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Taste-shape correspondences in context

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Abstract

A significant body of research demonstrates the existence of taste-shape correspondences. People associate tastes and visual shapes non-randomly. For example, round shapes are associated with sweet taste, while angular shapes are associated with sour and bitter tastes. Previous studies focused on one-to-one taste-shape associations, where either geometrical shapes or shapes on the packaging have been presented in isolation and evaluated separately, however, in real-life product displays, products are typically surrounded by other products. We examined whether shape contexts can influence the taste expectations of target products across five experiments (n=1087) using geometrical and shapes on the packaging varied in curvature. Participants saw a display set (target shape in the middle surrounded by shapes on both sides) and evaluated the target shape in different taste scales. The first two experiments (within-participants design) failed to confirm that shape contexts can influence the taste expectations of the target. However, the subsequent three experiments (between-participants design) consistently demonstrated that shape contexts influence taste expectations associated with the target. In the latter experiments, we manipulated only the surrounding shapes and fixed target shapes as neutral (intermediate between angular and round shapes). When the surrounding shapes were angular (vs. round), the target shapes were rated as sweeter/more umami and less sour/salty/bitter. Emotions (valence and arousal) mediated the relationship between shape contexts and taste expectations. We discuss the results in light of the theory on crossmodal correspondences and relative compatibility effects. The findings provide insights for food marketers when it comes to designing product package displays to convey taste information more effectively.

Keywords: crossmodal correspondences; tastes; shapes; display set; emotions

1. Introduction

Imagine the following scenario: Two supermarkets present various jams, with different logos, on a shelf. One supermarket places jam A in the centre of a shelf, where it is surrounded by other jams that use angular logos. Another supermarket places jam A in the centre of a shelf, where it is surrounded by jams that use round logos. When consumers see jam A in each of these supermarkets, what taste would they expect from jam A? Do the surrounding logos that vary in curvature influence taste expectations associated with such a product?

1.1. Taste-shape correspondences

People often associate features across the senses in a surprisingly consistent manner. These associations have been referred to as crossmodal correspondences (Spence, 2011, 2012), and research has revealed a variety of them across different combinations of senses (Knöferle & Spence, 2012; Motoki, Saito, Nouchi et al., 2019a, 2019b; Motoki, Satio, Park et al., 2020; Spence, 2013; Spence, Reinoso-Carvalho, Velasco et al., 2019; Velasco, Woods, Petit et al., 2016). Relevant to the present study, previous studies have documented the existence of taste-shaped correspondences, that is, the association between shape features and specific tastes (see Velasco et al., 2016, for a review). A variety of research including geometric shapes (e.g., Velasco, Salgado-Montejo, Marmolejo-Ramos et al., 2014; Hamamoto, Motoki & Sugira, 2020), typefaces (Velasco, Hyndman & Spence, 2018; Velasco et al., 2018), faces (Motoki, Saito, Nouchi et al., 2019), and products (Arboleda, & Arce-Lopera, 2020; de Sousa et al., 2020; Heatherly et al., 2019; Velasco et al., 2014) has shown consistent evidence suggesting that round shapes are associated with sweet taste, while angular shapes are associated with sour/bitter tastes (though there have been certain exceptions, see Machiels, 2018; Rolschau et al., 2020).

1.2. Relative contributions of crossmodal correspondences

In real-life product displays, products and their design elements are typically surrounded by other products and their corresponding design elements. Previous researches have investigated consumer attention and preferences using multiple product displays (e.g., Atalay et al., 2012; Chandon et al., 2009; Milosavljevic et al., 2012). Specifically, the addition of various types of product options can influence preference formation and choices (e.g., Dhar, & Simonson, 2003; Karmarkar, 2017; Khan et al., 2011; Park & Kim, 2005). A relevant example of this phenomenon is what is referred to as ‘phantom alternatives’ which refers to additional, but not available, options in a choice set. Even though the phantom option is unavailable (the participants cannot choose it), the existence of a phantom option in a choice set can influence decisions (e.g., Karmarkar, 2017; Park & Kim, 2005). Neurophysiological evidence also indirectly supports the phantom effect by showing that the brain encompasses the value of task-irrelevant options that consumers do not have to attend to (e.g., Chau et al., 2014; Lebreton et al., 2009; Motoki et al., 2018). In summary, previous studies suggest that product-irrelevant surrounding alternatives can influence the judgement of the consumer on a target product. In the present study, we were particularly interested in how task-irrelevant shape information associated with a product display would influence consumers’ taste expectations of a target product.

To our knowledge, no research on taste-based correspondences have examined the effects of shape contexts on target shape of product taste estimations (e.g., Knöferle & Spence, 2012; Spence, 2019; Spence & Van Doorn, 2017; Velasco et al., 2016; Wang et al., 2019 for reviews). Context here refers to the circumstances in which something occurs (Cardello & Meiselman, 2018). In sensory and consumer science research, context consists of various elements such as location, lightning, background noise, music, ambient temperature, and social setting, to name a few (e.g., Bravo-Moncayo, Reinoso-Carvalho, & Velasco, 2020;

Cardello & Meiselman, 2018; Dacremont & Sester, 2019; Motoki et al., 2020). Whilst previous research has dealt with how some of these variables influence food expectations and experiences, it is not clear how the shape context in which products are presented, that is, the geometrical designs associated with the visual context of a product on display, may influence taste expectations. Indeed, although previous research has studied taste-based correspondences manipulating other contextual variables such as music (e.g., Reinoso-Carvalho et al., 2019, Spence, 2020; Wang et al., 2019), the specific effect of the curvature context on an object and product taste estimations has not been investigated. Previous researches on taste-based correspondences and crossmodal correspondences has focused on one-to-one, taste-other sensory features, associations, without considering the shape characteristics of contextual variables (see Knöferle & Spence, 2012; Spence, 2019; Spence & Van Doorn, 2017; Velasco et al., 2016; Wang et al., 2019, for reviews). Relevant to the present study, previous studies on shape-taste correspondences presented shapes on packaging in isolation and evaluated their taste associations separately (e.g., Velasco et al., 2016, for a review). However, in a real-life product displays, products are typically surrounded by other products. Therefore, it is essential to understand how people's expectations of the taste of a product may be influenced by the surrounding product shape information (e.g., products' round logos next to the target product). This is, perhaps, reminiscent of the literature on visual search in which the similarity between a target and the distractors used in a visual display can influence search efficiency towards the target (Duncan & Humphreys, 1989; Wolfe & Horowitz, 2004). In the present study, we hypothesised that consumers' evaluation of a product with characteristic shape features may be influenced by the shape characteristics of the surrounding products, and thus their (dis)similarity with a target.

1.3. Predictions

In the case of taste-shape correspondences, it is reasonable to expect that the relative roundness/angularity of contextual items would influence the taste expectations of target items. For value-related choice, surrounding lower-value items increase preference for the target product by making it more attractive, while surrounding higher-value items decreases preferences for the target product by it less attractive (e.g., Furl, 2016; Louie, Khaw & Glimcher, 2013). Applying this logic to the present study, it can be predicted that having a less preferred context (e.g., angular, see Bar & Neta, 2006; Gómez-Puerto, Munar & Nadal, 2016) may increase the preferred taste (e.g., sweet, see Steiner, Glaser, Hawilo & Berridge, 2001; Velasco et al., 2015) and overall liking of the target. In contrast, a more preferred context (e.g., round) would lead to a decrease in the preferred taste, an increase in the less preferred taste (e.g., bitter), and also the overall liking of the target. However, an alternative view, based on processing fluency (Winkielman, Schwarz, Fazendeiro & Reber, 2003), would predict that it is, instead, the congruence between the context and the distractor, which would enhance the overall, corresponding taste expectation (e.g., round context + round target = more sweet, relative to other context/target combinations (cf., Velasco et al., 2016).

The present study investigated the influence of task-irrelevant contextual shapes, both abstract and as captured in a product's packaging on taste expectations. To assess this, we conducted five experiments, both within and between participants, that included geometric shapes and packages with logos of different shape properties.

2. Experiments 1A-1B: The effects of shape contexts on target shapes in within-participants design

2. 1. Methods

2.1.1. Participants

In Experiment 1A, data were obtained from 121 participants. The participants were recruited through the Prolific Academic (http://prolific.ac/) and they completed the survey on Qualtrics (https://www.qualtrics.com/jp/). Data from 24 participants were removed because they failed to respond to at least one question (n = 17), or because all their answers to the questions were the same (n = 7). Therefore, data obtained from a total of 97 healthy participants (60 females, M_{age} = 31.78 ± 11.85) were used for the analysis. Our sample sizes were similar to online research on crossmodal correspondences (e.g., Matthews et al., 2019; Motoki et al., 2020).

In Experiment 1B, data were obtained from 108 participants. The participants were recruited through the Prolific Academic (http://prolific.ac/) and they completed the survey on Qualtrics (https://www.qualtrics.com/jp/). A total of 23 participants were excluded because they failed to respond to at least one question. In total, the data of 85 healthy participants (59 females, M_{age} = 34.18 ± 12.59) were used for the analysis. Digital informed consent was obtained before all the experiments, and all experiments were conducted in accordance with the Declaration of Helsinki.

2.1.2. Taste-shape matching task

The study followed a 3 (target shape: round, angular, neutral) × 3 (surrounding shape: round, angular, neutral) within participants' design. The dependent variable consisted of taste (sweetness, sourness, saltiness, bitterness) ratings associated with the shape stimuli.

In both experiments, the participants saw a set of stimuli consisting of geometric shapes (Experiment 1A) or shapes on packaging (Experiment 1B) and their surrounding geometric shapes/shapes on packaging. They rated the extent to which they associated different tastes (sweetness, sourness, saltiness, and bitterness) with the target shapes (in the middle of a set of stimuli). The participants were asked, "To what extent do you associate the middle (not the right or left) of the shape/product with sweet, sour, salty, and bitter tastes?". The participants matched each geometric shape/packaging shape feature with the taste words on a visual analogue scale (VAS) ranging from 0 (not at all) to 100 (very much).

The geometric shape stimuli are shown in Figure 1, and examples of the packaging stimuli are shown in Figure 2. In Experiment 1A, there were 18 trials (all combinations of target shape, surrounding shape, and two different versions of the shape attributes, Appendix A). In Experiment 1B, there were 36 trials (all combinations of target shape, surrounding shape, two different versions of the shapes, and two product types: jam and sauce) (Figure 2). The order of the shapes and taste questions was randomised across participants. All tasks were designed and presented in Qualtrics.

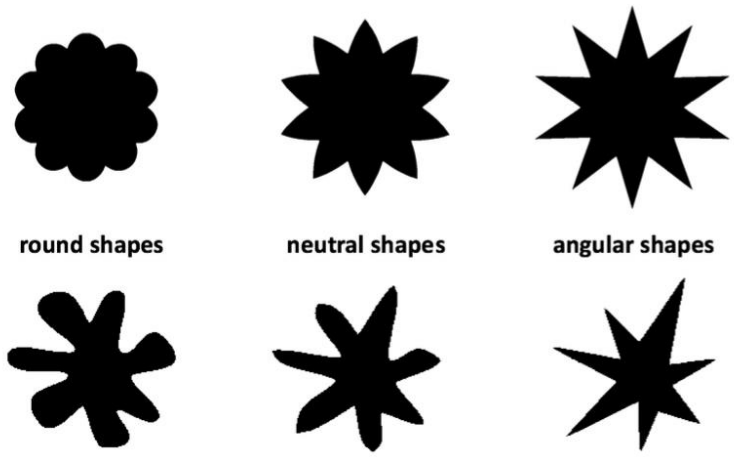


Figure 1. Geometric shape stimuli used in this study. The geometric shape stimuli are derived from Velasco et al. (2015). Velasco et al. (2015) manipulated shape roundness from 0% to 100% (0% = roundness, 100% = angularity). We refer to 0% shapes as round (or curved) shapes, 100% shapes as angular (or sharp) shapes, and 50% shapes as neutral shapes (mid-way between the rounder (or more curved) and more angular (or sharper) versions of the shape).

Figure 2. Examples of packaging shape feature stimuli used in Experiment 1B. The upper panel shows the target (middle) packaging with a round (or curved) shape and the surrounding (left and right) packages with angular (or sharp) shapes. The lower panel shows the target (middle) packaging with an angular (or sharp) shape and the surrounding (left and right) packages with round (or curved) shapes.

2.1.3. Statistical Analysis

Repeated measures analyses of variance (RM-ANOVA) was used to assess the effects of target shapes and the surrounding shapes on the taste expectations of the target. The analyses followed a 3 (target shape: round, angular, neutral) × 3 (surrounding shape: round, angular, neutral) within participants' design. The dependent variable consisted of expected taste ratings (sweetness, sourness, saltiness, bitterness). We focussed mainly on the interaction between the target and the surrounding shapes. We performed a post-hoc analysis to understand the interaction in detail where there was a significant interaction. The post-hoc analysis was conducted using Shaffer's modified sequentially rejective Bonferroni procedure. All statistical analyses were conducted using R software (R core Team, 2017). All ANOVA and subsequent tests were performed using anovakun, a function in R statistics.

2.2. Results

The main significant effect of the target shape was documented for all expected tastes in both experiments (Table 1, Figures 3-4). Round targets were rated as sweeter and less sour/salty/bitter than the neutral target and the angular target shapes. The angular target shape was rated as less sweet and more sour/salty/bitter than the neutral target shape. Only sourness in Experiment IA showed significant interaction.

The surrounding round shape increased the expected sourness of the target neutral shape to a greater degree than the surrounding angular shape (t_{96} = 3.043, adj.p = 0.009). Moreover, the surrounding angular shape increased the expected sourness of the target angular shape to a greater degree than the surrounding neutral shape (t_{96} = 2.855, adj.p = 0.016). However, the findings were not replicated in Experiment 1B. No significant interactions were observed for any of the tastes in Experiment 1B. Graphical illustrations of the results of Experiments 1A and 1B are shown in Figures 3 and 4, respectively.

		Experiment 1A			Experiment 1B		
	Effect	*F*	*p*	*p.eta^2*	*F*	*p*	*p.eta^2*
Sweet	Middle shape	58.976	<.001	0.381	65.538	<.001	0.438
	Surrounding shape	1.602	0.204	0.016	2.739	0.068	0.032
	Interaction	1.882	0.113	0.019	1.893	0.111	0.022
Sour	Middle shape	42.219	<.001	0.306	35.469	<.001	0.297
	Surrounding shape	1.849	0.160	0.019	1.286	0.279	0.015
	Interaction	3.457	0.009	0.035	0.986	0.415	0.012
Salty	Middle shape	16.138	<.001	0.144	13.632	<.001	0.140
	Surrounding shape	1.139	0.322	0.012	0.194	0.824	0.002
	Interaction	0.260	0.903	0.003	1.010	0.403	0.012
Bitter	Middle shape	40.749	<.001	0.298	49.562	<.001	0.371
	Surrounding shape	1.848	0.160	0.019	3.591	0.030	0.041
	Interaction	0.819	0.514	0.009	0.464	0.762	0.006

Table 1. Results of the ANOVAs performed on expected taste with the factors of middle and surrounding shapes for Experiments 1A and 1B.

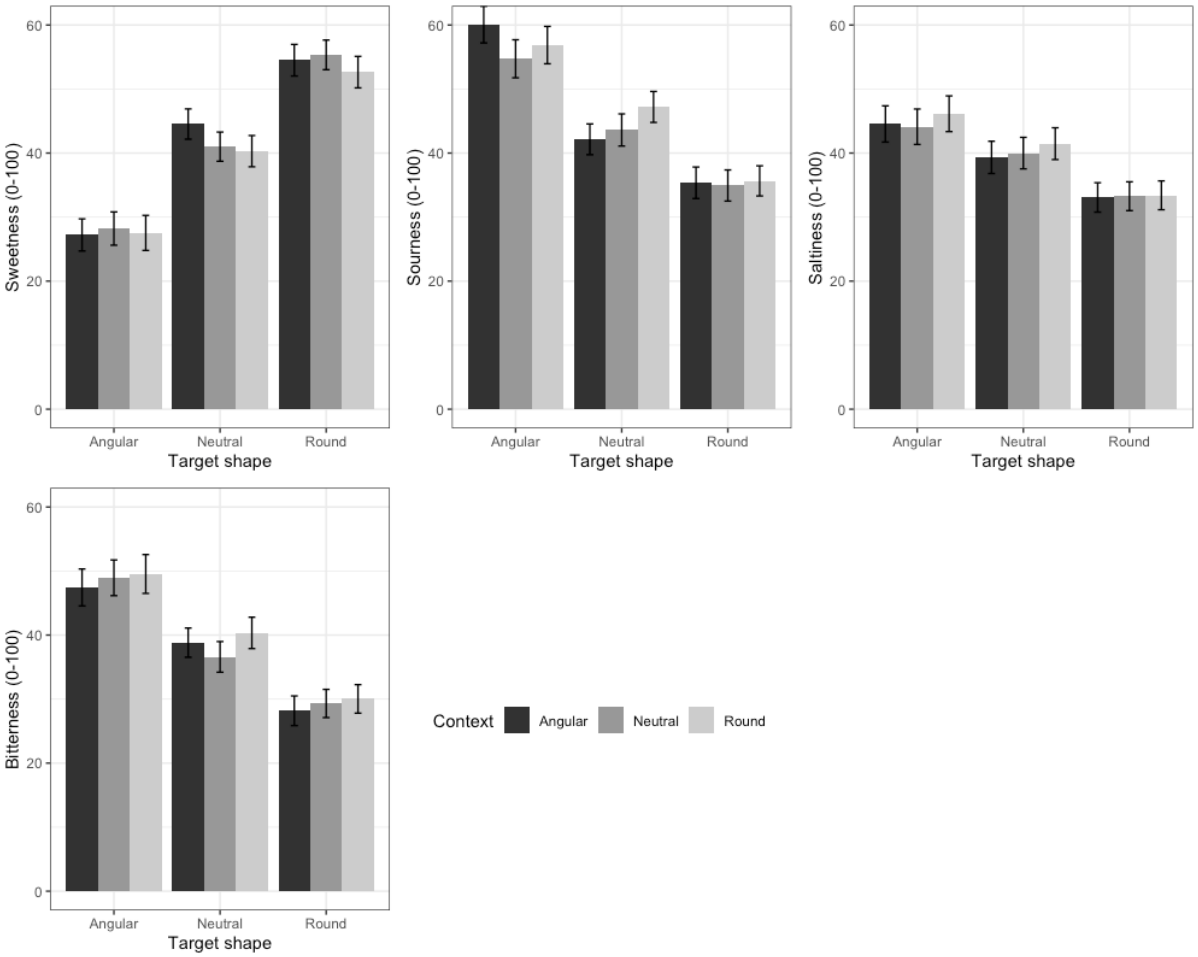


Figure 3. Results of Experiment 1A. The graphs highlight the relations between target shape, shape context and expected tastes. The rating scale ranged from 0-100 (‘not at all’ to ‘very much’). Error bars represent standard errors of the mean.

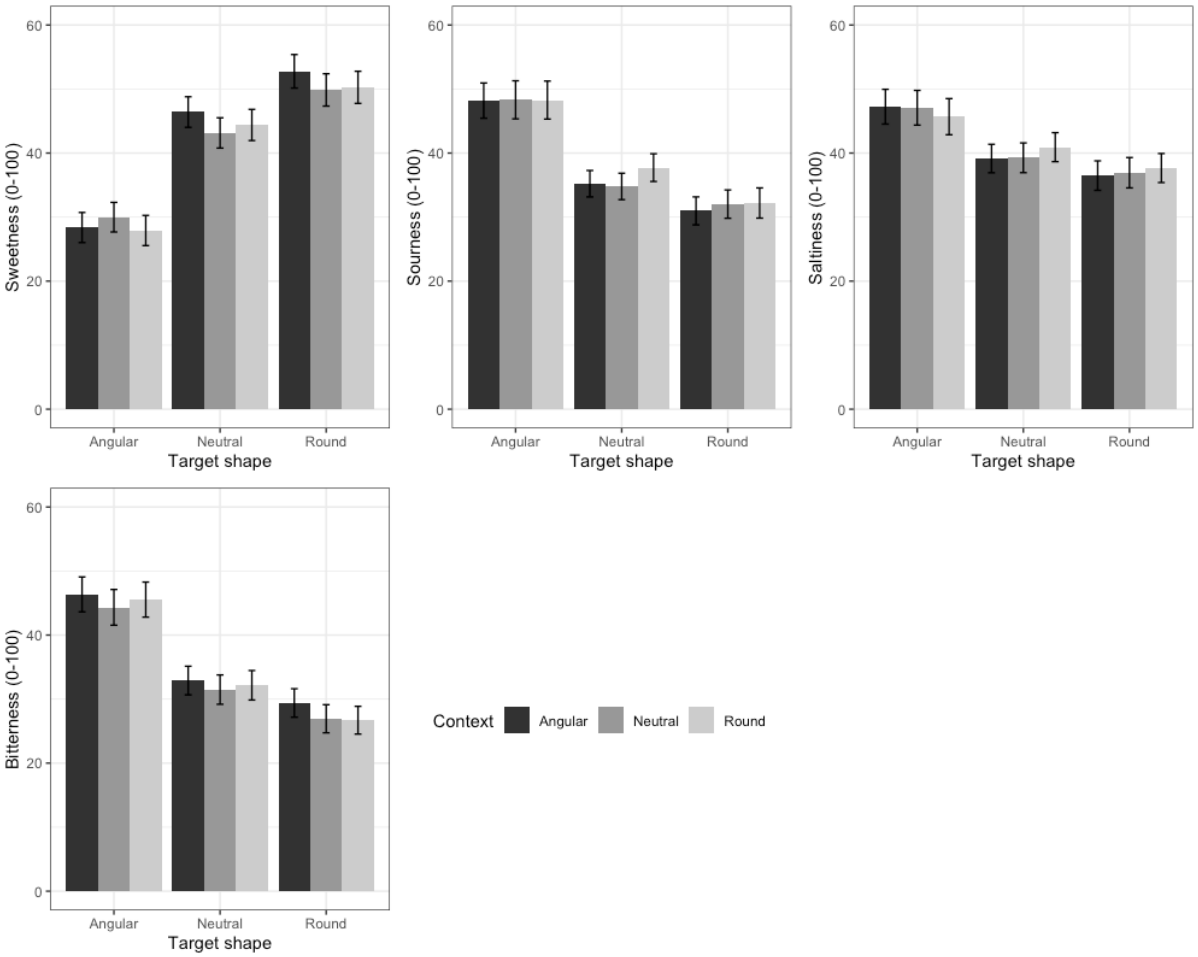


Figure 4. Results of Experiment 1B. The graphs highlight the relations between the target shape, shape contexts, and expected tastes. The rating scale ranged from 0-100 ('not at all' to 'very much'). Error bars represent standard errors of the mean.

2.3. Interim summary of Experiment 1

We investigated the contextual effects on taste-shape correspondences via within-participants designs in Experiment 1A and 1B. We replicated previous findings in terms of the role of shapes in product taste evaluation (Velasco et al., 2015, 2016). However, we did not find evidence in our data to support the expected effect of context on shape-taste associations, regardless of whether stimuli were geometric shapes or shapes on the packaging.

We suspect that our experimental design might explain the null results associated with the role of contexts in shape-taste associations. Our experiment followed a 3 (target shape: round/angular/neutral) × 3 (surrounding shape: round/angular/neutral) within-participants design. In this case, participants were presented with all combinations of target and surrounding shapes. The participants saw round, angular, and neutral target shapes in angular contexts as well as in round contexts. This might have caused habituation and diminished the hypothesised effects of contextual shapes (e.g., Charness, Gneezy & Kuhn, 2012). In fact, different experimental designs (within or between) sometimes yield different results, and act as contexts for the results of a study (e.g., Charness et al., 2012; Lakens, Semin & Foroni, 2012; Velasco et al., 2019). Considering this, the following experiments followed between-participants designs, where participants were exposed to a single set of shape stimuli. The between-participants design is less likely to cause habituation or carry-over effects (Charness et al., 2012).

In addition, in Experiments 2A-C, we fixed target shapes as neutral (i.e., intermediate between angular and round shapes). By fixing the target shape as neutral, there would perhaps be more room for the surrounding shapes to disambiguate its meaning (something that may be more strongly determined for angular and round shapes). This is also similar to the finding of a previous study regarding the relative nature of crossmodal correspondences between pitch and curvature (Brunetti et al., 2018). Brunetti and colleagues focussed on target trials associated with 'intermediate' pitch. The intermediate pitch could be considered 'higher' or 'lower' based on the high or low pitch in the preceding trial. In our result, a neutral (intermediate) shape could be considered 'rounder' or 'more angular' based on the 'angular' or 'round' contexts. Following this rationale, a neutral (intermediate) shape may be more strongly associated with sweet in angular contexts than in round contexts. Using this experimental design, in Experiments 2A-C, we investigated how and whether shape contexts influence taste matching/expectation of target and surrounding shapes.

In subsequent experiments, we also tested whether emotions (valence/arousal) mediate the relations between shape contexts and taste-shape correspondences. It can be predicted that having a less preferred and more arousing context (e.g., angular contexts) may increase valence and decrease arousal for the neutral target shape in comparison with having a more preferred and less arousing context (i.e., round contexts). The changes in emotions might increase sweetness and decrease sourness/bitterness in angular contexts (vs. round contexts). Additionally, we investigated the effects of shape contexts on surrounding shapes.

3. Experiment 2A-C: The effect of shape contexts on neutral target shape in between-participants design

3.1. Methods

3.1.1. Participants

We collected data for Experiment 2A from 302 participants (119 females, M_{age} = 41.08 ± 10.06), Experiment 2B from 294 participants (143 females, M_{age} = 40.74 ± 9.44) and Experiment 2C from 309 participants (144 females, M_{age} = 40.23 ± 10.63). For Experiments 2A–2C, we calculated the required sample size using G*Power (small to medium effect size f = 0.20, α = 0.05, 1-β = 0.85). These results showed that a minimum sample size of n = 279 was required. This meant that the sample sizes in Experiments 2A–2C significantly exceeded the required sample size, and that our sample sizes were large enough to detect the effects. The participants were recruited through Lancers (https://lancers.co.jp) and they completed the survey on Qualtrics (https://www.qualtrics.com/jp/). By using the forced responses on the Qualtrics survey, the data of all participants were used. All experiments described herein were approved by the ethics committee of Miyagi University.

3.1.2. Design

All the experiments followed a single factor between participant design with three surrounding shape levels: round, angular and neutral. The dependent variable consisted of different expected taste ratings (sweetness, sourness, saltiness, bitterness, and umami) for the target neutral shape. Experiment 2 included umami for taste ratings to cover all five basic tastes. In many cases, online research on crossmodal correspondences do not assess umami, presumably because it is difficult for some populations (e.g., Western participants) to imagine umami. However, participants in Experiment 2 were Japanese, who are typically familiar

with umami. Thus, we added umami in Experiment 2 (Japanese samples) to cover all basic tastes. We describe each experiment in detail below:

3.1.3. Taste matching task using geometric shapes (Experiment 2A)

Geometric shapes were used as stimuli (see Figure 5). The participants saw a display set (target neutral shape in the middle and a given set of surrounding shapes on both sides) and rated the extent to which they associated the target and surrounding shapes with different tastes (sweetness/sourness/saltiness/bitterness/umami). In particular, they were asked to answer: "To what extent do you associate the shape in the middle (not on both sides) with each taste?". Similarly, they were asked to answer: "To what extent do you associate the shape on both sides (not in the middle) with each taste?". The ratings were based on Likert scales ranging from 1 (not at all) to 7 (very much). We used Likert (1-7) rather than VAS (0-100) because the validity of VAS for between-participants design is a debateable issue (see Nielson et al., 2008). The participants were also asked to evaluate the stimuli in terms of the valence and arousal of each shape (the target shape, the surrounding shape). Shape types (see Figure 1) were randomised across participants, and they answered questions with shapes A or B.

3.1.4 Taste expectation task using shapes on packaging (Experiments 2B and 2C)

To confirm the generalisability and applicability of the findings of Experiment 2A, we conducted separate experiments using two food products (Figure 6). Shapes on a jam-like packaging were used in Experiment 2B and shapes on sauce-like packaging in Experiment 2C. The participants saw a display set (target neutral product with in the middle and its surrounding products on both sides). They evaluated the extent to which they expected each taste of the target: How much do you think the product in the middle (not on both sides) is sweet/sour/salty/bitter/umami? As in the target shape, they also evaluated the expected tastes of the surrounding products. Otherwise, the experimental procedure was identical to that used in Experiment 2A.

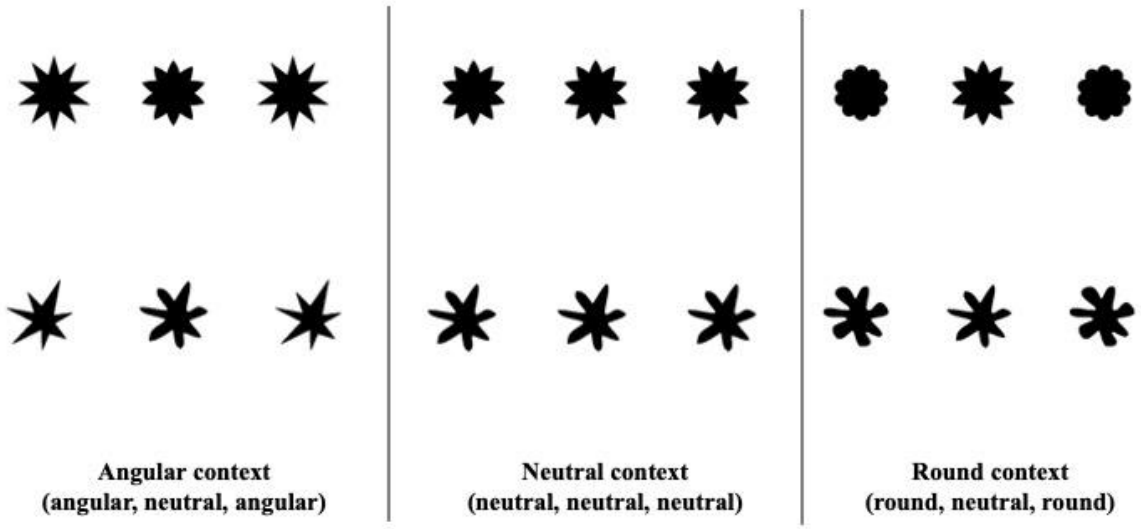


Figure 5. Examples of stimuli used in Exp 2A.

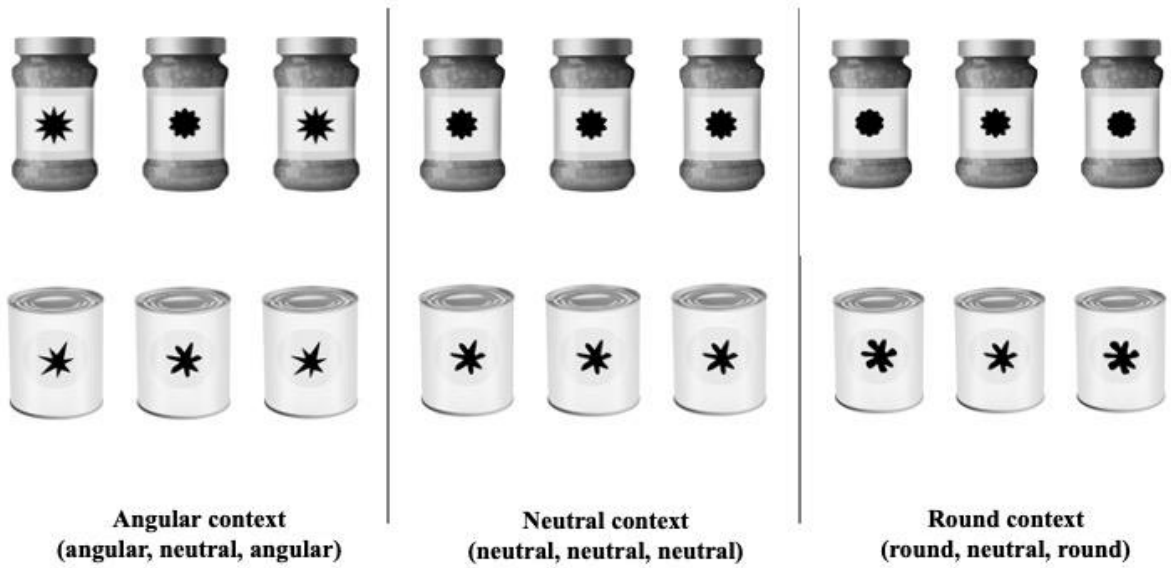


Figure 6. Examples of stimuli used in Exp 2B and 2C.

3.1.5. Statistical Analysis

We performed one-way ANOVA to determine the effect of the shape context on the expected taste ratings of the target items (in the middle) used in each experiment. The main dependent variable consisted of expected taste ratings (sweetness, sourness, saltiness, bitterness, umami) associated with the target item. We also performed ANOVA to determine the effect of the shape context on the expected taste ratings of the surrounding items (on both sides). The main dependent variable consisted of expected taste ratings (sweetness, sourness, saltiness, bitterness, umami) associated with the surrounding items. The post-hoc analysis was conducted using Shaffer's modified sequentially rejective Bonferroni procedure. All statistical analyses were performed using R software (R Core Team, 2017). All ANOVA and subsequent multiple tests were performed using the anovakun function in R.

To determine whether emotions (valence and arousal) mediated the relationship between shape contexts and expected taste ratings of the target item (in the middle), we conducted parallel mediation analysis using the PROCESS macro for SPSS (Hayes, 2013) with 5000 bootstrap samples. In this analysis, we entered shape contexts (angular context = 1, round context = 0) as the independent variable (X), each taste as the outcome variable (Y), both valence and arousal as the mediator variables (M). We estimated the indirect effects using unstandardized regression coefficients. If the 95% bias-corrected confidence intervals did not include zero, we regarded them as significant (Preacher & Hayes, 2004).

3.2. **Results of Experiment 2A (geometric shapes)**

A graphic illustration of the effects of shape contexts on expected taste and emotions of target shape is shown in Figure 7. All pairwise comparisons are reported in Table 2.

3.2.1. Target shape (in the middle of the display set)

The shape context had significant main effects on all kinds of expected tastes associated with the target shape (in the middle). Angular contexts (i.e., surrounding angular shapes) increased sweetness/umami ratings and decreased sourness/saltiness/bitterness ratings of the target shape, relative to the round contexts (i.e., surrounding round shapes). Moreover, angular

contexts increased positive valence and decreased arousal of the target shape when compared to the round contexts.

3.2.2. Surrounding shapes (on both sides of display set)

The shape context had significant main effects on all kinds of expected tastes of the surrounding shape (on both sides). Angular contexts decreased sweetness/umami matching and increased sourness/saltiness/bitterness matching of the surrounding shape when compared to the round contexts. Angular contexts decreased positive valence and increased arousal of the surrounding shape relative to the round contexts. All pairwise comparisons are shown in Table 2.

Table 2. Results of the ANOVAs performed on expected tastes and emotions with the factors of shape contexts (i.e., surrounding angular, neutral, or round shapes) for Experiment 2A.

Target shape	Round context (n = 102)		Neutral context (n = 95)		Angular context (n = 105)		Main effect			Round vs. Angular		Angular vs. Neutral		Round vs. Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*p.eta^2*	*t*	*adj.p*	*t*	*adj.p*	*t*	*adj.p*
Sweet	2.63	1.39	2.96	1.49	3.98	1.78	21.055	<.001	0.124	6.224	<.001	4.619	<.001	1.482	0.140
Sour	4.15	1.52	4.18	1.50	3.57	1.64	4.934	0.008	0.032	2.656	0.019	2.753	0.019	0.144	0.886
Salty	4.78	1.24	4.58	1.11	3.75	1.45	18.898	<.001	0.112	5.810	<.001	4.569	<.001	1.127	0.261
Bitter	4.05	1.64	4.28	1.59	3.36	1.57	9.094	<.001	0.057	3.087	0.002	4.069	<.001	1.030	0.304
Umami	3.26	1.37	3.17	1.43	3.69	1.49	3.769	0.024	0.025	2.117	0.035	2.554	0.033	0.472	0.637
Valence	3.53	1.29	3.66	1.30	4.30	1.23	10.943	<.001	0.068	4.380	<.001	3.558	<.001	0.737	0.462
Arousal	4.15	1.54	3.91	1.35	3.30	1.22	10.562	<.001	0.066	4.458	<.001	3.135	0.002	1.234	0.218

Context shape	Round context (n = 95)		Neutral context (n = 99)		Angular context (n = 100)		Main effect			Round vs. Angular		Angular vs. Neutral		Round vs. Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*p.eta^2*	*t*	*adj.p*	*t*	*adj.p*	*t*	*adj.p*
Sweet	5.08	1.76	3.19	1.55	2.19	1.30	92.785	<.001	0.383	13.441	<.001	4.565	<.001	8.572	<.001
Sour	2.89	1.44	4.12	1.49	4.98	1.59	50.052	<.001	0.251	9.967	<.001	4.053	<.001	5.693	<.001
Salty	3.36	1.45	4.38	1.31	4.69	1.33	26.408	<.001	0.150	6.975	<.001	1.588	0.113	5.224	<.001
Bitter	2.70	1.35	4.21	1.64	4.24	1.46	35.862	<.001	0.194	7.475	<.001	0.131	0.896	7.158	<.001
Umami	4.39	1.66	3.38	1.52	3.10	1.45	19.765	<.001	0.117	5.999	<.001	1.254	0.211	4.603	<.001
Valence	4.65	1.42	3.47	1.10	3.42	1.38	28.403	<.001	0.160	6.734	<.001	0.294	0.769	6.273	<.001
Arousal	3.19	1.27	3.94	1.32	5.14	1.44	55.691	<.001	0.271	10.454	<.001	6.326	<.001	3.910	<.001

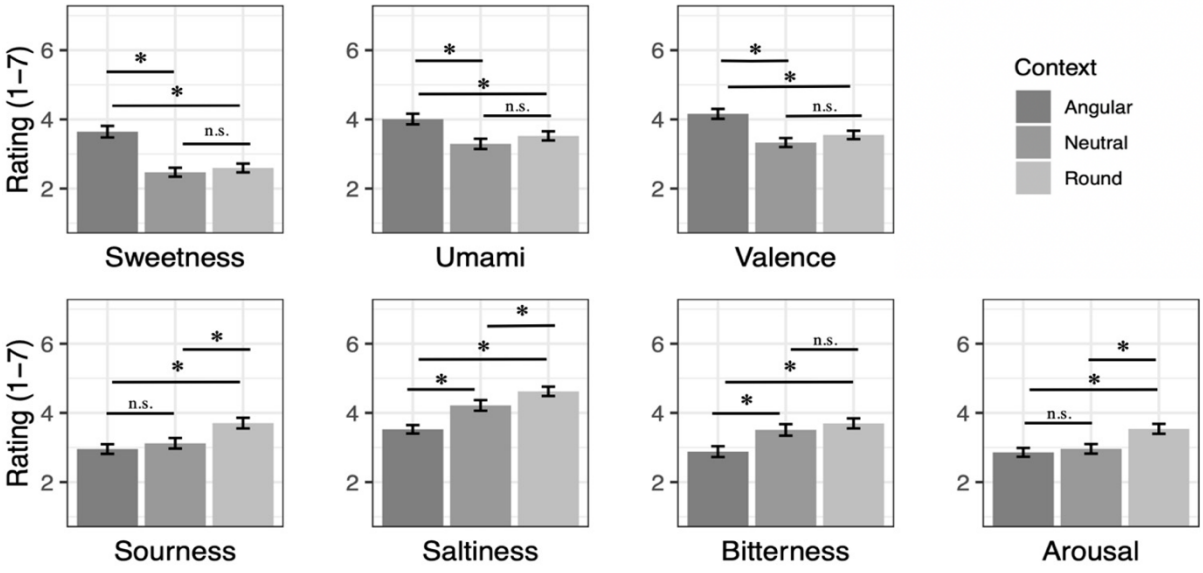


Figure 7. A graphic illustration of the results of Experiment 2A: Effects of shape contexts on expected tastes and emotions of target geometric shape. The Likert rating scale ranged from 1–7 ('not at all' to 'very much') except for valence ('negative' to 'positive'). Error bars represent standard errors of the mean. Asterisks highlight significant results ($p < .05$).

3.3. Results of Experiment 2B (shapes with jam-like product packaging)

A graphic illustration of the effects of shape contexts on expected taste and emotions of target shape is shown in Figure 8. All pairwise comparisons are shown in Table 3.

3.3.1. Target shape (in the middle of the display set)

Shape contexts had significant main effects on all kinds of expected tastes of the target shape (in the middle). Angular contexts increased expected sweetness/umami and decreased expected sourness/saltiness/bitterness of the target product relative to the round and neutral contexts. Angular contexts increased the positive valence and perceived roundness of the target product when compared to the round contexts.

3.3.2. Surrounding shapes (on both sides of display set)

Shape contexts had significant main effects on all kinds of expected tastes of the surrounding shape (on both sides). Angular contexts decreased expected sweetness/umami and increased expected sourness/saltiness/bitterness of the surrounding product relative to the round contexts. Angular contexts decreased the positive valence/perceived roundness of the surrounding product compared to the round contexts. Angular contexts increased the arousal of the surrounding product relative to the round contexts.

Table 3. Results of the ANOVA performed on expected tastes and emotions with the factors of shape contexts (i.e., surrounding angular, neutral, or round shapes) for Experiment 2B.

Target shape	Round context (n = 95)		Neutral context (n = 99)		Angular context (n = 100)		Main effect			Round vs. Angular		Angular vs. Neutral		Round vs. Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*p.eta^2*	*t*	*adj.p*	*t*	*adj.p*	*t*	*adj.p*
Sweet	2.77	1.45	3.01	1.57	4.18	1.57	23.740	<.001	0.140	6.407	<.001	5.381	<.001	1.098	0.273
Sour	4.11	1.59	3.38	1.52	3.13	1.40	10.899	<.001	0.070	4.504	<.001	1.165	0.245	3.362	<.001
Salty	4.29	1.38	3.64	1.55	3.16	1.29	15.653	<.001	0.097	5.578	<.001	2.386	0.018	3.231	0.001
Bitter	3.63	1.57	3.17	1.70	2.80	1.41	6.881	0.001	0.045	3.705	<.001	1.675	0.095	2.057	0.041
Umami	3.37	1.28	3.24	1.42	3.90	1.26	6.929	0.001	0.046	2.798	0.006	3.520	0.002	0.679	0.498
Valence	3.46	1.09	3.33	1.39	4.37	1.09	22.048	<.001	0.132	5.272	<.001	6.121	<.001	0.773	0.440
Arousal	3.23	1.57	2.89	1.38	3.03	1.16	1.506	0.224	0.010	–		–		–	
Round	2.91	1.31	3.53	1.39	4.78	1.22	51.965	<.001	0.263	9.985	<.001	6.740	<.001	3.339	<.001

Context shape	Round context (n = 95)		Neutral context (n = 99)		Angular context (n = 100)		Main effect			Round vs. Angular		Angular vs. Neutral		Round vs. Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*p.eta^2*	*t*	*adj.p*	*t*	*adj.p*	*t*	*adj.p*
Sweet	4.51	1.58	2.72	1.39	2.55	1.25	57.068	<.001	0.282	9.678	<.001	0.873	0.383	8.838	<.001
Sour	3.20	1.46	3.31	1.37	4.68	1.52	31.725	<.001	0.179	7.100	<.001	6.657	<.001	0.530	0.596
Salty	3.40	1.28	3.72	1.50	4.33	1.52	10.545	<.001	0.068	4.507	<.001	3.000	0.003	1.549	0.122
Bitter	2.89	1.54	3.24	1.64	3.58	1.61	4.401	0.013	0.029	2.967	0.010	1.482	0.140	1.508	0.133
Umami	4.19	1.37	3.17	1.40	3.42	1.30	14.768	<.001	0.092	3.923	<.001	1.320	0.188	5.239	<.001
Valence	4.34	1.23	3.09	1.13	3.62	1.21	26.847	<.001	0.156	4.213	<.001	3.116	0.002	7.307	<.001
Arousal	3.09	1.29	2.80	1.26	4.39	1.33	42.638	<.001	0.227	7.001	<.001	8.701	<.001	1.592	0.112
Round	5.04	1.19	3.34	1.34	1.98	1.12	152.063	<.001	0.511	17.415	<.001	7.836	<.001	9.703	<.001

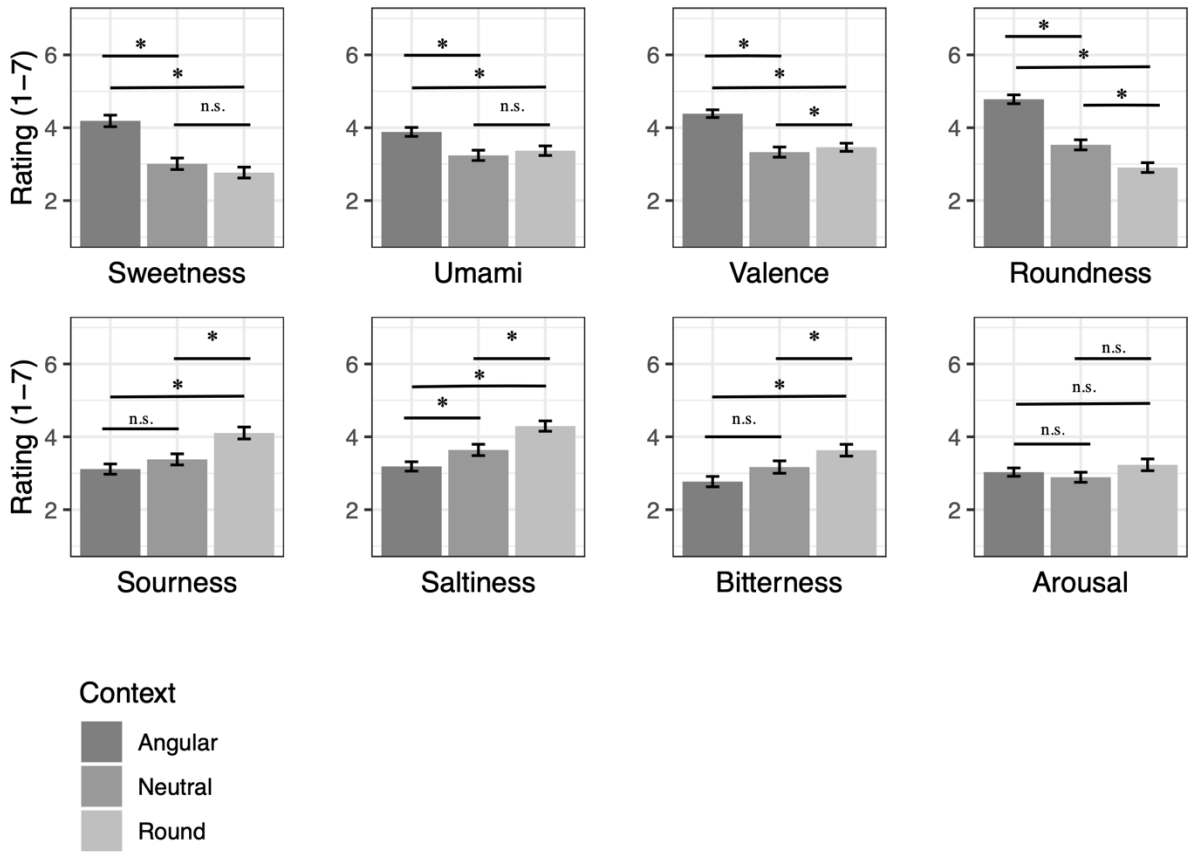


Figure 8. A graphic illustration of the results of Experiment 2B: Effects of shape contexts on expected tastes and emotions of the target product. Ratings on a 1–7 Likert scale ('not at all' to 'very much') except for valence ('negative' to 'positive') and roundness ('very angular' to 'very round'). Error bars represent standard errors of the mean. Asterisks highlight significant results ($p < .05$).

3.4. Results of Experiment 2C (shapes with sauce-like product packaging)

A graphic illustration of the effects of shape contexts on expected taste and emotions of target shape is shown in Figure 9. All pairwise comparisons are shown in Table 4.

3.4.1. Target shape (in the middle of the display set)

Shape contexts had significant main effects on all kinds of expected tastes of the target product (in the middle). Angular contexts increased expected sweetness/umami and decreased expected sourness/saltiness/bitterness of the target product relative to the round contexts. Angular contexts increased positive valence/perceived roundness and decreased arousal of the target product when compared to the round contexts.

3.4.2. Surrounding shapes (on both sides of display set)

Shape contexts had significant main effects on all kinds of expected tastes of the surrounding shape (on both sides). Angular contexts decreased expected sweetness/umami and increased expected sourness/saltiness/bitterness of the surrounding product when compared to the round contexts. Angular contexts decreased positive valence/perceived roundness and increased arousal of the surrounding product relative to the round contexts.

Table 4. Results of the ANOVA performed on expected tastes and emotions with the factors of shape contexts (i.e., surrounding angular, neutral, or round shapes) for Experiment 2C.

Target shape	Round context (n = 109)		Neutral context (n = 106)		Angular context (n = 94)		Main effect			Round vs. Angular		Angular vs. Neutral		Round vs. Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*p.eta^2*	*t*	*adj.p*	*t*	*adj.p*	*t*	*adj.p*
Sweet	2.60	1.32	2.47	1.32	3.62	1.63	19.204	<.001	0.112	5.107	<.001	5.694	<.001	0.644	0.520
Sour	3.71	1.61	3.12	1.57	2.94	1.35	10.899	<.001	0.070	3.593	0.001	0.864	0.388	2.810	0.005
Salty	4.62	1.41	4.22	1.57	3.54	1.18	15.081	<.001	0.090	5.464	<.001	3.386	0.001	2.121	0.035
Bitter	3.70	1.51	3.51	1.71	2.90	1.50	6.808	0.001	0.043	3.566	0.001	2.704	0.007	0.872	0.384
Umami	3.52	1.38	3.29	1.52	3.98	1.50	5.586	0.004	0.035	2.206	0.028	3.301	0.003	1.151	0.251
Valence	3.55	1.27	3.33	1.33	4.13	1.41	9.404	<.001	0.058	3.079	0.002	4.226	<.001	1.212	0.226
Arousal	3.54	1.49	2.96	1.42	2.84	1.23	7.554	<.001	0.047	3.575	0.001	0.618	0.537	3.048	0.003
Round	2.75	1.18	3.20	1.28	4.70	1.15	71.008	<.001	0.317	11.490	<.001	8.805	<.001	2.711	0.007

Context shape	Round context (n = 109)		Neutral context (n = 106)		Angular context (n = 94)		Main effect			Round vs. Angular		Angular vs. Neutral		Round vs. Neutral	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*p.eta^2*	*t*	*adj.p*	*t*	*adj.p*	*t*	*adj.p*
Sweet	3.95	1.67	2.67	1.56	2.36	1.33	31.11	<.001	0.169	7.319	<.001	1.415	0.16	6.082	<.001
Sour	2.95	1.33	3.15	1.62	4.48	1.56	29.852	<.001	0.163	7.193	<.001	6.224	<.001	0.958	0.339
Salty	3.40	1.35	4.10	1.64	4.69	1.25	20.64	<.001	0.119	6.396	<.001	2.900	0.004	3.588	<.001
Bitter	2.93	1.55	3.45	1.69	4.28	1.56	18.03	<.001	0.105	5.982	<.001	3.627	<.001	2.406	0.017
Umami	4.10	1.50	3.45	1.62	3.32	1.33	8.17	<.001	0.051	3.713	<.001	0.631	0.529	3.176	0.002
Valence	4.10	1.34	3.26	1.18	3.24	1.35	15.15	<.001	0.090	4.713	<.001	0.107	0.915	4.752	<.001
Arousal	3.13	1.27	2.94	1.26	4.49	1.60	36.91	<.001	0.194	7.027	<.001	7.930	<.001	0.986	0.325
Round	4.83	1.32	3.18	1.24	2.21	1.49	99.16	<.001	0.393	13.815	<.001	5.059	<.001	9.001	<.001

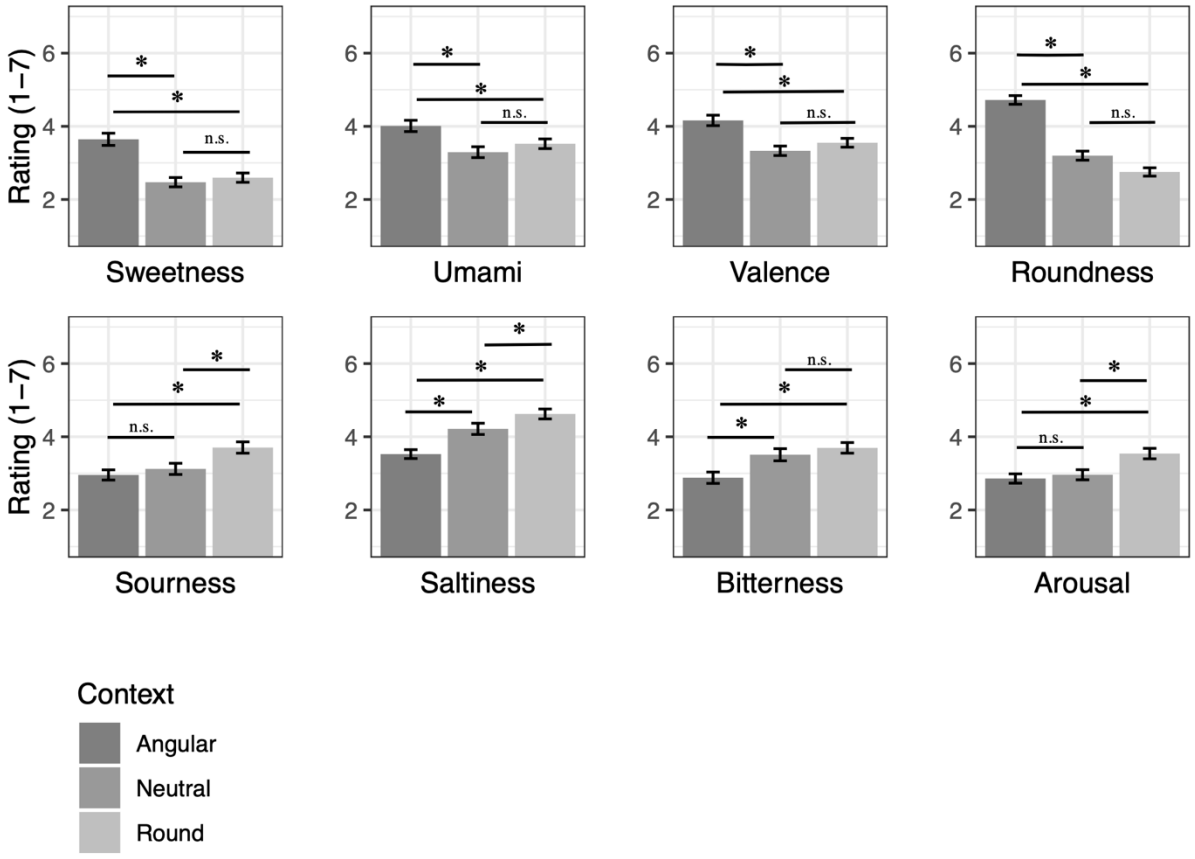


Figure 9. A graphic illustration of the results of Experiment 2C: Effects of shape contexts on expected tastes and emotions of the target product. Ratings on a 1–7 Likert scale ('not at all' to 'very much') except for valence ('negative' to 'positive') and roundness ('very angular' to 'very round'). Error bars represent standard errors of the mean. Asterisks highlight significant results ($p < .05$).

3.5. Results of the mediating role of emotions on contextual effects on taste-shape correspondences (Experiments 2A-2C)

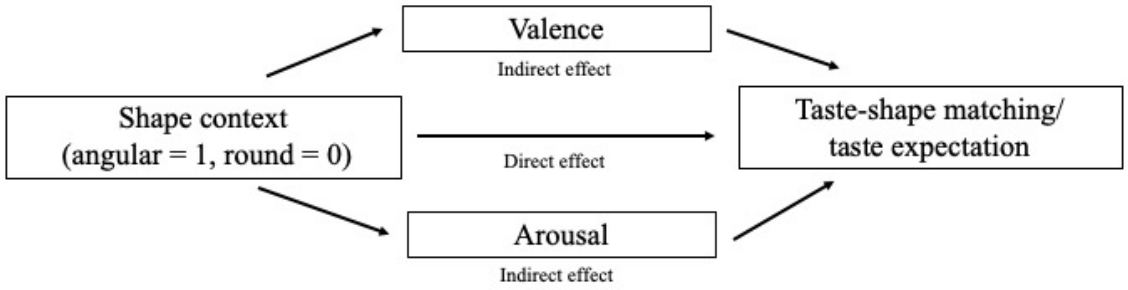
The results of the analyses of Experiment 2A revealed that valence and arousal mediated the relationship between shape contexts and taste-shape matching. Positive feelings towards the target neutral shape mediated the effects of angular (vs. round) context on sweet/umami-shape matching. Additionally, negative (or less positive) feelings towards the target neutral shape mediated the effects of angular (vs. round) context on bitter-shape matching. Moreover, arousing feelings towards the target neutral shape mediated the effects of angular (vs. round) context on sour/bitter-shape matching.

The results of the analysis of Experiment 2B revealed that positive feelings towards the target product mediated the effects of angular (vs. round) context on sweet/umami expectations of the target product. Additionally, negative feelings towards target shape mediated the effects of angular (vs. round) context on the bitter expectations of the target product. Moreover, arousing feelings towards the target product mediated the effects of angular (vs. round) context on sour expectations of the target product.

Table 5. Statistical summaries of mediation analyses (Experiment 2A-C)

Exp 2A	Sweetness						Sourness						Saltiness						Bitterness						Umami					
	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI
Total effect	1.354	0.222	6.102	<.001	0.916	1.791	-0.576	0.220	-2.614	0.010	-1.010	-0.141	-1.032	0.188	-5.504	<.001	-1.402	-0.662	-0.687	0.223	-3.077	0.002	-1.127	-0.247	0.421	0.199	2.115	0.036	0.028	0.814
Direct effect	0.995	0.234	4.252	<.001	0.533	1.456	-0.221	0.236	-0.935	0.351	-0.687	0.245	-1.000	0.207	-4.823	<.001	-1.409	-0.591	-0.106	0.228	-0.467	0.641	-0.556	0.343	0.144	0.203	0.709	0.479	-0.256	0.544
Indirect effect	Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI		
Total	0.359	0.136	**0.111**	**0.646**			-0.355	0.117	**-0.593**	**-0.133**			-0.032	0.098	-0.234	0.155			-0.581	0.125	**-0.841**	**-0.357**			0.277	0.130	**0.031**	**0.540**		
Valence	0.308	0.101	**0.131**	**0.532**			-0.124	0.084	-0.303	0.023			0.029	0.067	-0.106	0.166			-0.337	0.110	**-0.575**	**-0.154**			0.337	0.100	**0.163**	**0.552**		
Arousal	0.051	0.077	-0.105	0.208			-0.231	0.084	**-0.408**	**-0.080**			-0.061	0.070	-0.214	0.064			-0.244	0.082	**-0.417**	**-0.095**			-0.060	0.071	-0.212	0.065		
Exp 2B	Sweetness						Sourness						Saltiness						Bitterness						Umami					
Valence mediator	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI
Total effect	1.413	0.218	6.489	<.001	0.984	1.843	-0.974	0.215	-4.530	<.001	-1.398	-0.550	-1.133	0.192	-5.901	<.001	-1.512	-0.754	-0.834	0.214	-3.887	<.001	-1.257	-0.411	0.531	0.182	2.912	0.004	0.171	0.890
Direct effect	0.742	0.210	3.536	<.001	0.328	1.156	-0.989	0.236	-4.197	<.001	-1.453	-0.524	-0.983	0.207	-4.750	<.001	-1.391	-0.575	-0.556	0.233	-2.381	0.018	-1.016	-0.095	-0.007	0.168	-0.044	0.965	-0.339	0.324
Indirect effect	Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI		
Total	0.671	0.157	**0.381**	**1.001**			0.015	0.128	-0.244	0.267			-0.151	0.118	-0.421	0.048			-0.278	0.145	**-0.611**	**-0.036**			0.538	0.124	**0.293**	**0.788**		
Valence	0.654	0.158	**0.367**	**0.982**			0.047	0.108	-0.160	0.268			-0.101	0.101	-0.335	0.067			-0.253	0.132	**-0.547**	**-0.031**			0.554	0.115	**0.335**	**0.791**		
Arousal	0.018	0.028	-0.024	0.087			-0.033	0.043	-0.142	0.030			-0.050	0.058	-0.189	0.043			-0.025	0.039	-0.130	0.027			-0.016	0.024	-0.076	0.022		
Exp 2C	Sweetness						Sourness						Saltiness						Bitterness						Umami					
	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI	Effect	SE	t	p	LLCI	ULCI
Total effect	1.021	0.207	4.932	<.001	0.613	1.429	-0.770	0.211	-3.656	<.001	-1.186	-0.355	-1.081	0.184	-5.864	<.001	-1.445	-0.718	-0.793	0.212	-3.736	<.001	-1.212	-0.374	0.456	0.202	2.253	0.025	0.057	0.855
Direct effect	0.581	0.195	2.974	0.003	0.196	0.966	-0.607	0.227	-2.671	0.008	-1.055	-0.159	-0.935	0.193	-4.850	<.001	-1.316	-0.555	-0.254	0.210	-1.209	0.228	-0.668	0.160	0.175	0.180	0.969	0.334	-0.181	0.530
	Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI			Effect	BootSE	BootLLCI	BootULCI		
Total	0.440	0.129	**0.197**	**0.702**			-0.164	0.102	-0.370	0.041			-0.146	0.102	-0.347	0.054			-0.539	0.127	**-0.796**	**-0.303**			0.281	0.140	**0.009**	**0.564**		
Valence	0.345	0.117	**0.121**	**0.582**			-0.027	0.057	-0.152	0.084			0.031	0.050	-0.061	0.143			-0.277	0.100	**-0.485**	**-0.091**			0.339	0.117	**0.116**	**0.577**		
Arousal	0.095	0.065	-0.012	0.240			-0.136	0.074	**-0.299**	**-0.008**			-0.177	0.076	**-0.346**	**-0.049**			-0.263	0.092	**-0.464**	**-0.106**			-0.058	0.055	-0.185	0.036		

The results of the analysis of Experiment 2C revealed that positive feelings towards the target product mediated the effects of angular (vs. round) context on sweet/umami expectations of the target product. Additionally, negative feelings towards target shape mediated the effects of angular (vs. round) context on the bitter expectations of the target product. Moreover, arousing feelings towards the target product mediated the effects of angular (vs. round) context on sour/salty/bitter expectations of the target product. The detailed statistics are shown in Table 5 (see also Figure 10).



Dependent variable	Exp. 2A (taste-shape matching) Indirect effects	Exp. 2B (taste expectation) Indirect effects	Exp. 2C (taste expectation) Indirect effects
Sweetness	**Valence: B = 0.31, CI [0.13 – 0.53]** Arousal: B = 0.05, CI [-0.11 – 0.21]	**Valence: B = 0.65, CI [0.37 – 0.98]** Arousal: B = 0.02, CI [-0.02 – 0.09]	**Valence: B = 0.35, CI [0.12 – 0.58]** Arousal: B = 0.10, CI [-0.01 – 0.24]
Sourness	Valence: B = -0.12, CI [-0.30 – 0.02] **Arousal: B = -0.23, CI [-0.41 – -0.08]**	Valence: B = -0.12, CI [-0.30 – 0.02] **Arousal: B = -0.23, CI [-0.41 – -0.08]**	Valence: B = -0.03, CI [-0.15 – 0.08] **Arousal: B = -0.14, CI [-0.30 – -0.01]**
Saltiness	Valence: B = 0.03, CI [-0.11 – 0.17] Arousal: B = -0.06, CI [-0.21 – 0.06]	Valence: B = -0.10, CI [-0.33 – 0.07] Arousal: B = -0.05, CI [-0.19 – 0.04]	Valence: B = 0.03, CI [-0.06 – 0.14] **Arousal: B = -0.18, CI [-0.35 – -0.05]**
Bitterness	**Valence: B = -0.34, CI [-0.58 – -0.15]** **Arousal: B = -0.24, CI [-0.42 – -0.10]**	**Valence: B = -0.25, CI [-0.55 – -0.03]** Arousal: B = -0.03, CI [-0.13 – 0.03]	**Valence: B = -0.28, CI [-0.49 – -0.09]** **Arousal: B = -0.26, CI [-0.46 – -0.11]**
Umami	**Valence: B = 0.34, CI [0.16 – 0.55]** Arousal: B = -0.06, CI [-0.21 – 0.07]	**Valence: B = 0.55, CI [0.34 – 0.79]** Arousal: B = -0.02, CI [-0.08 – 0.02]	**Valence: B = 0.34, CI [0.12 – 0.58]** Arousal: B = -0.06, CI [-0.19 – 0.04]

Figure 10. Mediation Analysis of Experiment 2A-C. Valence and arousal mediate the relations between shape contexts and expected tastes of the target shape/product.

3.6. Interim summary of Experiment 2

The results of Experiment 2 demonstrated that shape context influenced taste matching/expectations in the middle target shape. Angular contexts (i.e., surrounding angular shapes) increased sweetness/umami/positive valence ratings and decreased sourness/saltiness/bitterness/arousal ratings of the target shape, relative to the round contexts (i.e., surrounding round shapes). Moreover, emotions (valence/arousal) mediated the effects of shape context on taste matching/expectation of the target product. Positive feelings towards the target product mediated the effects of angular (vs. round) context on sweet/umami expectations of the target product. Negative feelings towards the target's shape mediated the effects of angular (vs. round) context on the bitter expectations of the target product. Moreover, the arousing of feelings towards the target product mediated the effects of angular (vs. round) context on sour/bitter expectations of the target product.

4. Discussion

This study examined the role of shape curvature contexts in the taste-shape correspondences. It investigated how shape contexts would influence taste matching and expectations across five experiments with within- and between-participants design. The first two within-participants experiments found little evidence suggesting that shape contexts influence taste-shape matching. However, the subsequent three experiments (between-participants design) consistently demonstrated that shape contexts influence taste matching and expectations. When contextual shapes are angular (vs. round), the neutral target shapes are rated as sweeter/more umami and less sour/salty/bitter. Moreover, emotions mediated the relations between shape contexts and shape-taste matching/expectations. Specifically, shape context increased valence and/or arousal towards the target product, and then shifted taste expectations of the target products. For example, positive feelings towards the target product mediated the effects of angular (vs. round) context on sweet/umami expectations of the target product. Together, these findings suggest that surrounding shape environments influence consumer's taste expectations of the target product, and the effects of its surrounding shapes

depend on the characteristics of the experimental setting.. The findings deepen our understanding of the taste-based correspondences and inform food marketers of how they can design product package displays to convey taste information more effectively.

4.1. Relative nature of the taste-shape correspondences

The present findings are the first to show the relative nature of crossmodal correspondences involving shapes and taste expectations. Recently, it has been argued that pitch-based crossmodal correspondences are more relative than absolute (Brunetti et al., 2018; Reinoso Carvalho et al., 2016; Spence, 2020). For example, Brunetti and colleagues demonstrated that pitch-size correspondences are relative (Brunetti et al., 2018). They investigated whether speeded classification responses concerning the circle size (large vs. small) were modulated by relative pitch (Brunetti et al., 2018). A 1200 Hz tone acts like 'low tone' if it is followed by a 4500 Hz, while the 1200 Hz acts like 'high tone' if it is followed by a 300 Hz. Their results showed that relative pitch facilitated faster classification responses of circle sizes (e.g., when a small circle paired with the 1200 Hz followed by 300 Hz rather than 4500 Hz). Consistent with the pitch-based correspondences, the present study demonstrated that taste-shape correspondences are relative. The target shape-taste association can be changed as a function of relative shape roundness (i.e., the surrounding shape is more angular or rounder).

4.2. Contrast effect

Another possible alternative explanation may be associated with the theory of assimilation contrast effects (Sherif, Taub & Hovland 1958). This theory argues that consumers have an internal reference point to which stimuli are compared. Based on this, consumers assimilate a credible (congruent with his/her beliefs) anchor (e.g., a shape) when it is shown to them, whereas incredible, incongruent, anchors lead to contrast (see also Wang, Reinoso Carvalho, Persoone & Spence, 2017). It has been suggested that shape contrasts (the deviation of a perceived object from context or consumer experience) influence consumer evaluation (Sample et al., 2019 for a review). For example, an unusual-shaped container is perceived to be larger than an usual-shaped container (Folkes & Matta 2004). As a result, when consumers are presented with an angular context (thus anchored with it) and asked about the sweetness of a neutral target, this may lead to contrast, such that consumers may assign higher sweetness to the target, relative to say, when the context is rounder, and the target is neutral, which may be assimilated. Together, our findings add to the existing literature by showing that shape contrasts in terms of deviations of a target product from surrounding ones shift taste expectations. It should be noted that Experiments 1 and 2 differ in the experimental design (within vs. between), the participant's nationality (UK vs. Japan) and the kinds of target options (round/angular/neutral vs. only neutral). The other differences than experimental design might influence the results.

4.3. The possible role of experimental design in the contextual influences on taste-shape correspondences

This study also indicates that experimental design influences how shape contexts affect taste-shape matching. Within-participant experiments found little evidence to suggest that shape contexts influence taste-shape matching. In other words, taste expectations of the target shape were slightly influenced by the surrounding shape roundness. We speculated that in within-participants design, the participants experienced all conditions and saw all combinations of target and contextual shapes. This might cause habituation and diminish the effects of contextual shapes. Actually, previous study has found that habituation diminishes the contrast effect (Folkes & Matta 2004). Habituation to an unusual container (prior exposure to the container) reduces the perceived difference in volume estimation between the shape-

contrasted containers. This finding corroborates our findings that repeated exposure diminishes the effects of shape contexts. In contrast to the first two within-participants experiments, a set of three between-participants experiments consistently found that shape contexts influence taste-shape matching. The evidence from the between-participants design is important for marketers. Consumers are likely to only face a single decision in shopping environments (see Charness, Gneezy, & Kuhn, 2012). Thus, the results derived from the in between-participants design might have more external validity and practical applicability.

4.4. Affective account of contextual influences on taste-shape correspondences

The present study has shown that it is plausible to consider an affective account of contextual influences on taste-shape correspondences. Researchers have increasingly documented correspondences that may be explained by affect (Spence, 2020). Previous research has shown that crossmodal correspondences involving tastes are, at least in part, mediated by emotional valence (e.g., Deroy, Crisinel, & Spence, 2013; Kantono et al., 2019; Motoki et al., 2020; Reinoso-Carvalho et al., 2019; Velasco et al., 2015; Wang, Wang, & Spence, 2016). Relevant to our experiment, round shapes and sweetness are matched due to a similar valence (Velasco et al., 2015). The present research demonstrated that shape contexts influence taste-shape matching via affect. Based on this, shape contexts can be thought of as a sort of affective context. Positive feelings towards the target neutral shape mediated the effects of angular (vs. round) context on sweet/umami-shape matching. Additionally, negative (or less positive) feelings towards the target neutral shape mediated the effects of angular (vs. round) context on bitter-shape matching. Moreover, arousing feelings towards the target neutral shape mediated the effects of angular (vs. round) context on sour/bitter-shape matching. These findings suggest an affective account of contextual influences on taste-shape correspondences. People assign different valences, arousal and taste expectations to the same neutral shapes, based on the roundness/angularity of the surrounding shapes.

4.5. Replication of previous research on taste-shape correspondences

These findings confirm previous reports on taste-shape correspondences. Previous studies showed that round shapes are matched with sweet tastes, and angular shapes are matched with sour/bitter shapes, using geometric shapes and shapes on packaging (e.g., Velasco, Woods, Deroy, & Spence, 2015; Velasco, Beh, Le, & Marmolejo-Ramos, 2018). Using both simple shapes and packaging shapes, the present study conceptually replicated the previous findings in the UK and Japan by using geometric shape and shapes on packaging. Experiment 1 (within-participants design) demonstrated that the target round shapes were rated as sweeter, less bitter/sour/salty compared to the target angular shape in the UK. Experiment 2 (between-participants design) revealed that the surrounding round shapes (we manipulated shape roundness only for the surrounding shapes in Experiment 2) were rated as sweeter and less bitter/sour/salty compared to the surrounding angular shape in Japan. Together, these findings successfully replicated the main findings of previous studies on taste-shape correspondences regardless of country and experimental design and demonstrated the robustness of the findings.

4.6. Practical contributions

The present study has practical implications for product displays. Product packaging triggers consumers' sensory expectations for food products (e.g., Velasco & Spence, 2019). In a real-life shopping environment, food products are surrounded by other product alternatives. Consumers consider the value of options within the display set when they make decisions (e.g., Karmarkar, 2017). They might expect taste attributes of a product depending on the surrounding products in a given choice display. The present findings demonstrate that

consumers expect taste attributes of a product by relying on its surrounding shape roundness. If a product is around an angular environment, it is likely to be perceived as sweeter/more umami and less sour/salty/bitter. Thus, marketers should be cautious when it comes to the product display arrangement, especially in terms of the target/surrounding product curvature (dis)similarity, but perhaps even beyond, and the overall target/surrounding product (dis)similarity. Consequently, the findings provide practical implications for food marketers interested in conveying taste information in the product display more effectively and optimally.

Our findings may be specifically applicable to digital environments (e.g., e-commerce platforms and online grocery shopping). On e-commerce platforms, practitioners have relatively easy control over visual displays. Considering the growth in e-commerce and the increasing availability of image processing methods, practitioners may feel more motivated to implement our findings on e-commerce platforms. One may also be able to design and/or study objective metrics (via image processing) of, for instance, the spatial structure (e.g., curvature, symmetry, Thömmes & Hübner, 2018; Mayer & Landwehr, 2018) of both products and contexts in which a product is embedded as well as product performance metrics (de Vries, Jager, Tijssen, & Zandstra, 2018). Therefore, our findings provide practical applications for online sensory marketing (e.g., Petit et al., 2019), and offer the opportunity to see how contextual visual variables may influence online consumer expectations and behaviours.

5. Limitations and Future Studies

First, the current findings might be restricted to the shape types used in this study. To generalise the findings, we used two types of shapes. However, the angular shapes in our study were all star-shaped. Shape symmetry also influences taste expectations (Turoman et al., 2018). Further studies should use various types of shapes to investigate the role of surrounding shapes in taste-shape correspondences. Second, the number of surrounding items might influence the results. The present study used two surrounding shapes (light and left side of targets). In everyday marketplaces where people encounter this type of situation, the number of products and surrounding products can be quite diverse and extensive. Although a previous study using two vs. six available options did not show significant differences in preferences (Karmarkar, 2017), the taste-shape tasks with more numbers or surrounding shapes might influence the results. Further studies should investigate this issue. Third, we only used angular vs. round shapes as more or less dominant contextual features. However, other contextual characteristics (e.g., colour and product type) are important topics for future research. Furthermore, investigating "taste contexts" could be interesting. Further study is needed to test for the effects of taste contexts in which the taste of the surrounding product is sweet, sour, bitter, or mixed. Additionally, it could not be established whether participants deliberately or automatically process surrounding shape information. Investigating the processing mode (e.g., Shiv & Fedorikhin, 1999) is an interesting avenue for future research. Moreover, investigating the role of packaging contours might also be interesting. The contours of surrounding packaging might also influence taste expectations of the target product, as in the case of surrounding shapes on the packaging.

Importantly, in addition to the within vs. between changes from the first to the second set of experiments, other elements varied. In particular, the first experiments were conducted mostly with a database of participants, including predominantly participants from the UK and the second set of experiments with a database of participants that predominantly involved Japanese participants. In addition, while the first set of experiments varied the target's curvature, the second set of experiments kept it neutral and fixed. With these points in mind, a combination of these factors may likely explain the differences in the findings obtained in

the different experiments. Future study may inquire about within-participants design effects in correspondence as well as possible ceiling effects imposed by the sensory stimuli such that some stimuli (neutral) may leave more or less room for crossmodal stimuli to disambiguate a corresponding inference about it.

The terminology of shapes (i.e., round/angular) was also an issue. We used the dichotomy roundness/angularity because previous research on taste-shape correspondences used this terminology, however, participants regarded our round and angular stimuli as rounder and more angular, respectively (Velasco et al., 2015). It has been suggested that the use of the dichotomy curvature/sharpness is more appropriate than roundness/angularity (Gomez-Puerto et al. 2016). Further study should consider this issue.

6. Conclusion

In summary, the present study demonstrated contextual influences on taste-shape correspondences. Consumers expect taste information of the target product from its surrounding shape roundness. Affective accounts support contextual influences on taste-shape correspondences. These findings deepen the understanding of crossmodal correspondences involving shape and tastes and inform food marketers of how they can design product package displays to convey taste information more effectively.

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