krishna, 2012; Piqueras-Fiszman & Spence, 2012, 2015; Schifferstein & Cleiren, 2005; Spence, 2016; Spence & Wan, 2015), research systematically assessing the influence of material surface patterns on food and beverage evaluation is limited. At the same time, new technologies such as 3D printing nowadays provide ample opportunities to experiment with surface patterns. Hence, the latter type of research is highly warranted, both from a practical and scientific point of view.

Inspired by this scarcity of research on the one hand and opportunities for product differentiation and sensory marketing on the other, this study seeks to address the interplay between surface patterns, taste experience, and product evaluation. In doing so, we will draw on research testifying to the importance of the angular-round continuum in relation to food and beverage evaluation (e.g., Becker, van Rompay, Schifferstein, & Galetzka, 2011; Spence, Ngo, Percival, & Smith, 2013; Velasco, Salgado-Montejo, Marmolejo-Ramos, & Spence, 2014; Velasco, Woods, Petit, Cheok, & Spence, 2016; Westerman et al., 2012, 2013).

Importantly, however, we will address this factor in relation to visuotactile surface patterns (i.e., perceived by touch and vision). Building forth on previous research addressing cross-modal correspondence, two types of patterns (with either angular or rounded elements) were developed and used in product sample containers for either a sweet chocolate drink or a bitter coffee. The research aim was to study whether associations triggered by visuotactile product experience would transfer to taste. Additionally, the role of verbal taste descriptions (i.e., a product claim stressing either the drink's 'soft taste' or 'strong taste') was taken into account. Before elaborating on the details of this study, first we will discuss the key notions involved.

* Corresponding author at: Department of Communication Science, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands.
E-mail address: t.j.l.vanrompay@utwente.nl (T.J.L. van Rompay).

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2. Shape angularity and product evaluation

When considering research addressing the influence of shape on product evaluation, it becomes readily apparent that shape angularity (versus roundedness) is one of the most important determinants of product preference (e.g., Bar & Neta, 2006; Zhang, Feick, & Price, 2006). Apart from its influence on consumers' aesthetic responses to product and brand elements, shape angularity has also been traced to specific symbolic meaning portrayals, with angular forms connoting potency-related meanings such as *strength*, *intensity*, and *power*, whereas curved forms rather express *softness* and *harmony* (e.g., Becker et al., 2011; Berlyne, 1960). In line with these notions, Becker et al. (2011) showed that people not only perceive packaging variants with angular (as opposed to rounded) shapes as more powerful, but that they also experience the taste of packaging contents (i.e., yoghurt) as more intense when associated with an angular packaging design.

These results show that consumers rely on symbolic meanings connoted by packaging features such as shape and materials to draw inferences about its contents, even when the product attributes under evaluation are unrelated to the package's appearance (i.e., packaging appearance and materials have no direct influence on drink or food taste). This sequence involves an automatic process in which consumers draw on implicit schemata in which impressions derived from one source (e.g., packaging materials) shape expectations for subsequent product impressions (e.g., product taste; Huber & McCann, 1982; Pinson, 1986). Consumers are most likely to draw on such implicit product schemata when the product is new or when experience is limited (cf. Deliza & MacFie, 2001), and when product attributes are perceived in rapid succession (Garber, Hyatt, & Starr, 2001). These notions and research findings indicate that consumers may base expectations regarding product taste on the 'look and feel' of the package, especially in supermarkets where new taste variants are introduced constantly, and time devoted to purchase considerations is generally limited.

In line with these notions, experiments have shown that people intuitively make connections between different sensory domains, a phenomenon referred to as 'cross-modal correspondence' (e.g., Biggs et al., 2016; Crisinel, Jacquier, Deroy, & Spence, 2013; Schifferstein & Spence, 2008; Spence, 2012). For instance, a considerable body of research indicates that across food and beverage categories (including tea, cheese, chocolate, yoghurt, and fruit juice), cross-modal correspondences exist between angularity and a variety of taste evaluations (e.g., bitterness and sourness; see Velasco et al., 2016 for a review). For example, Ngo, Misra, and Spence (2011) visually presented different shapes in combination with different types of chocolate ranging from sweet to bitter. They showed that bitterness is readily associated with angular shapes. In contrast, sweetness is associated with round or organic shapes. Although different studies have focused on different taste attributes, a common, underlying dimension of taste experience seems to revolve around taste intensity or potency (cf. Becker et al., 2011; Spence et al., 2013), an argument in line with Boring's (1942) claim that different sense sensations share the dimension of intensity.

The theoretical basis underlying angularity effects is generally traced to the embodied cognition framework in which abstract meanings are accounted for in terms of concrete bodily interactions (Barsalou, 1999; Lakoff & Johnson, 1980, 1999; Van Rompay, Hekkert, Saakes, & Russo, 2005; Van Rompay & Ludden, 2015). For instance, the finding that angular (as opposed to rounded) shapes are perceived as powerful can be traced to interactions with natural (e.g., stones) and manmade (e.g., products) objects, in which we find that angular objects make for a more intense, forceful impression on our skin, whereas rounded objects generate a gentle and smooth interaction (Arnheim, 1974; Van Rompay & Ludden, 2015; Zhang et al., 2006).

Thus because of these affective experiences arising in interactions with objects, we associate angularity with strength or intensity, and curvature with harmony and softness. Interestingly then, the basis of aforementioned findings may foremost be found in our haptic, tactile interactions with objects. If correct, then experimenting with surface patterns of product packaging may be a particularly promising avenue for influencing taste intensity and specific taste attributes in particular (bitterness and sweetness in current research). Specifically, and in line with the rationale presented above, angular (as opposed to rounded) surface patterns should increase taste intensity as they make a more forceful impression on our skin.

As discussed, previous research assessing shape-taste correspondences (e.g., Ngo et al., 2011; Velasco et al., 2016) indicates that people entertain associations between angular shapes and bitterness on the one hand, and between rounded shapes and sweetness on the other. Although the basis for these associations is still a matter of debate, Velasco et al. (2016) suggest that people might 'match pairs of taste/shape stimuli when they denote similar hedonic and intensity-related properties' (see also Salgado-Montejo et al., 2015 for a similar stress on hedonic valence as a potential explanation for shape-taste associations). Of further relevance here, Spence and Gallace (2011) discuss the association between shape angularity and taste sharpness. These notions and findings suggest that effects of shape angularity on taste may (also) be grounded in embodied interactions in which we experience angular objects with straight lines and edges as 'sharp'.

However, as also pointed out by Spence and Wan (2015) and Spence (2016), experimental research addressing transfer effects of material surface patterns to taste is limited. Nonetheless, several researchers have recently demonstrated that different materials make for qualitatively different taste experiences (Biggs et al., 2016; Piqueras-Fiszman & Spence, 2012; Schifferstein, 2009; Spence & Wan, 2015; Tu, Yang, & Ma, 2015). For instance, both Schifferstein (2009) and Tu et al. (2015) had their participants taste drinks from cups made of different materials. Whereas Schifferstein (2009) showed, among others, that participants enjoyed their soda better when drunk from a plastic (rather than ceramic) cup, Tu et al. (2015) showed that participants perceived cold tea contained in glass cups as sweeter compared to cold tea contained in plastic cups. Furthermore, Biggs et al. (2016) recently showed that biscuits taste sweeter when sampled from a smooth, as opposed to a rough plate. Apart from showing that packaging or container materials impact taste, findings across studies also suggest that congruency between material surface and drink type should be considered.

The importance of 'fit' or congruence among different elements is well acknowledged within consumer research (e.g., Peracchio & Meyers-Levy, 2005; Van Rompay, Pruyn, & Tieke, 2009). Of special relevance to the current research, Okamoto et al. (2009) showed that different tastes were liked better when they were combined with words that were related (i.e., congruent with) these tastes. Additionally, research indicates that when a matching taste or flavor description is presented before a product is tasted, taste perceptions are more intense (Distel & Hudson, 2001; Herz & von Clef, 2001). These findings are highly relevant to the product packaging context where implicit or abstract elements such as shape and surface pattern are usually combined with explicit taste descriptions laid down in product claims or slogans.

To better understand such congruence effects, the processing fluency framework is of particular interest (Reber, Schwarz, & Winkielman, 2004; Van Rompay et al., 2009). According to this account, stimuli that can be easily processed are preferred (because fluent processing indicates that things in the environment pose no danger or cognitive challenges), which is subsequently attributed to the stimulus at hand, resulting in favorable product evaluations (e.g., Lee & Labroo, 2004; Reber et al., 2004). Importantly, congruence among product elements may facilitate processing (Van Rompay & Pruyn, 2011). After all, when confronted with products, consumers face the task of integrating meanings connoted across product elements (e.g., meanings connoted by materials on the one hand and textual elements on the other) into an overall impression. Mixed signals may elicit ambiguity with respect to product identity, thereby negatively affecting subsequent product evaluations. Encountering a product-appropriate package with matching materials and textual elements, on the other hand, allows for a clear and fluent product impression, and thus should result in positive evaluations.

In sum, current research seeks to address the influence of material surface patterns on taste evaluation as a function of both drink type and verbal product claims. Taking into account previous research findings and theorizing on the relationship between shape angularity and taste experience, it is expected that:

H1. An angular, versus rounded, surface pattern results in a *more bitter* and *less sweet* taste experience.

H2. An angular, versus rounded, surface pattern results in an overall *more intense* taste experience.

With respect to hedonic taste and overall product liking, it is expected that congruence between surface pattern and beverage type boosts evaluations such that:

H3a. An angular surface pattern in combination with a congruent coffee beverage (rather than an incongruent chocolate drink) enhances taste liking and product liking.

H3b. A rounded surface pattern in combination with a congruent hot chocolate beverage (rather than an incongruent hot coffee) enhances taste liking and product liking.

Finally, it is expected (inspired by the processing fluency framework) that verbal taste descriptions that match, rather than mismatch, surface pattern associations further enhance taste liking and product liking. Hence:

H4a. An angular surface pattern enhances taste liking and product liking when combined with a congruent product claim stressing strength (rather than softness).

H4b. A rounded surface pattern enhances taste liking and product liking when combined with a congruent product claim stressing softness (rather than strength).

To test these predictions, cups with either an angular or rounded surface pattern were 3D-printed and used as sample containers for either a sweet and soft hot chocolate drink, or a bitter and strong hot coffee. Finally, during the taste session, a poster was presented either stressing the strong or soft taste of the respective drink. Hence, a full factorial 2 (material surface pattern: angular versus rounded) $\times$ 2 (drink type: hot chocolate versus hot coffee) $\times$ 2 (verbal product claim: 'strong taste' versus 'soft taste') between-subjects design was employed.

3. Method

3.1. Materials

A set of two sample cups with rounded and angular pattern elements (varying in size) were 3D-printed. Specifically, the stimuli were manufactured from polylactic acid (PLA) with a Fused Deposition Modelling (FDM) 3-D printer. The printer, an Ultimaker 2, enables the creation of highly detailed and accurate (100 μm) customizable models. The printed models were designed to fit as a sleeve around a small, heat-resistant, paper cup (to be replaced per subject for hygienic purposes). These models were informally presented to participants to assess whether they could clearly differentiate between the two surface patterns. In the first iteration, this was not the case due to insufficient spacing between the angular elements. Based on these responses, a new version of the angular cup was printed and again presented to participants for evaluation (see Fig. 1 for detailed renderings and specifications). This time, spacing between the angular elements was sufficient. Participants could now differentiate (when asked to describe the surface patterns) between the variant presenting a rounded surface pattern, and the variant presenting a cube-like, angular surface pattern. Finally, the stimuli were darkened with a black, silk-matte spray paint (see Fig. 2).

To come up with suitable verbal claims, a slogan for each taste dimension (i.e., low versus high taste intensity) was developed, either stating "Try the new strong taste..." (high-intensity), or "Try the new soft taste..." (low intensity). A manipulation check involving 20 participants (who rated the fittingness of these product claims to the cups presented, i.e., "This slogan fits the cup", on 5-point rating scales) confirmed that the 'strong' verbal product claim better fitted the angular surface pattern ($M = 4.10$; $SD = 0.64$ versus $M = 1.65$; $SD = 0.49$), whereas the 'soft' verbal product claim better fitted the rounded surface pattern ($M = 4.25$; $SD = 0.97$ versus $M = 2.20$; $SD = 0.70$; both p's < 0.001).

As for the drink preparation, the 'Chocomel' brand was used for the chocolate condition, which was heated to a temperature of 90 degrees Celsius. The coffee was brewed (using a standard coffee machine with paper filters) with 'Douwe Egberts' pre-ground coffee beans. For each session, exact ratios of water and coffee were used (12 g of coffee beans for 200 ml of water). As the coffee machine heated the water to a few degrees above 90 degrees Celsius, the coffee was cooled down to a temperature of 90 degrees in order to match the temperature of the chocolate drink. Both drinks were subsequently poured into high-quality thermos flasks of the same brand. Prior to the main study, it was tested how long drink temperature remained constant. Based on this test, session duration was set at a maximum of two hours. During the sessions, approximately 20 ml of the respective drink (i.e., coffee or chocolate depending on the experimental condition) was poured into a sample cup for each respondent.

3.2. Participants and procedure

160 people (114 male and 46 female respondents; mean age: 26.6 years; age range: 18–60 years) participated in the experiment. Table 1 presents age and gender distribution across the experimental conditions. Analyses of variance confirmed that age and gender were equally distributed (both F's < 1, *ns*). Participants were approached at a shopping center and asked if they would be willing to participate in a product sampling taste test for a new coffee or chocolate drink. Upon agreement, participants were asked if they had any diet restrictions or food allergies (no respondents were excluded based on this screening question). Next, they tasted either the coffee or chocolate drink from one of the two sample cups (see Fig. 1). The verbal product claim stipulating a fictitious brand (i.e., "*Try the new strong/soft taste of Rieke's new hot coffee/hot chocolate*") was printed in A3 format and clearly pointed out to the participants prior to tasting. After tasting, participants filled out the questionnaire comprising the dependent measures.

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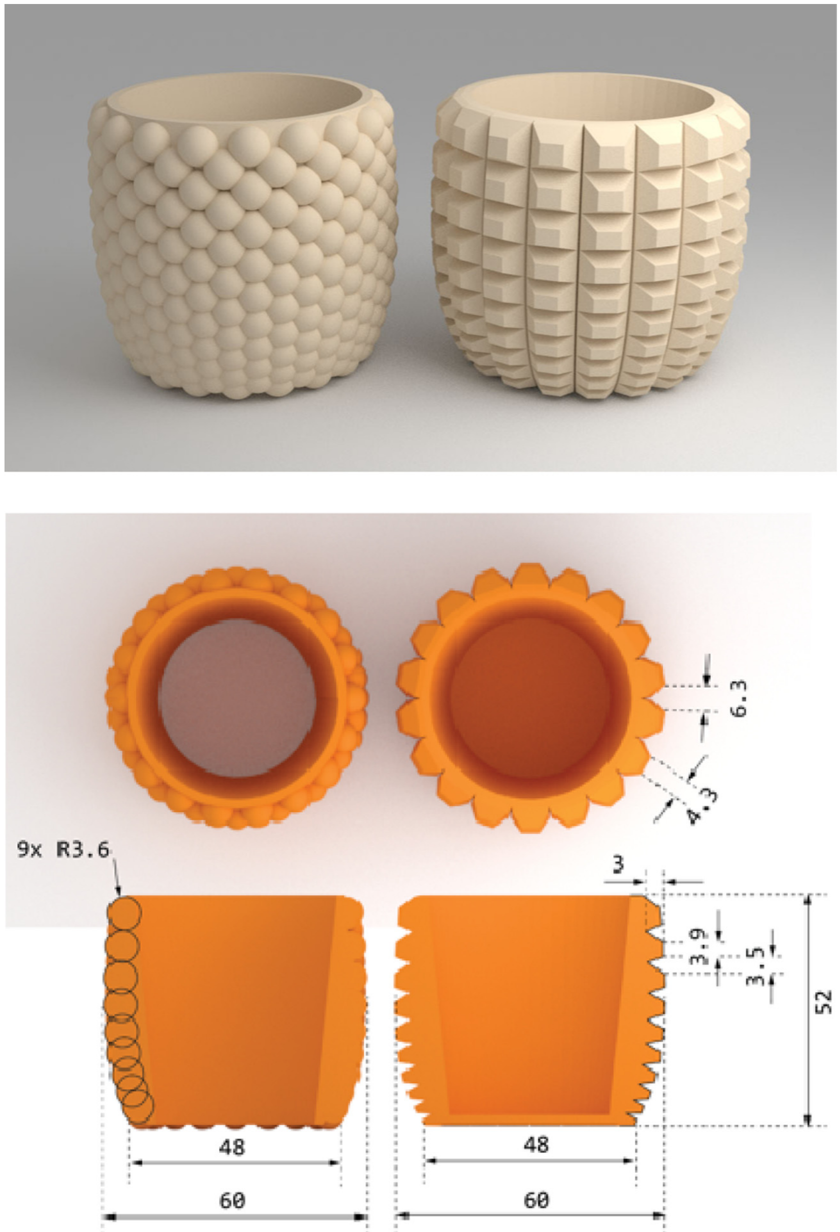

Fig. 1. Renderings and specifications of surface pattern variants.

Fig. 2. Finalized surface pattern variants (left panel: rounded surface pattern; right panel: angular surface pattern).

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Table 1
Demographics of participants for each experimental condition.

Condition	N	Age		Male
		M	SD	
Rounded pattern, chocolate, soft claim	20	26.2	10.4	70%
Rounded pattern, chocolate, strong claim	20	27.6	10.6	65%
Angular pattern, chocolate, soft claim	20	26.5	11.0	75%
Angular pattern, chocolate, strong claim	20	25.6	9.8	70%
Rounded pattern, coffee, soft claim	20	28.3	11.4	70%
Rounded pattern, coffee, strong claim	20	26.7	12.5	75%
Angular pattern, coffee, soft claim	20	24.8	10.1	70%
Angular pattern, coffee, strong claim	20	27.1	10.7	75%

3.3. Measures

3.3.1. Taste evaluation measures

Two single-item taste measures (i.e., "This drink has a bitter taste", and "This drink has a sweet taste") were used to measure perceived bitterness and perceived sweetness respectively.

The more general taste intensity construct, based on Becker et al. (2011), comprised the items *strong*, *powerful* and *intense* (alpha = 0.87).

Finally, hedonic taste evaluation was measured with the item "I like the taste of this drink". All items were scored on 7-point rating scales (scale anchors: "I strongly disagree" versus "I strongly agree").

3.3.2. Overall product liking

To measure overall product liking, Hirschman and Solomon's (1984) five-item brand evaluation scale was adapted to the current research. Example items include "I like this product" and "This product appeals to me" (alpha = 0.95).

4. Results

To investigate the effects of the independent variables, analyses of variance were conducted with surface pattern (rounded or angular elements), beverage type (hot coffee or hot chocolate beverage), and product description ('strong' versus 'soft' verbal taste description) as independent variables, and the taste measures and product evaluation measure as dependent variables. Follow-up analyses (i.e., pairwise comparisons) of significant interaction effects were conducted using tests of simple main effects (with Bonferroni correction).

4.1. Taste dimensions: bitter and sweet

An ANOVA with taste bitterness as dependent variable reveled a main effect of drink type ($F(1,152) = 35.70$, $p < 0.001$, $\eta 2 = 0.19$), showing that the hot coffee was (as expected) experienced as significantly more bitter than the hot chocolate drink ($M = 3.55$, SD 1.76 versus $M = 2.21$, $SD = 1.16$).

More interestingly, the expected main effect for surface pattern ($F(1,152) = 12.38$; $p = 0.001$, $\eta 2 = 0.08$) surfaced, showing that (regardless of drink type) the angular, as opposed to the rounded, surface pattern increased perceived bitterness ($M = 3.28$, $SD = 1.79$ versus $M = 2.49$, $SD = 1.35$). The main effect of taste description was not significant ($F < 1$, *ns*), neither were the interactive effects (drink type X surface pattern: $F(1,152) = 2.62$, $p = 0.11$, $\eta 2 = 0.02$; drink type X taste description: $F(1,152) = 2.62$, $p = 0.11$, $\eta 2 = 0.02$; surface pattern X taste description: $F < 1$, *ns*, & drink type X surface pattern X taste description: $F(1,152) = 3.00$, $p = 0.09$, $\eta 2 = 0.02$).

Likewise, for taste sweetness, a main effect of drink type surfaced ($F(1,152) = 174.77$, $p < 0.001$, $\eta 2 = 0.54$), showing that the hot chocolate was (in line with expectations) experienced as sweeter than the hot coffee ($M = 5.33$, $SD = 1.15$ versus $M = 2.85$, $SD = 1.35$). The effect of drink type, however, was dependent on taste description (as indicated by a significant 'drink type' by 'taste description' interaction; $F(1,152) = 7.13$, $p < 0.01$, $\eta 2 = 0.05$), showing that when accompanied by a 'soft' (as opposed to a 'strong') taste description, the chocolate drink was evaluated as even sweeter ($p < 0.001$).

As expected, the main effect of surface pattern reached significance ($F(1,152) = 16.05$, $p < 0.001$, $\eta 2 = 0.10$), this time showing that the rounded surface pattern induced (regardless of drink type) a sweeter taste ($M = 4.46$, $SD = 1.79$) compared to the angular surface pattern ($M = 3.71$, $SD = 1.66$). The main effect of product description was not significant ($F < 1$, *ns*). No other interaction effects were significant (all F's < 1, *ns*).

Besides confirming the effectiveness of the drink type manipulation (showing that the coffee was indeed perceived as more bitter and less sweet compared to the chocolate beverage, and vice versa), more importantly these findings confirm the potential of material surface patterns to enhance specific taste sensations (perceived bitterness and sweetness) of beverage consumption. In the following series of analyses, we will turn to our more global beverage evaluation measures: taste intensity, taste liking (hedonic taste evaluation), and overall product liking.

4.2. Taste intensity

An ANOVA with taste intensity as dependent variable again revealed a weak, albeit significant, main effect of drink type ($F(1,152) = 5.26$, $p = 0.04$, $\eta 2 = 0.03$), showing that the hot coffee was experienced as less intense compared to the hot chocolate ($M = 4.08$, $SD = 1.47$ versus $M = 4.44$, $SD = 1.05$). Likewise, the main effect of surface pattern on taste intensity was significant ($F(1,152) = 22.11$, $p < 0.001$, $\eta 2 = 0.13$), showing that the angular surface pattern resulted in a more intense taste sensation ($M = 4.67$, $SD = 1.15$) compared to the rounded surface pattern ($M = 3.84$; $SD = 1.29$).

Importantly, a significant interaction effect between surface pattern and drink type emerged ($F(1,152) = 14.47$, $p < 0.001$, $\eta 2 = 0.09$). As shown in Fig. 3, within the coffee condition, the angular (as opposed to the rounded) surface pattern increased taste intensity ($p < 0.001$). In the chocolate condition, this pattern did not transpire ($p = 0.53$). Furthermore, within the angular surface condition, the coffee and chocolate drink did not lead to significantly different taste intensity ratings ($p = 0.22$), whereas within the rounded surface pattern condition, the coffee drink was evaluated as less intense compared to the chocolate drink ($p < 0.001$).

In addition, the interaction between surface pattern and taste description was significant ($F(1,152) = 11.74$, $p = 0.001$, $\eta 2 = 0.07$). As shown in Fig. 4, taste intensity was rated higher when the angular cup was paired with the product claim stressing 'strength' rather than 'softness' ($p = 0.001$). For the rounded surface

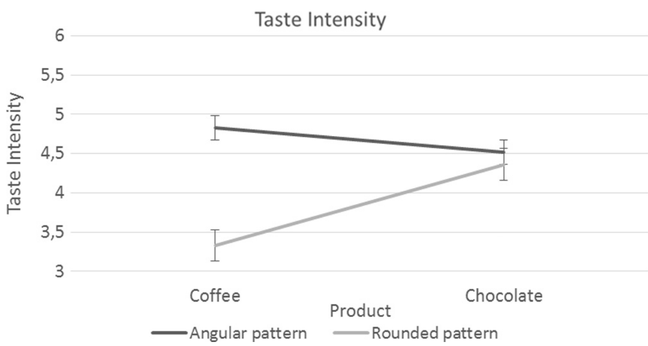

Fig. 3. Mean taste intensity (±SE) as a function of product type and surface pattern.

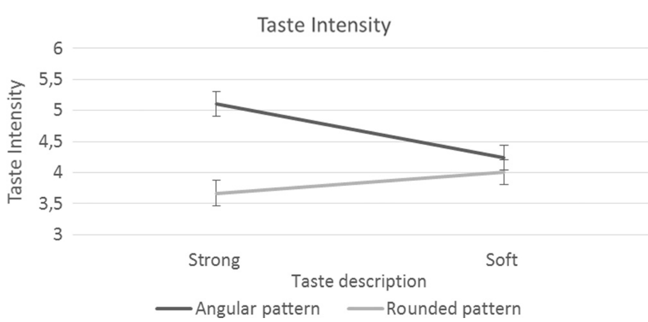

Fig. 4. Mean taste intensity (±SE) as a function of taste description and surface pattern.

pattern, the difference between the two taste description claims was not significant ($p = 0.16$). Furthermore, the surface patterns did not yield different intensity ratings within the taste description condition stressing 'softness' ($p = 0.37$), whereas the angular, as opposed to the rounded, surface pattern did result in higher intensity ratings when 'strength' was stressed ($p < 0.001$).

The interaction between drink type and taste description was not significant ($F(1,152) = 3.31$, $p = 0.07$, $\eta 2 = 0.02$), neither was the three-way interaction between drink type, surface pattern, and taste description ($F(1,152) = 2.51$, $p = 0.12$, $\eta 2 = 0.02$).

4.3. Hedonic taste

The main effect of drink type was again significant ($F(1,152) = 15.41$, $p < 0.001$, $\eta 2 = 0.09$), showing that participants liked the hot chocolate better than the hot coffee ($M = 5.84$, $SD = 0.92$ versus $M = 5.23$, $SD = 1.19$). The main effects of surface pattern and taste description were not significant (both *F*'s < 1, *ns*).

More importantly, however, the interaction between surface pattern and drink type was significant ($F(1,152) = 27.11$, $p < 0.001$, $\eta 2 = 0.15$). Pairwise comparisons (see Fig. 5) show that for the chocolate drink, the rounded, rather than the angular, surface pattern induced higher scores ($p = 0.001$), whereas for the coffee drink the angular, rather than the rounded, surface pattern increased taste liking ($p < 0.001$). Furthermore, within the rounded surface pattern condition, the chocolate drink taste was liked better than the coffee drink (p < 0.001), whereas this difference was not significant within the angular surface pattern condition ($p = 0.37$).

The interactive effects between drink type and taste description, and between surface pattern and taste description were not significant (both *F*'s < 1, ns). Likewise, the three-way interaction between drink type, surface pattern, and taste description was not significant ($F(1,152) = 2.83$, $p = 0.10$, $\eta 2 = 0.02$).

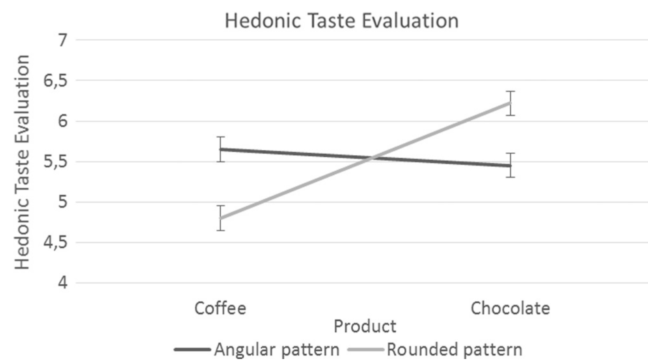

Fig. 5. Mean hedonic taste evaluation (±SE) as a function product type and surface pattern.

4.4. Overall product liking

In line with the main effect for taste liking, the main effect of drink type on overall product liking was also significant ($F(1,152) = 4.93$, $p = 0.03$, $\eta 2 = 0.03$), showing that participants preferred the chocolate drink over the coffee ($M = 5.30$, $SD = 0.94$ versus $M = 4.96$, $SD = 1.18$). The main effects of surface pattern and taste description were not significant (both *F*'s < 1, *ns*).

Further mirroring the results for taste liking, the interaction between surface pattern and drink type was also significant ($F(1,152) = 31.18$, $p < 0.001$, $\eta 2 = 0.17$), again showing (see Fig. 6) that within the angular surface condition, the coffee was preferred ($p = 0.02$), whereas within the rounded surface condition the chocolate drink was preferred ($p < 0.001$). Likewise, within the coffee drink condition, the angular surface pattern yielded higher product liking ($p < 0.001$), whereas within the chocolate drink condition, the rounded surface pattern increased product liking ($p < 0.001$).

The interaction between surface pattern and taste description was also significant ($F(1,152) = 4.64$, $p = 0.03$, $\eta 2 = 0.03$). As can be seen in Fig. 7, drinks are (marginally) liked better when the rounded surface pattern was paired with the 'soft', rather than the 'strong' taste description ($p = 0.06$). Within the angular surface pattern condition, the difference between the two taste descriptions was not significant ($p = 0.24$). Similarly, within the 'strength' taste description condition, the angular surface pattern increased product liking ($p = 0.07$), whereas within the (taste description) condition stressing 'softness', the difference between surface patterns was not significant ($p = 0.21$).

The interaction between drink type and taste description did not reach significance ($F(1,152) = 1.88$, $p = 0.17$, $\eta 2 = 0.01$), neither did the three-way interaction between drink type, surface pattern, and taste description ($F(1,152) = 2.56$, $p = 0.11$, $\eta 2 = 0.02$).

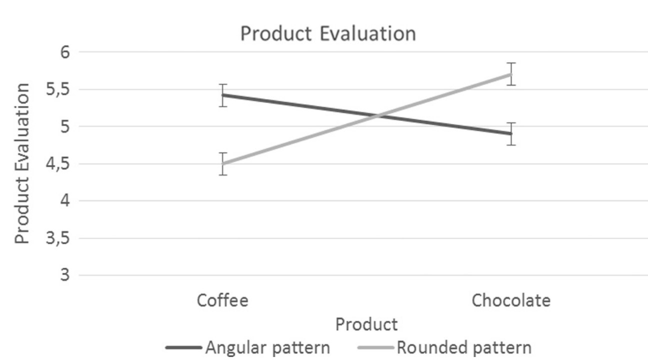

Fig. 6. Mean product evaluation (±SE) as a function of product type and surface pattern.

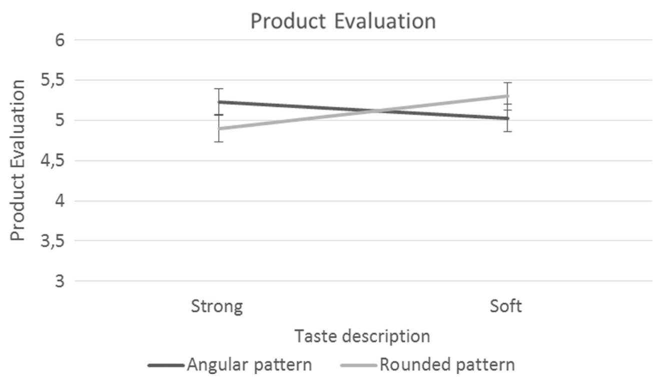

Fig. 7. Mean product evaluation (±SE) as a function of taste description and surface pattern.

5. General discussion

The findings presented clearly show that surface patterns may have a strong influence on beverage evaluation; strong main effects were obtained of surface pattern on taste evaluation. Specifically, and in line with previously reported findings on effects of overall product shape on sensory experience (e.g., Ngo et al., 2011), an angular, as opposed to a rounded, surface pattern resulted in a more bitter and less sweet taste experience. Additionally, and in line with Becker et al., 2011, our findings show that an angular, as opposed to rounded, surface pattern makes for a more intense taste experience. Furthermore, congruency of material surface patterns vis-à-vis drink type turned out to be important. Especially for hedonic taste and overall product liking (measures indicative of consumer preference), these effects were particularly strong (as indicated by the relatively large effect sizes).

On a theoretical level, these findings suggest that the angularity-intensity relationship might indeed be grounded in embodied, physical interactions with objects. That is, by showing that when visuotactile, rather than 'vision-only', experience takes center stage, aforementioned relationship by no means weakens or vanishes. In that sense, our findings not only hint at the suitability of the embodiment framework for studying effects of multisensory packaging appearance, they also underline the far-reaching potential of surface patterns to steer specific taste evaluation, and more general product evaluation measures.

For the latter types of measures in particular, the importance of congruence or 'fit' between surface pattern and beverage type stood out. Thus whereas the rounded surface pattern enhanced overall evaluations of the chocolate drink, the angular surface pattern did so for the coffee variant. Crucially then, the surface pattern should be perceived as matching the beverage consumed. Our findings clearly showed that the hot chocolate was (in comparison to the coffee) experienced as less bitter and sweeter compared to the coffee, and hence matching the rounded rather than the angular surface pattern and vice versa (cf. Ngo et al., 2011). Obviously then, surface patterns should be considered as a means to accentuate dominant taste attributes of beverage types.

Although far from conclusive, our results further suggest that the interplay between taste descriptions (usually represented in the product packaging context by claims or slogans) and surface patterns can provide additional benefits. Specifically, in our research, we showed that presenting a congruent claim alongside visuotactile perception of a surface pattern may enhance taste intensity and sweetness perception, and increase product liking. As such, these findings concur with previously reported findings (Distel & Hudson, 2001; Herz & von Clef, 2001; Okamoto et al., 2009).

However, these effects did not transpire across the whole range of analyses. Clearly, this interplay between more explicit and more implicit elements requires more research attention in follow-up studies. Of further interest (and in part accounting for why congruence effects were not consistently observed across our outcome measures) are the interaction effects suggesting that within the rounded (as opposed to the angular) surface pattern condition, taste description (for product liking) and drink type (for taste intensity and hedonic taste) are more influential. Arguably (although admittedly speculative), the angular surface pattern is more dominant in terms of experience compared to the rounded surface pattern and therefore may more easily overshadow effects of other variables. In other words, within the rounded surface pattern condition (experienced as less dominant), there might be more room for other factors to qualify (surface pattern) effects.

Admittedly, the surface patterns used in current research were embedded in containers for sample cups rather than in realistic package variants. Furthermore, the patterns applied were more extreme when compared to the subtler surface patterns used in beverage or food products (where mainly shiny-matte surface contrasts can be observed). Finally, apart from their difference in surface patterns, the cups also differed in terms of spacing (in between elements), spatial layout of elements, and total number of elements. Follow-up research could further zoom in on subtler and more systematic applications of surface patterns (also including other dimensions such as material warmth, i.e., heat conductivity, and material flexibility). However, as for the subtleness of surface patterns, 3D-printing technologies increasingly allow for more extreme and innovative surface variants. Taking into account the search for attention-grabbing packages presented at the point of purchase, experimentation with more extreme patterns might certainly align with goals for brand differentiation and positioning.

Furthermore, it should also be acknowledged that we cannot assess the relative contributions of vision and touch to the taste evaluation results presented. To provide a conclusive answer, in follow-up research a split-modality approach could be used in which subjects experience products through only one modality. On the other hand, our approach is faithful to real-life shopping situations in which shoppers see and subsequently feel product packaging (see also Biggs et al. (2016) for a similar line of reasoning on this issue).

Finally, future research could further zoom in on the psychological mechanisms underlying relationships between specific taste measures (such as bitterness and sweetness in current research) and surface patterns. In introducing our study, we argued that such relationships might be accounted for in terms of common hedonic and/or intensity-related properties (Velasco et al., 2016), an account in line with an embodied rationale likewise stressing intensity as a common dimension of both haptic and taste impressions (cf. Becker et al., 2011). Alternatively, the association between shape angularly and sharpness (Spence & Gallace, 2011) provides a potential (and arguably more specific) explanation for our results. That is, an angular surface pattern might enhance bitterness perceptions because its straight lines and angles contribute to an (embodied) impression of 'sharpness', which is subsequently transferred to taste experience. Clearly, future research is warranted to assess the validity of these speculations, and to assess the extent to which the (arguably more general) construct of taste intensity relates to more specific taste dimensions including bitterness, spiciness and sharpness.

Concluding, the research presented testifies to the potential of surface patterns for managing sensorial product experience and brand evaluation, but at the same time show that such endeavors should be informed by knowledge of food and beverage characteristics and promotional elements such as product claims also figuring at the point of purchase. Finally, it is our contention that

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insights in the embodied basis of meanings consumers perceive in (multisensory) product appearance provide a much-needed basis for further experimentation taking into account other surface pattern variants and additional sensory components (e.g., cross-modal relationships between odor and sound; Crisinel, Jacquier, Deroy, & Spence, 2013).

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