

Sensation transference from plateware to food:

The sounds and tastes of plates

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ABSTRACT

We report two experiments designed to extend the well-known Bouba/Kiki effect to the case of an unusual set of commercially-produced plateware, and further to assess the influences of these plates on the expected taste of a dessert based on the theory of crossmodal correspondences. The results demonstrate that plates having a smoother circumference are more likely to be matched to “Bouba”, while those with a pointier circumference are more likely to be matched to “Kiki” instead, thus demonstrating the typical Bouba/Kiki effect. Importantly, the shape and colour of the plates modulated people’s ratings of the expected taste and liking of the ice-cream/sorbet displayed on them. Specifically, the colour of the plate induced a general effect on the expected tastes that were consistent with the white-sweet and black-bitter associations, and the higher expected liking was attributed to the higher colour contrast between the food and plate. The shape of the plate modulated ratings of expected liking for the chocolate ice-cream, and the expected sweetness of the lemon sorbet, respectively. Finally, colour and shape conjointly modulated the expected sourness of the lemon sorbet. These results provide relevant insights for those chefs, restaurateurs, and Instagrammers wishing to optimize the plateware for specific dishes.

KEYWORDS: COLOUR; SHAPE; TASTE EXPECTATIONS; PLATEWARE; BOUBA-KIKI EFFECT; SOUND SYMBOLISM; CROSSMODAL CORRESPONDENCES; COLOUR CONTRAST.

Introduction

In the first century, the Roman Gourmand Apicius (see Apicius, 1936), stated that “the first taste is always with the eyes”. Those from the East are similarly known to emphasize attractive visual presentation as one of the three essential elements – appearance, aroma, and savour – for those wanting to deliver optimal Chinese cuisine. In order to increase the visual aesthetic experience of foods for those who are dining, or when advertising via modern webpages and/or social apps (e.g., Instagram’s “The Art of Plating”, <https://www.instagram.com/theartofplating>), there has been an explosion of interest in novel plateware designs in recent years (see Spence & Piqueras-Fiszman, 2014; Spence, Piqueras-Fiszman, Michel, & Deroy, 2014, for reviews). Where once pretty much every meal came on a large round white plate (often referred to as the American plate), increasingly, different materials such as slate and brick, even plant-pots and flat caps etc. are now being used instead (e.g., Connell, 2014). Nevertheless, little is currently known about what people’s implicit associations with such novel examples of plateware are, and how these associated attributes may modulate the subjective feelings regarding the foods displayed on them. This is clearly of great importance to practitioners because these associations have been demonstrated to influence people’s expectations of the food displayed on such unusual plateware, and those expectations can, in turn, influence the perceived taste/flavour experience (see Piqueras-Fiszman & Spence, 2015; Spence & Piqueras-Fiszman, 2014, for reviews).

Plate colour, for example, has been shown to influence people’s expectations and subsequent taste perception. A classic example of this comes from the results of a study by Piqueras-Fiszman, Alcaide, Roura, and Spence (2012) demonstrating that the same strawberry mousse was rated as tasting roughly 7% sweeter and 13% more flavourful when served on a round white plate than on a round black plate (see also Lyman, 1989; Stewart & Goss, 2013). Several other studies have also provided evidence in support of the claim that the colour of the plate, bowl, and cup that is used to serve food or drink can influence the perceived flavour when tasting (e.g., Harrar, Piqueras-Fiszman,

& Spence, 2011; Piqueras-Fiszman, Giboreau, & Spence, 2013; Piqueras-Fiszman & Spence, 2012; Schifferstein, 2009; Tu, Yang, & Ma, 2016; Van Doorn, Willemin, & Spence, 2014).

Elsewhere, researchers and practitioners have demonstrated that the shape of the plate or container modulates people's ratings regarding the food displayed on it. Specifically, in a study reported by Fairhurst, Pritchard, Ospina, and Deroy (2015), the expected taste of pieces of beetroot in a salad was rated as sweeter when displayed on the round white plate than on a square white plate instead. In another study in which the participants tasted lemon yogurt, the latter was rated as more intense when the participants had just viewed an angular rather than a rounded cup displayed on a screen. However, here it should be noted that the effect of viewing the angular cup on lemon yogurt was only significant for those participants who reported being sensitive to product aesthetics, thus potentially limiting the implications of these results (Becker, van Rompay, Schifferstein, & Galetzka, 2011). Meanwhile, Stewart and Goss (2013) considered the combined impact of plate colour and plate shape. In their between-participants experimental design, they demonstrated that a piece of cheesecake served on a round white plate was rated as tasting 20% sweeter than when exactly the same cake was served on an angular white plate, or either round or angular plate in black instead.

How plateware modulates expectations and the perception of taste?

One of the ways in which such surprising crossmodal influences resulting from the plateware on food have been explained is in terms of “sensation transference”. This is the name given to describe what happens when people transfer some of their feelings regarding the attributes of the packaging or receptacle to the product contained within (e.g., Cheskin, 1957; Schifferstein, 2009; Spence, 2012a). Nevertheless, for a given package or receptacle, its visual attributes may elicit certain taste/emotional attributes based on the crossmodal correspondences (see Spence, 2011, 2012b). One example of the crossmodal correspondences between colours and tastes has been known about for decades (e.g., Favre & November, 1979; Maga, 1974, for early examples), but

only recently have systematic investigations been conducted online across a number of countries revealing a picture that, in many cases, appears to be universally consistent (see **Figure 1**). So, for example, sweetness is associated with pink, purple, red, and sometimes white, sourness is typically associated with green and yellow, saltiness with blue and white, and bitterness with black (Ares & Deliza, 2010; Huisman, Bruijnes, & Heylen, 2016; Schifferstein, 2009; Spence et al., 2015; Tomasik-Krótki & Strojny, 2008; Wan et al., 2014; Woods, Marmolejo-Ramos, Velasco, & Spence, 2016; Woods & Spence, 2016). Such correspondences are thought to arise (by some researchers) as the result of many repeated pairings of the individual co-occurring sensations (such as limes being both green and sour; see the discussion in Woods, Poliakoff, Lloyd, Dijkterhuis, & Thomas, 2010), but also through various higher-order conceptual linkages (such as that riper fruits are generally redder and sweeter; see Marks, 1996; Spence et al., 2015, for reviews). The influence of the colour of the receptacle on the taste of the food can be explained partly by the existence of such colour-taste correspondences elicited by the colour of the plateware (or packaging) being transferred to the food displayed on/in it (e.g., Harrar et al., 2011; Piqueras-Fiszman et al., 2012; Schifferstein, 2009; Tu et al., 2016).

Insert Figure 1 about here

One of the crossmodal correspondences between shapes and tastes in the literature relates to the extension of one of the classic findings on “sound symbolism”: Numerous studies conducted over the last 80 years or so have demonstrated that the majority of people around the world associate the word “*Bouba*” with a more rounded shape while associating the word “*Kiki*” with an angular shape instead (e.g., Bremner et al., 2013; Chen, Huang, Woods, & Spence, 2016; Köhler, 1929, 1947; Ramachandran & Hubbard, 2001). Recent studies have demonstrated linkage of the Bouba/Kiki effect to tastes, such as that those rounded shapes and *Bouba*-esque sounds tend to be associated with food with sweeter taste (e.g., caramel and milk chocolate), whereas more angular shapes and

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Kiki-like sounds, associated with food with more sour and bitter tastes (e.g., cranberry juice and dark chocolate; see Bremner et al., 2013; Ngo, Misra, & Spence, 2011; Salgado-Montejo et al., 2015; Spence & Gallace, 2011; Velasco, Woods, Marks, Cheok, & Spence, 2016). Such shape-taste correspondences plausibly underpin the influence of the shape of the plate on the expected taste/flavour of food. Specifically, food served on round plates is typically rated as looking sweeter than when exactly the same food is served on a square plate instead (e.g., Fairhurst et al., 2015; Stewart & Goss, 2013). Intriguingly, some researchers have recently started using projection mapping to present visual shapes around food, and similar effects can be induced (Huisman et al., 2016).

Although shape-taste correspondences have been demonstrated repeatedly, they seem to lack relevance to everyday life. For example, milk chocolate and dark chocolate correspond to rounded and angular shapes, respectively (Ngo et al., 2011), but both kinds of chocolates are sold in various shapes (such as round chocolate buttons and angular chocolate stars). A number of researchers have therefore suggested that the shape-taste correspondences are perhaps (at least in part) mediated by the emotional valence of the stimuli (Deroy, Crisinel, & Spence, 2013; Velasco, Woods, Deroy, & Spence, 2015; Velasco, Woods, Marks, et al., 2016). Specifically, people typically prefer rounded shapes to angular shapes (Ares & Deliza, 2010; Bar & Neta, 2006; Westerman et al., 2012), and to rate rounder shapes as being more pleasant, peaceful and approachable while angular shapes are rated as more aggressive and aversive (Cotter, Silvia, Bertamini, Palumbo, & Vartanian, 2017; Lindauer, 1990). Hence, rounder shapes plausibly correspond to sweet taste because they are both associated with positive valence (such as associated with pleasantness), whereas angular shapes correspond to sour and bitter tastes because they are both associated with negative valence, such as associated with threat or disgust.

In addition, varying the shape of the plate on which a food is displayed might be expected to modulate the expected taste of food based on shape-potency correspondences: Angular, as compared to rounded shapes, are generally associated with stronger or more potent stimuli (Becker

et al., 2011; Hanson-Vaux, Crisinel, & Spence, 2013; Lyman, 1979; Velasco, Woods, Liu, & Spence, 2016).

Challenges: Congruency and generalizability

Together, the crossmodal modulations of packaging and plating on food can be understood in terms of the following process: The visual attributes of product packaging or any other receptacle, through crossmodal correspondences, induce associated attributes or feelings regarding tastes. The latter then transfers to the foods displayed on/in it (e.g., Ares & Deliza, 2001; Schifferstein, 2009; Tu et al., 2016). Crossmodal correspondences between colours and tastes, between shapes and tastes, and between shapes and potency have been demonstrated in several studies; however, inconsistent results have sometimes been reported. The inconsistent modulatory effects resulting from the fact that the visual attributes of a plate may sometimes induce incongruent expectations regarding tastes. Additionally, it is worth noting that the modulation of plateware may not be generalized to all foods, especially as each food has its own expected taste/flavour.

For example, the stronger tastes of lemon yogurt after viewing the angular cup rather than the rounded cup (as reported by Becker et al., 2011) is perhaps attributable to the fact that angular shapes are associated with potency and sour taste. In this case, shape-potency and shape-taste correspondences work together because they are congruent (and so, they are confounded). However, desserts displayed on white (associated with sweet taste) and round (associated with sweet but weak potency) plates are often rated as tasting sweeter (Fairhurst et al., 2015; Stewart & Goss, 2013), suggesting that shape-potency correspondences may be overridden by the colour-taste and shape-taste correspondences when they are incongruent.

One important topic that has received even less attention previously is whether the modulations from one type of plateware are generalizable to various different foods that might be displayed on it, because earlier studies mainly tested only one type of food. For instance, desserts, such as strawberry mousse and cheesecake, are rated as sweeter on white than black plates (Piqueras-

Fizman et al., 2012; Stewart & Goss, 2013); in contrast, salty popcorn and café latte (in which the sweet taste is not dominant) were rated as *less* sweet when displayed in a white container than in one that was blue, red, or transparent (Harrar et al., 2011; van Doorn, et al., 2014). Recently, it has been reported that shapes and materials of plateware only influenced people's expectations about some but importantly not all of the types of noodles that were shown (Zhou, Wan, Mu, Du, & Spence, 2015). Hence, testing different examples of foods in a study should hopefully help researchers to clarify whether the crossmodal modulation from plateware is a general or specific effect on foods (see Piqueras-Fizman et al., 2013).

A number of chefs have started using the unusual plateware shown in **Figure 2A** to serve their food, including those at the restaurant Montbar in Barcelona (<http://www.montbar.com>) and the Leeds (UK) chef, Michael O'Hare, who designed a plate of food served on this dish that looked like an eye (see Walsh, 2015). The question therefore arises as to whether these plates correspond well to the “rounded” and “angular” categories along the shape dimension, and what impact of this might have on the expected (and perhaps even actual) taste of the food displayed on such exotic plateware. For the former question, we used the Bouba/Kiki effect to test whether one of the plates is associated with “Bouba” while the other with “Kiki”. For the latter question, the shape (smoother or pointier) and achromatic colour (white or black) of the plates were manipulated orthogonally. Here, four predictions can be put forward: First, based on the literature on colour-taste and shape-taste correspondences, plates that are white and have a smoother circumference should lead to a higher rating of expected sweetness, whereas plates that are black and have a pointier circumference should lead to higher ratings of bitterness and/or sourness. Second, based on the shape-potency correspondences, the taste ratings of each dessert may be higher when presented on a plate with a pointier-circumference than on one with a smoother-circumference. Third, the orthogonal variation in the shape and colour of the plates would allow us to further assess the modulations of taste ratings from each factor (shape or colour) were separate, or interactive in terms of their congruency (e.g., Stewart & Goss, 2013, on this theme). Finally, two different flavours/colours of dessert were

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used in order to test whether a given plate would induce general, or specific, modulations on different sample foods.

Experiment 1

In Experiment 1, we investigated whether two novel plates – one with smoother circumference, the other, with a pointier circumference – would be associated with “Bouba” and “Kiki”, respectively. The hope was that the results of this initial study would indicate whether these two plates belong to rounded and angular categories, respectively, and thus potentially would be associated with different kinds and intensities of tastes. Typical visual patterns used in previous studies of the Bouba/Kiki effect were also included in order to check that the sound-shape correspondences of this group of participants were in line with what has been reported previously (Bremner et al., 2013; Chen et al., 2016). All of the plates and patterns were presented in black and white, in order to determine whether the Bouba/Kiki decision would be modulated by the visual appearance of the plateware.

Methods

Participants

Two hundred participants (94 males, mean age: 33.6 years, range: 18-68 years) were recruited from Prolific Academic (<https://prolific.ac>) and took part in the study in exchange for 0.5 UK Sterling (Prolific Academic’s Country of Origin filter was used, to only recruit participants born in the UK). Among these participants, 197 were from the UK, one from Ireland, one from Romania, and one from India. The participants received cash in their online account in return for taking part in the study. One additional participant failed to complete the experiment and so his/her data were excluded from further analysis. All of the participants were naïve as to the purpose of the study. The participants gave their informed consent before the experiment began. All of the procedures were carried out in accordance with the Declaration of Helsinki and were approved by the ethical

committee in Medical Sciences Inter Divisional Research Ethics Committee, University of Oxford (MSD-IDREC-C1-2014-141).

Stimuli and Design

Two images of plates, one with a smooth wavy circumference, the other with a pointy ‘splash-like’ shape, were downloaded from <http://www.acmehosteleria.com/bcn.html> (31/05/2016). The two plates came in black or white against a homogeneous 50% grey background (450 x 450 pixels) created by image processing using GIMP (version 2.8.4, <https://www.gimp.org/>; **Figure 2A**). This manipulation gave rise to two factors: Plate Shape (smoother or pointier circumference) and Plate Colour (black or white). The two rounded and angular patterns (used in previous studies testing for sound-shape correspondences for the Bouba/Kiki effect), were presented with black or white outlines against the homogeneous 50% grey background (see **Figure 2D**). The two manipulated factors were therefore Pattern Shape (rounded vs. angular) and Pattern Colour (black vs. white).

The auditory stimuli consisted of the meaningless words “Bouba” and “Kiki” spoken by a female native English speaker (32 bit mono; 44,100 Hz digitization). Each non-word was recorded three times with slightly different speeds and tones. All six sound files were edited to the same length (400 ms) and their sound pressure level (in terms of the value of root mean square) were equalized. The experiment was conducted on the internet through the JavaScript transpiled, Haxe-based, Xperiment 2 software (<http://www.xperiment.mobi>; <https://haxe.org/>).

Insert Figure 2 about here

Procedure

Before starting the main experiment, the participants had to provide their consent and confirm that they could hear the sounds clearly (by typing in the three digits that were played out loud to them). All of the participants evaluated the four plates in the first session, and then the four patterns in the second session. This design was chosen to reduce the likelihood that the participants would

realize the link to the Bouba/Kiki effect underlying the experiment, should they be familiar with the latter phenomenon.

In each session, the participants were presented with the four plates (or patterns) simultaneously on the monitor, and informed that they would have to respond to each of the figures in turn. Subsequently, each of the four plates/patterns was presented on the monitor in a randomized order. In each trial, a plate/pattern was presented in the centre of the monitor, and the participants had to judge whether the words “Bouba” or “Kiki” (which they heard) provided a better match for the seen plate/pattern – they had to choose one or the other in order to proceed. The order of presentation of “Bouba” and “Kiki” was randomized on a trial-by-trial basis. Next, the question “How confident are you regarding the matching between the figure and the sound you chose?” was presented on the monitor, and the participants rated their confidence using a slider on the scale anchored at either end with the terms “not at all” on the left and “very much so” on the right. Note that the pointer on the slider was initially hidden and only appeared at the point where the participant moved the mouse over the line drawn between the two anchors. The slider could be placed anywhere between the two ends, and the location was then converted into percentage values proportional to the two ends of the whole scale (“not at all” = 0%, and “very much so” = 100%).

Results

Plates

The agreement of participants’ matching judgments for each plate (see **Figure 2B**) was assessed using chi-square tests to determine whether the participants consistently judged a given plate as better matching “Bouba” or “Kiki”, or else as not different from chance level (50%). For the four plates, the two smoother plates were better matched with “Bouba” (smoother/black: $\chi^2(1) = 12.50$, $p < .001$; smoother/white: $\chi^2(1) = 10.58$, $p < .005$), whereas the pointier/white plate was better matched with “Kiki” ($\chi^2(1) = 18.00$, $p < .001$). The pointier/black plate was rated as “Bouba” or “Kiki” equally often ($\chi^2(1) = 0.72$, $p = .40$).

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The participants' confidence ratings were compared between the values from those who matched the plate to "Bouba" to the values from those who matched the plate to "Kiki" (see **Figure 2C**). The results demonstrated that for the pointier/black plate, the participants were more confident when they matched the plate with "Kiki" than with "Bouba" ($t(188) = 2.71, p < .01$ two-tailed, unequal variance assumed). Nevertheless, for the other three plates, the confidence ratings did not differ significantly when the participants matched the plate to either "Bouba" or "Kiki" (all t s $< .09, p$ s $> .36$).

In order to examine whether both or only one of the factors – Plate Shape and/or Plate Colour – significantly modulated participants' responses, we used logistic regression in the lme4 (linear mixed effect) package (version 1.1-8, Bates et al., 2015) in R (version 3.2.1) to fit the data using the maximum likelihood method to reach the optimal coefficient for each factor (see **Table 1A**). The results demonstrate that only the Plate Shape factor (either smoother or pointier) effectively predicted the participants' matching with "Bouba" or "Kiki" ($p < .001$).

Patterns

The agreement of participants' matching judgments for each pattern (see **Figure 2E**) replicated the Bouba/Kiki effect: The two rounded shapes were associated with "Bouba" (rounded/black: $\chi^2(1) = 44.18, p < .001$; rounded/white: $\chi^2(1) = 20.48, p < .001$), whereas the two angular shapes were associated with "Kiki" (angular/black: $\chi^2(1) = 44.18, p < .001$; angular/white: $\chi^2(1) = 62.72, p < .001$). The results of the confidence ratings demonstrated consistent patterns (see **Figure 2F**): The participants were more confident when they associated the rounded shapes with "Bouba" (rounded/black: $t(98) = 4.82, p < .001$; rounded/white: $t(147) = 3.34, p < .005$), and more confident when they associated the angular shapes with "Kiki" (angular/black: $t(103) = 2.70, p < .01$; rounded/white: $t(67) = 2.05, p < .05$).

The results of a logistic regression (see **Table 1B**) revealed that only the Pattern Shape factor (either rounded or angular) effectively predicted the participants' matching with "Bouba" or "Kiki" ($p < .001$).

Insert Table 1 about here

Discussion

The results of Experiment 1 extend the Bouba/Kiki effect from simple patterns to real commercially-produced objects; in this case, plateware. Specifically, the smoother-circumference plates were associated with the word “Bouba”, whereas the pointier-circumference plates were more strongly associated with the word “Kiki” instead, in terms of the participants’ matching response or confidence ratings regarding their choice. The colour of the plates failed to significantly predict the Bouba/Kiki effect when using the plateware as visual stimuli. Hence, the plates with the smoother circumference and the pointier circumference are associated with two perceptual categories. In turn, the modulations induced by these two distinct shapes of the plates would be likely to be revealed (see Becker et al., 2011). In addition, the classic Bouba/Kiki effect for the patterns was replicated in terms of both the matching response and confidence ratings. Similarly, this effect was robust irrespective of the colour of the patterns.

The confidence that people have in the consensual nature of their responses is referred to as the “feeling of knowing”. It occurs despite the fact that there may be no objectively correct answer to the question under consideration (Koriat, 1975, 2008; Woods, Spence, Butcher, & Deroy, 2013). Koriat (2008) refers to the positive correlation between the consistency of judgments at the group level and an individual’s confidence concerning their own judgment as the *consensuality principle*. The replication of the classic Bouba/Kiki effect for the patterns, and the individual’s higher confidence when their answer is consistent with that given by the majority of respondents fits with this principle.

Note, though, that when matching the plates and meaningless spoken words, the participants’ subjective judgments and their consensuality seem to dissociate – that is, most of the participants judged a particular plate to better match with a particular word, but both majority and minority

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groups were equally confident of their answers (for the smoother/black, smoother/white, and pointier/white plates). A further dissociation between the participants' judgments and consensuality comes from the results of the pointier/black plate condition: There was no obvious agreement regarding whether the pointier/black plate better matched "Bouba" or "Kiki"; nevertheless, the participants who called it "Kiki" were more confident of their match. These results suggest that the information used by people when judging sound-shape correspondences, and the information when judging their confidence concerning them, may be different. This result stands as an exception to the consensuality principle, according to which, one would expect a high degree of correlation between the group-level consistency and individual confidence (Koriat, 2008).

Experiment 2

In Experiment 2, we tested whether plates associated with "Bouba" or "Kiki" would induce different expectations regarding the taste of food displayed on it. In addition to varying the shape of the plate, its colour was manipulated orthogonally too, in order to test whether the shape and colour of the plateware would exert any influence over people's taste expectations independently (e.g., Piqueras-Fiszman et al., 2012) or interactively (e.g., Stewart & Goss, 2013). In addition, we selected chocolate ice-cream and lemon sorbet as food samples, because the former is dark brown in colour and widely associated with a bittersweet taste, while the latter is white and associated with sweet and sour tastes instead. By comparing the modulations resulting from the plates on these two very different desserts (in terms of their colours and tastes) would help to verify whether these effects are generalizable to different foods.

The participants were presented with a photo of a scoop of ice-cream/sorbet on either one of the plates, and had them rate the expected attributes of the dessert. Several recent studies have demonstrated that such methods provide a useful tool with which to try and understand the influence of the receptacle on the expected flavour of food (e.g., Wan et al., 2016; Wan, Woods, Seoul, Butcher, & Spence, 2015).

Methods

Participants

Two hundred and four participants (151 males, mean age: 31.9 years, range: 18-68 years) from the same online participant pool as Experiment 1 were tested in exchange for £1 (UK Sterling). These participants were from Europe (100), Asia (49), North America (29), South America (20), Africa (3), and Australia (2), and one did not report (inadvertently, we did not use Prolific Academic's Country of Origin filter here, to only recruit participants from the UK as done in Experiment 1). One additional participant failed to complete the experiment and so his/her data were excluded from further analysis.

Stimuli and Design

Pictures of a scoop of chocolate ice-cream or lemon sorbet was carefully inserted into the picture of four plates: black/white x smoother/pointier used in Experiment 1 (see **Figure 3**), thus giving rise to eight target pictures.

Insert Figure 3 about here

Procedure

Before starting the main experiment, the participants were requested to provide their consent and confirm that they could clearly hear the sounds (by typing in the three digits that they heard). In each trial, the participants were presented with one of the pictures on the monitor, and were had to rate how sweet, sour, and bitter they expected the dessert to taste. They were also asked how much they thought that they would like the dessert. Note that the participants were not informed about the flavour of the ice-cream/sorbet. The participants rated each attribute using a slider on the scale anchored at either end with the terms “not at all” on the left and “very much so” on the right. These four ratings of a given target picture were each conducted on a separate screen in a random order.

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After having rated the dessert, the participants matched the smoother- and pointier-circumference plates, and rounded and angular shapes, to the sound of “Bouba” or “Kiki”, and rated their confidence concerning their choice (just as in Experiment 1). Only the white plates and patterns were used in this study because these were the stimuli that had been shown to elicit a reliable Bouba/Kiki effect in Experiment 1.

Results

The ratings of the sweetness, sourness, bitterness, and liking of the target stimuli (see **Figure 4**) were separately submitted to a three-way analysis of variance (ANOVA) with the factors of Dessert (chocolate ice-cream or lemon sorbet), Plate Shape (smoother vs. pointier circumference), and Plate Colour (black or white).

Sweetness

The participants expected the chocolate ice-cream to taste sweeter than the lemon sorbet ($F(1,203) = 61.44, p < .001$). Confirming previous results, they also thought that both of the desserts looked sweeter when presented on the white plate than on the black plate ($F(1,203) = 9.32, p < .005$).

There was a significant two-way interaction between Dessert and Plate Shape ($F(1,203) = 5.34, p < .05$). Participants rated the lemon sorbet as looking sweeter when presented on the pointier plate than on the smoother plate ($t(203) = 2.21, p < .05$), while there was no such difference for the chocolate ice-cream (pointier vs. smoother plate: $t(203) = 0.84, p = .40$).

Sourness

Unsurprisingly, the participants expected the lemon sorbet to taste sourer than the chocolate ice-cream ($F(1,203) = 61.91, p < .001$). Interestingly, the analysis also revealed a statistically significant three-way interaction between Dessert, Plate Shape, and Plate Colour ($F(1,203) = 3.90, p = .05$).

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In order to unpack this three-way interaction, two two-way ANOVAs with the factors of Plate Shape and Plate Colour were conducted for the chocolate ice-cream and lemon sorbet separately. These follow-up analyses revealed that the lemon sorbet was expected to taste sourer when presented on the black than on the white plate ($F(1,203) = 5.08, p < .05$). The influence of plate colour on the expected taste of the lemon sorbet was further modulated by the shape of the plate, with the Plate Shape x Plate Colour interaction being marginally significant ($F(1,203) = 3.22, p = .07$). In order to confirm the source of the two-way interaction, planned *post-hoc* tests were conducted. The results revealed that the lemon sorbet was expected to taste sourer when presented on the pointier/black plate than on the pointier/white plate ($t(203) = 2.93, p < .005$). No such difference was observed when the lemon sorbet was presented on the smoother/black or smoother/white plate ($t(203) = 0.68, p = .50$). For the chocolate ice-cream, by contrast, there wasn't any significant main effect nor an interaction (all F s $< 1.00, p$ s $> .31$).

Bitterness

The participants expected both desserts to taste more bitter when displayed on the black plate than on the white plate ($F(1,203) = 13.93, p < .001$). No other main effect or interaction was significant (all F s $< 1.72, p$ s $> .19$).

Liking

Higher liking ratings were obtained for the chocolate ice-cream than for the lemon sorbet ($F(1,203) = 55.90, p < .001$). This effect was modulated by plate shape (Dessert x Plate Shape interaction: $F(1,203) = 8.26, p < .005$), as well as by plate colour (Dessert x Plate Colour interaction: $F(1,203) = 12.42, MSE = 275.49, p < .005$).

Our participants expected that they would like the chocolate ice-cream more when presented on the smoother plate than on the pointier plate ($t(203) = 2.30, p < .05$), but no such difference was observed for the lemon sorbet ($t(203) = 1.57, p = .12$). The participants reported that they expected that they would like the chocolate ice-cream more when it was presented on a white plate than on a

black plate ($t(203) = 3.10, p < .005$). However, a reverse tendency was observed for the lemon sorbet ($t(203) = 1.77, p = .08$).

Sound-shape matching

The participants in Experiment 2 matched the plate with the smoother-circumference more often to “Bouba” than “Kiki” ($\chi^2(1) = 20.08, p < .001$), while only showing a weak tendency to match the pointier-circumference plate more often to “Kiki” than to “Bouba” that did not reach statistical significance ($\chi^2(1) = 1.59, p = .21$; see **Figure 5**)¹. For both plates, the participants’ confidence ratings regarding their matching responses were similar for both answers (both t s $< 1.72, p$ s $> .08$).

The typical Bouba/Kiki effect was observed: The rounded shape was matched with “Bouba” ($\chi^2(1) = 20.08, p < .001$) whereas the angular shape was matched with “Kiki” ($\chi^2(1) = 31.37, p < .001$). The participants were more confident when matching the angular shape to “Kiki” than to “Bouba” ($t(105) = 2.02, p < .05$), but no such difference was observed for the rounded shape ($t(142) = 1.52, p = .13$).

Insert Figure 5 about here

Discussion

In Experiment 2, a scoop of either chocolate ice-cream or lemon sorbet was presented on four different plates: smoother/black, smoother/white, pointier/black, and pointier/white. The participants expected the chocolate ice-cream to taste sweeter, and less sour, than the lemon sorbet. These results therefore suggest that most of the participants correctly recognized the flavours of the desserts, even though they had not been informed about them in advance. The participants also

¹ Given that the current group of participants did not consistently match the pointy plate to “Kiki”, the influence of the shape of plate on the expected tastes and liking may have been weakened. We therefore reanalyzed the data by only including those participants who matched the smooth plate as “Bouba” and the pointy plate with “Kiki” ($N = 71$). However, no additional effect associated with the shape of the plates was statistically significant as compared to the results reported in the Results section of Experiment 2.

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preferred the chocolate ice-cream to the lemon sorbet based on the higher rating of expected liking for the former.

The effects induced by the colour of the plate can be summarized as follows: First, the participants expected that the food displayed on the white plate would taste sweeter, thus replicating the results reported by Piqueras-Fiszman et al. (2012) and Stewart and Goss (2013). Second, the participants expected that the food displayed on the black plate would taste more bitter, consistent with the black packaging inducing an expected bitter taste of milk dessert reported by Ares and Deliza (2010). The above two results are consistent with the sensation transference account, according to which the colour of the plates carried-over to influence people's expectations of the food displayed on it. Finally, the food shown on the plate with higher-contrast colour (i.e., chocolate ice-cream seen against the white plates, and the lemon sorbet when seen against the black plates) were preferred as compared to the lower-contrast matching (cf. Lampi, 1973). This result suggests that the higher liking of strawberry mousse on a white plate than on a black plate (Piqueras-Fiszman et al., 2012) should perhaps be attributed to the colour contrast between the food and the plate (see also Lyman 1989), rather than simply to the higher familiarity, or general preference, for white plates. Furthermore, the preference for food that is attributable to the colour of the plateware should not simply be attributed to the achromatic (or luminance) contrast either (Bruno, Martani, Corsini, & Oleari, 2013). One possibility here is that the simultaneous contrast between colours provided by the receptacle made the food appear more vivid (Ekroll, Faul, & Niederée, 2004; Grether, 1942). Alternatively, however, the high figure-ground contrast images may simply have been processed more fluently (Reber & Schwartz, 2001), leading to a stronger preference (see Reber, Schwartz, & Winkielman, 2004, for a review).

Most critically, and interestingly, the shape of the plates induced distinct effects on the two desserts. The participants expected that they would like the chocolate ice-cream more when it was displayed on the plate with the smoother-circumference than on the pointier-circumference plate, while no such effect was observed for the lemon sorbet. The former effect is perhaps attributable to

the fact that smoother circumferences are associated with more pleasant feelings (e.g., Ares & Deliza, 2010; Salgado-Montejo et al., 2015; Velasco, Salgado-Montejo, et al., 2016; Velasco, Woods, Liu, & Spence, 2016), which further enhanced the participants' general liking of the chocolate ice-cream.

In contrast, the participants expected the lemon sorbet to taste sweeter when displayed on the plates with the pointier-circumference than on the smoother plates, but no such difference was observed for the chocolate ice-cream. Given that angular shapes are generally associated with sour rather than with sweet tastes, the shape-taste correspondences cannot provide an explanation for the results obtained here. Instead, the shape-potency correspondences suggesting that the pointier circumference of the plate is associated with greater potency (Becker et al., 2011; Velasco, Woods, Liu, & Spence, 2016) may provide a basis for sensation transference, resulting in the lemon sorbet being rated as sweeter on the pointier- than smoother-circumference plates.

Finally, plate shape and plate colour conjointly modulated ratings of the expected sourness of the lemon sorbet: This dessert was rated as looking sourer when displayed on the pointier/black plates than on the pointier/white plate, but no such difference due to colour was observed when the lemon sorbet was displayed on the two smoother plates. It has been suggested that the association between angular shapes and sour tastes is mediated by negative emotional valence (Salgado-Montejo et al., 2015; Spence & Gallace, 2011; Velasco, Salgado-Montejo, et al., 2016). The black colour is not associated with sourness (Spence et al., 2015; Woods & Spence, 2016); nevertheless, black links to negative emotional valence, partly due to its association with bitterness (Woods & Spence, 2016). We suggest that, because the colour black and angular shapes are both associated with negative emotional valence, black may therefore additively enhance the sensation transference of sourness from the pointier-circumference plate to the lemon sorbet displayed on it.

Taken together, the results of our second experiment demonstrate that the colour and shape of the plate on which a food is displayed (chocolate ice-cream or lemon sorbet in this case) potentially modulates the expected taste of food via several different mechanisms: The modulations of plate

colour are based on the crossmodal correspondence between colour and taste, whereas the modulations of plate shape are plausibly mediated by shape-emotional valence and shape-potency correspondences. The colour and shape of plates conjointly modulates the expected taste of food if they are associated with the same emotional valence (i.e., they are congruent in terms of their associations).

General Discussion

In the present study, we tested how novel plateware designs modulate people's expectations regarding the food that was displayed on them. In Experiment 1, we demonstrated that the plates with smoother and pointier circumference corresponded to the meaningless spoken words “Bouba” and “Kiki”, respectively. Hence, plates with a smoother vs. pointier circumference can be dissociated as rounded and angular types along the shape dimension, respectively. This is consistent with the notion of crossmodal correspondences, namely, that the critical visual features of a given object are implicitly associated with certain features presented in another sensory modality (with people considering that the features “go together”).

Building on the results in Experiment 1, we further examined how the shape and colour of these unusual plates modified the expected taste of the chocolate ice-cream and lemon sorbet that was displayed on them. The colour of the plates induced a general effect on taste expectations – with white inducing a sweeter rating, and black, a more bitter rating (Ares & Deliza, 2010; Piqueras-Fiszman et al., 2012; Stewart & Goss, 2013). The colour of the plates also enhanced the participants' liking by providing a simultaneous contrast to the colour of the food itself (Reber et al., 2004). Nevertheless, the shape of the plate induced a more specific effect: The smoother plate only enhanced expected liking for the chocolate ice-cream, whereas the pointy plate only enhanced the expected sweetness of the lemon sorbet. Finally, the colour and shape of the plate interactively modulated the expected sourness of the lemon sorbet. These modulatory effects induced by the colour and/or shape of the plates were specific only to some of the attributes ratings, implying that

the underlying mechanism is *not* halo-dumping (where one might expect all of the attributes to be affected by the colour and shape manipulations, e.g., Clark & Lawless, 1994).

When comparing the modulatory effects of the colour and shape of the plates on food perception, colour induced a general effect on certain attributes irrespective of the type of dessert that was displayed, whereas shape only influenced either the chocolate ice-cream or the lemon sorbet. This result is consistent with Ares and Deliza's (2010) study demonstrating that colour is relatively more influential than the shape of the packaging, especially regarding the expected flavours (e.g., chocolate or vanilla), liking, and willingness to purchase a product. In order to explain such differences in terms of general vs. specific modulations, further research will undoubtedly be needed in order to determine the dominance hierarchy of the crossmodal correspondence associated with colours or shapes. Our current suggestions, based on previous research, are addressed in terms of the nature of these crossmodal correspondences as follows.

Recent studies suggest that the mappings between colours and the four basic tastes are universally consistent (Spence et al., 2015; Woods & Spence, 2016; see the examples shown in **Figure 1**), which should be based on either the participants' collective prior experience or their knowledge (Spence et al., 2015; Woods et al., 2010). Nevertheless, the mapping between shapes and tastes is mediated, at least in part, by the emotional valence of the stimuli (see Salgado-Montejo et al., 2015; Turoman, Velasco, Chen, Huang, & Spence, submitted; Velasco, Salgado-Montejo, et al., 2016; Velasco, Woods, Liu, & Spence, 2016). Furthermore, the shape-taste and shape-potency correspondences sometimes seem to compete: Our participants expected the lemon sorbet to taste sweeter on the pointier plates than on smoother plates, therefore follows shape-potency rather than shape-taste correspondences (see also Becker et al., 2011).

Plate colour and plate shape conjointly modulate expected taste in terms of their congruency in at least two possible ways (see **Figure 1**): First, when shape and colour are associated with the same taste, they may enhance the expectation, and eventually the actual perception, of that taste. For example, rounded shape and white colour are both associated with sweetness, so the food served on

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such plates was rated as tasting sweeter (Stewart & Goss, 2013). Second, shape and colour may interact in terms of their associated emotional valence. For example, angular shapes are associated with sour taste of the lemon sorbet, mediated by the negative emotional valence; this negative valence is perhaps strengthened by the black colour that may also be considered as negative.

Interestingly, the shape of the plates, or its congruency with the colour of the plates, only modulated the ratings of sweetness and sourness of lemon sorbet rather than its bitterness. Critically, sweet and sour (but not bitter) are the two dominant tastes of lemon sorbet. In Ares and Deliza's (2010) earlier study, the shape of the packaging (either round or square) mainly modulated expected sweetness, rather than sourness or bitterness, of a milk dessert. Taken together, then, the suggestion that emerges here is that the modulations of the shape of packaging or receptacles would be most effective on the main the tastes/flavours of the food displayed on it.

In sum, the results of the two experiments reported here clearly demonstrate that the colour and shape of plateware modulate the expected taste of the food that is displayed on it. Such knowledge is likely important for chefs and practitioners of packaging when choosing the plates or packages in which to serve their foods, because the plates or packages would likely enhance the customers' expectation or experience before or during tasting. Universally consistent crossmodal correspondences (such as between colours and tastes) likely induce a general modulation, while indirect and competing crossmodal correspondences (such as between shapes and tastes, and between shapes and potency) can only mildly attenuate the expected attributes of the food. In some cases, different crossmodal correspondences can conjointly modulate certain ratings together when they are congruent, leading to a specific modulatory effect on tastes associated with a particular food (see also Salgado-Montejo et al., 2015; Velasco, Michel, et al., 2006). In addition to these modulations from plateware to the expected tastes of the food displayed on it, it is clear that using a high figure-ground contrast between food and plateware enhances liking ratings. Therefore, we would argue that a careful consideration of one's choice of plateware to display food is clearly

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warranted given that it provides an effective means of optimizing the visual appearance and attractiveness of a dish.

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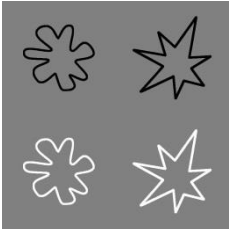
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Table 1. The coefficient, SE, 95% confidence interval, z value, and p value ($\mu = 0$) for each factor in the logistic regression analysis in Experiment 1.

	Factor	Coefficient	SE	95% confidence interval		z -values	p
				Upper	Lower		
(A) Plate 	Plate shape	0.87	0.15	1.16	0.58	5.87	< .001
	Plate colour	0.28	0.15	0.56	-0.01	1.89	= .06
	Constant	-0.64	0.13	-0.38	-0.89	-4.87	< .001
(B) Pattern 	Pattern shape	1.99	0.16	2.30	1.67	12.38	< .001
	Pattern colour	0.31	0.16	0.62	-0.01	1.91	= .06
	Constant	-0.99	0.14	-0.72	-1.26	-7.18	< .001

Note: The model of the logistic regression was `glmer(Response ~ 1 + Plate (or Shape) + Colour + (1|ID))`

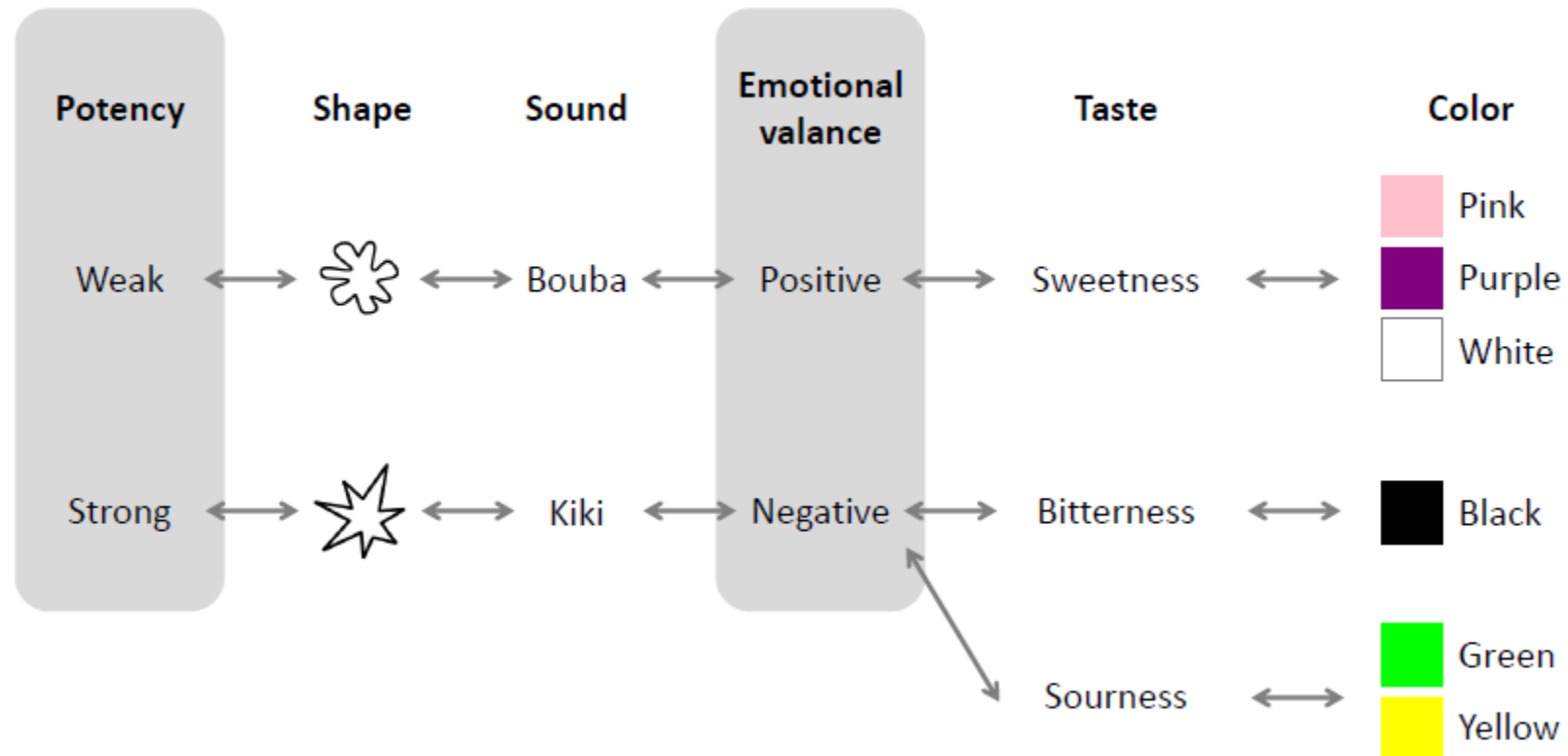


Figure 1. Summary of crossmodal correspondences that has been established to date, including correspondences between shapes and sounds (i.e., the Bouba/Kiki effect), between shapes and potency, and between shapes and tastes that are plausibly mediated by emotional valance, and finally, between colours and tastes.

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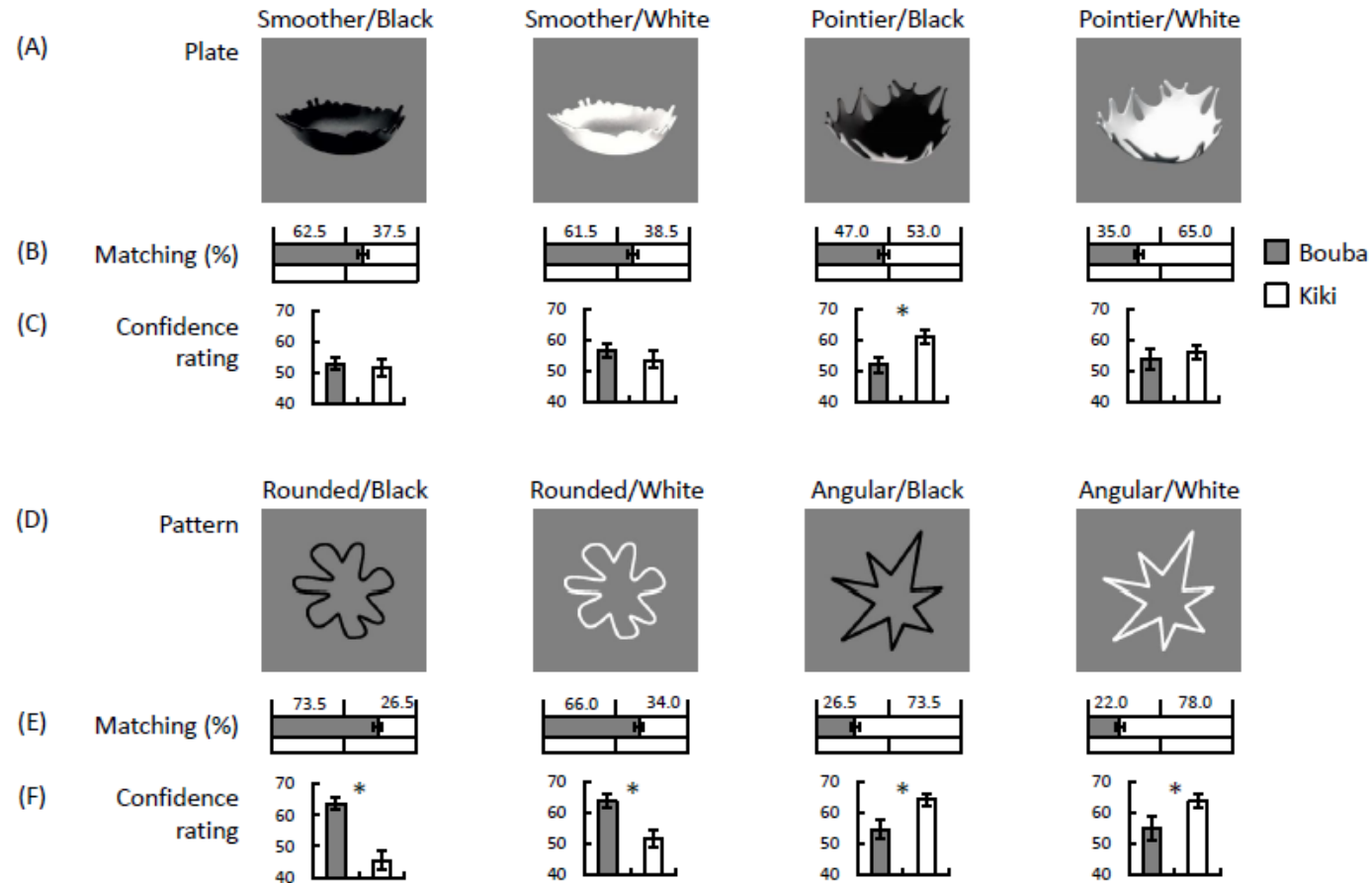


Figure 2. The stimuli and results from Experiment 1: (A) the black or white plates with a smoother- and pointier-circumference; (B) the results (and the 95% confidence intervals) of the matching between smoother/pointier plates to the meaningless spoken sound “Bouba” or “Kiki”; (C) confidence ratings (and the ± 1 standard error of the means) regarding the participant’s own matching between each plate to either “Bouba” or “Kiki”; (D) the classic rounded and angular patterns used in the Bouba/Kiki effect consisting of either black or white lines; (E) the results (and the 95% confidence intervals) of the matching between the rounded/angular patterns to “Bouba” or “Kiki”; (F) confidence ratings (and the ± 1 standard error of the means) regarding the participant’s own matching between each pattern to either “Bouba” or “Kiki”. *: $p < .05$ in a two-tailed t-test, unequal variance assumed.



Figure 3. The stimuli used in Experiment 2. A scoop of either chocolate ice-cream or lemon-sorbet was displayed on each plate.

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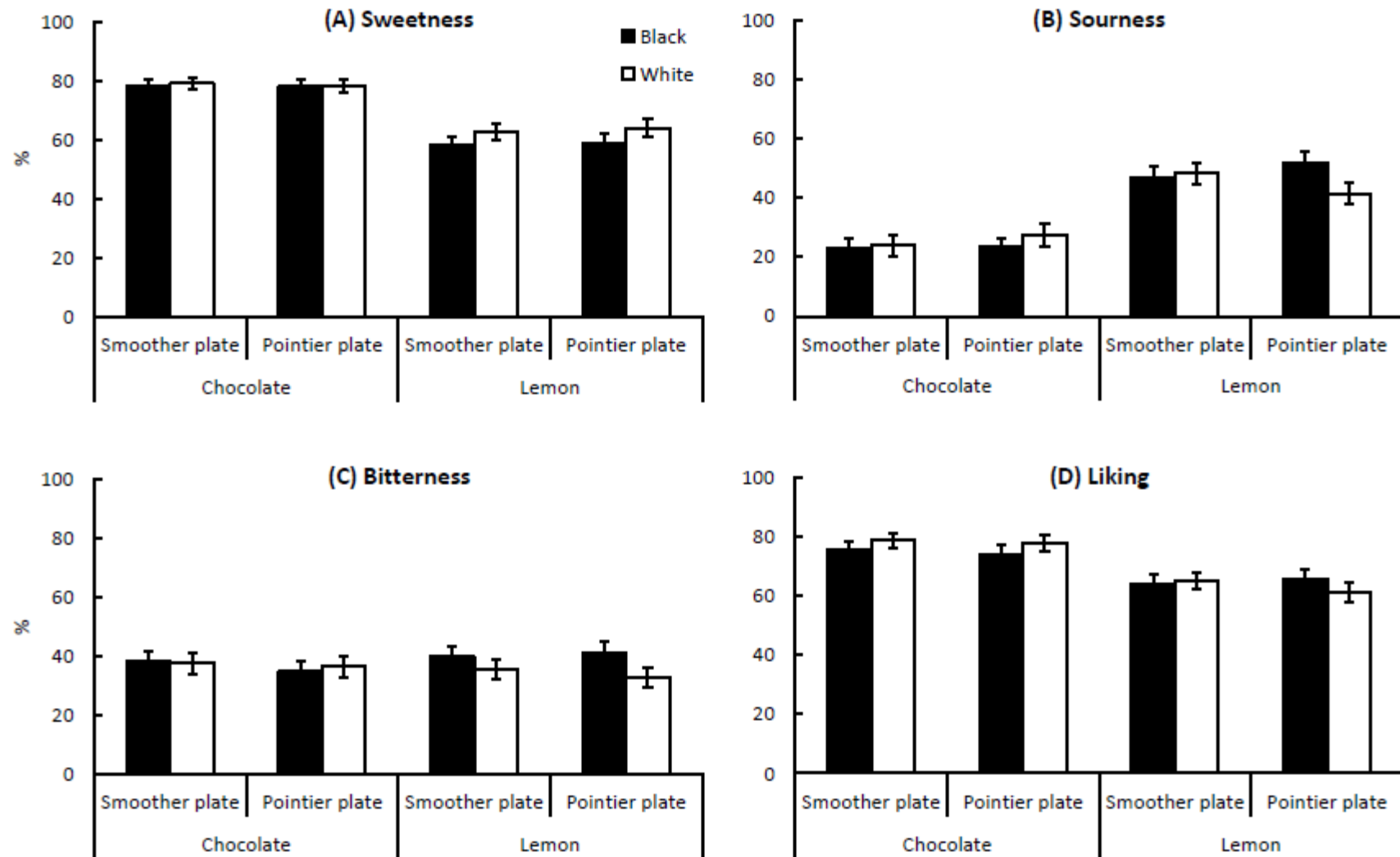


Figure 4. The rating (%) of each attribute for the chocolate ice-cream and the lemon sorbet: (A) sweetness; (B) sourness; (C) bitterness; and (D) liking in Experiment 2. The error bars represent the ± 1 standard error of the means.

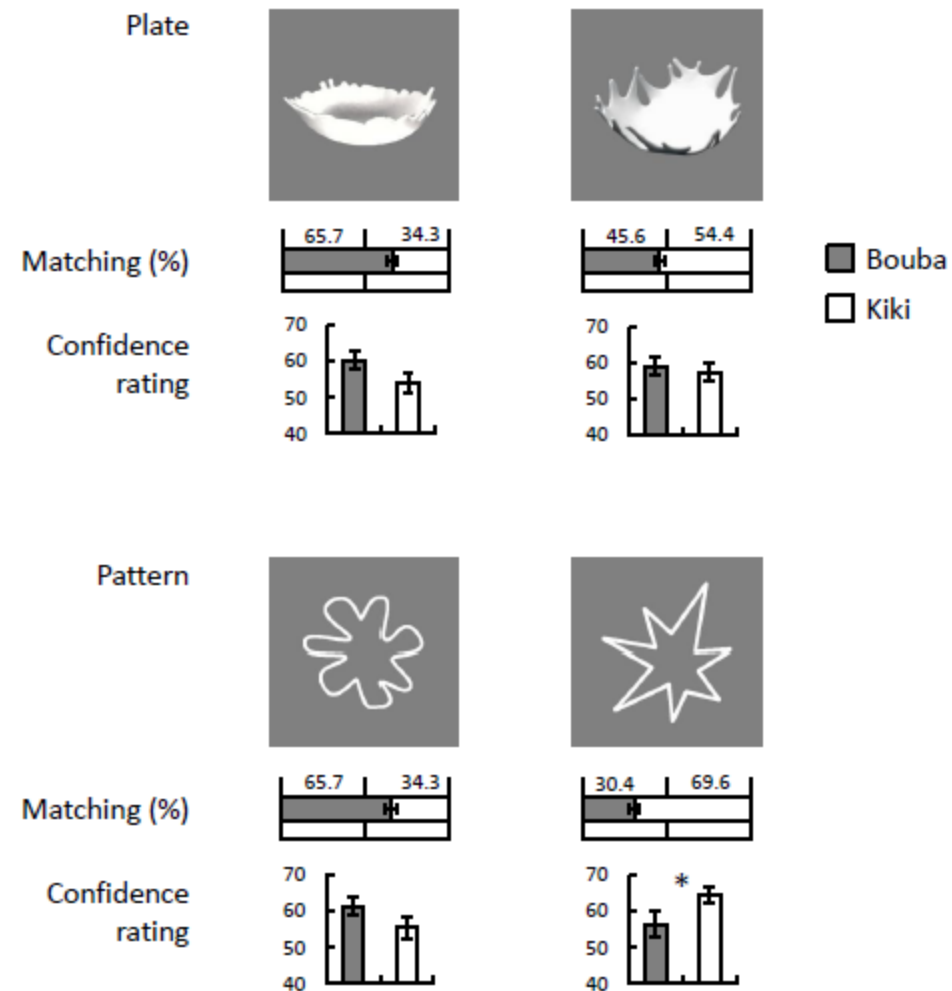


Figure 5. The stimuli and results of the matching (and the 95% confidence intervals) between the smoother/pointier plate or rounded/angular pattern to the meaningless spoken sound “Bouba” or “Kiki”, and the participants’ confidence ratings (and the ± 1 standard error of the means) regarding their own matching in Experiment 2. *: $p < .05$ in a two-tailed t-test, unequal variance assumed.