RUNNING HEAD: DRINKING VESSELS FOR COFFEE

**Assessing the influence of the coffee cup
on the multisensory tasting experience**

Charles Spence¹ & Fabiana M. Carvalho²

1. Crossmodal Research Laboratory, University of Oxford
2. Department of Food and Nutrition, School of Food Engineering, University of
Campinas, Brazil

WORD COUNT: 10,350 WORDS

RESUBMITTED TO: *FOOD QUALITY & PREFERENCE*

DATE: MARCH, 2019

CORRESPONDENCE TO: Prof. Charles Spence, Department of Experimental Psychology,
Anna Watts Building, University of Oxford, Oxford, OX2 6GG, UK. E-mail:
charles.spence@psy.ox.ac.uk

ABSTRACT

This review summarizes the latest evidence concerning the impact of the colour, shape, texture, weight, and other material properties of the drinking receptacle on the perception of coffee. The colour of the cup, for instance, has been shown to prime notions of sweetness (e.g., pink cup) or acidity (e.g., yellow or green cup) that may carry over to influence the tasting experience. Meanwhile, the shape and surface feel of the drinking vessel have also been shown to exert a profound influence over the perceived aroma/taste of coffee. Given that the various sensory attributes of the drinking vessel can exert such a striking influence over the drinking experience, the challenge, moving forward, is to optimize the design of the receptacle in order to enhance the multisensory tasting experience for the consumer. Given that different styles/varieties of specialty coffee have different dominant/desirable qualities (e.g., acidity/sweetness), in the future, the design of coffee cups may need to be customized for different coffee drinking experiences (e.g., origin or roast), much as seen in the world of fine wine (with different glasses for different grape varieties).

KEYWORDS: COFFEE; DRINKING VESSEL; AROMA; TASTE; FLAVOUR; COLOUR; TEXTURE; SHAPE; WEIGHT.

Introduction

Despite the global popularity and consumption figures for coffee (e.g., see SCA 2017a, b), there has been remarkably little research on the drinking vessel. According to Ernesto Illy (2002), for instance, writing in *Scientific American*, by the year 2000, 400 billion cups of coffee were being consumed each and every year around the world. It is therefore surprising to find how little published research there has been given the range of coffee drinks, the widespread emergence of speciality coffee culture around the world, and the fact that coffee, or at least specialty coffee (e.g., Rhinehart, 2009), is chemically complex containing something like 1,200 volatiles (Clarke, 2013; see also Caporaso, Whitworth, Cuic, & Fisk, 2018; Illy, 2002; though see Spence & Wang, 2018, on the complex relationship between chemical and perceived complexity).

Given coffee's global popularity, and given the explosion of coffee culture in recent years (e.g., Luttinger & Dicum, 2006), it seems bizarre that there has been so little interest in the science of the drinking vessel from which all that coffee is consumed. Currently, this globally popular beverage is consumed from a wide range of different receptacles, that vary in terms of their size, weight, shape, material properties (i.e., compressibility; cf. Krishna & Morrin, 2008), colour, texture, etc. Furthermore, in certain markets, and at certain points in time, there have also been unusual rituals around the consumption of coffee. One such example comes from the historic Finnish approach of pouring coffee onto the saucer from the cup and drinking from there, undoubtedly helping both to cool the drink and perhaps also to accentuate, or certainly to modify, the orthonasal olfactory contribution to the tasting experience. (Although little practised today, there are certainly still a few older Finns who recall a time when such a practice was reasonably commonplace; see e.g., https://www.reddit.com/r/TheWayWeWere/comments/7zxipa/women_drinking_coffee_from_saucers_ca_1930_finland/.)

Why drinking vessels influence the tasting experience

In terms of the theoretical framework underpinning this area of research, one might want to ask why it is that the sensory properties of the drinking vessel should influence people's perception of the contents as much as they do. The influence of the receptacle on the taste/flavour of the contents can be broken down into potential physico-chemical and psychological influences, both of which are potentially important. In the world of fine wine, there is much discussion

(and measurement) of the composition of the aromatic volatiles in the headspace over the liquid (the wine that is; e.g., Liger-Belair, 2005; Liger-Belair, Bourget, Pron, Polidori, & Cilindre, 2012; see also Rahman, 2014). Physicists and chemists stress the importance of maximizing the surface area of the liquid in the glass while reducing the aperture at the lip of the glass in order to try and keep as much of the volatile-rich air in the glass as possible. In fact, across a number of studies, higher aroma intensity ratings have been shown to correlate positively with serving glasses where the ‘maximum diameter/opening diameter’ ratio (D-ratio) is highest (e.g., Fischer, 1996; Fischer & Loewe-Stanienda, 1999; Parpinello, Meglioli, Ricci, & Versari, 2018; see also Manska, 2018). On the other hand, it is also important to highlight the fact that if the aperture of the receptacle becomes too narrow then the taster’s nose will no longer fit into the glass while they are tasting with their lip on the receptacle’s rim. This will obviously make it difficult, if not impossible, to sniff the odour orthonasally while simultaneously tasting. Note, though, that the challenges around the release of desirable volatiles is likely to be more pronounced in the case of a wine, served at low temperature (in an alcoholic substrate), than for a water-based coffee, normally served hot. By contrast, the challenges may be more with how to retain the aromatic volatiles coming off the surface of a hot drink, such as coffee. Indeed, the increased volatility of the aroma molecules in the case of a hot beverage will presumably simply make it much harder to retain them in the headspace of the drinking vessel, regardless of the shape that the vessel may have. On the other hand, the addition of a foamy milk head to a cappuccino, or the crema on the espresso, suppresses the release of volatiles from the liquid’s surface, capturing them in the aerated bubbles, and thus potentially improving the drinking experience at the moment of consumption.

It is important to note that we rarely taste anything without first having made a prediction about what that drink will taste like first, and whether or not (and how much) we expect to like the experience (see Piqueras-Fiszman & Spence, 2015, for a review). These expectations then anchor the tasting experience when we subsequently come to evaluate the drink itself. If the tasting experience is close to the expectation then we tend to live very much in the world of our expectations. However, should the tasting experience be too far removed from the expectation then we may well experience a negatively-valenced disconfirmation of expectations response (Schifferstein, 2001). Sensory and hedonic expectations are likely generated by the sensory properties of the coffee itself – think colour (e.g., Little, Chichester, & Mackinney, 1959; and see Wan, Zhou, Mu, Du, Velasco, Michel, & Spence, 2014, on tea colour) as well as any other visual appearance cues, and by the orthonasal aroma. Our

expectations concerning the taste/flavour and quality of a beverage are however also determined, both consciously and unconsciously, by a host of other sensory cues. These cues include everything from the colour or the drinking vessel through to the environment in which we happen to be drinking (Gal, Wheeler, & Shiv, 2007), not to mention the brand of coffee itself, assuming that we have been made aware of it (e.g., Martin, 1990; Sakai, 2014). In fact, even the sound of the coffee machine has been implicated in helping to set people's coffee expectations (Knöferle, 2012), as has the genre and sonic properties of the music playing in the background (Gater, 2010; Spence, 2017b). Furthermore, any descriptive/semantic information (Fenko, de Vries, & van Rompay, 2018) that may be provided, as well as the coffee's ecological credentials (e.g., Sörqvist, Hedblom, Holmgren, Haga, Langeborg, Nörtl, et al., 2013) can also influence people's ratings. It is currently an open question as to whether drinking tea from a cup that says Starbucks Coffee is a less pleasurable experience, because it is a little harder to process. The experience may, in other words, be less fluent (see Reber, Winkielman, & Schwartz, 1998).

One psychological notion that may be relevant here is 'sensation transference'. According to researchers, what we think or feel about one stimulus, may be transferred, at least in part, to what we think about another (e.g., Cheskin, 1957; see Skaczkowski, Durkin, Kashima, & Wakefield, 2016, for a recent review). Hence, if we happen to like the cup that we are drinking from, or feel that it is high-quality, these attributes may well carry-over to influence what we think about the coffee should we be asked to rate it (Masson, Delarue, Bouillot, Sieffermann, & Blumenthal, 2016). In terms of the expectations set by the drinking receptacle, Van Doorn, Woods, Levitan, Wan, Velasco, Bernal-Torres, and Spence (2017) conducted an online study showing that the various different shapes of coffee cup, shown visually, were associated with quite different expectations in the minds of the consumers taking part (see **Figure 1**). As we will see below, the colour of the cup can also prime specific taste expectations (e.g., see Carvalho & Spence, in press; Schifferstein, 2009).

INSERT FIGURE 1 ABOUT HERE

Multisensory contributions to flavour perception

At the outset, it is important to note that the desirable taste of coffee itself results from the integration of multiple cues including gustatory, olfactory, and oral-somatosensory components (e.g., Heath, 1988; Navarini, Cappuccio, Suggi-Liverani, & Illy, 2004; see Spence,

2015a, for a review). Olfactory cues, specifically retronasal olfaction, has been suggested to contribute the majority of what people commonly consider to be the pleasurable taste (see Spence, 2015b, for a review of the evidence underpinning this particular claim). Anecdotally it has been observed that the aroma of coffee is often rated as more pleasurable than its taste (e.g., Ge, 2012; Rozin, 1982). That is orthonasal olfaction this would seem to be a key element in the total experience. The ambient smell of coffee has also been reported to exert a noticeable effect on consumer behaviour (see Spence, 2015c; though see also Forster & Spence, 2018). No surprise, then, that a number of companies have been working in recent years to improve the availability of coffee aroma by modifying the design of coffee cup lids (see Spence, 2017, for a review). So, for instance, this goes all the way from simply adding aroma holes in the middle of the lid through changing the surface profile to provide a little headspace (see, for example, the Viora lid; <https://www.vioralid.com/>).

As mentioned already, the coffee beverage is highly complex in terms of its aromatic volatile composition (e.g., Sunarharum, Williams, & Smyth, 2014). Furthermore, it turns out that this perceptually complex olfactory experience represents a domain of experience that is particularly rich in crossmodal associations, for instance, in the realm of shape and sound correspondences (see Deroy, Crisinel, & Spence, 2013, for a review). This means that the majority of people, surprising as it may seem, will match, or associate, particular odours with certain specific geometrical shapes or class of sounds. Sweet notes in the coffee, for instance being associated with rounder shapes, while bitter notes are associated more with angularity (cf. Crisinel, Cosser, King, Jones, Petrie, & Spence, 2012). Furthermore, congruent (as compared to incongruent) combinations of odour and visual/auditory stimuli have been shown to enhance recognition performance (e.g., Demattè, Sanabria, & Spence, 2009) as well as people's ratings of perceived intensity and pleasantness (Seo & Hummel, 2011; Zellner & Whitten, 1999). Thus, the complex aromas of specialty coffee are likely to be influenced (psychologically-speaking) by a number of product-extrinsic cues, including the sensory properties of the drinking receptacle. Crossmodally congruent features could potentially be used to improve the overall drinking experience when consuming coffee, perhaps by drawing the taster's attention to something in their tasting experience that they like/appreciate, and hence making it more salient to them.

Research on the psychological impact of the physical properties of the receptacle

Below, the evidence concerning a number of the physical attributes of coffee receptacles that have been studied to date is reviewed.

Cup colour

Several studies have demonstrated that the colour of the cup biases people's expectations and thereafter on their experience of milk-based coffee beverages. For instance, Van Doorn, Willemin, and Spence (2014) reported that the colour of the cup matters in the case of café latte. In particular, Van Doorn, et al. conducted a pair of studies in Australia demonstrating that a hot milky coffee drink (i.e., a café latte) was rated as having a flavour that was more intense when it was served in a white ceramic mug than from a clear glass beaker, or else a blue mug (Experiment 1). In a second experiment, serving the hot beverage in a transparent glass with a white rubber sleeve led to it being rated as tasting less sweet than when the same drink was served in a clear glass or a glass with a blue-sleeve instead (see **Figure 2**). By contrast, no significant influence of the colour of the drinking vessel was reported on any of the other dependent measures (e.g., sweetness, aroma, bitterness, quality, or acceptability). To date, two possible explanations have been put forward for such colour-based effects on tasting. According to one account, colour sets expectations/primes specific taste/flavour properties based on the crossmodal correspondences (see Spence, in press). By contrast, according to a second account, colour (e.g., of a coffee cup) may influence the taste of a drink by changing the drink's visual appearance properties via colour contrast (e.g., Ekroll, Faul, & Niederée, 2004; Hutchings, 1999; Lyman, 1989; see Spence, 2018, for a review).

INSERT FIGURE 2 ABOUT HERE

Carvalho and Spence (in press) recently conducted a series of three experiments with social (i.e., non-expert) specialty coffee drinkers in coffee shops in Brazil. A total of 457 participants were given brewed or espresso specialty coffee to taste. The coffee either had high acidity (Kenyan) or high sweetness (Brazilian), and was served in one of four cups whose outer surface had been painted pink, green, yellow, or else less left white (see **Figure 3**). Note that the inner colour of the cup was white, in order to minimize the impact of any change in the colour contrast (between the coffee and the inner surface of the cup; Lyman, 1989; Spence, 2018) on the perceived appearance properties of the coffee. The participants first rated their expectations of sweetness and acidity of the drink, and subsequently, their experience of those attributes on tasting the coffees, as well as rating their liking. Note here that participants were given no

information about the nature of the coffee that they were going to taste. Crucially, the colour of the cup exerted a significant influence on both pre- and post-tasting ratings for all of the attributes measured. Prior to tasting, the colours pink and green were associated with sweetness and acidity, respectively, whereas yellow was associated with both tastes. In the post-tasting phase of the study, the participants were exposed both to congruent (pink/sweet) and incongruent (green and yellow/acidic) pairings of the colour of the cup and coffee flavour profile. Interestingly, liking ratings significantly decreased in the incongruent pairing conditions – which also increased the unexpected acidity (based on participants' ratings of expected acidity) of the Kenyan coffee when tasted from the pink cup.

INSERT FIGURE 3 ABOUT HERE

Results such as these might be taken to suggest that the participants may have transferred the experience of the pinkness of the cups (or rather, their intuitions about pink foodstuffs being sweet; see Spence, Wan, Woods, Velasco, Deng, Youssef, & Deroy, 2015) to their judgments of the drinking vessels themselves. Moreover, the colour of the cup was shown to significantly impact not only sensory but also hedonic judgements of specialty coffee. At the same time, however, it is also worth noting that by keeping the colour on the inside of the cup constant (white), and by manipulating only the outer surface, a foreground-background colour combination was created that may help to prime a specific taste even more effectively than either of the component colours when presented individually. Along just these lines, Woods, Marmolejo-Ramos, Velasco, and Spence (2016) demonstrated that people categorize pink on white as sweet more consistently (and somewhat more rapidly) than they do the best of the component colours (i.e., either pink or white).

The association between the pink colour of the drinking receptacle and sweetness documented by Carvalho and Spence (in press) extends the findings reported a decade ago by Schifferstein (2009). In particular, Schifferstein had his Dutch participants (20 participants in each condition in his Experiment 2) evaluate the experience of various drinking receptacles when empty, while other groups of participants analysed the drinking experience when the drinking receptacles were part-filled with warm tea or a chilled soft drink (7-Up). Four of the receptacles in this study had a pinkish hue and one was transparent. While the material of the receptacles also varied, the key point to note here is that the participants' ratings of the sweetness that they associated with the transparent receptacle was significantly lower than for any of the pinkish cups. Schifferstein (2009, p. 273) concluded that: "*participants may have combined the*

sweetness of the drink with the ‘experienced sweetness’ induced by the pinkness of the cups in their judgments.” However, that said, it should be noted that in a subsequent study, Schifferstein, Smeets, and Hallensleben (2011) went on to demonstrate that the same descriptors might be interpreted somewhat differently as a function of the particular context in which they happen to be presented. Given that the latter study was conducted with separate groups of participants assessing drinks or drinking receptacles (cups), the key point to note here is that one should be cautious in interpreting the results of between-participants studies such as that reported by Schifferstein (2009). One other point to note in relation to Carvalho and Spence’s (in press) study is that by explicitly having their participants consider the taste that they associated with the cup colour, this may somehow have imbued the cup colour with a meaning, or relevance, that it might perhaps not normally have if one simply picks up a coloured cup of coffee.

Elsewhere, Dichter (1964) reported a study in which the impact of the colour of the pot from which coffee was served on people’s perception of the taste/aroma was assessed. Two hundred North Americans were given four cups of coffee to compare and evaluate (see Favre & November, 1979, p. 64, for a summary of the results). Each cup of coffee was served from a pot having a different colour (brown, red, blue, and yellow). According to the results, 73% of those tested reported that the coffee served from the brown receptacle was ‘too strong’; 84% of the female participants suggested the coffee served from the red pot to be rich and full-bodied; The aroma of the coffee from the blue jar was rated as having a milder aroma; And the coffee in the yellower container seemed to come from a weaker blend. However, the coffee was the same in all cases. Once again, therefore, these results add to the growing literature illustrating the widespread impact of (product-extrinsic) colour on taste/flavour perception. That said, it should be stressed that the latter study lacks methodological details and, what is more, no statistical analysis of the findings were reported. Hence, caution should be exercised when extrapolating from Dichter’s early findings (see **Table 1** for a summary of research that has investigated the impact of drinking receptacle on people’s ratings of coffee).

INSERT TABLE 1 ABOUT HERE

Guéguen and Jacob (2012) had 120 French participants taste coffee from four different coloured cups (blue, green, red, and yellow) and indicate which coffee was warmest (in terms of its temperature): 38% of participants rated the coffee served in the red cup as the warmest, followed by yellow (28%), green (20%) and, finally, the blue cup (13%). Note that such results

are consistent with other findings highlighting the existence of a crossmodal correspondence between colour and temperature (e.g., see Ho, Van Doorn, Kawabe, Watanabe, & Spence, 2014). These results are also in line with a broader literature on the impact of drinking receptacle on a variety of drinks including everything from water to hot chocolate (e.g., Piqueras-Fiszman & Spence, 2012a; Risso, Maggioni, Olivero, & Gallace, 2015).

Other visual appearance cues

As far as sight is concerned, the main attribute of an espresso cup is its foamy crema. In the typical espresso coffee cup serving of 25-30 mL, crema represents at least 10% of the total volume. Despite sharing several characteristics with other food foams like beer foam, the espresso coffee crema contains solid coffee cell-wall fragments which gives it sensory characteristics that are highly complex (see Illy & Navarini, 2011). The formation and stabilization of crema on espresso coffee is very important since it contributes to the aroma intensity of the cup (D'Agostina, Boschini, Bacchini, & Arnoldi, 2004). It also provides an indicator of under- or over-extracted espresso coffees. Overextraction is a technical term that is used to describe what happens with increasing extraction time (e.g., > 30 seconds for espresso). According to Illy (2002, p. 90), writing in *Scientific American*, cell wall fragments (solid materials) make their way into the crema, along with less desirable aroma notes, thus potentially reducing the pleasantness of the tasting/drinking experience. In addition to the sensory perception of espresso, crema also exerts a major impact on the consumers' hedonic experience (Labbe, Sudre, Dugas, & Folmer, 2016). Thus, transparency may be good for the drinking vessels used to serve espresso as it will presumably help to draw the taster's attention to the quality of the crema. As a case in point of this approach, one only needs to look at all the advertising for Nespresso (Kuehlwein, 2017) or the Illy espresso Nude series (<https://www.matteothun.com/project/117/espresso-cup-nude-for-illy>).

In addition to aesthetics, it is worth noting that Pyrex glass is also the most suitable cup material as far as the ability to maintain the warmth of the beverage for longer, when compared to porcelain and ceramic cups, for example. It is the material with the lowest thermal conductivity (1.1 W/mK, against 2.1 W/mK for porcelain and 3.8 W/mK for ceramic) and with similar specific heat transfer values to the other two materials (728 J/kgK against 753 J/kgK for porcelain and 782 J/kgK for ceramic; see <https://thermtest.com/materials-database>). Nespresso has recently introduced a range of three short-stemmed, heavy-based crystal glasses (created

by Riedel) especially for their coffees. The Reveal Range (with one glass for intense espresso, one for mild espresso, and one for café lungo) of glassware is supposed to optimize the consumers' perception of the multisensory flavour (<https://www.nespresso.com/nl/en/reveal-accessories-collection>). The website explicitly draws attention to the various sensory elements of the tasting experience (and can be seen as drawing the analogy with what happens in the world of wine tasting; just take the following quote that appears there: *"The ritual of coffee invites you to first see, then smell and lastly taste your coffee. The crystal glass' transparency fulfills your eyes; the aromas are directed onto your palate to satiate your nose and your ears awaken to the resonance of this lasting, quality material."*).

Elsewhere, in an intriguing development in the world of digital technology, Okajima and his colleagues in Japan have developed augmented reality software that now allows one to virtually add milk to a cup of coffee. The rendition of the milky appearance of the coffee in this case is highly realistic (see Ueda, Masuda, & Okajima, 2014). It will be interesting in future research to investigate what effects the addition of such virtual milk will have on the consumer's experience on tasting the coffee. Use of angular shapes on the side (or even inside) of the cup itself may also be used to prime notions that the coffee will taste bitter (see Van Doorn, Colonna-Dashwood, Hudd-Baillie, & Spence, 2015). This suggestion builds on research concerning the crossmodal correspondences that are now known to exist between shape properties and taste (see Spence, 2012, for a review; and Turoman, Velasco, Chen, Huang, & Spence, 2018, for recent findings).

Texture

That the texture of the drinking receptacle should exert an influence over the tasting experience, while surprising, is nevertheless entirely consistent with a number of other recent studies that have demonstrated the impact of feeling sandpaper vs. velvet-like textures on the perception of the biscuitiness and pungency (i.e., gingeriness) of biscuits (Biggs, Juravle, & Spence, 2016; Piqueras-Fiszman & Spence, 2012b), not to mention the taste/aroma of wine (Wang & Spence, 2018). Such findings also fit with the early intuitions of the Italian Futurists when writing about 'syn-tactilismo' (e.g., see Marinetti, 1932/2014). A priori, one might expect that the rough texture of the drinking vessel would help draw the taster's attention to the rough tannins that may be present in the coffee (Savolainen, 1992).

Carvalho, Moksunova, and Spence (in preparation) recently conducted three studies with coffee experts (Q-graders) and amateur consumers in Brazil and Russia (229 participants in total) to test whether the feel of sandpaper (Experiment 1 – preliminary study) or the roughness of the finish of a bulbous ceramic cup (vs. a smooth one – Experiments 2 and 3) (see **Figure 4**) would impact ratings of olfactory, gustatory, and oral-somatosensory attributes. The results of these experiments demonstrated that haptic sensations from touching rough surface textures did indeed influence the coffee tasting experience, both in terms of basic tastes and mouthfeel, albeit with no difference in aroma ratings in this case. Overall, all of the various coffees that were served in this study were perceived as being significantly drier or rougher in the aftertaste when the participants touched a rough surface (sandpaper or rough ceramic cup) instead of not touching the sandpaper or holding the smooth ceramic cup instead. The coffee was also rated as more acidic from the rough cup by Q-graders, and sweeter from the smooth cup by amateur consumers. However, given the paucity of the literature in the area of surface textural effects on the multisensory tasting experience thus far, this research is a little more exploratory in nature (though for a more hypothesis-led approach see van Rompay & Groothedde, 2018; Van Rompay, Kramer, & Saakes, 2018). Nevertheless, it is interesting to see how some innovative plateware designers are already starting to take these insights concerning the role of felt texture on board in their commercial designs (e.g., NEFF Press, 2018).

INSERT FIGURE 4 ABOUT HERE

Shape and size

Carvalho and Spence (2018) recently demonstrated that the shape of the cup influences aroma, taste, and hedonic judgements of specialty coffee. 276 participants were tested at a specialty coffee event in Brazil. The participants were divided into three testing groups according to the shape of the cup in which the coffee was served (tulip, open, or split; see **Figure 5**). Tasters evaluated their experience of the aroma, sweetness, acidity, and liking of the coffee. Multivariate analysis of variance was conducted in order to determine the effect of cup shape on sensory and hedonic ratings, and whether expertise modulated these ratings. Both amateurs and experts judged: (1) the aroma to be significantly stronger in the tulip cup, and (2) the sweetness and acidity to be significantly more intense in the split cup. The tulip cup was the one with the highest ‘D-ratio’ (defined as the ratio of maximum diameter to opening diameter), which indicates that the physical properties of the receptacle do indeed play a role when it

comes to the perception of complex odours, in both wine and specialty coffee. According to the wine literature, there is a positive correlation between the perceived aroma intensity and the D-ratio (see Spence & Wan, 2015, 2016, for a review). The split cup was the roundest cup tested, and round shapes have been shown to influence both expectation and the actual perception of sweetness in different foods and drinks (see Velasco & Spence, 2019).

INSERT FIGURE 5 ABOUT HERE

Interestingly, however, the split cup received the lowest liking scores from the amateurs, but not from the experts. Assuming that enhanced sweetness and acidity perceived in the split cup was not related to the unpleasantness of the coffee itself (given the experts' ratings), a plausible explanation for this result is that the split cup might have been perceived as an unusual drinking receptacle for coffee. In fact, consumers typically tend to prefer more typical designs because of the ease with which they can process them. Design typicality is a stimulus-inherent determinant of perceptual fluency, with high levels of novelty leading to lower pleasure (e.g., Landwehr, Wentzel, & Herrmann, 2013).

Taken together, Carvalho and Spence's (2018) results demonstrate that the shape of the cup significantly affects the perception of the sensory attributes of specialty coffee, in both amateur and expert consumers. Such results are consistent with a small but growing body of research suggesting that the shape of the receptacle can influence the perception of a range of beverages beyond the world of wine (e.g., Cavazzana, Larsson, Hoffmann, Hummel, & Haehner, 2017; Mirabito, Oliphant, Van Doorn, Watson, & Spence, 2017; Van Rompay, Finger, Saakes, & Fenko, 2017; and see Cliff, 2001; Hummel, Delwiche, Schmidt, & Hüttenbrink, 2003; Venturi, Andrich, Sanmartin, Taglieri, Scalabrelli, Ferroni, & Zinnai, 2016, on the shape of the wine glass). That said, it should be noted that simply changing the shape of the drinking receptacle does not always change the taste/flavour of a drink (see Machiels, 2018, for one such recent partial null result). The question, moving forwards, is therefore to identify which specific features of the shape gave rise to this effect, and to determine the relative contribution of psychological to physico-chemical influences on the consumer's tasting experience. While, until recently, researchers interested in the influence of the shape of the drinking vessel on tasting have had to rely on designs that have been created by designers, the emergence of 3D printing is now starting to enable more researchers to move more toward hypothesis-led drinking vessel shapes.

We are not aware of any research specifically on the size of the cup for different serves of coffee. Generally-speaking, though, depending on the serve, the cup should either be filled (as in the case of a cappuccino), or else not (e.g., in the case of an espresso). Nevertheless there would appear to be norms for the size of the cup depending on the particular serve of coffee. Having said that, one online study did assess the influence of the size (and shape) of the cup on people's coffee flavour expectations (Van Doorn et al, 2017; see **Figure 1**). The size of the cups presented visually in this study could vary in terms of their height (tall vs. short), diameter (wide vs. narrow), and the thickness of rim (thick vs. thin). Both shorter cups and cups with a narrower diameter were associated with (that is, led to expectations of) more bitter, more aromatic, and more intense coffees. In addition, those cups with a wider diameter were associated with sweeter-tasting coffees.

Weight

While we are not aware of anything having been published specifically in the world of coffee, it is certainly true that in a range of other food and beverage categories, heavier is normally equated with better (i.e., be it more expensive, better quality, and/or more satiating; e.g., Piqueras-Fiszman & Spence, 2012c; though see also Lin, 2013). For example, Kampfer, Leischnig, Ivens, and Spence (2017) reported on a couple of experiments in which they added a small weight to the underside of various examples of product packaging (e.g., a box of chocolates). Most relevant to current concerns, these researchers added a 60-gram weight to the underside of cans of fizzy soft drink. The participants in this study had to pick the can up (note that this was a between-participants study), open it, take a sip of the contents, and then rate the taste of the contents. The participants rated the unbranded cola drink from the heavier can as tasting better than from the lighter (see Maggioni, Risso, Olivero, & Gallace, 2015, for similar results concerning the impact of a heavier cup on people's rating of sparkling water; cf. Gatti, Spence, & Bordegoni, 2014, for work on fragrance intensity perhaps akin to orthonasal odour judgments in the world of coffee).

Coffee receptacles that modify the tasting experience

Having demonstrated the profound effect that the sensory properties of the drinking vessel can have on the experience of both social coffee drinkers and on the experience of coffee experts,

the follow-up question then becomes one of how the design of the drinking receptacle can be modified in order to enhance specific elements of the coffee drinking experience. Here, though, it is important to stress that given the variety of beans, post-harvest processes (Schwan, Silva, & Batista, 2012), *terroir* (Barbosa, Borém, Cirillo, Malta, Alvarenga, & Alves, 2012), roasting methods (Fisk, Kettle, Hofmeister, Virdie, & Silanes Kenny, 2012), and preparation procedures, there is unlikely to be a single cup design that will optimize the tasting experience of all coffees (not to mention for all tasters). Rather, in the future, for a particular serve, say filter coffee, one could imagine the development of a range of drinking vessels targeted at optimizing the taster's experience of specific taste, aroma, flavour, or oral-somatosensory (i.e., mouthfeel) properties in the drink. At this point, of course, another question that crops up concerns just how many different receptacle types would be needed for each serve of coffee. There are obviously limits to what might be considered practical in this space.

What are the attributes that are especially prized by people in the world of specialty coffee? The intensity and balance between the non-volatiles (i.e., organic acids and sugars) and volatiles (i.e., aromatic compounds) extracted in-cup impacts the flavour composition of the beverage as well as its perceived quality. Despite sensory perception, and hence consumer preference, being to a certain extent subjective (Geel, Kinnear, & De Kock, 2005), high quality coffee should undoubtedly contain positive/pleasant aromas as well as distinguishable acidity and sweetness, stemming from the presence of fruit acids and sugars (Buffo & Cardelli-Freire, 2004; Lingle, 1986; Xu, 2003). The positive aromas will impact both orthonasal (dry and wet aromas) as well as retronasal (flavour) perception. In addition to the olfactory and gustatory attributes, the mouthfeel (or body) is also a determining factor of coffee quality. Mouthfeel is an oral-somatosensory sensation, and has two distinct aspects, namely weight and texture, which are correlated with the non-volatile components of the beverage. Finally, these various aspects of the coffee must be in balance, that is, they must work together and complement each other (rather than contrast with each other), be it in terms of intensity or quality (Lingle & Menon, 2017; Yeretizian, 2017).

There has understandably been a lot of work developing a coffee vocabulary (e.g., Seo, Lee, & Hwang, 2009; see also Calviño, Zamora, & Sarchi, 1996). Indeed, just as in the world of wine, coffee has its own flavour wheel (see Spencer, Sage, Velez, & Guinard, 2016; see also Gupta, 2016). Across a range of categories, from wine to water, describing the specific attributes has been shown to change the way in which those attributes may be experienced by consumers. At the same time, however, there is undoubtedly still further work to be done in relation to the

language of coffee when talking to consumers (e.g., to the non-expert; Croijmans & Majid, 2016; International Coffee Organization, 2002; World Coffee Research, 2016).

There are also important cross-cultural and individual differences in terms of people's coffee preferences (e.g., Van Doorn et al., 2017) and reasons for consuming coffee in the first place (see Labbe, Ferrage, Rytz, Pace, & Martin, 2015). Such differences may, in some small part, originate from differences in an individual's taster status (e.g., Bartoshuk, 1993; Garneau, Nuessle, Sloan, Santorico, Coughlin, & Hayes, 2014), or even gender (Cristovam, Russell, Patterson, & Reid, 2000). However, while it might be interesting to consider developing cups specifically for tasters and non-tasters (either different drinking receptacles for each group, or else perhaps different experiences, or textures, on different parts of cup), manufacturers would be well advised to stay away from the design of explicitly gendered coffee cups (see Paskin, 2018, for a recent unsuccessful foray in this area; and see Spence, 2019a, for a review).

Conclusions

While coffee is currently served in receptacles that come in all sizes, shapes, and colours, little thought appears to have been given to optimizing the cup (in terms of maximizing the taster's enjoyment of the multisensory tasting experience), excepting in terms of matching the size to the serve. And while claims are often made by cup/glass manufacturers (thus far, primarily in the world of wine), as far as we can tell, they are rarely backed up by hard scientific data. A few examples are FIGGJO OSLO – Tim Wendelboe (tulip, open, and split shapes) (tested in Carvalho & Spence, 2018); LOVERAMICS BREWERS (sweet, floral, and nutty shapes): <https://www.loveramics.com/collections/brewers>; and KRUBE EQ: <https://www.krubeinc.com/pages/eq>. It is interesting to note that all of the above-mentioned companies claim (e.g., on their respective websites) that the cups that they have developed actually enhance specific flavour attributes (e.g., sweetness, acidity, and even specific aroma notes). However, what is noticeably absent thus far is any empirical evidence actually supporting such claims. This would seem like a lost opportunity given that the latest research has shown that all aspects of the receptacle (including its colour, weight, size, texture, and shape), can potentially exert a significant influence over the tasting experience. Furthermore, such results have been demonstrated in both social drinkers and coffee experts. By now, they have also been demonstrated for a range of coffees and preparation methods. And while the world of wine glassware seems relatively narrow in terms of the kinds of drinking receptacles

that the consumer will accept (see Spence, 2011, for a review), coffee feels like it may be far less constrained in this regard. Perhaps unsurprisingly, the growing realization that the drinking vessel can profoundly affect the drinking experience is also now starting to play out in a range of other drinks including, for example, cocktails (e.g., Farrell, 2018; though see also Palmer, 2018).

Taken together, the evidence that has been reviewed here clearly demonstrates the profound impact that the drinking receptacle has on the perception of brewed, espresso, and milk-based coffee beverages. On one hand, the research shows that the physical properties of the cup or mug impact the sensory-discriminative judgments of both amateur consumers and experts. A taster's olfactory, gustatory, and oral-somatosensory experiences can all be affected by the colour, texture, and/or shape of the cup in which the coffee is served. On the other hand, the cup also influences consumers' hedonic responses – a reflection of preferences (e.g., aesthetic, cultural) or congruent/incongruent pairings of specific crossmodal features. Of course, moving forward, it will be important that any influence of the drinking vessel can be shown to influence the experience of consumers in naturalistic drinking situations over the longer-term, and not just under highly-controlled laboratory conditions (see Bangcuvo, Smith, Zumach, Pierce, Guttman, & Simons, 2015; Clicerì, Petit, Garrel, Monteleone, & Giboreau, 2018; cf. Petit & Sieffermann, 2007). Given this sentiment, it is worth noting how much of our own research in this sphere has been conducted in naturalistic settings (e.g., in coffee shops and professional coffee congresses; e.g., see Van Doorn et al., 2015). And given the realization of how important the cup can be to the consumer's perception of coffee, companies focused on specialty coffee accessories are increasingly thinking about the opportunities that may be associated with the introduction of signature branded servingware that, ideally, conveys some functional benefit to the consumer's experience.

Despite the small body of research that has been published to date, it is interesting to note that many of the observed crossmodal influences (e.g., of shape and texture) on coffee flavour are robust enough to be experienced by experts. In the future, though, the cross-cultural similarities and differences in the impact of the cup specific physical attributes on consumers' perception of coffee will need to be examined.

Over the last two decades, with the so-called “third-wave” phenomenon (Baccellieri, 2006), the specialty coffee industry is increasingly becoming the new wine of the fine beverage market. Specifically, many consumers are now willing to pay to appreciate coffee for its origin

and individual characteristics, and with record prices paid for “Special Reserve Coffees” (Teuber & Herrmann, 2012). Third wave coffee shops are already adopting the sommelier concept by providing consumers with background information in relation to the origin of the coffee, as well as the post-harvest and roasting processes that have been used in the preparation of the coffee beverage (Kleidas & Jolliffe, 2010). It is essential that the coffee industry learn from the wine industry not only in regard to the focus on the quality of the product itself (e.g., fermentation processes, plantation management) but also in terms of how to enhance the multisensory product experience (Folmer, 2014). Adding value to a product also includes understanding how to create pleasure for the customer. Innovative service includes creating new (multisensory) experiences for consumers and, at the same time, being aware of their expectations. As is increasingly the case for wine, the coffee industry should nurture the potentially fruitful dialogue with academia to advertently explore and optimize specialty coffee tasting experience (see Spence, 2019b, for a review).

Nevertheless, thinking about the design and introduction of new drinking vessels in the future, it will be important to assess the longer-term consequences of any innovation in design (see Landwehr, Wentzel, & Herrmann, 2013). As yet, there is very little longer-term research assessing the impact of changes in servingware to consumer perception/behaviour (cf. Akyol, Ayaz, Inan-Eroglu, Cetin, & Samur, 2018). Future research should be challenged by relevant factors in the specialty coffee consumption market, such as the cultural background/preferences of the population tested, as well as the specific sensory attributes of the coffee being tasted (e.g., *terroir*, post-harvest processing; see Illy, 2002). This is crucial in order to move beyond the unsubstantiated marketing hype to arrive at a more evidence-based, multisensory-inspired approach to design, what some have called the new gastrophysics (see Spence, 2017).

REFERENCES

- Akyol, A. Ayaz, A., Inan-Eroglu, E., Cetin, C., & Samur, G. (2018). Impact of three different plate colours on short-term satiety and energy intake: A randomized controlled trial. *Nutrition Journal*, **17**:46.
- Baccellieri, M. (2006). Let's talk about estate coffees and the fourth wave! *Tea & Coffee Trade Journal*, **178**(12), 28-31.
- Bangcuyo, R. G., Smith, K. J., Zumach, J. L., Pierce, A. M., Guttman, G. A., & Simons, C. T. (2015). The use of immersive technologies to improve consumer testing: The role of ecological

validity, context and engagement in evaluating coffee. *Food Quality and Preference*, **41**, 84-95.

Barbosa, J. N., Borém, F. M., Cirillo, M. A., Malta, M. R., Alvarenga, A. A., & Alves, H. M. R. (2012). Coffee quality and its interactions with environmental factors in Minas Gerais, Brazil. *Journal of Agricultural Science*, **4(5)**, 181.

Bartoshuk, L. M. (1993). The biological basis of food perception and acceptance. *Food Quality & Preference*, **4**, 21-32.

Biggs, L., Juravle, G., & Spence, C. (2016). Haptic exploration of plateware alters the perceived texture and taste of food. *Food Quality & Preference*, **50**, 129-134.

Buffo, R. A., & Cardelli-Freire, C. (2004). Coffee flavour: An overview. *Flavour and Fragrance Journal*, **19**, 99-104.

Calviño, A. M., Zamora, M. C., & Sarchi, M. I. (1996). Principal components and cluster analysis for descriptive sensory assessment of instant coffee. *Journal of Sensory Studies*, **11**, 191-210.

Caporaso, N., Whitworth, M. B., Cuic, C., & Fisk, I. D. (2018). Variability of single bean coffee volatile compounds of Arabica and Robusta roasted coffees analysed by SPME-GC-MS. *Food Research International*, **108**, 628-640.

Carvalho, F. M., Moksunova, V., & Spence, C. (2018). *Does the feel of the cup influence the taste of the coffee?* Manuscript in preparation.

Carvalho, F. M., & Spence, C. (2018). The shape of the cup influences aroma, taste, and hedonic judgements of specialty coffee. *Food Quality & Preference*, **68**, 315-321.

Carvalho, F. M., & Spence, C. (in press). Cup colour influences consumers' expectations and experience on tasting specialty coffee. *Food Quality & Preference*.

Cavazzana, A., Larsson, M., Hoffmann, E., Hummel, T., & Haehner, A. (2017). The vessel's shape influences the smell and taste of cola. *Food Quality and Preference*, **59**, 8-13.

Cheskin, L. (1957). *How to predict what people will buy*. New York, NY: Liveright.

Clarke, R. J. (2013). *Coffee: Volume 1. Chemistry*. New York, NY: Springer.

Cliceri, D., Petit, E., Garrel, C., Monteleone, E., & Giboreau, A. (2018). Effect of glass shape on subjective and behavioral consumer responses in a real-life context of drinking consumption. *Food Quality and Preference*, **64**, 187-191.

Cliff, M. A. (2001). Influence of wine glass shape on perceived aroma and colour intensity in wines. *Journal of Wine Research*, **12**, 39-46.

Crisinel, A.-S., Cosser, S., King, S., Jones, R., Petrie, J., & Spence, C. (2012). A bittersweet symphony: Systematically modulating the taste of food by changing the sonic properties of the soundtrack playing in the background. *Food Quality and Preference*, **24**, 201-204.

Cristovam, E., Russell, C., Patterson, A., & Reid, E. (2000). Gender preference in hedonic ratings for espresso and espresso-milk coffees. *Food Quality & Preference*, **11**, 437-444.

- Croijmans, I., & Majid, A. (2016). Not all flavour expertise is equal: The language of wine and coffee experts. *PLoS ONE*, **11**(6):e0155845.
- D'Agostina, A., Boschin, G., Bacchini, F., & Arnoldi, A. (2004). Investigations on the high molecular weight foaming fractions of espresso coffee. *Journal of Agricultural and Food Chemistry*, **52**, 7118-7125.
- Demattè, M. L., Sanabria, D., & Spence, C. (2009). Olfactory identification: When vision matters? *Chemical Senses*, **34**, 103-109.
- Deroy, O., Crisinel, A.-S., & Spence, C. (2013). Crossmodal correspondences between odors and contingent features: Odors, musical notes, and geometrical shapes. *Psychonomic Bulletin & Review*, **20**, 878-896.
- Dichter, E. (1964). *Handbook of consumer motivations*. New York, NY: McGraw-Hill.
- Ekroll, V., Faul, F., & Niederée, R. (2004). The peculiar nature of simultaneous colour contrast in uniform surrounds. *Vision Research*, **44**, 1765-1786.
- Farrell, K. (2018). *How different cocktail glasses affect the way you taste*. <https://eatsiptrip.10best.com/2018/06/26/how-different-cocktail-glasses-affect-the-way-you-taste/>.
- Favre, J.-P., & November, A. (1979). *Colour and communication*. Zurich: ABC-Verlag.
- Fenko, A., de Vries, R., & van Rompay, T. (2018). How strong is your coffee? The influence of visual metaphors and textual claims on consumers' flavor perception and product evaluation. *Frontiers in Psychology*, **9**:53. <https://doi.org/10.3389/fpsyg.2018.00053>
- Fischer, U. (1996). Weinglasser – Aesthetik oder sensorische Eignung? [Wine glass – aesthetic and sensory suitability?]. *Deutsche-Weinbau*, **22**, 22-26.
- Fischer, U., & Loewe-Stanienda, B. (1999). Impact of wine glasses for sensory evaluation or Importance of the tasting glass in sensory evaluation. *Journal International des Sciences de la Vigne et du Vin (International Journal of Vine and Wine Sciences, Wine Tasting, Special Edition)*, **33 (Suppl. 1)**, 71-80.
- Fisk, I. D., Kettle, A., Hofmeister, S., Virdie, A., & Silanes Kenny, J. (2012). Discrimination of roast and ground coffee aroma. *Flavour*, **1**:14.
- Folmer, B. (2014). How can science help to create new value in coffee? *Food Research International*, **63**, 477-482.
- Forster, S., & Spence, C. (2018). "What smell?" Temporarily loading visual attention induces a prolonged loss of olfactory awareness. *Psychological Science*, **29**, 1642-1652.
- Gal, D., Wheeler, S. C., & Shiv, B. (2007, unpublished manuscript). *Cross-modal influences on gustatory perception*. Available at SSRN: <http://ssrn.com/abstract=1030197>
- Garneau, N. L., Nuessle, T. M., Sloan, M. M., Santorico, S. A., Coughlin, B. C., & Hayes, J. E. (2014). Crowdsourcing taste research: Genetic and phenotypic predictors of bitter taste perception as a model. *Frontiers of Integrative Neuroscience*, **8**:33.
- Gater, J. (2010). *The influence of musical genre on the sensory perception of coffee*. Unpublished manuscript.

- Gatti, E., Spence, C., & Bordegoni, M. (2014). Investigating the influence of colour, weight, & fragrance intensity on the perception of liquid bath soap. *Food Quality & Preference*, **31**, 56-64.
- Ge, L. (2012). Why coffee can be bittersweet. *FT Weekend Magazine*, **October 13/14th**, 50.
- Geel, L., Kinnear, M., & De Kock, H. L. (2005). Relating consumer preferences to sensory attributes of instant coffee. *Food Quality & Preference*, **16**, 237-244.
- Guéguen, N., & Jacob, C. (2012). Coffee cup color and evaluation of a beverage's "warmth quality". *Color Research and Application*, **39**, 79-81. DOI:10.1002/col.21757.
- Gupta, S. (2016). One man's quest to reinvent the wheel — The flavor wheel, that is. *NPR (The Salt)*, **December 30th**. <https://www.npr.org/sections/thesalt/2016/12/30/506144786/one-mans-quest-to-reinvent-the-wheel-the-flavor-wheel-that-is>.
- Heath, B. (1988). The physiology of flavour: Taste and aroma perception. In R. J. Clarke & R. Macrae (Eds.), *Coffee, Vol. 3, physiology* (pp. 141-170). London, UK: Elsevier Applied Science.
- Ho, H.-N., Van Doorn, G. H., Kawabe, T., Watanabe, J., & Spence, C. (2014). Colour-temperature correspondences: When reactions to thermal stimuli are influenced by colour. *PLoS ONE*, **9**:e91854.
- Hummel, T., Delwiche, J. F., Schmidt, C., & Hüttenbrink, K.-B. (2003). Effects of the form of glasses on the perception of wine flavors: A study in untrained subjects. *Appetite*, **41**, 197-202.
- Hutchings, J. B. (1999). *Food color and appearance* (2nd Ed.). Gaithersburg, Maryland: Aspen Publishers.
- Illy, E. (2002). The complexity of coffee. *Scientific American*, **286(6)**, 86-91.
- Illy, E., & Illy, A. (2015). The science of a perfect cup of coffee. *Scientific American*, **June**, 10-15.
- Illy, E., & Navarini, L. (2011). Neglected food bubbles: The espresso coffee foam. *Food Biophysics*, **6(3)**, 335-348.
- International Coffee Organization (ICO). (2002). *Consumer oriented vocabulary for coffee*. <http://www.ico.org/vocab.asp>.
- Kampfer, K., Leischnig, A., Ivens, B. S., & Spence, C. (2017). Touch-taste-transference: Assessing the effect of the weight of product packaging on flavor perception and taste evaluation. *PLoS ONE*, **12(10)**.
- Kleidas, M., & Jolliffe, L. (2010). Coffee attraction experiences: A narrative study. *Turizam: medunarodni znanstveno-stručni časopis*, **58(1)**, 61-73.
- Knöferle, K. M. (2012). Using customer insights to improve product sound design. *Marketing Review St. Gallen*, **29(2)**, 47-53.
- Krishna, A., & Morrin, M. (2008). Does touch affect taste? The perceptual transfer of product container haptic cues. *Journal of Consumer Research*, **34**, 807-818.

- Kuehlwein, J. P. (2017). Nespresso - the 'Crema' de la Crème. *Ueber Brands*, **October 30th**. <https://medium.com/ueberbrands/nespresso-the-crema-de-la-cr%C3%A8me-6bdc1f58a22e>.
- Labbe, D., Ferrage, A., Rytz, A., Pace, J., & Martin, N. (2015). Pleasantness, emotions and perceptions induced by coffee beverage experience depend on the consumption motivation (hedonic or utilitarian). *Food Quality and Preference*, **44**, 56-61. doi: <http://dx.doi.org/10.1016/j.foodqual.2015.03.017>.
- Labbe, D., Sudre, J., Dugas, V., & Folmer, B. (2016). Impact of crema on expected and actual espresso coffee experience. *Food Research International*, **82**, 53-58.
- Landwehr, J. R., Wentzel, D., & Herrmann, A. (2013). Product design for the long run: Consumer responses to typical and atypical designs at different stages of exposure. *Journal of Marketing*, **77**(5), 92-107.
- Liger-Belair, G. (2005). The physics and chemistry behind the bubbling properties of champagne and sparkling wines: A state-of-the-art review. *Journal of Agricultural and Food Chemistry*, **53**, 2788-2802.
- Liger-Belair, G., Bourget, M., Pron, H., Polidori, G., & Cilindre, C. (2012). Monitoring gaseous CO₂ and ethanol above champagne glasses: Flute versus coupe, and the role of temperature (2012). *PLoS ONE*, **7**(2):e30628.
- Lin, H. (2013). Does container weight influence judgments of volume? *International Journal of Research in Marketing*, **30**(3), 308-309.
- Lingle, T. R. (1986). *The coffee cupper's handbook: A systematic guide to the sensory evaluation of coffee's flavor*. Washington, DC: Coffee Development Group.
- Lingle, T. R., & Menon, S. N. (2017). Cupping and grading—Discovering character and quality. In B. Folmer (Ed.), *The craft and science of coffee* (pp. 181-203). London, UK: Academic Press.
- Little, A. C., Chichester, C. O., & Mackinney, G. (1959). On the color of coffee. III. Effect of roasting conditions on flavor development for a given color. Role of initial moisture level on roasting characteristics of green coffee beans. *Food Technology*, **13**, 684-688.
- Luttinger, N., & Dicum, G. (2006). *The coffee book: Anatomy of an industry from crop to the last drop*. New York, NY: The New Press.
- Lyman, B. (1989). *A psychology of food, more than a matter of taste*. New York, NY: Avi, van Nostrand Reinhold.
- Machiels, C. J. A. (2018). Bittersweet findings: Round cups fail to induce sweeter taste. *Beverages*, **4**:12.
- Maggioni, E., Risso, P., Olivero, N., & Gallace, A. (2015). The effect of a container's weight on the perception of mineral water. *Journal of Sensory Studies*, **30**, 395-403.
- Manska, G. F. (2018). Technical report—Applying physics and sensory sciences to spirits nosing vessel design to improve evaluation diagnostics and drinking enjoyment. *Beverages*, **4**:93.

- Marinetti, F. T. (1932/2014). *The futurist cookbook* (Trans. S. Brill, 1989). London, UK: Penguin Books.
- Martin, D. (1990). The impact of branding and marketing on perception of sensory qualities. *Food Science & Technology Today: Proceedings*, **4**(1), 44-49.
- Masson, M., Delarue, J., Bouillot, S., Sieffermann, J. M., & Blumenthal, D. (2016). Beyond sensory characteristics, how can we identify subjective dimensions? A comparison of six qualitative methods relative to a case study on coffee cups. *Food Quality and Preference*, **47**, 156-165.
- Mirabito, A., Oliphant, M., Van Doorn, G., Watson, S., & Spence, C. (2017). Glass shape affects the perceived taste of beer. *Food Quality and Preference*, **62**, 257-261.
- Navarini, L., Cappuccio, R., Suggi-Liverani, F., & Illy, A. (2004). Espresso coffee beverage: Classification of texture terms. *Journal of Texture Studies*, **35**, 525-541.
- NEFF Press (2018). Creative product design ideas – The flavor boosting plates. *Living.com*, **July 9th**.
- Palmer, J. (2018). Why the martini glass is a classic, despite its shape. *Economist* 1843, **December 23rd**. <https://www.1843magazine.com/design/built-to-last/why-the-martini-glass-is-a-classic-despite-its-shape>.
- Parpinello, G. P., Meglioli, M., Ricci, A., & Versari, A. (2018). Effect of different glass shapes and size on the time course of dissolved oxygen in wines during simulated tasting. *Beverages*, **4**(1):3.
- Paskin, B. (2018). Whisky glasses for women are condemned as sexist. *Scotch Whisky*, **March 6th**. <https://scotchwhisky.com/magazine/latest-news/18071/whisky-glass-for-women-condemned-as-sexist/>.
- Petit, C., & Sieffermann, J. M. (2007). Testing consumer preferences for iced-coffee: Does the drinking environment have any influence? *Food Quality and Preference*, **18**, 161-172.
- Piqueras-Fiszman, B., & Spence, C. (2012a). Does the color of the cup influence the consumer's perception of a hot beverage? *Journal of Sensory Studies*, **27**, 324-331.
- Piqueras-Fiszman, B., & Spence, C. (2012b). The influence of the feel of product packaging on the perception of the oral-somatosensory texture of food. *Food Quality & Preference*, **26**, 67-73.
- Piqueras-Fiszman, B. & Spence, C. (2012c). The weight of the container influences expected satiety, perceived density, and subsequent expected fullness. *Appetite*, **58**, 559-562.
- Piqueras-Fiszman, B., & Spence, C. (2015). Sensory expectations based on product-extrinsic food cues: An interdisciplinary review of the empirical evidence and theoretical accounts. *Food Quality & Preference*, **40**, 165-179.
- Rahman, K. (2014). Has the fizz gone out of flutes? Champagne tastes better from a normal wine glass, say scientists. *Daily Mail Online*, **October 20th**.

- Reber, R., Winkielman, P., & Schwartz, N. (1998). Effects of perceptual fluency on affective judgments. *Psychological Science*, **9**, 45-48.
- Rhinehart, R. (2009). *What is specialty coffee?* <http://www.scaa.org/?page=RicArtp1>.
- Risso, P., Maggioni, E., Olivero, N., & Gallace, A. (2015). The association between the colour of a container and the liquid inside: An experimental study on consumers' perception, expectations and choices regarding mineral water. *Food Quality and Preference*, **44**, 17-25.
- Rozin, P. (1982). "Taste-smell confusions" and the duality of the olfactory sense. *Perception & Psychophysics*, **31**, 397-401.
- Sakai, N. (2014). The psychology of eating from the point of view of experimental, social and applied psychology. *Psychology in Russia: State of the Art*, **7**, 16-22.
- Savolainen, H. (1992). Tannin content of tea and coffee. *Journal of Applied Toxicology*, **12**, 191-192.
- SCA (2017a) <http://www.scanews.coffee/2017/11/29/2017-u-s-specialty-coffee-consumption-trends/>.
- SCA (2017b) <http://www.scanews.coffee/2017/11/28/2017-western-european-coffee-market-size-report/>.
- Schifferstein, H. N. J. (2001). Effects of product beliefs on product perception and liking. In L. Frewer, E. Risvik, & H. Schifferstein (Eds.), *Food, people and society: A European perspective of consumers' food choices* (pp. 73-96). Berlin: Springer Verlag.
- Schifferstein, H. N. J. (2009). The drinking experience: Cup or content? *Food Quality and Preference*, **20**, 268-276.
- Schifferstein, H. N. J., Smeets, M. A. M., & Hallensleben, R. (2011). Stimulus sets can induce shifts in descriptor meanings in product evaluation tasks. *Acta Psychologica*, **138**, 237-243.
- Schwan, R. F., Silva, C. F., & Batista, L. R. (2012). Coffee fermentation. In Y. H. Hui (Ed.), *Handbook of plant-based fermented food and beverage technology* (pp. 677-690). Boca Raton, FL: CRC Press.
- Seo, H.-S., & Hummel, T. (2011). Auditory–olfactory integration: Congruent or pleasant sounds amplify odor pleasantness. *Chemical Senses*, **36**, 301-309.
- Seo, H.-S., Lee, S.-Y., & Hwang, I. (2009). Development of sensory attribute pool of brewed coffee. *Journal of Sensory Studies*, **24**, 111-132.
- Skaczkowski, S., Durkin, S., Kashima, Y., & Wakefield, M. (2016). The effect of packaging, branding and labeling on the experience of unhealthy food and drink: A review. *Appetite*, **99**, 219-234.
- Sörqvist, P., Hedblom, D., Holmgren, M., Haga, A., Langeborg, L., Nörtl, A., et al. (2013). Who needs cream and sugar when there is eco-labeling? Taste and willingness to pay for "eco-friendly" coffee. *PLoS One*, **8**(12):1-9.
- Spence, C. (2011). Crystal clear or gobbletigook? *The World of Fine Wine*, **33**, 96-101.

- Spence, C. (2012). Managing sensory expectations concerning products and brands: Capitalizing on the potential of sound and shape symbolism. *Journal of Consumer Psychology*, **22**, 37-54.
- Spence, C. (2015a). Multisensory flavour perception. *Cell*, **161**, 24-35.
- Spence, C. (2015b). Just how much of what we taste derives from the sense of smell? *Flavour*, **4**:30.
- Spence, C. (2015c). Leading the consumer by the nose: On the commercialization of olfactory-design for the food and beverage sector. *Flavour*, **4**:31.
- Spence, C. (2017a). *Gastrophysics: The new science of eating*. London, UK: Viking Penguin.
- Spence, C. (2017b). Sonic seasoning. In L. Minsky & C. Fahey (Eds.), *Audio branding: Using sound to build your brand* (pp. 52-58). London, UK: Kogan Page.
- Spence, C. (2018). Background colour & its impact on food perception & behaviour. *Food Quality & Preference*, **68**, 156-166.
- Spence, C. (2019a). Do men and women really live in different taste worlds? *Food Quality & Preference*, **73**, 38-45.
- Spence, C. (2019b). Multisensory experiential wine marketing. *Food Quality & Preference*, **71**, 106-116.
- Spence, C. (in press). On the relationship(s) between colour and taste. *Experimental Psychology*.
- Spence, C., & Wan, I. (2015). Beverage perception & consumption: The influence of the container on the perception of the contents. *Food Quality & Preference*, **39**, 131-140.
- Spence, C., & Wan, I. (2016). Assessing the influence of the drinking receptacle on the perception of the contents. In B. Piqueras-Fiszman & C. Spence (Eds.), *Multisensory flavor perception: From fundamental neuroscience through to the marketplace* (pp. 269-296). Duxford, CB: Elsevier.
- Spence, C., Wan, X., Woods, A., Velasco, C., Deng, J., Youssef, J., & Deroy, O. (2015). On tasty colours and colourful tastes? Assessing, explaining, and utilizing crossmodal correspondences between colours and basic tastes. *Flavour*, **4**:23.
- Spence, C., & Wang, Q. J. (2018). On the meaning(s) of complexity in the chemical senses. *Chemical Senses*, **43**, 451-461.
- Spencer, M., Sage, E., Velez, M., & Guinard, J.-X. (2016). Using single free sorting and multivariate exploratory methods to design a new coffee taster's flavor wheel. *Journal of Sensory Studies*, **81**, S2997-S3005.
- Sunarharum, W. B., Williams, D. J., & Smyth, H. E. (2014). Complexity of coffee flavor: A compositional and sensory perspective. *Food Research International*, **62**, 315-325.
- Teuber, R., & Herrmann, R. (2012). Towards a differentiated modeling of origin effects in hedonic analysis: An application to auction prices of specialty coffee. *Food Policy*, **37**, 732-740.

- Turoman, N., Velasco, C., Chen, Y.-C., Huang, P.-C., & Spence, C. (2018). Tasting transformations: Symmetry and its role in the crossmodal correspondence between shape and taste. *Attention, Perception, & Psychophysics*, **80**, 738-751.
- Ueda, J., Masuda, M., & Okajima, K. (2014). Effects of vision and sound information of AR-modified drinks on taste and texture. *Proceedings of the ITE Annual Convention*, pp. 22.4.1-22.4.2 (2014) [in Japanese].
- Van Doorn, G., Colonna-Dashwood, M., Hudd-Baillie, R., & Spence, C. (2015). Latté art influences both the expected and rated value of milk-based coffee drinks. *Journal of Sensory Studies*, **30**, 305-315.
- Van Doorn, G., Woods, A., Levitan, C. A., Wan, X., Velasco, C., Bernal-Torres, C., & Spence, C. (2017). Does the shape of a cup influence coffee taste expectations? A cross-cultural, online study. *Food Quality and Preference*, **56**, 201-211.
- Van Doorn, G., Wüillemin, D., & Spence, C. (2014). Does the colour of the mug influence the taste of the coffee? *Flavour*, **3**:10.
- Van Rompay, T. J., Finger, F., Saakes, D., & Fenko, A. (2017). “See me, feel me”: Effects of 3D-printed surface patterns on beverage evaluation. *Food Quality & Preference*, **62**, 332-339.
- van Rompay, T. J. L., & Groothedde, S. (2018). The taste of touch: Enhancing saltiness impressions through surface texture design. *Food Quality and Preference*. doi: <https://doi.org/10.1016/j.foodqual.2018.11.003>
- Van Rompay, T. J. L., Kramer, L.-M., & Saakes, D. (2018). The sweetest punch: Effects of 3D-printed surface textures and graphic design on ice-cream evaluation. *Food Quality and Preference*, **68**, 198-204.
- Velasco, C., & Spence, C. (Eds.). (2019). *Multisensory packaging: Designing new product experiences*. Cham, Switzerland: Palgrave MacMillan.
- Venturi, F., Andrich, G., Sanmartin, C., Taglieri, I., Scalabrelli, G., Ferroni, G., & Zinnai, A. (2016). Glass and wine: A good example of the deep relationship between drinkware and beverage. *Journal of Wine Research*, **27**, 153-171.
- Wan, X., Zhou, X., Mu, B., Du, D., Velasco, C., Michel, C., & Spence, C. (2014). Crossmodal expectations of tea colour based on its flavour. *Journal of Sensory Studies*, **29**, 285-293.
- Wang, Q. J., & Spence, C. (2018). Drinking texture? Tactile influences on the evaluation of wine. *International Journal of Gastronomy & Food Science*, **14**, 9-13.
- Woods, A. T., Marmolejo-Ramos, F., Velasco, C., & Spence, C. (2016). Using single colours and colour pairs to communicate basic tastes II; Foreground-background colour combinations. *i-Perception*, **7**:5.
- World Coffee Research (2016). *World coffee research sensory lexicon: unabridged definitions and references*. 1st ed. College Station, Tex.: World Coffee Research. www.worldcoffeeresearch.org.
- Xu, J. (2003). Coffee. *Journal of Agricultural & Food Information*, **5**(3), 79-86.

Yeretzian, C. (2017). Coffee. In A. Buettner (Ed.), *Springer handbook of odor* (pp. 107-128). Cham, Switzerland: Springer International Publishing.

Zellner, D. A., & Whitten, L. A. (1999). The effect of color intensity and appropriateness on color-induced odor enhancement. *The American Journal of Psychology*, **112**, 585-604.

FIGURE LEGENDS

Figure 1. A screenshot from Von Doorn et al.'s (2017) study of the expectations set by different coffee cups.

Figure 2. The coloured sleeves used to study the impact of receptacle on a milk based coffee drink by Van Doorn et al. (2014).

Figure 3. The coloured coffee cups used in a recent study by Carvalho and Spence (in press).

Figure 4. The two differently-textured coffee cups used in Carvalho, Moksunova, and Spence's (in preparation) research.

Figure 5. The three differently-shaped coffee cups used in Carvalho and Spence's (2018) recent study.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

Rough texture

Loveramics®
(Brewers – 'nutty')

Smooth texture

Figgjo Oslo®
(Tim Wendelboe – 'tulip')

Figure 5.