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The taste of visual textures

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ABSTRACT

Numerous crossmodal correspondences between visual elements and basic tastes have been documented in recent years. Research has shown that many of these correspondences can influence taste expectations when applied in food packaging. However, research on correspondences between visual textures and tastes is scarce, despite the ability of the former to convey specific information about materials and objects. In the present study, we conducted two online experiments designed to study crossmodal correspondences between basic taste words and visual textures with common material properties. In Experiment 1 ($N = 194$), we evaluated explicit associations between six visual texture categories (with four levels of each category) and basic taste words. The results revealed moderate associations between one of the *fluffy* visual textures and sweetness and between a *rough* and a *crunchy* visual texture and saltiness. In Experiment 2 ($N = 407$), we superimposed the visual textures associated with the basic tastes found in Experiment 1 on food extrinsic factors (i.e., packaging, napkin) served in combination with products of three taste qualities (i.e., neutral/ambiguous, sweet, salty). We did not find evidence supporting the idea that visual textures that are crossmodally corresponding to specific tastes, as revealed in Experiment 1, influenced taste expectations. The results of the study suggest that the strength of the crossmodal correspondence between visual textures and basic taste words studied here is moderate.

1. Introduction

Packaging in foodstuffs has been demonstrated to be a powerful tool to convey information about products and influence judgements about them (Guinard et al., 2001; Velasco & Spence, 2019). Visual attributes (e.g., colour, shapes, luminance) are some of the most pervasive factors in packaging, and they can influence consumers' expectations about products (Gómez et al., 2015; Silayoi & Speece, 2004). Indeed, previous research has shown that visual elements in packaging can influence consumers' expected taste of products (Velasco et al., 2018). An important factor that guides taste expectations relates to individuals' associations with different visual elements. The tendency of individuals to associate features or dimensions from a specific modality (e.g., vision) with features from another modality (e.g., taste) is referred to as crossmodal correspondences (Spence, 2011).

Recent literature has uncovered a myriad of crossmodal correspondences between tastes and different visual elements, such as colours and shapes, applied in packaging design (Velasco et al., 2014), and the use of these correspondences has been found to influence taste expectations. Nevertheless, a visual element that has been overlooked relates to visual textures. Visual textures are the visual representation of tactile textures, and they present mostly repeating patterns (Groissboeck et al., 2010). An important aspect of the interaction between vision and touch, relevant to visual textures, is that individuals can perceive certain tactile cues through visual stimuli. For example, vision provides similar information to touch in terms of the perception of softness (Cavdan et al., 2021). Visual textures can be classified by the most predominant feature of their pattern (e.g., striped), the material properties of the tactile texture they represent (e.g., rough), or the material they portray (e.g., wood). Visual textures are highly relevant to foodstuffs and packaging since they can trigger mappings to specific materials or properties that may transfer to the food product itself, not only in terms of texture—both hand touch and mouthfeel—but also taste. In addition, some textures can alter taste perception. For instance, Slocombe et al. (2016) found that stimuli with a rough surface are perceived as more sour than identical stimuli with a smooth texture. Here it is possible to argue that, since visual textures convey information about tactile textures, and tactile textures can influence taste perception, transitive logic implies that visual textures may also impact taste perception (Fields et al., 1984; see also Deroy et al., 2013). For example, consider the application of

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smooth or fluid-like visual textures on chocolate packaging to convey that the chocolate is smooth, which at the same time may trigger associations with sweet, melted products. In the present work, we address this gap in the literature by investigating the existence of crossmodal correspondences between visual textures and basic taste words and examining their potential effect on taste expectations when applied to food extrinsic factors.

Previous research on the congruency and the effects of tactile textures incorporated in extrinsic factors of foodstuffs (e.g., packaging, receptacles, plateware) on taste expectations and perception may elucidate potential directions in associations between visual textures and basic tastes. The literature has found significant effects of tactile textures, mainly on the perception of two basic tastes, namely sweet and salty (Biggs et al., 2016; Vermeir & Roose, 2020). For instance, van Rompay and Groothedde (2019) found that potato crisps sampled from a cup with a rough (vs. smooth) texture increased their saltiness perception. Similarly, van Rompay et al. (2021) found that rough 3D-printed textures in receptacles can enhance the saltiness perception of bouillon. However, it is important to note that the effect varied depending on the level of saltiness of the food stimuli (i.e., low, medium, high) in both studies. More specifically, in the study involving potato crisps, the effect was only present in the medium-salt and high-salt crisps, not in the no-salt crisps. In the study involving bouillon, the cups with rough and rough/irregular textures increased saltiness perception in the medium- and high-salt bouillon stimuli. However, this effect was reversed in the low-salt condition, so this bouillon was perceived as saltier in the smooth-textured cup than in the cup with the rough/irregular texture. As the authors suggested, the differences in the effects of the textures on the receptacles differing on the initial level of saltiness were likely due to assimilation/contrast effects (Sherif et al., 1958). These latter effects occur when consumers adjust their judgements of a new product to minimise the difference between the actual experience and an internal reference point (e.g., expectations). It is also worth noting that in these latter studies, participants perceived the texture of the cup both tactually and visually. Hence, it is not possible to disentangle whether the driver of the effect on saltiness perception was the visual or the tactile texture.

Related to sweetness, Riofrio-Grijalva et al. (2020) found that smooth, velvety, and fluffy tactile textures are associated with sweetness. Furthermore, van Rompay et al. (2018) found that consumers perceived both vanilla and lemon ice cream as sweeter when tasted from a smooth textured cup as opposed to a sharp one. Similarly, Carvalho et al. (2020) found that non-coffee professionals perceived specialty coffee to be sweeter when tasted from a smooth cup than when tasted from a rough cup. Moreover, coffee professionals rated the coffee as more acidic when tasted from the rough cup compared to the smooth one.

Tying the studies on the effects of tactile textures on taste perception to visual textures and their correspondences with taste, the literature on correspondences between tastes and low-level visual features, such as curvature, may help further elucidate potential directions. For instance, round shapes tend to be associated with sweetness, whereas angular shapes tend to be associated with sourness and saltiness (Velasco, Woods, Petit, et al., 2016). Curvature is an important aspect of the spatial structure of objects to study on its own due to the myriad of associations stemming from it (Blazhenkova & Kumar, 2018), as well as their pervasiveness and ease of implementation in intrinsic (e.g., food shape, food texture) and extrinsic factors (e.g., packaging) of foodstuffs. In addition, curvature is particularly relevant in the study of visual textures since it can convey different material properties such as softness and weight (Schmidt et al., 2020) and trigger potential indirect mappings to specific objects that can subsequently drive taste associations. Moreover, objects and shapes with varying levels of curvature influence affect in individuals differently. People across multiple populations find curved shapes to be more pleasurable than angular ones (Bertamini et al., 2016; Gómez-Puerto et al., 2016). Moreover, as Leder et al. (2011) found, individuals prefer curved versions of neutral (e.g., watch, sofa) and positively valenced (e.g., sailboat, teddy bear) objects compared to sharp versions of them, although there is no difference for negatively valenced (e.g., snake, bomb) objects. Hence, it is possible that an affective account drives correspondences between visual textures and tastes. Considering that curvature can convey affective information (Etzi et al., 2014; Faucheu et al., 2019; Iosifyan & Korolkova, 2019), and that several correspondences between taste and visual elements seem to derive from common affective connotations (Velasco, Woods, Petit, et al., 2016), it is likely that the correspondences studied here emerge from corresponding/congruent affect evoked by specific features of the visual textures and tastes. For instance, Velasco, Woods, Marks, et al. (2016) found that round shapes are associated with the word sweet, whereas angular shapes are associated with the words sour, salty, and bitter.

Based on the literature on tactile textures, curvature, and taste presented above, we expected to observe two main patterns in the associations between visual textures and basic tastes. More specifically, we expected visual textures with curved/round features (e.g., fluffy, porous, wavy) to be associated with sweetness, whereas visual textures with angular patterns (e.g., cracked, rough, noisy) would be associated with saltiness and sourness. More formally, we hypothesised that:

H_{1A}: Rounded (vs. angular) visual textures are associated with sweetness (vs. saltiness).
H_{1B}: Rounded (vs. angular) visual textures are associated with sweetness (vs. sourness).
H_2: Fluffy (vs. rough) visual textures evoke positive (vs. negative) valenced emotions.
H_3: Fluffy (vs. rough) visual textures applied to extrinsic food factors (e.g., packaging, napkins) enhances expectations of sweetness (vs. saltiness) of the food product.

To test these hypotheses, we conducted two online experiments. In the first one, we evaluated explicit associations between different categories of visual textures and basic taste words. In the second experiment, we applied the visual textures associated with specific basic tastes found earlier to food extrinsic factors of different food products, and we examined whether they could enhance the expectations of the basic tastes with which they were associated.

2. Experiment 1

Experiment 1 aimed to uncover potential explicit crossmodal correspondences between visual textures and basic tastes and what emotions the different visual textures evoked. To this end, we conducted an online experiment and asked people to evaluate to what extent they associated different visual textures with each of the five basic tastes (sweet, sour, salty, bitter, and umami). Moreover, we asked participants to evaluate what emotion each visual texture evoked.

2.1. Methods

2.1.1. Participants

A total of 200 native English speakers took part in the online experiment in exchange for GBP 1.68. The average total duration to complete the experiment was 22.80 min ($SD = 12.77$). The data of six participants was removed as their total duration to complete the experiment was outside two standards deviations from the mean. The final data comprised 194 participants (124 females, 70 males), aged 18 – 67 years ($M_{age} = 34.69$ years, $SD_{age} = 12.81$). The two experiments reported in the present study were programmed and conducted in Qualtrics (https://www.qualtrics.com/), and participants were recruited from Prolific (https://www.prolific.co/). Participants provided their informed written consent before taking part in any of the two experiments reported here. Both experiments complied with the World

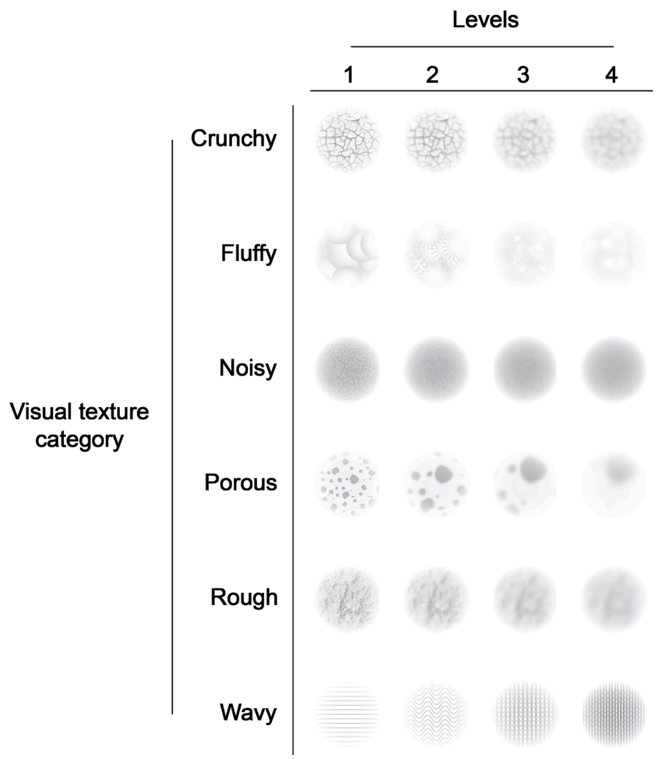

Fig. 1. Stimuli used in Experiment 1, consisting of six visual texture categories (*crunchy*, *fluffy*, *noisy*, *porous*, *rough*, and *wavy*) and four levels manipulating distortion in each category.

Medical Association's Declaration of Helsinki.

2.1.2. Apparatus and materials

The stimuli consisted of images of 24 different visual textures derived from six categories (*crunchy*, *fluffy*, *noisy*, *porous*, *rough*, *wavy*; see Fig. 1 for the complete set of stimuli) with predominant textural properties. The visual textures were explicitly designed for this study by a professional graphic designer. The images were created with Adobe Illustrator CC (17.1). All images were adjusted with a greyscale filter to standardise their colour. The levels of the *crunchy*, *noisy*, *porous*, and *rough* visual textures were created by applying a 25%-increment Gaussian blur filter to each level. The levels of the *fluffy* and the *wavy* visual textures were created by applying a 25%-increment Zig Zag filter to each level. Finally, a circle-shaped mask was used to frame the final images. The basic taste words evaluated were sweet, sour, salty, bitter, and umami.

2.1.3. Design and procedure

Each participant evaluated the 24 visual texture images presented in random order, and all questions required a response. At the beginning of the experiment, the participants provided their informed written consent to take part in the experiment. Moreover, to investigate whether any correspondence could derive from an affective account, participants read instructions on responding to the single-response emotion questionnaire from Jaeger et al. (2020) presented as a circumplex. Descriptions of the five basic tastes were also presented as follows:

Sweet: comes from foods rich in sugar (e.g., candy, honey).
Salty: comes from foods rich in salt (e.g., salt).
Sour: comes from higher acidic foods such as citrus (e.g., lemons, vinegar).
Bitter: comes from those foods with stronger, more earthy flavours (e.g., black tea, dark chocolate).
Umami: comes from savoury foods and is meaty or brothy (e.g., anchovies, parmesan cheese, ripe tomatoes).

After the instructions, participants began the experiment and were presented with the visual textures one at a time and in random order. They were asked to indicate to what extent they associated the visual texture with each basic taste through a 100-point visual analogue scale (VAS) from 0 (*Not at all*) to 100 (*Very much*). Next, participants indicated the emotion that best described how they felt when considering the visual texture presented using the circumplex with twelve pairs of emotion adjectives by Jaeger et al.'s (2020). Jaeger et al.'s (2020) model evenly spans the valence (x-axis) and arousal (y-axis) dimensions from the canonical circumplex model of core affect. The model includes, at the end of the axes, the emotion adjectives *Active, alert* (12o'clock); *Happy, satisfied* (3o'clock); *Passive, quiet* (6o'clock); and *Unhappy, satisfied* (9o'clock). This set of emotion adjectives has been widely validated in product-oriented research, including foodstuffs, and multiple languages. Considering these factors, we selected Jaeger et al.'s (2020) model, as we aimed to extract the underlying affective dimensions evoked by the different stimuli with high granularity. Moreover, the model is easy for consumers to use and understand. Jaeger et al.'s (2020) twelve emotion adjectives allowed us to achieve this with a theoretically- and practically- relevant select set of emotion adjectives instead of an endless pool of vague emotion words or abstract valence and arousal scales. Afterwards, as a manipulation check, participants indicated how strongly they associated the visual texture with the six different properties (i.e., crunchy, fluffy, noisy, porous, rough, wavy) on which the visual texture categories were developed. Finally, participants indicated their age and gender.

2.1.4. Data analysis

As a manipulation check, we first conducted an analysis of variance-type statistic (ATS) with texture property (6 levels) and visual texture level (24 levels) as within-subject factors plus subject ID as a vector for individual subjects. ATS does not make assumptions about the distribution of the data or equal variances, and it is appropriate for non-normal data with outliers (Erceg-Hurn & Mirosevich, 2008). All the analyses in the present study were performed in R (R Core Team, 2021). The ATS was conducted with the {nparLD} R statistical software package (Noguchi et al., 2012). To examine the associations between the different visual textures and the five basic tastes, we conducted an ATS with basic taste (5 levels) and visual texture level (24 levels) as within-subject factors and subject ID as a vector for individual subjects. For all ATSs, we used the relative treatment effects (RTEs) as per the {nparLD} package as a measure of effect sizes. The RTEs indicate the tendency of participants to have higher (or lower) taste associations for a given visual texture compared to the pool of all participants' ratings for the other visual textures. RTEs range from 0 to 1, and larger differences between RTEs indicate larger differences in the ratings. Next, we performed Bonferroni corrected Wilcoxon Signed Rank tests to uncover significantly different visual texture pairs in terms of their taste associations. To examine the emotions that the visual textures evoked, we conducted Cochran's Q tests for each stimulus to identify significant differences in the proportion of selected emotions. Significant differences were further analysed via pairwise comparisons using Bonferroni-adjusted McNemar's tests.

2.2. Results

The analysis on the perception of the predominant textural properties of the visual textures revealed significant main effects of texture property, $F_{ATS}(4, \infty) = 38.60$, $p < .001$ and visual texture level, $F_{ATS}(17, \infty) = 52.27$, $p < .001$, as well as a significant interaction between both factors, $F_{ATS}(43, \infty) = 60.55$, $p < .001$. Level 1 of the *crunchy* visual texture was indeed evaluated as crunchy ($M = 60.44$, $SD = 33.76$) but mostly rough ($M = 69.42$, $SD = 30.94$). Level 1 of the *rough* visual texture was evaluated as rough ($M = 55.38$, $SD = 34.67$). Level 1 of the *fluffy* visual texture was considered fluffy ($M = 53.92$, $SD = 35.46$), and level 2 of the *wavy* visual texture was evaluated as wavy ($M = 81.66$, SD

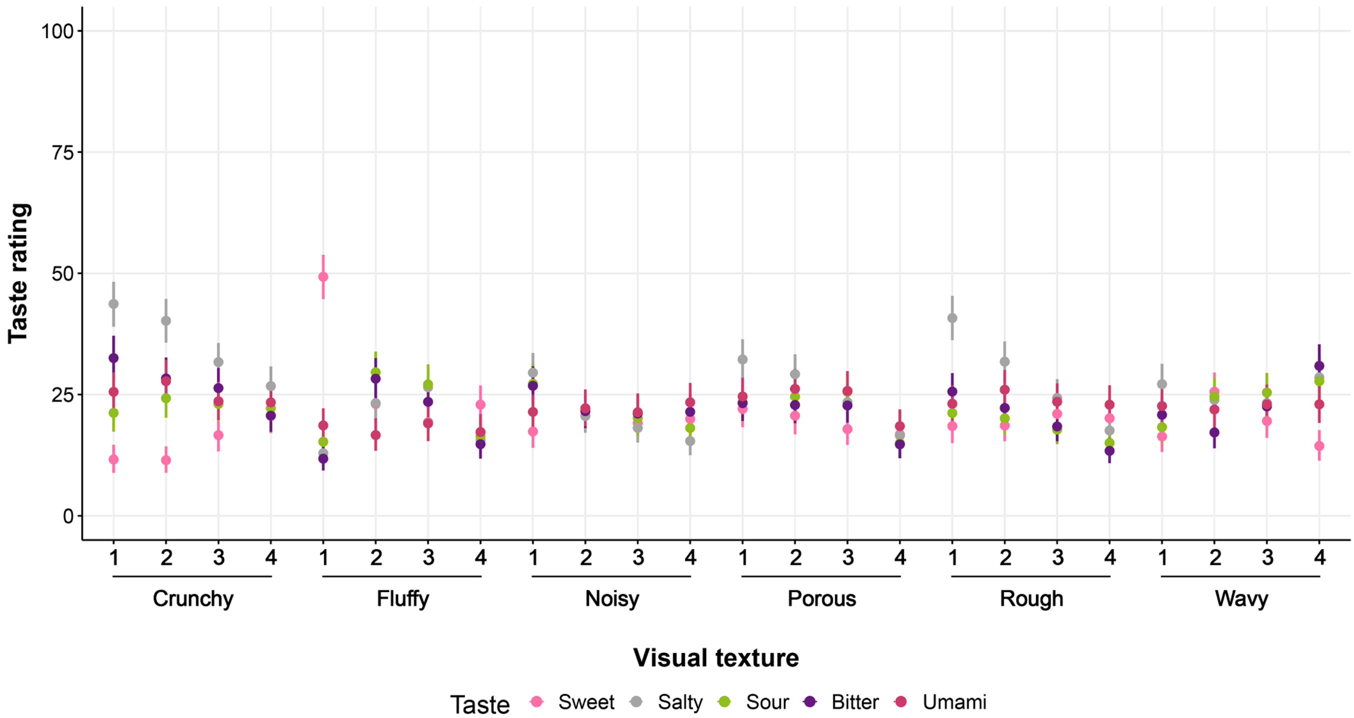

Fig. 2. Mean taste ratings of the visual textures in Experiment 1. The rating values are based on a 100-point VAS from 0 (*not at all*) to 100 (*very much*). Error bars indicate confidence intervals based on Rousselet et al.'s (2021) method. All ratings were below 50.

= 26.37). Appendix Table A1 presents descriptive statistics and the relative treatment effects (RTE). None of the *porous* or the *noisy* visual textures were evaluated as porous or noisy, respectively.

Regarding the associations between visual textures and taste, the analysis revealed significant main effects of taste, $F_{ATS}(3, \infty) = 20.31$, $p < .001$ and visual texture level, $F_{ATS}(19, \infty) = 13.56$, $p < .001$, as well as a significant interaction effect between taste and visual texture, $F_{ATS}(46, \infty) = 12.51$, $p < .001$. Three visual textures were moderately associated with two basic tastes (see Fig. 2). Consistent with H_{1A}, level 1 of the *fluffy* visual texture was associated with sweetness ($M = 49.30$, $SD = 32.67$), and level 1 of the *rough* visual texture ($M = 40.78$, $SD = 32.52$) was associated with saltiness; although level 1 of the *crunchy* visual texture ($M = 43.70$, $SD = 33.00$) had a higher saltiness rating. None of the visual textures achieved an average rating beyond the midpoint, with level 1 of the *fluffy* visual texture being the highest. Appendix Table A2 presents descriptive statistics and the relative treatment effects (RTE).

Regarding the emotions evoked by the visual textures, the Cochran's Q tests showed significant effects ($p < .05$) in all visual textures except for level 1 of the *porous* visual texture, $Q(11) = 14.58$, $p = .20$. The results of Cochran's Q and McNemar's tests are presented in Appendix Table A3. Consistent with H_2, level 1 of the *fluffy* visual texture seemed to evoke positive-valenced, medium- to high-arousal emotions. Levels 1 and 2 of the *crunchy* visual texture seemed to evoke negative-valence, low-arousal emotions. The *wavy* visual textures seemed to evoke positive- to neutral-valenced, high arousal emotions; although level 4 of the *wavy* visual texture evoked neutral- to negative-valenced, high-arousal emotions. Fig. 3 presents a visual representation of the emotions evoked by the different levels of each visual texture category.

3. Experiment 2

Experiment 2 set to apply the associations between visual textures and taste words found in Experiment 1 into industry-relevant contexts by evaluating whether the visual textures could influence taste expectations of different foods. Since the associations found in Experiment 1 were only moderate and none of the mean values of the visual texture categories surpassed the midpoint of the scale, we selected one level per visual texture category with a mean value greater than 40 for any taste. More specifically, we selected level 1 of the *fluffy* visual texture category (associated with sweetness), as well as level 1 of the *crunchy* and *rough* categories since both were almost equally associated with saltiness. We decided to manipulate food extrinsic factors (i.e., packaging, napkin), as they are critical in forming expectations of food, often before purchase. Moreover, in the case of packaging, the visual textures can be implemented on a large scale and make products stand out on crowded shelves. To this end, we superimposed the three visual textures with the highest associations found in Experiment 1 into either the packaging of or a napkin next to a specific food item. The food items were selected based on the associations found before, so we chose foods characteristically sweet, salty, and neutral/ambiguous.

3.1. Methods

3.1.1. Participants

A total of 413 participants took part in the experiment. The data of six participants was removed as their duration was outside two standards deviations from the mean. The final data comprised 407 native English speakers from the UK (282 females, 124 males, 1 unreported), aged 18–71 years ($M_{age} = 37.14$ years, $SD_{age} = 14.00$). Participants received GBP 0.63 in return for their participation. To obtain a statistical power of 0.8, a power calculation based on a mixed model ANOVA with an alpha level of 0.05 and a small effect size of Cohen's $f = 0.1$ indicated a required sample size of 336.

3.1.2. Apparatus and materials

The stimuli consisted of six different products incorporating the visual textures with the highest associations found in the first experiment (level 1 *fluffy* – sweetness, level 1 *crunchy* – saltiness, level 1 *rough* – saltiness). The selection of the products was guided by the taste associations found before and the potential location where the visual texture could realistically be incorporated. Hence, we selected foods with sweet,

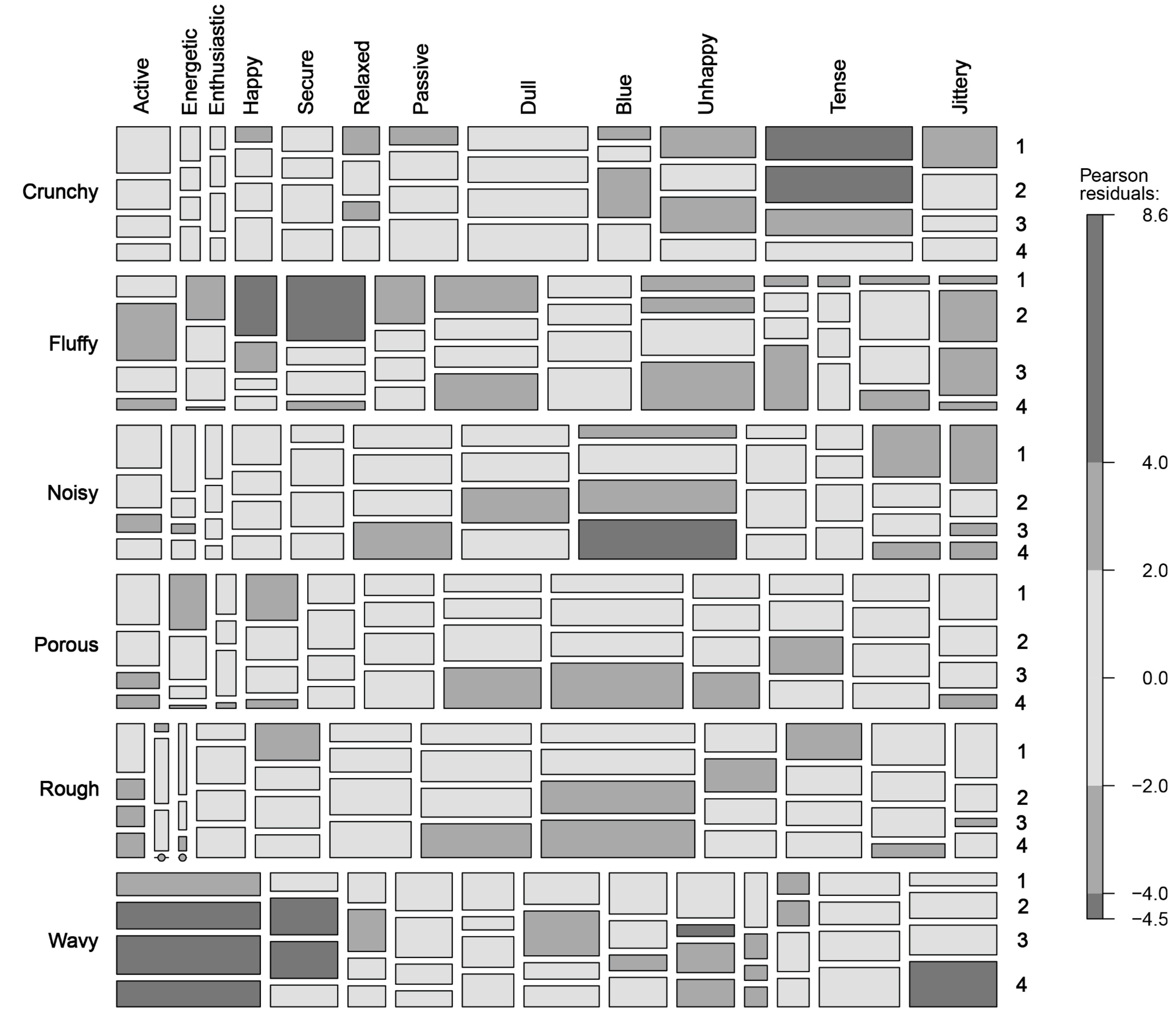

Fig. 3. Mosaic plot of emotions evoked by the visual textures in Experiment 1. The mosaic plot presents the proportion of emotion adjectives (top side) selected as a function of the Visual texture category (left side) and level of the visual texture categories (right side). The area of the squares is proportional to the number of observations within a corresponding category.

salty, and neutral/ambiguous taste qualities. In addition, we selected two locations where the visual textures—varying in closeness to the food item itself—could be incorporated, namely packaging and a napkin next to a homologous plated food. To maintain the ecological validity of the study and portray realistic product formats and presentations, we chose two different but highly related products for each taste quality—one for the packaging and one for the napkin. The food items consisted of a chocolate bar and a chocolate cake for the sweet category, a bag of crisps/chips and fries for the salty category, and a box of crispbreads and loaves of bread for the neutral/ambiguous category. The visual textures were therefore incorporated either in the packaging of the food item (i.e., chocolate bar, crisps, crispbreads) or in a napkin next to a plate containing the food item (i.e., chocolate cake, fries, bread). The images were made grayscale to avoid biases that could be introduced by colours and their associations with specific tastes. Fig. 4 presents all the stimuli in Experiment 2.

3.1.3. Design and procedure

The study followed a 4 (Visual texture: control, crunchy, fluffy, rough) × 3 (Taste quality: neutral, sweet, salty) × 2 (Format: packaging, napkin) mixed experimental design, in which visual texture was a between-subjects factor and taste quality and format were within-subject factors. Thus, each participant was exposed to all six food items incorporating only one of the four visual textures.

Before starting the study, participants were first presented with the general aim of the study; they provided their informed written consent to participate and read instructions on how to respond to the single-response emotion circumplex of Jaeger et al. (2020). Afterwards, participants were presented with the food items one at a time, and they indicated how salty or sweet they expected them to be using a 9-point VAS from 1 (*not at all*) to 9 (*very much*). Participants only evaluated expected saltiness for the salty items (i.e., crisps, fries), whereas they only evaluated expected sweetness for the sweet items (i.e., chocolate bar, chocolate cake). In the case of the neutral items (i.e., crispbreads, bread), they evaluated expected sweetness and saltiness. Participants

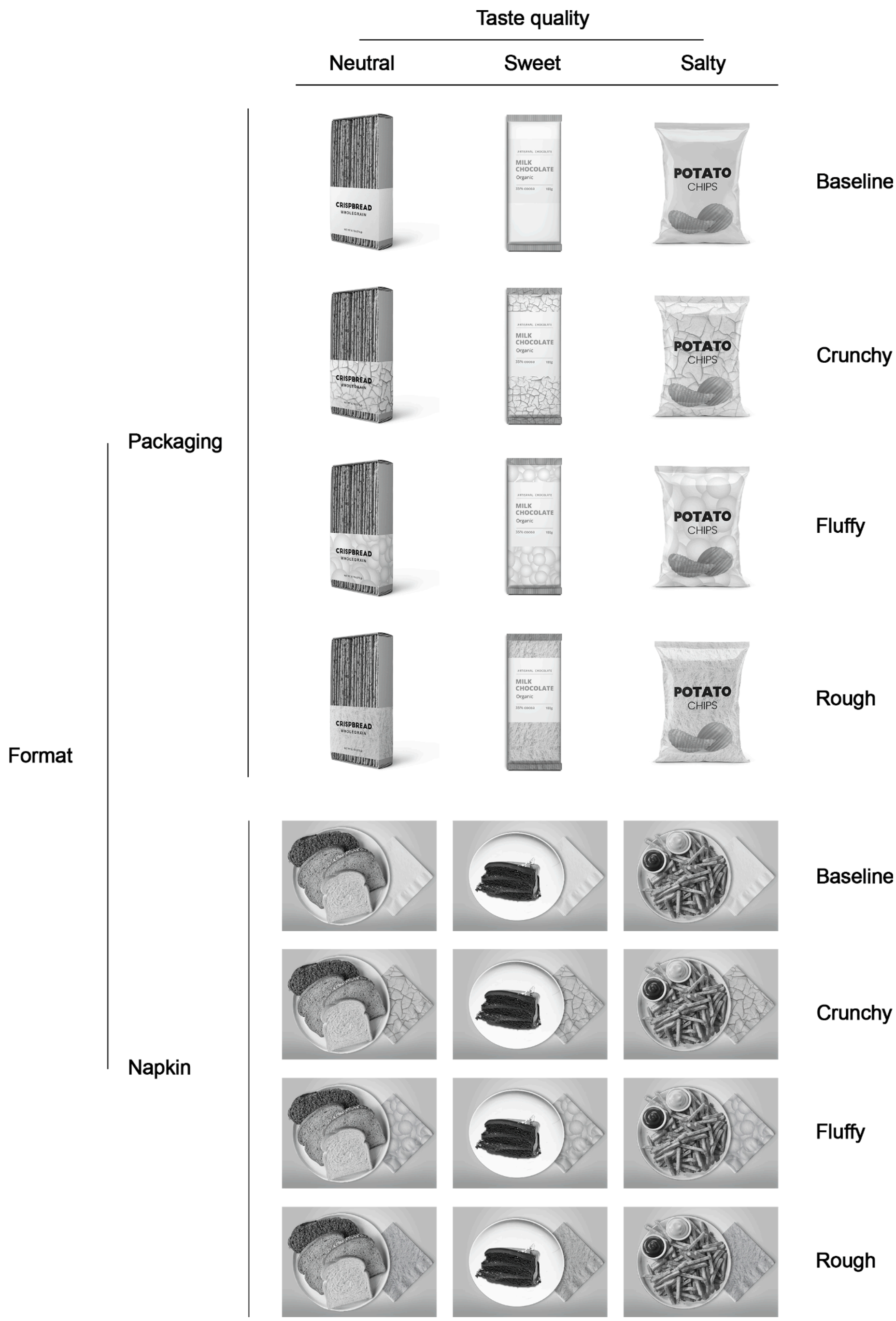

Fig. 4. Stimuli used in Experiment 2.

also indicated which emotion they expected the products to make them feel. The order of the food items and whether participants evaluated their taste or emotional expectations first for each product were randomised. At the end, participants indicated their age and gender. The experiment lasted approximately four minutes.

3.1.4. Data analysis

To analyse the sweetness and saltiness expectations, we ran two separate linear mixed models (LMMs) with sweetness/saltiness expectations as dependent variables. Visual texture, Taste quality, and Format entered the model as fixed factors along with their interactions, and subject ID entered the model as a random factor. To conduct the LMMs, we used the *lmer* function from the {lme4} R package (Bates et al., 2015). The *p*-values were computed with the Satterwhite method using the {lmerTest} (Kuznetsova, 2017) and {pbkrtest} (Halekoh & Højsgaard, 2014) R packages. Differences in sweetness and saltiness expectations among different visual textures categories for each product were then calculated through post hoc tests with Bonferroni corrections using the *glht* function of the {multcomp} R package (Hothorn et al., 2008). We computed partial eta-squared (η_p^2) as a measure of effect sizes using the *eta_squared* function of the {effectsize} R package (Ben-Shachar et al., 2020). Furthermore, similar to Experiment 1, the proportion of emotions evoked by each of the products with each of the visual textures were analysed via Cochran's Q tests and, when significant, Bonferroni-corrected pairwise comparisons using McNemar's tests.

3.2. Results

The analysis on the expectation of sweetness of the different products revealed that there were significant main effects of Taste quality, $F(1) =$

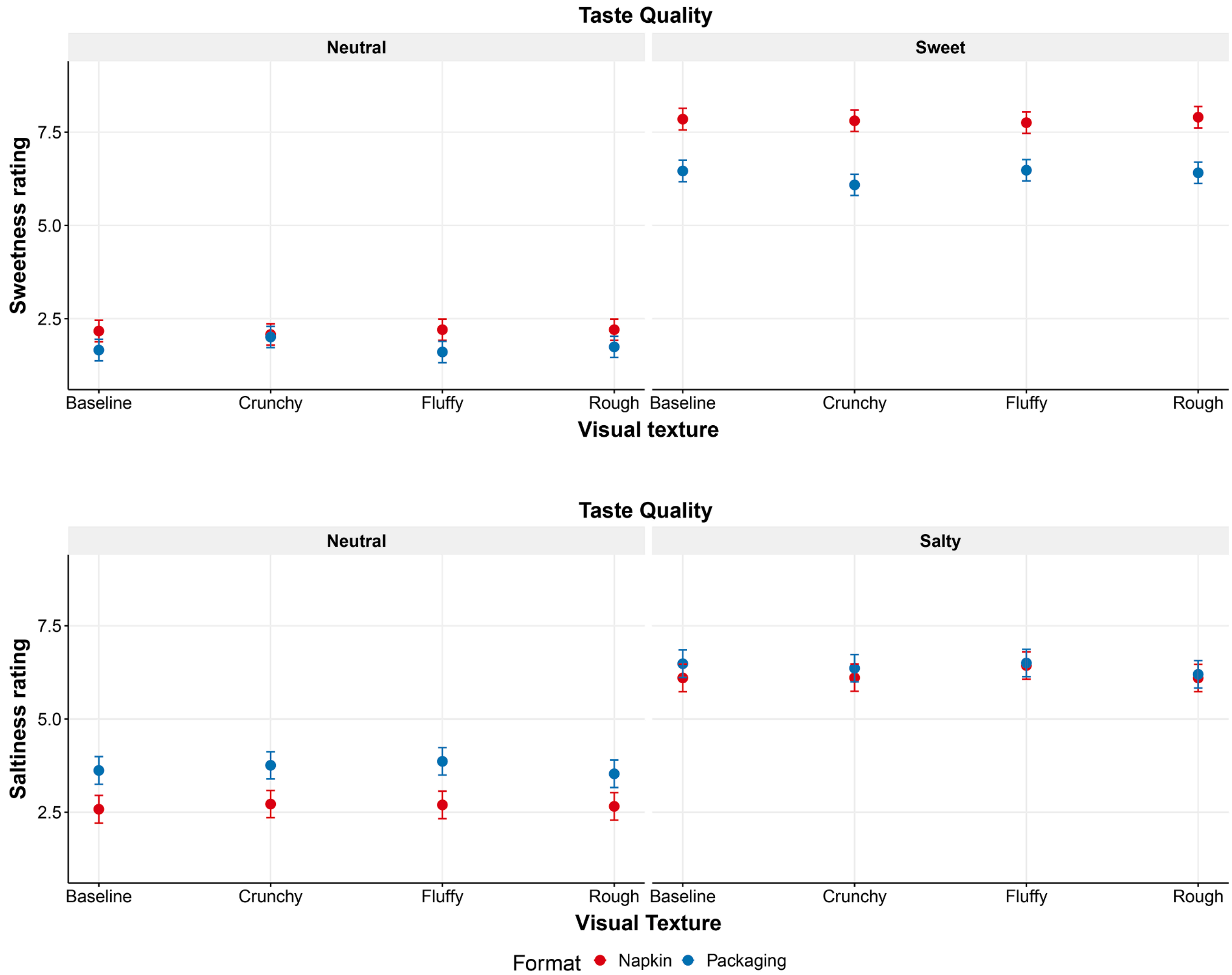

Fig. 5. Results of expected sweetness and saltiness in Experiment 2. The upper panel presents the results of expected sweetness for the neutral and sweet products, and the lower panel presents the results of expected saltiness for the neutral and salty products. The values are based on a 9-point scale VAS from 1 (*not at all*) to 9 (*very much*). Error bars indicate 95% confidence intervals.

5,840.29, p <.001, $\eta_p^2 = 0.83$ and Format, $F(1) = 195.28$, p <.001, $\eta_p^2 = 0.15$, as well as their interaction, $F(1) = 62.14$, p <.001, $\eta_p^2 = 0.05$. As anticipated, both sweet products (i.e., chocolate bar, chocolate cake) were expected to be significantly sweeter than the neutral products (i.e., crispbreads, bread), and the chocolate cake was expected to be significantly sweeter than the chocolate bar (see Fig. 5). However, there were no differences in expected sweetness across the different visual textures for the same product. As per the saltiness expectations, the analysis revealed that there were significant main effects of Taste quality, $F(1) =$ 1,623.41, p <.001, $\eta_p^2 = 0.57$ and Format, $F(1) = 63.56$, p <.001, $\eta_p^2 =$ 0.05, as well as their interaction, $F(1) = 29.00$, p <.001, $\eta_p^2 = 0.02$. Similar to the case of sweetness expectations, the salty products (i.e., fries, chips) were expected to be saltier than the neutral products. In this case, the crispbreads were expected to be saltier than the bread. Nevertheless, there were no significant differences between the different visual textures of the same product. Hence, the results failed to provide support to H_3.

The Cochran's Q tests showed significant effects (p <.05) in all products with all visual textures. The results of Cochran's Q and McNemar's tests are presented in Appendix Table A4. Overall, all products, except the neutral ones, were mainly expected to evoke positively valenced emotions, especially *Happy/satisfied*. On the other hand, the neutral products were expected to generate negative-valenced, low arousal emotions, especially *Dull/bored*. Fig. 6 presents a visualization of the proportion of emotions selected for each product decomposed by its taste quality, visual texture category, and format.

4. General discussion

We investigated the existence of crossmodal correspondences between six visual texture categories with predominant textural properties and five basic tastes through an online experiment. Moreover, we set to investigate whether the use of the visual textures associated with specific basic tastes in different formats of food stimuli could enhance their corresponding taste expectations. The results revealed the existence of moderate crossmodal associations between a fluffy visual texture and sweetness and between crunchy and rough visual textures and saltiness. That said, when these visual textures were incorporated in packaged and plated products of different taste qualities (i.e., sweet, salty, neutral/ambiguous), we did not observe evidence in our data supporting the idea that these visual textures influence taste expectations.

Our results, together with previous research on the affective information conveyed by textures, suggest that the crossmodal correspondences found here may be explained by an affective account. This means that specific visual textures and tastes may convey similar affective information and are therefore matched together. As the results of both experiments revealed, positive valenced emotion adjectives (mainly *Happy, satisfied*) were selected to describe the *fluffy* visual textures. This

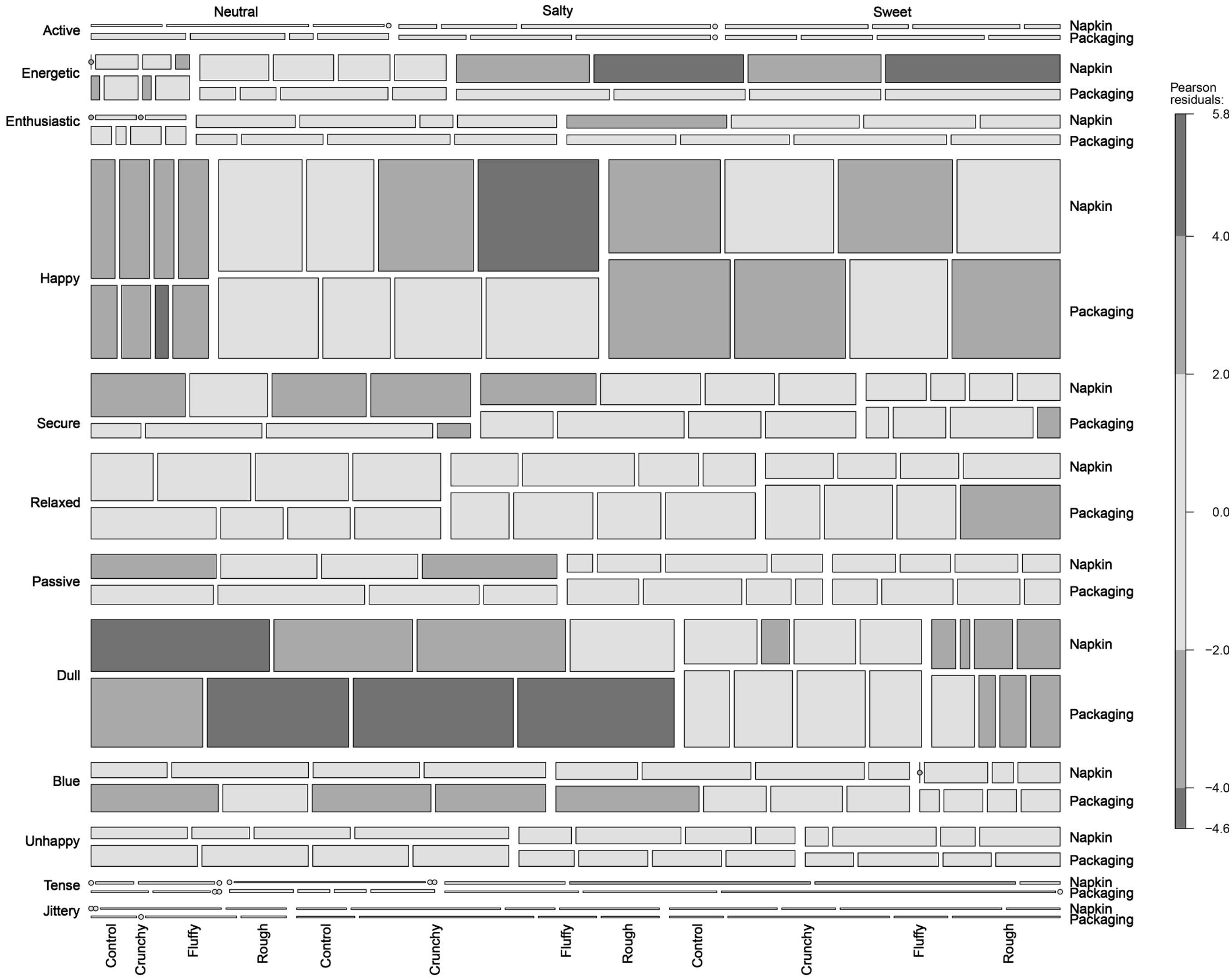

Fig. 6. Mosaic plot of emotions evoked by the different products per visual texture in Experiment 2. The mosaic plot presents the proportion of emotion adjectives (left side) selected as a function of the Taste quality of the products (top side), Visual texture (bottom side) and Format of the visual texture (right side). The area of the squares is proportional to the number of observations within a corresponding category.

suggests that valence is the most relevant dimension of core affect explaining these correspondences. The correspondence between the *fluffy* visual texture and sweetness may originate from the positive affect evoked by both features. The positive affect associated with the *fluffy* visual texture may come from indirect mappings to fluffy or soft tactile textures (Iosifyan & Korolkova, 2019), as well as from the positive valence associated to round shapes and sweetness (Salgado-Montejo et al., 2015). That said, it is important to consider that the context in which the visual textures are presented may influence their affective connotations. The visual textures may evoke different affective values when presented in isolation, compared to when they are incorporated in food packaging. For example, while the fluffy visual texture may evoke positive valence by itself, negative affect toward the packaging (or some of its features such as higher angularity) can offset the positive valence of the visual texture. Indeed, as Motoki and Velasco (2021) found, contextual shapes influence correspondences between tastes and shapes via affect. In the study, people assigned different affective values and tastes expectations to the same neutral target shape depending on the curvature of the shapes surrounding the target. In addition, the identity of the product itself may frame consumers' expectations about the product and therefore modulate the impact of visual textures on consumer's evaluations (Velasco, Salgado-Montejo, Elliot, et al., 2016; Velasco, Woods, Petit, et al., 2016). For instance, consumers likely expect chocolate to be sweet at the outset, so here, for example, the effect of angular textures would be negligible, or it is possible that the identity of the product may restrict the effect of the visual textures. Furthermore, it is possible that in Experiment 2, solely the food products (and not the visual textures) evoked positive valence. This seems to be supported by the positive affect evoked by seemingly incongruent pairings of foods and visual textures, such as the crisps and the *fluffy* visual texture.

An alternative explanation for the correspondences between the visual textures and basic tastes may lie in an associative learning account. The visual textures may have triggered indirect mappings to specific objects and materials with given taste properties, leading to associations between a visual texture and a basic taste. For instance, as van Rompay and Groothedde (2019) suggested, the visual (and tactile) aspects of rough and irregular surfaces, such as those of the *rough* and *crunchy* visual textures used here, may have generated indirect associations with salt crystals and individuals' interaction with them. Similarly, the *fluffy* visual texture may have caused associations with sweet products such as marshmallows, bubble gum, or melted chocolate. It is worth highlighting that correspondences occurring through associative learning are to some extent idiosyncratic, as they are dependent on each individual's previous experiences (Spence, 2011); although they may present a relatively high degree of similarity within cultures.

It is worth noting that the degree of roundness/angularity of the visual textures may influence the correspondences studied here in a non-mutually exclusive way (see Velasco et al., 2016 for a review on correspondences between tastes and shapes in packaging). As Spence and Deroy (2014) found, round shapes are associated with sweetness, whereas angular shapes are associated with saltiness, sourness, and bitterness (see also Motoki & Velasco, 2021). In this way, the round shapes of the *fluffy* visual texture may have driven the sweetness association. On the other hand, the angular shapes from the fissures in the *crunchy* visual texture, and those formed by the irregularities of the *rough* visual texture, may have driven the association with saltiness.

The null effects of the visual textures on taste expectations in Experiment 2 may be explained by the strength of the crossmodal correspondences found, assimilation effects between food types and visual textures, and relative compatibility effects. As the results of Experiment 1 showed, the crossmodal correspondences found did not go above the midpoint of the scale, indicating a low strength of these correspondences. Consequently, it is possible that, while people may have associated some visual textures with certain basic tastes, the specific visual textures studied here are not as strongly associated with these basic tastes to influence taste expectations when applied to food extrinsic factors. Particularly in the case of napkins, the effect of visual textures on taste expectations may be even lower than in packaging, as napkins are not part of a food product in the same way as packaging is (e.g., napkins are more distant from the food since consumers do not eat directly from them) and are meant to be thrown away. The null results in taste expectations are similar to those in a series of experiments by Velasco et al.'s (2019). The latter authors found associations between higher vertical spatial positions and sweetness but no consistent taste-verticality congruency effects on product evaluations. As the authors suggested, the null effects may be due to weak associations between verticality and basic tastes (see Parise, 2016; Velasco et al., 2015 for other studies discussing the strength of crossmodal associations). That said, a vast body of literature shows that different visual elements, especially incorporated in the packaging of foodstuffs, can affect consumers' expectations about the food they contain (see Piqueras-Fiszman & Spence, 2015).

The null results in Experiment 2 may have also been caused by the product expectations individuals generally hold based on specific food types and an assimilation effect. According to the assimilation/contrast theory, individuals have internal reference points (i.e., expectations) to which new stimuli (i.e., targets) are compared, and the magnitude of the difference between them can lead to either assimilation or contrast effects. An assimilation effect occurs when the difference between the reference point and the target is relatively small, so the consumer's judgements shift toward the features of the reference point. On the other hand, a contrast effect occurs when there is a relatively large difference between the reference point and the target, so the consumer's judgements shift toward the target. Pertaining to our study in which we investigated expectations about the basic tastes of different products, on the one hand, the specific food types serve as a reference point in consumers' minds that shape their taste expectations of these products. On the other hand, the specific products being evaluated function as targets. Indeed, as Velasco, Woods, Petit, et al. (2016) suggested, product type (together with their associated packaging features) provide a frame of reference for taste expectations about given products. The results in Experiment 2 suggest the presence of assimilation effects between food types and visual textures, as the difference between the experimental stimuli and the products with which consumers are familiar in each respective product category, may have been relativity small. Consequently, participants may have evaluated the stimuli in the experiment following their taste expectations of the average product in the category, based on their previous knowledge.

It is also worth considering that there may be relative compatibility effects in the correspondences studied here (see Spence, 2019). For instance, individuals may need to be exposed to contrasting visual textures for these crossmodal correspondences to emerge. While this type of contrast was present in Experiment 1, where participants observed the six categories of visual textures, this was not the case in Experiment 2, where each participant evaluated six different products but all with the same visual texture. The presence of contrasting stimuli may especially be required for significant effects on taste expectations.

Further research on crossmodal correspondences involving visual textures and tastes could study them using actual tastants instead of basic taste words, and then investigate their influence on taste perception of food products. On the same line, further research could compare the effects of visual vs. tactile textures on taste perception. Furthermore, future studies could probe the relativity of these correspondences and exploit different experimental designs. For instance, future experiments could manipulate a specific feature of visual textures (e.g., curvature) and present sets of visual textures with different magnitudes of variation to be matched with a given taste in both between-participants and within-participants designs.

5. Conclusions

Our results provide evidence for the existence of crossmodal correspondences between visual textures and basic taste words, although the implementation of these correspondences on food extrinsic factors did not influence taste expectations. Notably, the strength of these correspondences seems to be only moderate and relative, as it may require explicit comparisons with different visual textures. The present work thus contributes to the discussion on the strength of crossmodal correspondences and their relative nature. Furthermore, our study provides insights into how food types themselves can modulate the crossmodal effect of visual elements on taste evaluations.

Transparency Statement

Data, script, and additional materials are openly available at the project's Open Science Framework page (https://osf.io/7uycp/). We have no conflicts of interest to disclose. Preliminary results of this study were presented at the 9th European Conference on Sensory and Consumer Research. Carlos Velasco would like to thank the Research Funding from the Department of Marketing, BI Norwegian Business School.

CRediT authorship contribution statement

Francisco Barbosa Escobar: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing, Visualization, Resources. **Qian Janice Wang:** Methodology, Writing – original draft, Writing – review & editing. **Andrés Corredor:** Conceptualization, Writing – original draft, Writing – review & editing, Visualization, Resources. **Carlos Velasco:** Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing, Resources, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

Table A1
Descriptive statistics and relative treatment effects (RTE) of textural property ratings of the visual textures in Experiment 1. The RTEs indicate the tendency of participants to have a higher (or lower) taste associations for a given visual texture compared to the pool of all participants' ratings for the other visual textures. RTEs range from 0 to 1, and larger differences between RTEs indicate larger differences in the ratings.

		Property																	
Visual Texture Category	Level	Crunchy			Fluffy			Noisy			Porous			Rough			Wavy		
		M	*SD*	RTE	*M*	*SD*	RTE	*M*	*SD*	RTE	*M*	*SD*	RTE	*M*	*SD*	RTE	*M*	*SD*	RTE
Crunchy	1	60.44	33.76	0.77	6.19	11.30	0.29	42.94	35.32	0.63	36.61	32.04	0.60	69.42	30.94	0.83	12.54	18.84	0.38
	2	55.70	32.60	0.74	9.24	18.25	0.32	42.56	34.44	0.62	36.43	33.24	0.58	57.41	31.13	0.76	16.15	23.15	0.41
	3	40.78	32.35	0.64	18.08	24.87	0.42	32.92	30.75	0.56	33.21	29.31	0.58	41.59	33.12	0.65	17.63	22.19	0.43
	4	22.65	26.82	0.49	32.71	32.05	0.56	24.53	28.41	0.50	34.27	30.35	0.59	25.75	27.80	0.51	18.39	22.39	0.44
Fluffy	1	11.43	17.79	0.36	53.92	35.46	0.71	17.18	23.07	0.43	23.55	28.18	0.49	7.30	12.90	0.31	28.78	28.22	0.54
	2	37.71	32.91	0.60	13.76	20.51	0.39	39.63	32.77	0.62	21.96	25.59	0.47	39.66	34.00	0.61	18.44	22.89	0.45
	3	26.50	30.19	0.50	18.96	25.86	0.43	30.35	31.59	0.55	32.97	29.58	0.58	30.42	30.67	0.54	18.03	23.47	0.43
	4	10.22	18.56	0.33	36.48	33.83	0.59	15.36	23.22	0.39	33.54	31.87	0.57	14.07	22.27	0.38	18.16	23.40	0.43
Noisy	1	25.86	28.73	0.51	18.62	25.43	0.42	43.34	36.09	0.64	35.99	31.73	0.60	37.40	31.09	0.61	10.53	16.40	0.36
	2	13.62	18.54	0.40	31.49	31.81	0.54	24.89	29.14	0.50	28.68	29.27	0.54	22.14	26.38	0.48	14.91	21.71	0.39
	3	9.99	18.15	0.34	35.04	33.77	0.56	17.71	24.54	0.43	21.45	25.46	0.47	13.19	21.17	0.38	12.92	19.57	0.38
	4	7.85	13.80	0.31	35.86	33.88	0.57	18.37	26.34	0.42	18.38	23.73	0.43	11.55	18.54	0.36	13.30	20.76	0.38
Porous	1	42.27	34.34	0.64	10.97	18.31	0.35	31.70	30.17	0.56	42.97	34.07	0.65	37.08	33.35	0.59	11.59	17.92	0.37
	2	35.54	33.32	0.58	12.63	20.23	0.37	27.26	28.90	0.52	42.30	33.75	0.64	35.17	32.51	0.58	12.23	19.23	0.37
	3	18.09	25.48	0.42	22.95	28.32	0.47	19.76	25.93	0.45	35.93	30.79	0.60	20.04	25.85	0.45	13.78	19.36	0.40
	4	8.47	16.06	0.32	34.52	31.80	0.59	11.34	18.29	0.37	20.31	25.20	0.46	11.79	20.80	0.35	14.16	20.31	0.40
Rough	1	45.28	33.22	0.67	13.35	21.51	0.37	33.28	30.71	0.57	30.13	29.42	0.56	55.38	34.67	0.73	13.81	20.76	0.39
	2	31.21	29.47	0.55	26.26	29.55	0.51	25.65	27.42	0.51	26.71	26.52	0.53	41.41	33.12	0.63	16.54	21.70	0.42
	3	15.86	23.09	0.40	35.71	33.30	0.59	19.37	25.42	0.45	26.62	28.42	0.52	22.81	26.51	0.48	22.41	25.71	0.49
	4	9.77	17.33	0.34	40.64	34.16	0.62	16.30	23.19	0.40	20.78	25.62	0.46	15.71	23.82	0.40	18.98	22.32	0.46
Wavy	1	25.38	29.00	0.50	8.26	17.12	0.30	27.74	29.00	0.52	18.78	25.02	0.42	20.21	25.80	0.46	18.46	28.00	0.40
	2	21.14	26.03	0.46	14.87	21.41	0.40	40.64	33.65	0.62	19.68	26.39	0.44	18.75	24.34	0.44	81.66	26.37	0.90
	3	27.58	29.46	0.52	9.47	16.66	0.34	42.40	32.93	0.64	23.15	26.88	0.49	33.50	30.94	0.57	55.24	35.43	0.73
	4	33.22	32.50	0.56	7.36	11.85	0.32	47.10	35.22	0.67	32.56	29.90	0.56	44.15	32.22	0.66	31.37	33.48	0.54

Table A2
Descriptive statistics and relative treatment effects (RTE) of taste property ratings of visual textures in Experiment 1. The RTEs indicate the tendency of participants to have a higher (or lower) taste associations for a given visual texture compared to the pool of all participants' ratings for the other visual textures. RTEs range from 0 to 1, and larger differences between RTEs indicate larger differences in the ratings. Numbers in bold correspond to the mean value of the visual texture most strongly associated with each basic taste.

Visual Texture Category	Level	Property														
		Sweet			Salty			Sour			Bitter			Umami		
		M	*SD*	RTE	*M*	*SD*	RTE	*M*	*SD*	RTE	*M*	*SD*	RTE	*M*	*SD*	RTE
Crunchy	1	11.62	20.67	0.37	**43.70**	32.98	0.68	21.23	28.31	0.47	**32.53**	32.23	0.59	25.57	28.83	0.53
	2	11.47	19.42	0.37	40.21	32.19	0.66	24.25	29.28	0.50	28.33	29.97	0.56	**27.76**	30.89	0.54
	3	16.64	24.34	0.43	31.70	28.33	0.61	23.06	25.60	0.52	26.34	29.33	0.54	23.62	28.17	0.51
	4	20.76	27.22	0.47	26.75	28.76	0.54	22.21	26.96	0.49	20.64	23.94	0.50	23.38	27.11	0.51
Fluffy	1	**49.30**	32.37	0.74	12.91	19.37	0.40	15.27	21.76	0.43	11.78	18.51	0.39	18.63	25.13	0.46
	2	23.07	28.21	0.49	23.23	26.48	0.52	**29.59**	30.27	0.57	28.28	30.49	0.54	16.64	23.70	0.44
	3	19.29	24.49	0.47	26.51	29.40	0.54	27.10	29.26	0.55	23.50	26.25	0.52	19.05	26.76	0.46
	4	22.92	27.99	0.49	15.54	23.04	0.43	16.40	23.20	0.44	14.77	21.88	0.42	17.28	25.28	0.44
Noisy	1	17.39	25.08	0.44	29.51	28.79	0.58	27.23	28.30	0.56	26.80	28.30	0.55	21.42	24.95	0.50
	2	20.71	26.10	0.48	20.57	24.45	0.49	21.79	26.63	0.49	21.59	25.49	0.51	22.18	27.03	0.50
	3	19.13	26.94	0.45	18.12	22.09	0.47	20.18	26.71	0.46	21.08	26.75	0.48	21.36	27.33	0.48
	4	19.96	26.06	0.47	15.42	21.07	0.43	18.10	24.95	0.46	21.44	26.52	0.49	23.40	27.49	0.51
Porous	1	22.05	27.73	0.49	32.24	29.60	0.60	23.35	29.44	0.50	23.23	27.10	0.51	24.61	27.35	0.52
	2	20.64	27.70	0.47	29.20	29.88	0.57	24.58	28.70	0.51	22.86	27.68	0.51	26.18	28.70	0.54
	3	17.88	23.53	0.45	23.43	26.39	0.52	25.55	27.94	0.53	22.75	26.54	0.50	25.75	28.40	0.53
	4	16.78	22.81	0.44	16.54	23.06	0.45	14.96	21.28	0.43	14.73	20.99	0.42	18.48	24.03	0.46
Rough	1	18.51	25.42	0.45	40.78	32.52	0.67	21.19	25.57	0.49	25.61	27.15	0.54	23.12	26.27	0.52
	2	18.61	23.96	0.47	31.78	29.40	0.61	20.11	23.80	0.49	22.24	24.71	0.51	26.00	28.56	0.54
	3	21.02	28.46	0.47	24.30	27.56	0.53	17.77	22.33	0.47	18.43	22.72	0.47	23.52	26.33	0.52
	4	20.12	25.62	0.48	17.59	23.31	0.46	15.04	20.91	0.43	13.40	18.59	0.41	22.91	27.61	0.50
Wavy	1	16.36	23.49	0.43	27.15	30.00	0.55	18.28	23.41	0.46	20.82	25.60	0.48	22.63	27.82	0.50
	2	25.59	28.34	0.53	23.91	27.88	0.52	24.60	27.84	0.52	17.19	23.73	0.45	21.92	26.99	0.49
	3	19.54	25.63	0.47	23.24	25.68	0.52	25.42	28.65	0.53	22.56	25.98	0.50	22.99	28.04	0.50
	4	14.42	22.64	0.42	28.56	30.21	0.55	27.77	30.75	0.54	30.91	31.77	0.56	22.99	27.61	0.50

Table A3
Percentage (%) of emotions selected per visual texture in Experiment 1. The top row represents the emotion adjectives from (Jaeger et al., 2020), starting from *Active/Alert* (1) and moving clockwise. Analyses are based on Cochran's Q tests (presented in the last two columns). Values within each row not sharing a superscript letter are significantly different ($p < .05$) as per post the hoc multiple pairwise comparisons using Bonferroni-corrected McNemar's tests.

Visual texture	Level	1	2	3	4	5	6	7	8	9	10	11	12	Q	*p*
Crunchy	1	11^{abcd}	3^{abe}	2^{e}	3^{ae}	6^{abce}	5^{abce}	6^{abce}	13^{bcd}	3^{abe}	13^{bcd}	22^{d}	14^{cd}	102.41	<0.001
	2	7^{ab}	2^{a}	2^{a}	5^{ab}	5^{ab}	6^{ab}	9^{ab}	14^{bc}	4^{ab}	11^{abc}	24^{c}	12^{bc}	102.91	<0.001
	3	5^{abc}	2^{a}	3^{ab}	5^{abc}	9^{abcd}	3^{ab}	8^{abcd}	15^{cd}	12^{bcd}	15^{cd}	18^{d}	5^{abc}	77.42	<0.001
	4	4^{ab}	3^{ab}	2^{a}	7^{abc}	7^{abc}	6^{ab}	13^{bc}	20^{c}	9^{abc}	9^{abc}	12^{bc}	8^{abc}	64.68	<0.001
Fluffy	1	6^{abc}	8^{abc}	11abd	23^{d}	11^{abd}	17^{ad}	8^{abc}	8^{abc}	2^{bc}	2^{c}	3^{bc}	2^{bc}	111.07	<0.001
	2	15^{a}	6^{ab}	6^{ab}	6^{ab}	5^{ab}	10^{ab}	8^{ab}	8^{ab}	4^{b}	4^{b}	15^{a}	13^{ab}	46.62	<0.001
	3	7^{abc}	6^{ab}	2^{a}	8^{abc}	5^{ab}	10^{abc}	11^{abc}	19^{c}	4^{ab}	4^{ab}	12^{bc}	12^{bc}	55.65	<0.001
	4	3^{ab}	1^{a}	3^{a}	3^{ab}	5^{abc}	17^{cd}	16^{cd}	25^{d}	13^{bcd}	7^{abc}	6^{abc}	2^{a}	146.58	<0.001
Noisy	1	9^{ab}	7^{ab}	4^{a}	9^{ab}	4^{a}	10^{ab}	10^{ab}	9^{ab}	4^{a}	5^{ab}	16^{b}	12^{ab}	35.61	<0.001
	2	7^{ab}	2^{a}	2^{a}	5^{ab}	9^{abc}	13^{bc}	14^{bc}	21^{c}	10^{abc}	5^{ab}	7^{ab}	6^{ab}	74.58	<0.001
	3	4^{abc}	1^{a}	2^{ab}	6^{abcd}	8^{abcd}	11^{cde}	17^{de}	24^{e}	10^{bcde}	8^{abcd}	7^{abcd}	3^{abc}	113.42	<0.001
	4	4^{ab}	2^{a}	1^{a}	5^{abc}	6^{abc}	16^{cd}	14^{bcd}	28^{d}	7^{abc}	7^{abc}	5^{abc}	4^{a}	155.36	<0.001
Porous	1	10^{ns}	9^{ns}	4^{ns}	11^{ns}	6^{ns}	7^{ns}	8^{ns}	11^{ns}	7^{ns}	7^{ns}	9^{ns}	12^{ns}	14.58	0.203
	2	7^{ab}	7^{ab}	2^{a}	8^{ab}	8^{ab}	8^{ab}	9^{ab}	16^{b}	8^{ab}	10^{ab}	10^{ab}	8^{ab}	25.46	0.008
	3	3^{ab}	2^{a}	4^{abc}	6^{abcd}	5^{abcd}	10^{abcd}	16^{d}	14^{cd}	9^{abcd}	12^{bcd}	11^{abcd}	7^{abcd}	52.43	<0.001
	4	3^{abc}	1^{a}	1^{a}	2^{ab}	5^{abc}	12^{cde}	18^{de}	27^{d}	11^{bce}	9^{bce}	9^{bce}	4^{abc}	164.14	<0.001
Rough	1	6^{abc}	1^{a}	3^{ab}	4^{abc}	11^{bc}	7^{abc}	10^{bc}	13^{c}	9^{bc}	12^{bc}	14^{c}	10^{bc}	49.34	<0.001
	2	3^{ab}	4^{ab}	1^{a}	8^{abcd}	7^{abcd}	9^{abcd}	15^{cd}	18^{c}	11^{bcd}	10^{bcd}	10^{bcd}	5^{abd}	61.22	<0.001
	3	3^{ab}	3^{ab}	1^{a}	7^{abc}	9^{bcd}	13^{cd}	14^{cd}	23^{d}	8^{bc}	8^{bc}	10^{bcd}	2^{ab}	104.27	<001
	4	3^{ab}	0^{a}	0^{a}	7^{abc}	7^{abc}	13^{bcd}	17^{cd}	26^{d}	9^{bc}	9^{bc}	5^{ab}	5^{ab}	144.97	<0.001
Wavy	1	15^{a}	6^{ab}	5^{ab}	10^{ab}	9^{ab}	11^{ab}	11^{ab}	12^{ab}	6^{ab}	3^{b}	8^{ab}	5^{ab}	30.91	0.001
	2	18^{a}	11^{ab}	7^{ab}	10^{ab}	3^{b}	15^{a}	7^{ab}	3^{b}	3^{b}	4^{b}	8^{ab}	10^{ab}	61.71	<0.001
	3	25^{a}	11^{ab}	4^{bc}	5^{bc}	7^{bc}	6^{bc}	4^{bc}	8^{bc}	2^{c}	6^{bc}	11^{ab}	12^{ab}	99.20	<0.001
	4	17^{a}	7^{abc}	4^{b}	4^{bc}	8^{abc}	7^{abc}	8^{abc}	7^{abc}	2^{b}	4^{bc}	14^{ac}	18^{a}	72.10	<0.001

Table A4

Percentage (%) of emotions selected per visual texture and product in Experiment 2. The top row represents the emotion adjectives from (Jaeger et al., 2020), starting from *Active/Alert* (1) and moving clockwise. Analyses are based on Cochran's Q tests (presented in the last two columns). Values within each row not sharing a superscript letter are significantly different ($p < .05$) as per post the hoc multiple pairwise comparisons using Bonferroni-corrected McNemar's tests.

Visual texture	Product	1	2	3	4	5	6	7	8	9	10	11	12	Q	p
Control	Bread	1[a]	0[a]	0[a]	12[abc]	16[bc]	12[abc]	13[abc]	36[c]	5[ab]	5[ab]	0[a]	0[a]	147.20	<0.001
	Cake	4[ab]	15[ac]	10[ab]	40[c]	7[ab]	7[ab]	5[ab]	5[ab]	0[b]	2[ab]	3[ab]	2[ab]	152.72	<0.001
	Chips	2[ab]	2[ab]	1[ab]	31[c]	8[ab]	11[abc]	8[ab]	14[abc]	16[bc]	4[ab]	2[ab]	1[a]	103.04	<0.001
	Chocolate	2[a]	7[a]	5[a]	45[b]	3[a]	12[a]	5[a]	13[a]	2[a]	3[a]	2[a]	1[a]	196.16	<0.001
	Crispbread	4[ab]	1[a]	2[ab]	8a[b]	3[ab]	15[bc]	10[abc]	30[c]	15[abc]	10[abc]	1[a]	1[a]	97.52	<0.001
	Fries	1[ab]	8[ab]	6[ab]	35[c]	15[bc]	9[ab]	2[ab]	13[abc]	6[ab]	4[ab]	0[a]	1[ab]	122.96	<0.001
Crunchy	Bread	1[abc]	3[abc]	1[ab]	15[bcd]	14[bcd]	17[cd]	10[abcd]	27[d]	9[abcd]	3[abc]	1[ab]	0[a]	98.67	<0.001
	Cake	1[a]	17[bc]	8[ab]	37[c]	4[ab]	6[ab]	4[ab]	2[ab]	6[ab]	9[ab]	6[ab]	1[a]	137.88	<0.001
	Chips	3[ab]	2[ab]	4[abc]	20[c]	13[abc]	15[abc]	11[abc]	17[bc]	7[abc]	5[abc]	1[a]	3[ab]	59.29	<0.001
	Chocolate	2[a]	6[a]	4[a]	41[b]	7[a]	15[a]	8[a]	5[a]	4[a]	5[a]	2[a]	3[a]	157.62	<0.001
	Crispbread	4[a]	4[a]	1[a]	9[a]	7[a]	8[a]	12[a]	36[b]	10[a]	10[a]	1[a]	0[a]	123.14	<0.001
	Fries	2[a]	6[a]	7[a]	28[b]	13[ab]	15[ab]	5[a]	5[a]	8[ab]	8[ab]	2[a]	3[a]	73.50	<0.001
Fluffy	Bread	1[a]	2[ab]	0[a]	10[abc]	17[bc]	18[bc]	9[abc]	28[c]	7[ab]	5[ab]	2[ab]	2[ab]	100.59	<0.001
	Cake	3[a]	16[ab]	7[a]	39[b]	5[a]	6[a]	5[a]	8[a]	2[a]	3[a]	5[a]	3[a]	137.06	<0.001
	Chips	3[ab]	6[ab]	6[ab]	26[c]	7[abc]	12[abc]	5[ab]	21[bc]	8[abc]	5[ab]	1[a]	1[a]	81.53	<0.001
	Chocolate	3[a]	6[a]	7[a]	36[b]	11[a]	12[ab]	7[a]	8[a]	3[a]	3[a]	5[a]	1[a]	111.18	<0.001
	Crispbread	1[ab]	1[ab]	3[ab]	4[ab]	10[ab]	7[ab]	9[ab]	41[c]	14[b]	9[ab]	0[a]	2[ab]	168.82	<0.001
	Fries	5[a]	6[a]	2[a]	40[b]	7[a]	8[a]	8[a]	11[a]	8[a]	5[a]	0[a]	1[a]	145.92	<0.001
Rough	Bread	0[a]	1[ab]	1[ab]	15[bc]	18[c]	17[c]	13[bc]	20[c]	8[abc]	8[abc]	0[a]	1[ab]	78.94	<0.001
	Cake	1[a]	21[bc]	5[ab]	36[c]	5[ab]	10[ab]	3[a]	8[ab]	4[ab]	7[ab]	1[a]	0[a]	145.06	<0.001
	Chips	0[a]	3[ab]	5[ab]	34[c]	10[ab]	17[bc]	3[ab]	14[bc]	7[ab]	5[ab]	2[ab]	1[a]	125.29	<0.001
	Chocolate	2[a]	8[ab]	5[ab]	40[c]	3[a]	21[bc]	4[ab]	8[ab]	4[ab]	4[ab]	0[a]	2[a]	172.92	<<0.001
	Crispbread	3[a]	4[a]	2[a]	11[a]	2[a]	11[a]	6[a]	40[b]	13[a]	8[a]	0[a]	1[a]	159.88	<0.001
	Fries	0[a]	6[a]	6[a]	50[b]	10[a]	7[a]	4[a]	10[a]	3[a]	3[a]	0[a]	2[a]	246.24	<0.001

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