RUNNING HEAD: HAPTIC INFLUENCES ON WINE EVALUATION

A smooth wine? Haptic influences on wine evaluation

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ABSTRACT

Although product-extrinsic touch is often overlooked as far as flavour perception is concerned, recent research unequivocally demonstrates that the perceived flavour and hedonic evaluation of foods and drinks can be modulated by the surface texture of packaging materials and servingware (as well, of course, as by the oral-somatosensory texture of the food and drink itself). The present study was designed to assess the impact of touching markedly different surface textures on the wine-tasting experience, both in terms of orthonasal olfaction as well as for in-mouth sensations. A preliminary study conducted at a science and wine symposium confirmed that touching velvet, as opposed to sandpaper, enhanced the perceived sweetness of an off-dry white wine. In the main study, participants (N=60) evaluated a red dessert wine whilst simultaneously touching either a swatch of velvet or sandpaper with their dominant hand. The participants first smelled the wine while touching each material. They rated the aroma of the wine in terms of its intensity, acidity, fruitiness, and pleasantness. Next the participants tasted the wine while stroking each material. The wine was rated in terms of its acidity, sweetness, tannin level, and pleasantness. Overall, the aroma of the wine was judged to be significantly fruitier when participants simultaneously touched the velvet rather than the sandpaper. When it came to tasting, the wine was rated as significantly sweeter and more pleasant when the participants touched the velvet rather than the sandpaper. These results imply that product-extrinsic surface textures can influence not only the in-mouth flavour experience, but also orthonasal olfactory evaluations as well. One explanation for the tactile influence on smell, taste, and liking may be due to the hedonic mapping between stimuli. These results could have important implications for the hospitality industry, e.g., when thinking about innovative coatings for new drinking receptacles or beverage packaging.

KEYWORDS: CROSSMODAL CORRESPONDENCES; SMELL; TASTE; TACTILE PERCEPTION; SURFACE TEXTURE; WINE EVALUATION; HEDONIC MAPPING.

Introduction

Not long after the First World War, the Italian Futurists staged elaborate dinner parties where all the senses were stimulated in new and unexpected ways (see Marinetti, 1932/2014). These daring events included hosting tactile dinner parties, where the diners would wear pyjamas covered in swatches of different textiles and were instructed to touch each other while eating without the aid of knife and fork(Marinetti, 1932/2014, pp. 170-171). The Futurists even defined a term *"Contattile"* (Marinetti, 1932/2014, p. 231) to describe *"the tactile affinity of a given material with the flavour of a given food"*. For example, the Futurists believed that there was contattile between the experience of eating a banana and the feel of velvet, presumably due to both having a soft texture.

At the multisensory culinary design studio and Gastrophysics Chef's Table at Kitchen Theory in London (https://gastrophysics.co.uk/), hosted by chef Jozef Youssef, diners have, for a few years now, been presented with wooden cubes covered in different materials (velvet, sandpaper, and Velcro). During the dining experience, the guests are told to touch the different sides of the cube while enjoying their food (Bosker, 2015). According to some diners, the elements in the dish tasted saltier and crunchier while touching the rough gritty sandpaper or Velcro, as compared to when feeling the velvety sides of the cube.

Beyond artistic whimsy, however, a recent body of empirical research has demonstrated that the flavour and hedonic evaluation of food and beverages can indeed by influenced by the surface texture of packaging materials (Piqueras-Fiszman & Spence, 2012; Tu et al., 2015), servingware (Biggs et al., 2016; van Rompay et al., 2017), and the food itself (Slocombe et al., 2016). One of the first studies to show that product-extrinsic tactile textures can influence food perception comes from Piqueras-Fiszman and Spence. The participants in their study tasted digestive biscuits and separately yoghurt, from yoghurt containers that had either a smooth or a sandpaper rough outer surface texture. Pieces of biscuit tasted from the pots with a rougher surface feel were rated as crunchier and harder than those tasted from the normal smooth-sided yogurt pots instead. Notably, no such influence was observed when tasting the yoghurt, leading to the suggestion that there may be limiting conditions on the foodstuffs (or food attributes) that may be influenced by tactile influences.

Another recent study involving biscuits was conducted by Biggs and colleagues (2016). In this case, caramelised biscuits were served on two plates of the same shape, one with a rough and grainy surface texture, the other with a smooth and shiny texture instead. Biscuits taken from the rougher of the two plates were rated as crunchier and rougher than those from the smooth plate. In a subsequent study both jelly babies and biscuits were served on textured plates. In this case, the jelly babies were rated as feeling significantly chewier (as opposed to crunchier) when served in the rough plate. (In other words, it seemed as if the rougher feel accentuated whichever textural property was dominant in the food itself.)

Beyond influences on food texture, van Rompay and his colleagues (2017) demonstrated that 3D-printed surface patterns influenced bitterness, sweetness, and taste intensity. Namely, hot chocolate and coffee tasted from a cup with a rounded outer surface pattern were rated as tasting sweeter and less intense than the same beverages when tasted from a cup that had a much more angular outer pattern instead. Conversely, the angular surface pattern increased perceived bitterness and taste intensity when compared to the rounded pattern. Slocombe and colleagues (2016) examined the influence of surface texture on sweetness, bitterness, and sourness of lemon curd. While these researchers failed to observe an influence of plate texture (rough vs. smooth) on the taste of these food samples, they did observe that, when it came to the surface texture of the food itself, samples of flavoured fondant sugar were rated as tasting significantly more sour when it had a rough surface texture as compared to a smooth one.

It has been suggested that sensation transference (e.g., Cheskin, 1957) might help to explain why it is that the product-extrinsic tactile/haptic sensations should influence the rated sensory properties of food. The basic idea here being that a person's thoughts and feelings about any relevant (or attended) product-extrinsic sensory cues (in this case, surface texture) can be carried over to influence their evaluation of some intrinsic property of the product itself (e.g., its mouthfeel or taste). Spence and Gallace (2011) coined the term "affective ventriloquism" to describe those situations in which when sensation transference affects people's hedonic ratings. The fact that touch might induce an emotional response is not unfounded; Physiological measurements of cerebral blood flow have been used to demonstrate that touching samples of fabric and foliage significantly decreased activity in the orbitofrontal cortex (which correlates to a calming response) compared to a metallic sample (Koga & Iwasaki, 2013). Beyond surface texture, haptics-based instances of sensation transference include differences in the weight (Kampfer et al., 2017; Michel et al., 2015; Piqueras-Fiszman et al., 2011), firmness/compressibility (Krishna & Morrin, 2008), and material composition (Piqueras-Fiszman et al., 2012) of packaging materials and cutlery (Welch et al., 2016).

What current research has yet to uncover, however, is the influence of surface texture on aroma.[1] Aroma is a critical component of enjoyment of food and beverages (Auvray & Spence, 2008), comprising of 70-95% of what we think we taste according to popular/scientific estimates (though see Spence, 2015 for a critical evaluation of this claim). Aroma is especially important when it comes to the evaluation of wine. Manufacturers of wine glasses such as Riedel produce a wide array of glasses shapes, citing in-house research that by *"increasing the inner surface area of the glass has a positive impact on the perception of the bouquet and flavour of the wine"* (www.riedel.com, though see also Cliff, 2001; Spence, 2011). Acquiring additional evidence concerning the impact of felt texture on both the aroma and flavour of wine is clearly of growing relevance, especially as 3D printing technology becomes ever more widely available (van Rompay et al., 2017).

The goal of the present study was to assess the influence of external tactile feedback on the wine-tasting experience. Specifically, we wanted to replicate van Rompay et al.'s (2017) result for wine, showing that smooth surface texture enhances sweetness compared to a rougher surface texture. Furthermore, we aimed to separate the process of smelling (orthonasal aroma, as when sniffing) from tasting (involving both gustation and retronasal aroma), in order to determine whether surface texture can impact the aroma of the wine as well as its flavour. Furthermore, we hypothesised that surface texture may also influence the perceived mouthfeel of the wine, via sensation transference (see Spence & Piqueras-Fiszman, 2016).

Preliminary study

[1] That said, Gatti, Spence, and Bordegoni (2014) have previously demonstrated that people rate the fragrance of a hand-washing solution as smelling more intense when presented in a heavier package.

Prior to our main study, a pre-test was conducted at a neuroscience and wine symposium in Barcelona, Spain in order to validate whether touching different materials can indeed influence sweetness perception. During the break of the symposium, a test station was set up with pieces of sandpaper on one end and a long swatch of soft velvety cloth on the other end (see Figure 1). An off-dry Chardonnay wine (Codorniu Viñas de Anna Chardonnay 2016, 13% ABV, 10 g/L residual sugar) was served in opaque black 50 mL plastic cups on both sides of the table. The participants at the symposium were encouraged to taste the wines at either side while touching the material found on the same side of the table with their dominant hand. After tasting each wine, they rated the wine's pleasantness, its flavour intensity and sweetness on 9-point scales. The paper questionnaire dictated the order in which the participants touched the materials, and they were shuffled so that the order of materials would be balanced across participants.

Figure 1. Pretest set-up. Participants at the wine symposium were encouraged to touch the material at each side of the table while tasting the wine in a cup located on the same side of the table.

Forty participants (22 male, 16 female, 2 unreported) completed the questionnaire (13 in the 18-35 years-old age group, 29 in the 35-60 years-old age group). A repeated-measured analysis of variance (RM-ANOVA) revealed a significant effect of tactile material on sweetness ratings ($F(1,38) = 8.35$, $p = .006$, $\eta^2 = 0.09$), with the wine tasted while touching the velvet rated as tasting sweeter than the wine tasted while touching sandpaper ($M_{velvet}(SE) = 5.83(0.19)$, $M_{sandpaper}(SE) = 5.12(0.22)$, $p = .007$).

No significant effect of material was observed on ratings of wine pleasantness ($F(1,38) = 1.32$, $p = .26$) or flavour intensity ($F(1,38) = 3.94$, $p = .055$).

The pre-test validated our initial hypothesis that touching different materials could indeed influence people's perception of wine, especially when it comes to the perception of sweetness (van Rompay et al., 2017). Next, we moved on to the main study, where a more elaborate procedure was used to determine the influence of external haptic information on both the smelling and tasting experience.

Methods

Participants

A total of 60 participants (36 women, 22 men, 2 unreported) aged 23-66 years (M=34.74, SD=10.26) took part in this study. The participants reported their level of wine expertise, with 40 reporting novice, 14 intermediate, and 1 expert (5 failed to respond). The participants were recruited in London via mailing lists and social media. All of the participants gave their informed consent to take part in the study. None of the participants reported a cold nor any other known impairment of their sense of smell, taste, or hearing at the time of the study. The study was approved by the Central University Research Ethics Committee of Oxford University (MSD-IDREC-C1-2014-205).

Tactile stimuli

Swatches of velvet and sandpaper were used. Sandpaper was coarse grade (255 P) and was cut into pieces of approximately 40 x 50 mm. Yellow coloured velvet ribbon was obtained to match as closely as possible the colour of sandpaper and cut into swatches in similar size to the sandpaper (see Figure 2).

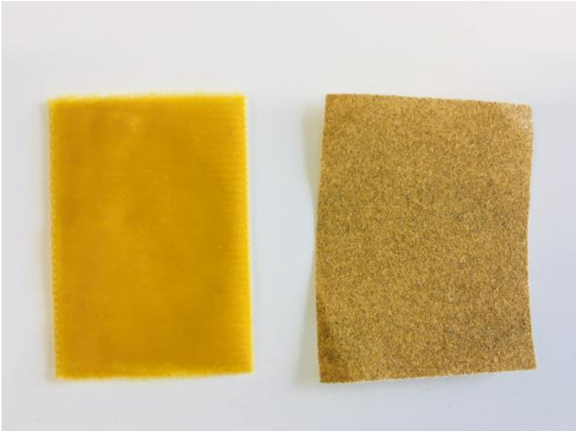

Figure 2. Swatches of sandpaper and velvet used in the present study.

Wine

A red dessert wine, Chateau d'Aydie's Maydie Tannat 2013, was chosen because we wanted to investigate any possible effect of texture on the feeling of astringency in the mouth, which required the wine to have tannins. The wine was produced from old-vine (at least 30 years old) Tannat grape, known for its dark colour and high tannin levels (Robinson & Harding, 2015). Alcoholic fermentation was interrupted by fortification to 17% ABV, leaving 110 g/L of residual sugar in the wine. The wine was served in 30 mL samples.

Design and Procedure

The study was designed with tactile material (sandpaper or velvet) as the within-participant factors. The study was divided into two tasks, an orthonasal olfaction task followed by a tasting task.

Each participant was seated at a table with a paper questionnaire, a swatch of velvet, a swatch of sandpaper, and two glasses of wine. Unbeknownst to the participants, the wines were, in fact, the same. In the orthonasal olfaction task, the participants smelled the two wines, one at a time, while touching either the sandpaper or velvet swatch with their dominant hand. Half of the participants touched the sandpaper while smelling and tasting the first wine, and velvet while smelling and tasting the second wine. The remainder of the participants experienced the reverse order. For each wine, participants rated its aroma intensity, acidity, fruitiness, and pleasantness on a 7-point scale (where 1 = not at all, 7=extremely high).

In the second tasting task, the participants took a mouthful of each wine while again touching either the sandpaper or velvet swatch with their dominant hand. The order of touching each tactile material was the same as for the first orthonasal olfaction task (i.e., if a participants touched sandpaper then velvet in the olfaction task, they also touched sandpaper then velvet for the tasting task). They were asked to rate the wine's acidity, sweetness, tannins, and pleasantness on 7-point scales (for tannin, 1 = very smooth, 7 = very rough).

The experiment lasted for around 15 minutes and the participants were debriefed afterwards.

Data Analysis

A RM-MANOVA was conducted on reported orthonasal aroma data with 'tactile material' as the within-participants factor. The model included aroma intensity, acidity, fruitiness, and pleasantness as measures. A similar RM-MANOVA was conducted on reported tasting data with acidity, sweetness, tannins, and pleasantness as measures. All post-hoc pairwise comparisons were Bonferroni corrected.

Results

To get an overview of how the rating variables are interrelated, Pearson's correlation coefficients were calculated for variables measured during the smelling task (see Table 1) and the tasting task (see Table 2).

Table 1. Pearson's correlation coefficients between different ratings in the wine smelling task. * indicates significance at .05 level, and ** indicates significance at the .01 level.

	Aroma intensity	**Acidity**	**Fruitiness**	**Pleasantness**
Aroma intensity	1.0	0.28 **	0.11	0.03
Acidity	-	1.0	-0.13	-0.35 **
Fruitiness	-	-	1.0	0.52 **
Pleasantness	-	-	-	1.0

Table 2. Pearson's correlation coefficients between different ratings in the wine tasting task. * indicates significance at .05 level, and ** indicates significance at the .01 level.

	Acidity	Sweetness	Tannins	Pleasantness
Acidity	1.0	-0.20 *	0.34 **	-0.10
Sweetness	-	1.0	-0.15	0.10
Tannins	-	-	1.0	-0.05
Pleasantness	-	-	-	1.0

The mean values of the participants' wine ratings for the smell and tasting tasks are shown in Figure 3. In terms of the olfactory task, the RM-MANOVA revealed a main effect of tactile material ($F(4,53) = 2.73$, $p = .039$, Wilks' Lambda = .83). Follow-up univariate tests revealed that tactile material had a significant effect on ratings of fruitiness ($F(1,56) = 10.89$, $p = .002$, $\eta^2 = 0.16$), but not on aroma intensity ($F(1,56) < 1$, *n.s.*), acidity ($F(1,56) = 2.77$, $p = .10$), or pleasantness ($F(1,56) = 3.99$, $p = .051$). Post-hoc comparisons revealed that the wine smelled fruitier when the participants simultaneously touched the swatch of velvet as compared to when touching the sandpaper ($M_{velvet}(SE) = 4.79(0.23)$, $M_{sandpaper}(SE) = 3.98(0.23)$, $p = .002$).

For the tasting task, an RM-MANOVA once again revealed a significant main effect of tactile material type ($F(4,53) = 3.03$, $p = .025$, Wilks' Lambda = .81). Follow-up univariate tests revealed that tactile material exerted a significant influence over sweetness ($F(1,56) = 7.86$, $p = .007$, $\eta^2 = 0.12$) and pleasantness ratings ($F(1,56) = 6.02$, $p = .017$, $\eta^2 = 0.10$), but not over ratings of acidity ($F(1,56) = 1.43$, $p = .24$) or tannins ($F(1,56) < 1$, n.s.). Post-hoc comparisons revealed that the wine tasted sweeter while the participants simultaneously touched the swatch of velvet as compared to when they touched the sandpaper ($M_{velvet}(SE) = 5.83(0.19)$, $M_{sandpaper}(SE) = 5.12(0.22)$, $p = .007$). The wine tasted while touching the velvet was also rated as more pleasant as compared to when touching the sandpaper ($M_{velvet}(SE) = 5.40(0.21)$, $M_{sandpaper}(SE) = 4.97(0.22)$, $p = .017$).

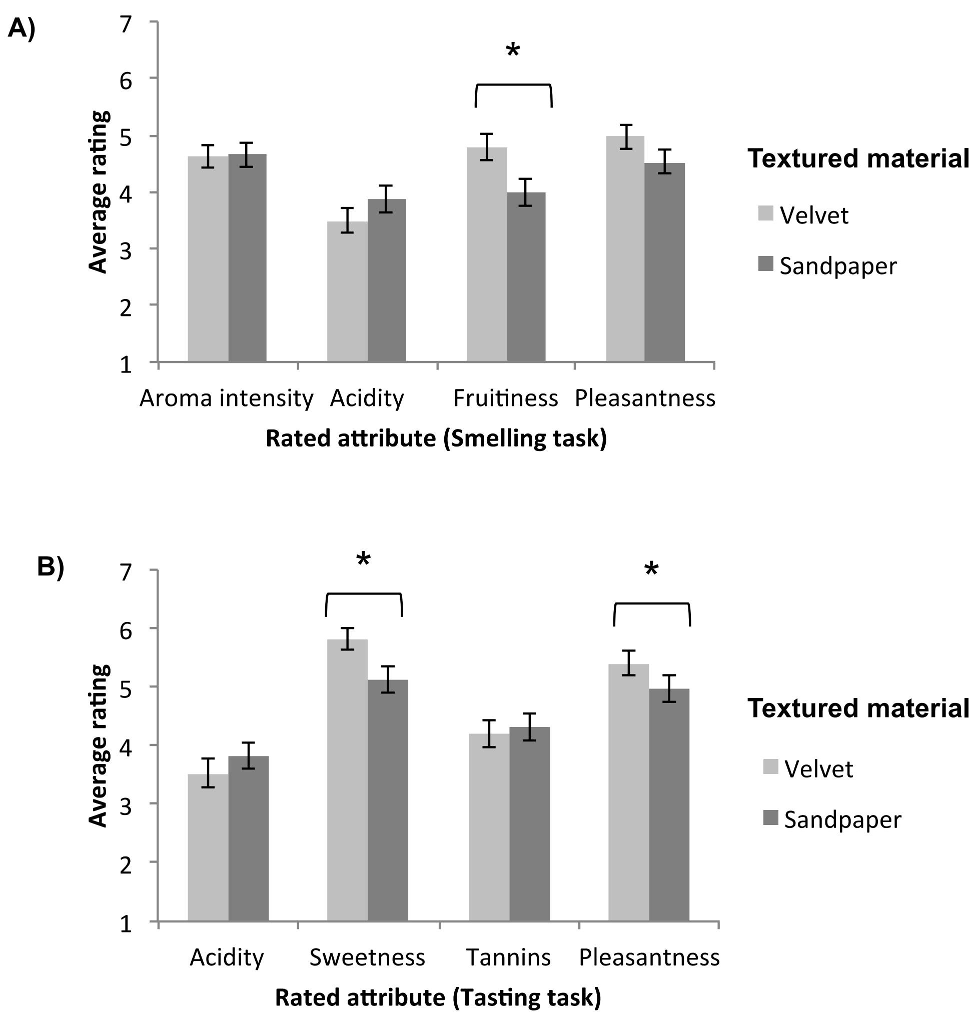

Figure 3. Mean values of ratings from the smell task (A) and tasting task (B) for the fortified Maydie Tannat wine, for both types of tactile stimuli (i.e., velvet and sandpaper). Error bars indicate the standard error of the means. Asterisk '*', indicates statistical significance at p<.05.

Discussion

The results of the present study demonstrate that haptic sensations from touching different surface textures can (at least when attended) influence the wine-tasting experience, both in terms of olfaction and in terms of in-mouth sensations. The wine was rated as smelling fruitier, as tasting sweeter[2] and more pleasant, when the participants touched the velvet as compared to when they touched the sandpaper.

[2] We performed a mediation calculation to test whether the influence of tactile materials on orthonasal olfaction mediated the changes in perceived sweetness on the palate. Mediation analysis was performed using the MEMORE macro for repeated measures (Montoya & Hayes, 2017), using fruitiness aroma

Affective ventriloquism (Spence & Gallace, 2011), a type of sensation transfer effect, provides one theory with which to explain how haptic sensations influence people's wine evaluations, especially when it comes to people's hedonic ratings. Etzi et al. (2014), for instance, demonstrated that people prefer smoother to rougher textures. In fact, the preference for velvet over sandpaper, in this case, might have biased a person's estimates of the quality and pleasantness of the wine itself. This would explain the increased pleasantness ratings on the palate. This might also explain the increased sweetness experienced on the palate, as sweetness is typically rated as pleasant (Steiner et al., 2001).

Interestingly, the surface texture that participants touched did not influence the perception of tannins in the mouth, as had been hypothesised. One possible explanation for this null result is that as 40 out of the 60 participants were self-reported wine novices, i.e., they were not used to assessing the drying sensation of tannins on the palate (Hughson & Boakes, 2001; also see Vidal et al., 2016 on the complexity of tannin evaluation). Instead, the evaluation of pleasantness and basic tastes (sweetness, acidity) may have taken precedence and thus any changes in mouthfeel might have been overlooked. This illustrates the need for future studies to focus on the role of individual differences, such as expertise. It is plausible that wine experts, who are more attuned to subtle differences in tannic mouthfeel, might experience greater differences in mouthfeel due to external tactile influences.

One limitation of the present study is the lack of ecological validity in the way we incorporated texture into the drinking experience. It is, of course, a rather artificial exercise to ask participants to touch a swatch of sandpaper or velvet with one hand at the same time that they taste wine (though being true to the Futurists; see Marinetti, 1932/2014). Instead, it would have been a more natural experience for the participants had we been able to manipulate the texture of the drinking receptacle themselves (for instance, wrapping strips of sandpaper or velvet around the stem of wine glasses). This practice has already been used successfully by cocktail makers such as Tony Conigliaro of 69 Colbrooke Row (Spence, 2017a). Alternatively, participants could have been given smooth and rough textured napkins along with the wines, although

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ratings as the mediator, texture material as the independent variable, and sweetness as the dependent variable. We did not find a significant indirect effect of tactile texture on sweetness perception through fruitiness (R^2 = .056, F(2,55) = 1.64, p = .20). In other words, there was no evidence that that the enhanced fruitiness aromas (due to haptic feedback) influenced sweetness perception in the mouth.

that would introduce the issue of ensuring that participants interacted with the napkins in a consistent manner (some people might not even use the napkin). For the most natural approach, it should be kept in mind that while most wine glasses have rounded stems, there do exist wine glasses with angular/ridged stems. It would be interesting to replicate the current study with these different types of glasses, where the different textures are naturally built into the glass and participants' attention wouldn't be drawn to artificial interventions like clearly altered glassware.

In summary, the results of the present study demonstrate for the first time that 'sensation transference' from the haptic feedback of surface texture can apply to orthonasal olfaction as well as to the taste and hedonics of foodstuffs. This has implications for those in the hospitality and food packaging industries, for example, for those designing specialty glassware (e.g. Riedel). In addition to altering the bowl size of different glasses to best suit different types of wine, the width and texture of the glasses stem could also be altered, for instance, using a rough-textured stem to tone down the heady overripe fruit notes found in some warm climate red wines (e.g. Barossa Shiraz). The rising popularity of bowl foods (Baraniuk, 2016) also gives creative designers an opportunity to experiment with texture-flavour interactions, especially if people are eating while holding the bowl in one hand (see Spence, 2017b). Furthermore, with utensils, textures can be incorporated to stimulate touch in the hand (via the handle) and in the mouth (via the tines in a fork or the head of the spoon) at the same time. Such textured utensils could stimulate touch at two places, which might give a greater combined effect – imagine a dessert spoon with a velvety handle and smooth bowl, which is designed to enhance sweetness in foods (see Spence, 2017b; Welch et al., 2016, for some examples along just such lines). Such utensils can be used as part of healthy eating interventions (e.g., sold with low-sugar yoghurts or ice cream), to help maintain consumer satisfaction with reduced-sugar alternatives.

As a next step, studies needs to apply the present results to a more integrated context – for instance, by applying varying surface textures to the stem of a wine glass say – to assess the applicability of surface textures in terms of altering the wine-tasting experience. Alternatively, given the estimated third of beverages that are consumed directly from their packaging, it might be as easy to alter the consumer experience by changing the surface feel of cans and bottles rather than replacing all of one's stemware (see Gallace & Spence, 2014; Spence, in press). Looking back, the Italian Futurists were indeed ahead of their time, and it might not be too long before products whose packaging share *Contattile* with their contents start appearing on the supermarket shelves.

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