

The Form of Taste

On the Origins, Implications, and Applications of
Shape -Taste Crossmodal Correspondences

shape
taste symmetry
orientation
balance
texture
neatness

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A growing body of experimental research now demonstrates that neurologically-normal individuals associate different taste qualities with design features such as curvature, symmetry, orientation, texture, and spatial location. In fact, the form of everything from the food itself through to the curvature of the plateware on which it happens to be served, and from glassware to typeface, not to mention the shapes of/on food product packaging have all been shown to influence people's taste expectations, and, on occasion, also their taste/food experiences. At the same time, however, curvature in small and larger-scale architectural forms (such as furniture, and the internal layout of the servicescape) is also associated with preference and approach motivation and may thus potentially be used to bias, or nudge, the food behaviour (and choices) of consumers. Although the origins of shape-taste and other form-taste crossmodal correspondences have yet to be fully elucidated, that has not prevented a growing number of designers (including typeface designers, plateware manufacturers/potters), marketers, advertisers, and chefs, from starting to incorporate the emerging insights concerning these various, and seemingly ubiquitous, affinities between form and taste as a source of inspiration for their creative practice.

While the colours we associate with tastes may well be based on the internalization of the statistics of the environment in the form of crossmodal correspondences (Motoki, Takahashi, & Spence, 2021; Spence, Wan, Woods, Velasco, Deng, Youssef, & Deroy, 2015), it is much harder to forward such a statistical account of the close connection that has also been shown to exist between shape, or other form features, and basic tastes (Spence & Deroy, 2012, 2013b). This is especially obvious in the case of the shape properties that people tend to associate with drinks such as beer and carbonated/still water, given that the latter typically do not have a specific form.

There have long been hints that a subset of synaesthetes experience shape concurrents in response to taste/flavour inducers, such as the synaesthete reported some years ago by Cytowic (1993) who was once overheard saying that the roast chicken that he was preparing was burnt because it had 'too many points' (see Day, 2011, p. 12, pp. 16-17). The synaesthete in this case, a man by the name of Michael Watson noted that "Sugar made things taste 'rounder' while citrus added 'points'." (quoted in Cytowic, 1993, p. 66). At the same time, chefs such as Paul Bertolli of the Oliveto restaurant in Oakland, California have occasionally described how they construct menus based on the shape properties they metaphorically associated with tastes and flavours of the dishes, drinks, and/or ingredients. Intriguing research (though totally underpowered by today's more rigorous scientific standards) reported by Cytowic and Wood (1982) suggested that a gustatory-shape synaesthete tended to associate acidity with angularity.¹ The use of shape/form language is also common in the world of expert wine writing (e.g., terms such as linear, rounded, balanced, etc.; Peynaud, 1987).² Similarly, it is interesting to see

how researchers attempting to describe the sensation associated with the addition of kokumi, the so-called 6th taste, suggests that it adds 'roundness' (see Devenyns, 2019). By contrast, certain cheeses are commonly described as having a 'sharp' taste. Nevertheless, an emerging body of crossmodal correspondences research demonstrates that the majority of neurologically normal people do indeed tend to associate specific shape properties, such as curvilinearity and symmetry, with particular taste qualities, at least amongst the four or five most commonly-mentioned basic tastes (e.g., sweet, sour, bitter, salty, and possibly also umami).

Intriguingly, shape properties have been shown to influence our (food) behaviours at multiple scales. The shape of food itself, as well as the shape of the plateware on which it happens to be presented bias both people's taste expectations and on occasion their taste experiences as well. Meanwhile, the shape of the furniture/table, and even the shape of dining environment (or servicescape) may influence a viewer's approach/avoidance tendencies/behaviours (Vartanian, Navarrete, Chatterjee, Fich, Leder, Modroño, Nadal, Rostrup, & Skov, 2013). And, given that people generally prefer curvature over angularity, incorporating more of the former into one's designs may well elicit more approach motivation too. Intriguingly, the preference for curvature is not uniquely human, but has also been documented in great apes. In fact, according to Ingrid Lee (2018), author of *Joyful: The surprising power of ordinary things to create extraordinary happiness*, the reason why round forms are appealing is because of their link to the shapes found in nature.

Going one stage further, one might even consider the space of the building itself, especially when one considers such striking

designs as the iconic building in which the Vespertine restaurant is housed in Los Angeles, California. Certainly, the evidence that has been published to date already suggests that larger-scale interior architectural features (such as shape and colour) may be associated with taste qualities, and thus bias taste experiences (Chen, Huang, Faber, Makransky, & Perez-Cueto, 2020; Motoki et al., 2022; Spence, 2020a; Spence, Velasco, & Knoeferle, 2014; Velasco, Jones, King, & Spence, 2013).³ Note, though, that such perceptual effects stand apart from, though may be linked to, any effect that they may have on approach/avoidance motivation/behaviour.

Anecdotally, it has been suggested that even small-scale form features may bias the likelihood that people will try a given food. For instance, leading UK 'nose-to-tail' chef, Fergus Henderson, has been quoted as saying that: "Disgust is always rooted in a perception of asymmetry," he says suddenly. "Geometry cures it. Take the haggis, for instance. It's made of sheep's stomach and sheep's lights, but people will eat it because it's comfortably round. Sausages have always been allowed in because of their shape. People are somehow reassured." (Gopnik, 2012, pp. 138-139). While a clear and full understanding of the origin(s) of such form-taste correspondences is yet to be forthcoming, that certainly hasn't stopped a growing number of innovative designers from starting to incorporate such knowledge concerning the crossmodal correspondences as sources of inspiration in their creative practice, including in the world of food and drink experience design. In this narrative historical review, I summarize the literature on form-taste correspondences, and highlight a number of the recent attempts to apply the insights in the fields of design and experiential marketing.

While there has long been an interest in the interface between architecture and artistic culinary practice (Horwitz & Singley, 2004), the emerging awareness of the crossmodal correspondences that connect form features with taste qualities and the oral-somatosensory attributes of food (such as creaminess and spiciness), is currently inspiring a number of creative individuals toward a new approach to design, one that operates across a wide range of spatial scales and media. Illustrative examples of a number of the ways in which form-taste correspondences have recently been incorporated into various aspects of design practice, from the design of functional plateware (i.e., plateware that enhances the desirable attributes of taste) through to immersive virtual reality advertising and sensory marketing are discussed.

1. VISUAL FORM CORRESPONDENCES WITH BASIC TASTE QUALITIES

Although many form features can be assessed by touch/haptics as well as by eye, the majority of the empirical research that has been published to date has tended to assess such crossmodal correspondences visually. And perhaps the single most extensively studied visual design feature is curvilinearity.

1.1. Curvilinearity

An extensive body of research conducted over the last decade or so has unequivocally demonstrated that people intuitively match roundness with sweetness, while picking angular forms to represent the other four basic tastes (Spence & Deroy, 2012, 2013b). Roundness is also associated with, and tends to accentuate, creaminess. Meanwhile, it turns out that sourness and spiciness are both strongly associated with angularity

(Gil-Pérez, Rebollar, Lidón, Martín, van Trijp, & Piqueras-Fiszman, 2019).

Researchers have demonstrated that participants from both India and China also tend to match sweetness with roundness (Liang, Biswas, Vinnakota, Fu, Chen, Quan, Zhan, Zhang, & Roy, 2016). At the same time, however, Bremner Caparos, Davidoff, de Fockert, Linnell, and Spence (2013) documented a strikingly different pattern of taste shape correspondences in the case of still/sparkling water and chocolate varying in terms of its bitterness. While Western consumers have been documented to match carbonation, and increasing bitterness (e.g., in chocolate samples) with increased angularity, the Himba tribe of Kaokoland in Northern Namibia exhibited a very different pattern of results. The 34 unschooled semi-nomadic herders with little exposure to Western culture or artifacts did not exhibit a significant association between angularity and carbonation, while showing the reverse mapping when asked to pick the rounded versus angular shape in response to chocolate samples varying in cacao content (30%, 70%, 90%). As yet, there is no convincing explanation for this cultural difference in shape-taste crossmodal correspondences, though it would be helpful to see this isolated empirical finding replicated.

1.2. Symmetry

There are several kinds of symmetry, including rotational, reflectional, and translational. Nevertheless, in a series of online studies that was conducted by Turoman and colleagues, and published in 2018, asymmetry was shown to be associated with acidity/sourness and bitterness in groups of participants from Taiwan and the West (UK, US, and Canada). At the same time, however, the latest research

also provides some evidence to suggest that symmetry (or regularity of form) may also be associated with sweetness (Juravle, Olari, & Spence, 2022).

1.3. Texture

Researchers have recently established that people preferentially match specific tastes with particular visually-perceived textures as well. Such crossmodal correspondences go beyond specific food forms that are semantically linked to specific taste qualities, such as the textural appearance of candyfloss being associated with sweetness. Back in the 1930s, the Italian Futurists had already intuited the existence of a certain relationship between felt textures and tastes, a phenomenon they christened 'Syn-tactilismo'. It is, though, important to stress that the ubiquitous nature of such intuitive crossmodal associations, as documented by contemporary research, has tended to move people's thinking away from searching for an explanation for such phenomena in terms of synaesthesia (given that the latter is rare, and defined in terms of idiosyncratic connections between inducer and concurrent) and rather towards an explanation in terms of the increasingly popular crossmodal correspondences instead (Spence, 2011).⁴ Intriguingly, there is mounting evidence that textural cues, seen and/or felt, can accentuate certain taste, oral-somatosensory attributes of food (Velasco et al., 2013).

1.4. Tasting typeface

Different typeface designs vary in a number of visual features including curvilinearity and weight etc. (Velasco & Spence, 2019). Early research on taste-typeface by Velasco, Woods, Hyndman, and Spence (2015) demonstrated that people associate sweetness with a more rounded typeface while associating a more angular

typeface the other basic tastes (at least in the Western participants whom they tested). Velasco et al. (2018) subsequently went on to show that the same typeface curvature-to-taste correspondence applies in groups of participants from Colombia and China (i.e., in different languages involving, in the latter case, a different script). Other researchers, meanwhile have investigated the taste qualities associated with curvilinearity of typeface in the context of a range of food product packaging (Velasco, Salgado-Montejo, Marmolejo-Ramos, & Spence, 2014) and the design of a chalkboard menu for beer (Otterbring, Rolschau, Furrebøe, & Nyhus, 2022).

1.5. From 2D to 3D forms

Cytowic and Woods (1982) introduced a range of 23 abstract shapes (one 2D line and the rest abstract 3D shapes) to their earlier study. However, the very small sample size – one gustatory-shape synaesthete, one chef/restaurateur, and two

other control participants – did not allow for any concrete conclusions, as acknowledged by the authors themselves. In 2011, Deroy and Valentin had a larger group of participants (N = 46) match three beers to a set of 34 shapes, half of which were 2D and the remainder 3D. However, in the latter case, it appeared to be curvilinearity rather than the distinction between 2D vs. 3D that was driving the participants' associations, though there was some hint in the data concerning sweetness and voluminousness.

More recently, Juravle et al. (2022) evaluated the taste associations that participants had with the so-called platonic solids together with several other 3D shapes (see Fig. 1). Intriguingly, it turned out that the sphere was strongly associated with sweetness and to a lesser extent with umami. By contrast bitter and sour were associated with the more angular forms. Surprisingly, none of the shapes were significantly associated with the salty taste.⁵

1.6. Orientation, position, and movement

A spatial element to taste has been reported recently, with sweet tastes being associated with higher locations. There may be a link here to the higher pitch that tends to be associated with sweetness. One might also speculate on the question of whether sweet-tasting foods are more likely to be found above the ground, whereas bitter-tasting foods are perhaps a little more likely to be found on/under the ground instead. Were such a speculation to be confirmed empirically, it might then provide a statistical account for such elevation-basic taste correspondences.

There is growing research on the importance of orientation to the aesthetic appreciation of food. Ascending to the right is seemingly often preferred over ascending to the left. The cardinal orientations are often preferred over oblique orientations for linear elements.

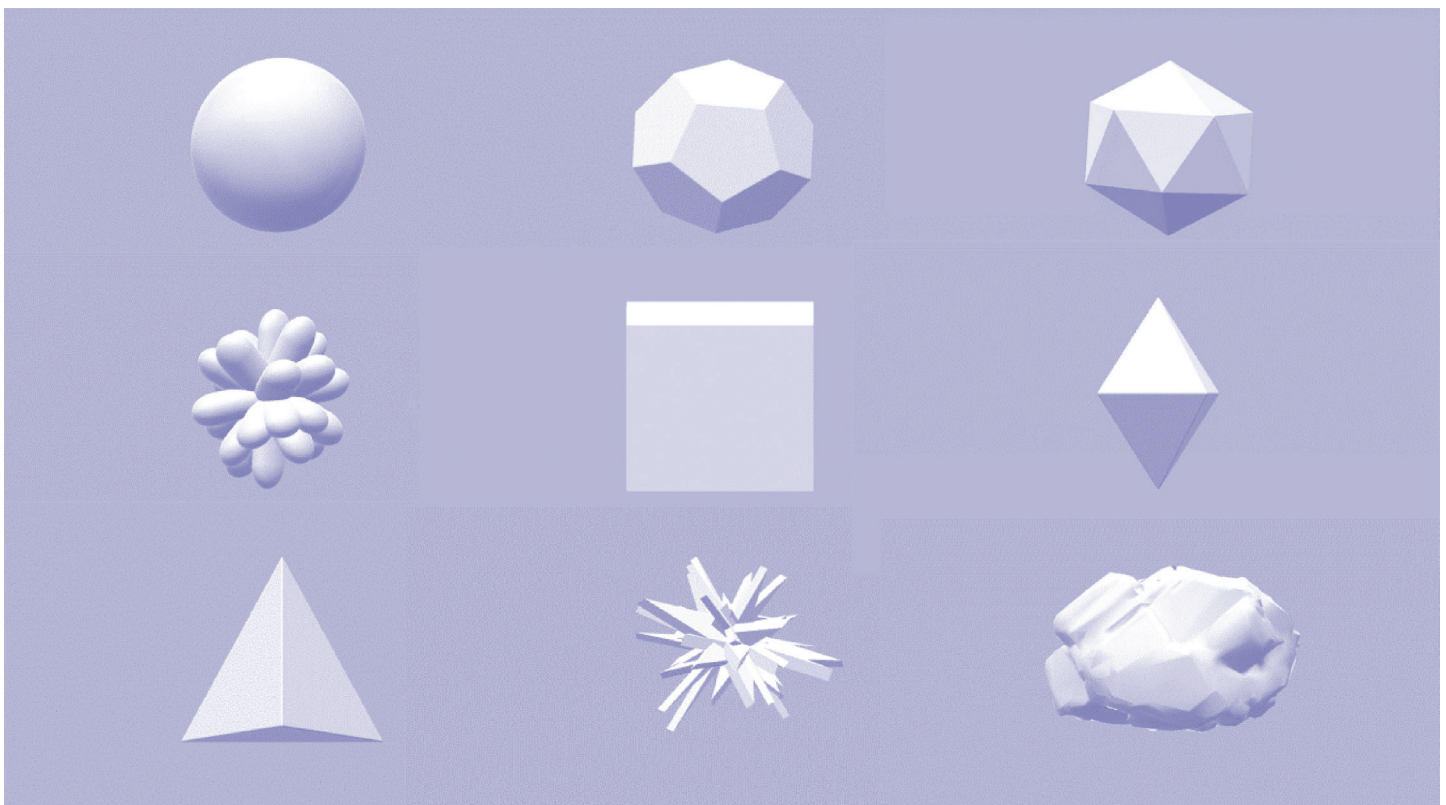


Fig. 1 -. The nine shapes (including the five Platonic solids) that were associated with taste properties in Juravle et al.'s (2022) recent online research. Note that the participants saw each of the shapes rotating continuously in the actual study. [Reprinted under Creative Commons CC BY 4.0.]

The ascending to right preference in the arrangement of linear food elements appears to hold regardless of language (and hence reading direction) and culture.⁶ Meanwhile, when it comes to angular shapes, such as the triangle, then it turns out that food arranged in an inverted triangle is liked just that little bit less than the same food when oriented away from the viewer/diner (Michel, Woods, Neuhäuser, Landgraf, & Spence, 2015).

Different foods and, by extension, different dominant basic tastes have also been associated with speed (Woods, Spence, Butcher, & Deroy, 2013). So, for example, the majority of people will rate lemons as 'fast' rather than 'slow', whereas prunes and bananas are commonly rated as slow. Such speed-taste correspondences may link to the speed at which different taste sensations are experienced phenomenologically, with acids being much more soluble in saliva, and hence being perceived more rapidly than the other basic tastes.⁷

1.7. Balance, neatness, and harmony

Several studies have revealed that, as might have been expected, balance, neatness, and harmony are all relevant features as far as the aesthetic appreciation of food design are concerned (Velasco, Michel, Woods, & Spence, 2016). They can perhaps be considered as collative stimulus properties. However, aesthetically plated food is rated as more attractive than effortfully arranged plating that is not as especially aesthetically pleasing. At the same time, the ratio of the various elements on the plate has also been reported to play a role, with one industry-sponsored piece of 'research' suggesting that arranging one's curry with rice in accordance with the golden ratio helps to make it look more attractive (Deroy & Spence,

2014). Ultimately, however, it appears as though consumers are normally drawn to energy density, and hence the spatial layout of food that gives rise to the impression of the greatest amount of food is likely to be appreciated most (Woods, Michel, & Spence, 2016). Relevant here, the preference for round plates for serving food might also be explained by the psychophysical bias toward estimating circular food presentations as containing more food than rectangular presentations.

2. EXPLAINING SHAPE-TASTE CORRESPONDENCES

The spatial aspects of taste sensation, has long been linked to the discredited tongue map. Certainly, different oral sensations have a different spatial localization/volume. For instance, consider only how the 6th taste 'kokumi' is often described as giving rise to a sensation of mouth-fillingness (Devenyns, 2019).

2.1. The shape of taste experiences

To date, very few studies have taken seriously the hypothesis that a richer spatial dimension is present in flavour experiences, as in most other perceptual experiences. That said, this hypothesis appears in the writing of William James, who considered that "in the sensations of smell and taste, (the) element of varying vastness seems less prominent but not altogether absent. Some tastes and smells appear less extensive than complex flavors, like that of roast meat or plum pudding, on the one hand, or heavy odors, like musk or tuberose, on the other." (James 1887, p. 2). James also presented this perceptible spatial dimension as an explanation for the kind of correspondences that have been documented between taste and

shape/form: "The epithet sharp given to the acid class", he wrote, "would seem to show that to the popular mind, there is something narrow, and as it were, streaky in the impression they make, other flavors and odors being bigger and rounder" (James, 1887, p. 2)."

Meanwhile, the famous French oenologist Emile Peynaud (1987, p. 220) wrote that: "However lacking in imagination he might be, when a taster works the wine in his mouth and feels it with his tongue, he absorbs not only impressions of taste, but also impressions of volume, form and consistency. He forms a physical image of the wine. This is part of a curious 'optical effect' of a taste, a phenomenon which it would not be inappropriate to call *stéréogustation*." Once again, the crossmodal matching would appear to be based on automatically-generated visual mental image of the form of the wine (Spence & Deroy, 2013a). A few pages later, Peynaud writes that "Anyone who has tasted a Jurançon, the sweet wine from the Pyrenees foothills, will understand Orizet when he writes: "It is the contradictory nature of Jurançon to be rounded at one end, and pointed at the other."" (Peynaud, 1987, p. 272).

2.2. Emotional/hedonic mediation

Emotional, or hedonic, mediation has been suggested as a possible explanation of the crossmodal correspondence between taste and shape by a number of authors (e.g., Velasco, Woods, Deroy, & Spence, 2015). The basic idea being that liked tastes (such as sweetness) would be paired with preferred shapes (such as roundness), whereas generally disliked (or dangerous) tastes such as bitterness and spiciness would be associated with threatening shapes (e.g., those that are angular). According to the results of a series of studies conducted by Velasco, Woods,

Marks, Cheok, and Spence in 2016, a semantic differential space with the principal components (or dimensions) of hedonics and intensity accounts for people's responses to taste.

Should emotional/hedonic mediation provide part of the explanation for why certain tastes are matched with particular shapes, then there may be interesting research to be done by varying sweetness intensity, given that populations tend to split into sweet-likers, sweet-neutral, and sweet-dislikers, as a function of increasing sweetness (e.g., Velasco, Woods, Liu, & Spence, 2016). At the same time, however, it should also be noted that individual differences in the preference for curvature in objects have been reported, possibly mediated by shape familiarity, expertise, self-construal, and an individual's loneliness (Chen, Jiao, Fan, & Li, 2021).

2.3. Spatiotemporal analogy

One might also wonder whether there might be some spatio-temporal analogizing at play in the matching of taste experiences with the temporal experience of tasting, such that taste sensations that evolve slowly on the palate, such as sucrose may be matched with curvature (i.e., gradual spatial transitions) whereas sour tastes, which tend to appear and disappear from perceptual experience.⁸ The rate of alcohol evaporation, and hence mouth cooling is often reported as being important for wine-tasting when trying to judge the alcohol content hence hinting at rate of change of sensations also possibly being important. One might consider such structural isomorphism, should it be demonstrated to occur, as a form of metaphorical crossmodal mapping. Once again, something similar has now been demonstrated in chimpanzees in the audiovisual domain.

2.4. Semantic associations between shape and taste

Certain shapes may take on more of a semantic meaning, as when a curved horizontal line is seen as a smile or frown (Spence, 2021). Anthropomorphism can also influence the meaning associated with shape stimuli, potentially imbuing them with emotional meaning and thereafter taste. There may be important cultural factors at play here, considering, for example, the close affinity that many Italians feel between particular pasta shapes being paired with specific sauces.

2.5. Imprinting

One might also consider whether there may be some form of imprinting of taste-shape correspondences based on early experiences.⁹ For newborn humans, consider only how the earliest conscious taste experiences are presumably based on the sweet-umami taste of breast milk associated with distinctive rounded red-purple aureole. By only a few months of age, the evidence shows that babies are already picking up on the statistics of the environment in terms of the colours and shapes of objects associated with taste.

2.6. Interim summary

While several speculative accounts have been put forward to explain why it is that people consensually match various form features with taste qualities, none has yet been generally accepted, and indeed several of the explanations may help to explain some of the data. One point to bear in mind here, though, is that just because people consensually match shape/form properties with basic tastes when tasked to do so, that does not mean that such crossmodal correspondences would necessarily be dominant (or top-of-mind) under those

conditions (or in those contexts) where other visual stimulus parameters (such as colour or material properties) might also be varying (see Motoki, Saito, & Velasco, in press; Motoki & Velasco, 2021). Colour is often more salient than form/shape features. It has recently been reported that people with high autistic traits show fewer consensual crossmodal correspondences between visual features and tastes. As yet, the implications of such findings for an understanding of the causes of crossmodal correspondences between shape/form, colour, and taste are unclear.

3. SENSORY NUDGING WITH FORM-TASTE CORRESPONDENCES

The evidence goes beyond merely showing that people share consensual mappings between shape and taste. These natural affinities may even bias our food behaviours, and hence may provide a subtle means of nudging our food behaviours moving forward. This is both in terms of the intelligent means of nudging people's taste expectations, and possibly also their experience through shape. It may also bias, or nudge, people's approach/avoidance behaviours. Across a wide range of spatial scales preference for approach motivation toward round forms has been documented. However, some of the research that has started to investigate whether it is possible to nudge people's choice behaviour in relation to food through manipulating typeface curvilinearity has thrown up some surprising results.

3.1. On the shape of sweetness/creaminess

The shape of creaminess: Consumers expect and perceive rounded chocolates to be creamier than squared chocolates. Psychophysical research confirms

earlier observations from the marketplace concerning the impact of rounding the shape of foods (chocolate) on creaminess/sweetness perception. The alternative explanation in terms of melting differences should perhaps also be mentioned, though this suggestion has attracted little empirical support.

There is evidence that staring at angular shapes can bring out the sharpness of cheddar cheese. Liang, Roy, Chen, and Zhang published research in 2013

demonstrating that participants showed a small, but significant reduction in their threshold for tasting sweetness after being presented with subthreshold visual images that were either rounded or angular. That being said, it is worth noting that people may associated different degrees of curvilinearity with the aroma, taste, and mouthfeel/texture of complex foods such as cheeses (Spence et al., 2013). At the same time it is also worth bearing in mind that certain iconic confectionary shapes may come

to take on a semantic/branded association – be it iconic triangular shape of Toblerone, though to the seashell shape of (Guylian).

3.2. Food design

The chef Jozef Youssef has worked these insights into another of the dishes served at his *Synaesthesia* dining concept. Just take a look at Fig. 2, and ask yourself which half-plate you would call 'bouba', and which 'kiki'? The answer to this question should be obvious. The food on the left of the plate is the

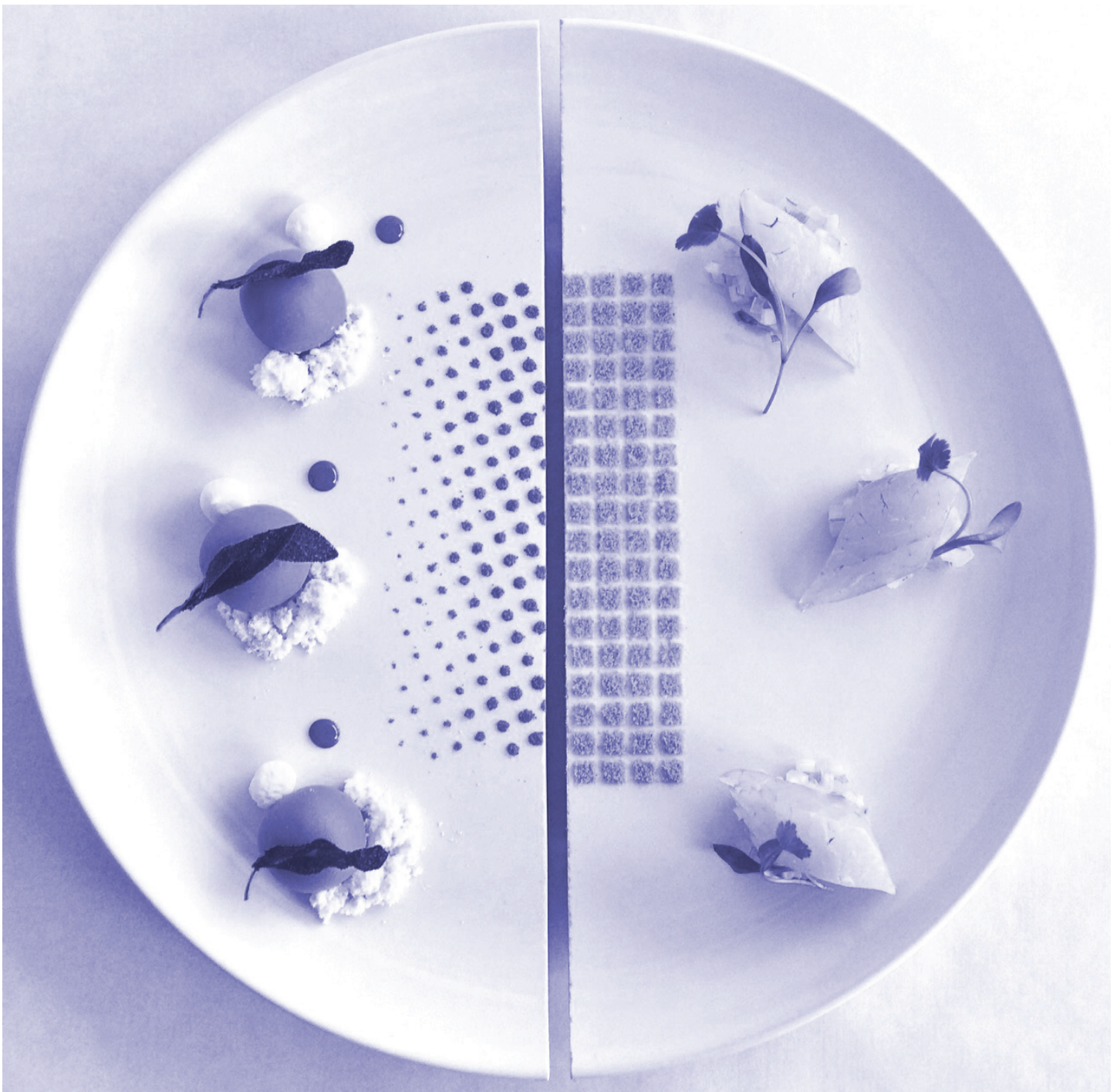


Fig. 2 - The Bouba-Kiki dish created by chef Jozef Youssef of Kitchen Theory as part of his Synaesthesia dining concept.

bouba, whereas the other food is the kiki. Certainly, that is the way that the majority of the diners in the restaurant responded when the dish was placed before them in the restaurant. The chef had deliberately chosen to incorporate tastes, flavours, and textures to match each side of the plate. Angular fish with sharp crunchy rhubarb on the right, and bouba-esque potato dumplings on the left.

With the rise in 3-D food printers, there is growing interest in conveying taste/flavour properties through the use of complex form features. Across a series of three experiments, Li, Liang, Zhou, and Kang demonstrated that people's preference for symmetry in foods may be linked to/mediated by perceptions of naturalness in a study published in 2022.

3.3. Glassware shape

Curvature in beer and wine glasses brings out fruitiness. In such cases, it is natural to consider the shape features of the glassware as affecting physico-chemical properties of volatiles in the headspace over the glass. However, it would seem more likely that it is the psychological crossmodal correspondence between taste and shape that is really doing the work, especially given research showing that simply varying the outer texture of the drinking vessel can elicit such effects. There would also appear to be a correspondence between the shape of a coffee cup and the expected taste of the contents. At the same time, however, glass shape has also been shown to influence drinking behaviour, though the mechanism is likely to be somewhat different.

3.4. Plate shape

Jialin Deng created a set of conceptual plates designed to match each of the five basic tastes (Spence, 2020a; Spence et

al., 2015) (see Fig. 3). Meanwhile Reiko Kaneko the potter from the Midlands created the first set of perception-enhancing sculptural plateware for Neff kitchens and launched as part of the Eurocucina trade show in Milan in 2018 (Hauer-Bain, 2018) (see Fig. 4). Several research groups have now demonstrated the influence of plate shape on people's expectations of the food that is served from them. Chen et al. (2018) assessed the impact of rounded plateware with rounded protrusions that were more or less pronounced. Given the other findings just mentioned, this factor was combined with plate colour (white vs. black). That said, not everyone is necessarily equally enamoured with the recent explosion in unusually-shape plateware. The MasterChef judge, William Sitwell, for one, has argued that square dining plates are an 'abomination'.

There may though be an important question here about foreground-background interactions. In one of the first studies to investigate the impact of plate colour and shape scientifically, Piqueras-Fiszman and her colleagues served a pyramid shaped mousse off of one of three plates that varied from round to more angular (see Fig. 5). However, contrary to the findings of the majority of the subsequent research that has been published, the shape of the plate exerted no influence over participants' taste ratings. In hindsight, one possible explanation for this early null result may have been that the striking foreground shape properties of the food may have overridden any impact of the shape of plateware that may have faded into the background. Relevant here, separate research has shown that people have been shown to respond differently to the inferred taste of colour pairs depending on whether they are presented side-by-side, or one in front of another (Woods,

Marmolejo-Ramos, Velasco, & Spence, 2016; Woods & Spence, 2016).¹⁰

Researchers have recently started to investigate the impact of shapes presented on the plate itself; Others, meanwhile, have used digital technology to project an angular asymmetric green shape over foods and so potentially enhance the sourness.

3.5. On the shapes on/of food product packaging

There are correlations between shape and taste (Velasco, Woods, Petit, Cheok, & Spence, 2016). In an early design study, Overbeeke and Peters (1991) demonstrated how the form of unbranded dessert packages were consensually associated with particular kinds of desserts. In the case of form/shape rounded labels, and rounded packaging forms are both more approachable and linked with sweetness. Many years ago, Cheskin anecdotally reported how rounding the angular corners of the Fleischman's gin bottle label helped because it would make the product more approachable to women. By contrast, in the context of packaging, angular forms may help to capture the customers' attention which may be advantageous. Other researchers have recently assessed the impact of transparent windows in product packaging.

Downward-pointing angular shapes, such as an inverted triangle automatically capture people's attention because of a link with the brain's fear circuits. This can either be a good or bad thing in the context of food product packaging. On the one hand, the use of inverted triangle may be beneficial to capturing consumer attention in the wine aisle, given the wide and ever-changing range of bottles that are displayed. By contrast, displaying angular slices of cake/pizza,

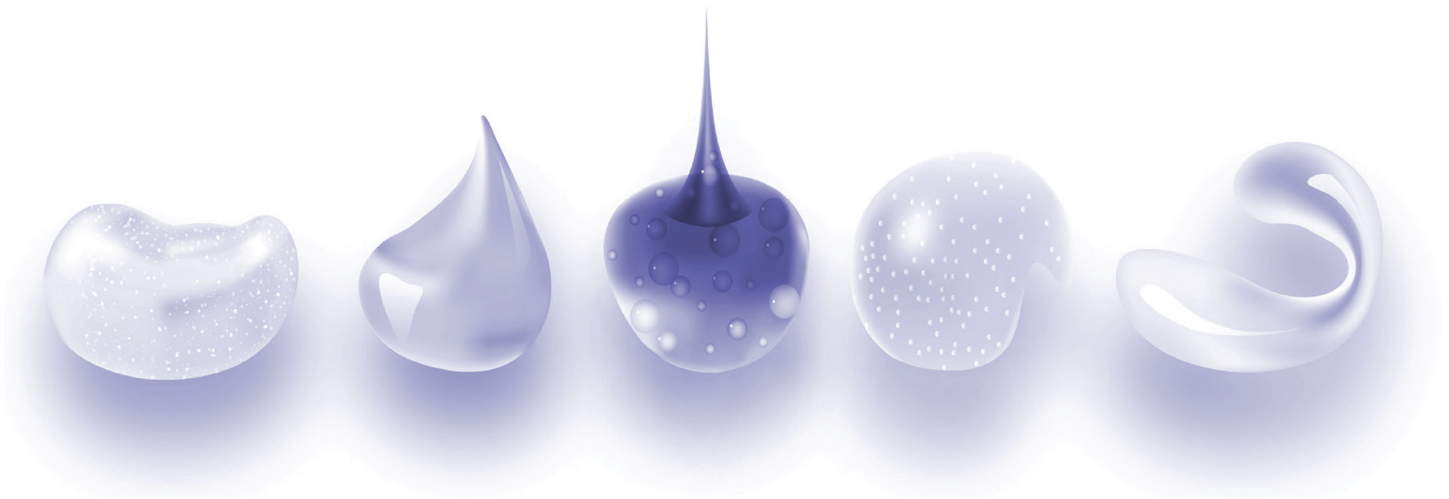


Fig. 3 - Jailin Deng's plates conceptual plates designed to match each of the basic tastes

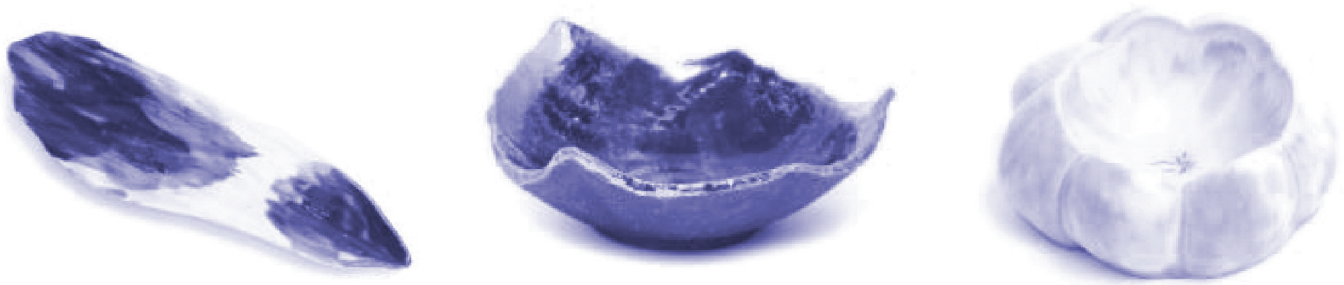


Fig. 4 - Reiko Kaneko's plates for seafood, Thai green curry, and a sweet dessert bowl. These designs were based on the emerging literature on the crossmodal correspondences between shape, colour, texture, and taste.



Fig. 5 - The angularly-shaped strawberry dessert served to participants from one of three differently-shaped plates in a study by Piqueras-Fiszman et al. that was published in 2012. The shape of the food in the foreground may have minimized any impact of the variation in plate shape in this study, perhaps explaining the null results reported.

pointing down, or rather oriented toward a customer are liked that little but less and between shape/symmetry and healthfulness. Of course, playing with the shape of a product and/or its packaging can act as a design innovation strategy.

3.6. Typeface design to bias taste perception and food choice

Researchers have demonstrated that people will rate a sweet-sour food, such as a jelly bean as tasting slightly sourer if presented in a bowl with curvy typeface saying 'Eat me', as compared to eating jelly bean from a bowl with angular typeface instead (Velasco, Hyndman, & Spence, 2018). In 2020, Rolschau and colleagues conducted an intriguing study where they manipulated the angular vs. curvy typeface on a chalked beer menu. They were

able to show that the curvature influenced expectations, though biased choice and taste perception in a slightly unexpected way (seeing sweet but choosing sour, as the title of their paper put it). In a subsequent study, they went on to show typeface angularity effects on older, but not younger, consumers (Otterbring et al., 2022). Again, why this should be is currently unclear, but suggests that further research is needed.

3.7. Furniture forms and interior layout

Approach behaviour toward round (as compared to angular) forms, be that furniture forms, through rounded tables and interior floorplans (Vartanian et al., 2013). Circular vs. angular servicescape has been shown to influence the customer’s response to a fast service encounter. It has also been reported that approach/avoidance can be predicted from curvature features present in images (Thömmes & Hübner, 2018).

3.8. Multisensory environmental design

Combining round environmental shapes with sweet colours of pink/red/purple. Velasco, et al. (2013) were able to demonstrate that people’s ratings of a whisky were significantly higher in terms of perceived sweetness than when compared to other multisensory environments that were designed to bring out grassiness, or textured finish of the aftertaste. Meanwhile, Chen et al. (2020) conducted a VR tasting study and were able to demonstrate that shape features of the environment

influenced taste (see Fig. 6).

3.9. Advertising/marketing

It is intriguing that various multisensory (audiovisual) virtual reality (VR) installations have now been created on the basis of correspondences. Take, for example, the pop song and music video developed by The Roots in collaboration with Stella Artois beer (e.g., <https://www.anheuser-busch.com/newsroom/2016/08/stella-artois-and-the-roots-stimulate-the-senses-with-a-one-of-a-kind-song-you-can-taste/>).

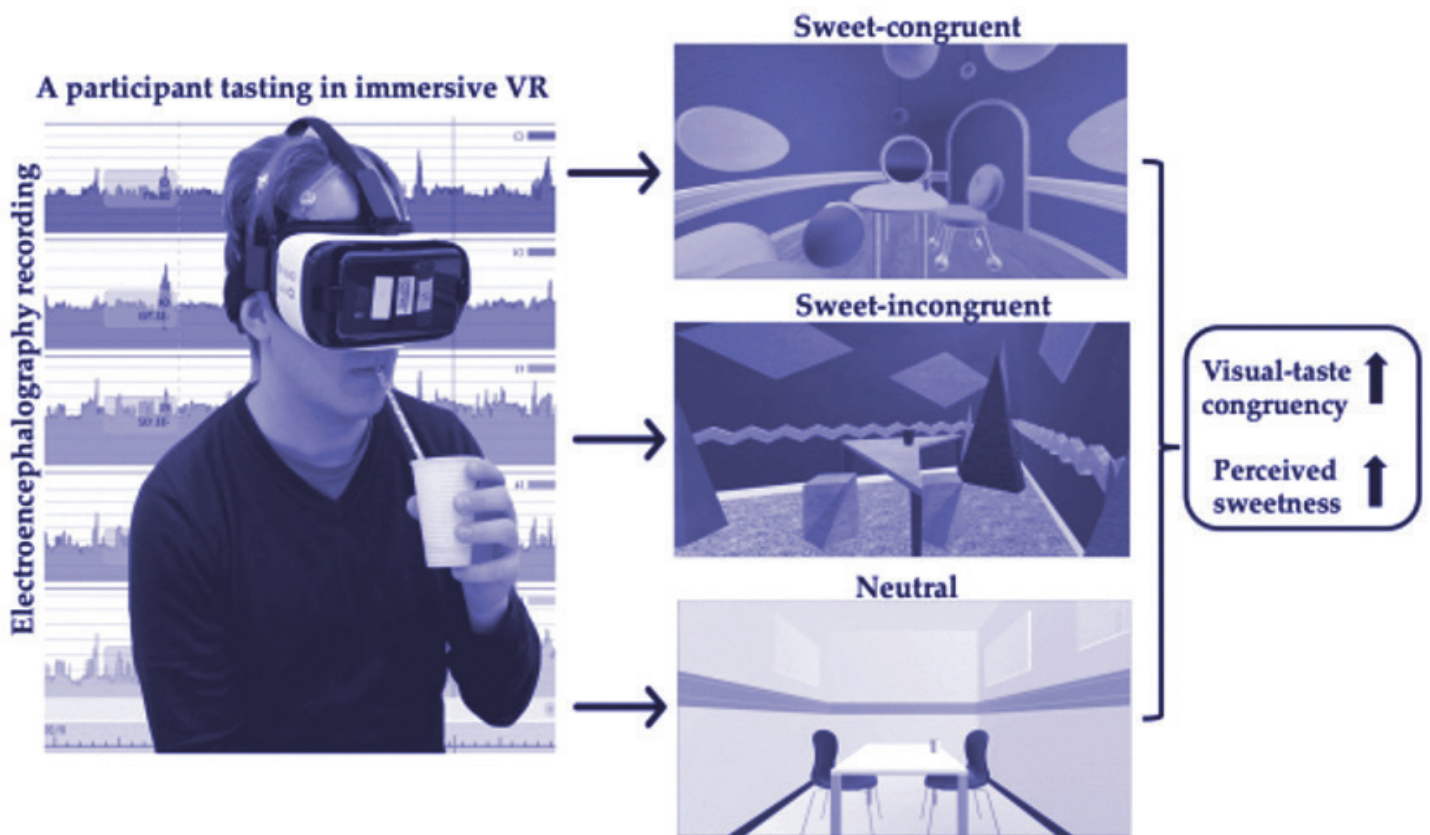


Fig. 6 - Sweet-congruent, sweet-incongruent (i.e., bitter), and neutral VR environments that were presented to participants in Chen et al.’s (2020) studies. The round shapes and pink-red colours of the sweet environment enhanced sweetness as predicted when compared to sweetness in the bitter environment with black and grey colours and angular shapes. [Reprinted under Creative Commons CC BY 4.0.]



Fig. 7 - Two stills frames (shown side by side) from the Stella Artois x The Roots collaboration highlighting the different forms and colour used for the bitter and sweet versions of the music video.

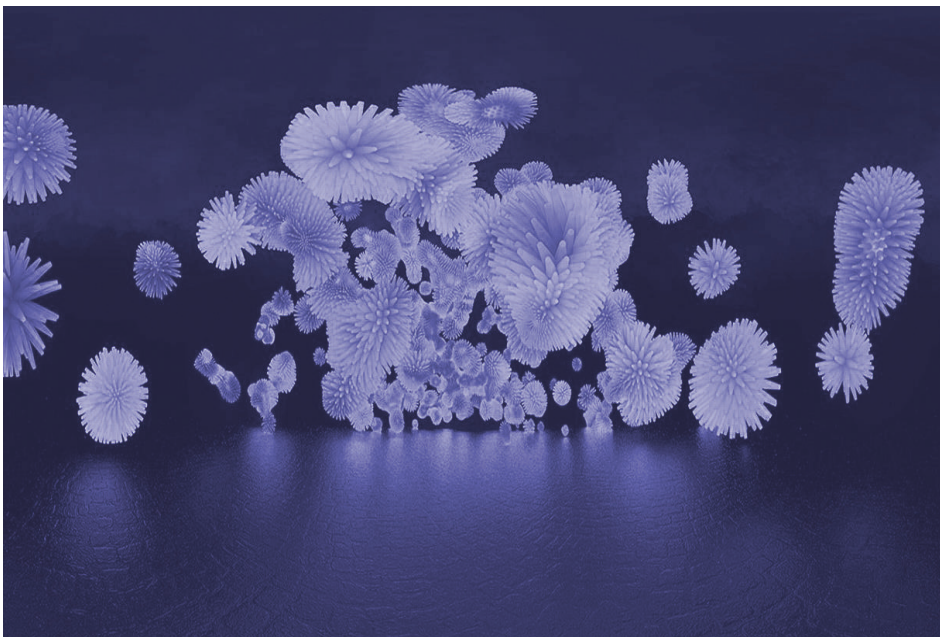


Fig. 8 - Two stills from the Guinness VR experience, highlighting the different forms and colours associated with the taste of two of the three beers.

Stella Artois teamed up with The Roots, the experience designers, Bompas and Parr, and myself to create a special music video in 2016 as part of Le Savoir, a multisensory entertainment platform (e.g., Birkner, 2016). The idea being that people sitting at home might enjoy the drink (Stella Artois beer), and by moving the cursor on their screen while watching the specially composed track and associated music video (called "Sweet to the Bitter End") in order to bring out a sweeter (fruitier) or more bitter version of the instrumentation/video backdrop (the bitterness

associated with the hops) (see Fig. 7). The suggestion that this personalized version of sonic seasoning could then be used to adjust the drink to taste.

According to the research, black (and white) is one of the colours most strongly associated with bitterness, while red is often associated with sweetness; Bitterness is associated with angularity and sweetness with roundness; Low-pitched notes and brassier sounds tend to be associated with bitterness, while tinkling high notes (e.g., of the hi-hat) are associated with

sweetness. Albeit with a little artistic license, these visual and auditory correspondences were all incorporated into the track, which also referenced sweetness and bitterness. The online activation was also associated with a series of dinners. Todd Allen, VP of Global Marketing at Stella Artois had the following to say: "It's bringing millennials' passion points of food, music and art together under one platform to deliver an immersive dining experience, all perfectly paired with Stella Artois...We're very excited to bring it to the market." (quoted in Birkner, 2016).

Manuka honey recently created an immersive audiovisual installation based on the emerging knowledge concerning crossmodal correspondences between form and taste, Guinness created a VR experience for shoppers in Tesco supermarket ('Guinness VR Immersive taste sensation MPC Creative', 2017; Glenday, 2017; Hills-Duty, 2017; see Fig. 8), while Johnnie Walker Blue Label developed their Flavour Organ concept that incorporated texture, colour, and sonic seasoning to help take premium customers around the world on a flavour journey. In all cases, digital visual content created inspired in terms of colour, movement, and form, based on emerging research from crossmodal correspondences. The emerging findings concerning the consensual mappings between form and taste are increasingly being used as an inspiration for those wishing to create immersive, multisensory, experiential, (and occasionally experimental) tasting events.

4. CONCLUSIONS

In recent years, a number of putative explanations have been put forward in order to try and help explain the consensual mappings that have increasingly been documented between shape and taste/mouthfeel characteristics. Ultimately,

while it is still unclear which of these explanations may help to explain the existence of shape-taste correspondences, they are increasingly being incorporated in the design of foodscapes and the built environment. There have also been a number of creative examples of digital content designed to match, and possibly also modify/enhance the tasting experience based on such form-taste correspondences (Velasco et al., 2013), sometimes combined with elements of 'sonic seasoning'. The latter can be considered as another kind of crossmodal correspondence.

Ultimately, such research can be seen as highlighting the potential of the emerging field of gastrophysics (Spence, 2017), to take us beyond traditional, more synaesthetic approaches to design, and to provide an innovative new direction for research at the interface of architecture and food.

REFERENCES

- Birkner, C. (2016). Stella Artois and The Roots created a music video you can taste: Sounds enhance the beer's sweet and bitter notes. *AdWeek*, August 19th. <http://www.adweek.com/brand-marketing/stella-artois-and-roots-created-music-videoyou-can-taste-173057/>.
- Bremner, A., Caparos, S., Davidoff, J., de Fockert, J., Linnell, K., & Spence, C. (2013). Boubas and Kiki in Namibia? A remote culture make similar shape-sound matches, but different shape-taste matches to Westerners. *Cognition*, 126, 165-172. <http://dx.doi.org/10.1016/j.cognition.2012.09.007>.
- Chen, N., Jiao, J. (J.), Fan, X., & Li, S. (K.) (2021). The shape of loneliness: The relationship between loneliness and consumer preference for angular versus circular shapes. *Journal of Business Research*, 136, 612-629.
- Chen, Y., Huang, A. X., Faber, I., Makransky, G., & Perez-Cueto, F. J. A. (2020). Assessing the influence of visual-taste congruency on perceived sweetness and product liking in immersive VR. *Foods*, 9:465. doi:10.3390/foods9040465.
- Chen, Y.-C., Woods, A., & Spence, C. (2018). Sensation transference from plateware to food: The sounds and tastes of plates. *International Journal of Food Design*, 3(1), 41-62. doi: 10.1386/ijfd.3.1.41_1
- Cytowic, R. E. (1993). *The man who tasted shapes*. USA: G. P. Putnam's Sons.
- Cytowic, R. E., & Wood, F. B. (1982). Synaesthesia II: Psychophysical relations in the synaesthesia of geometrically shaped taste and colored hearing. *Brain and Cognition*, 1, 36-49.
- Day, S. A. (2011). The human sensoria and synaesthetic approach to cooking. *Collapse*; VII: 378-409.
- 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. doi 10.3758/s13423-013-0397-0.
- Deroy, O., & Spence, C. (2014). Can you find the golden ratio in your plate? *Flavour*, 3:5. doi:10.1186/2044-7248-3-5.
- Deroy, O., & Valentin, D. (2011). Tasting liquid shapes: Investigating the sensory basis of cross-modal correspondences. *Chemosensory Perception*, 4, 80-90. doi: 10.1007/s12078-011-9097-1.
- Devenyns, J. (2019). Kokumi: The sensation that makes tasting better. *FoodDive*, June 24th. <https://www.fooddive.com/news/kokumi-the-sensation-that-makes-tasting-better/553761/>.
- Favre, J.-P., & November, A. (1979). *Colour and communication*. Zurich: ABC-Verlag.
- Gil-Pérez, I., Rebollar, R., Lidón, I., Martín, J., van Trijp, H. C. M., & Piqueras-Fiszman, B. (2019). Hot or not? Conveying sensory information on food packaging through the spiciness-shape correspondence. *Food Quality and Preference*, 71, 197-208. <https://doi.org/10.1016/j.foodqual.2018.07.009>.
- Glenday, J. (2017). Guinness tantalises Tesco shoppers with VR tasting experience. *The Drum*, May 18th. <https://www.thedrum.com/news/2017/05/18/guinness-tantalises-tesco-shoppers-with-vr-tasting-experience>.
- Gopnik, A. (2012). *The table comes first: Family, France, and the meaning of food*. London, UK: Quercus.
- 'Guinness VR Immersive taste sensation MPC Creative' (2017). May 24th. <http://mpccreative.io/project/dsknvx>.
- Hauer-Bain, V. (2018). The flavour boosting plates: NEFF launches exclusive plate collection inspired by the science of gastrophysics. *Press Release*. Milan, April 17th.
- Hills-Duty, R. (2017). VR in the supermarket with Guinness VR tasting-experience. *VR Focus*, May 20th. <https://www.vrfocus.com/2017/05/vr-in-the-supermarket-with-guinness-vr-tasting-experience/>.
- Horwitz, J., & Singley, P. (Eds.). (2004). *Eating architecture*. Cambridge, MA: MIT Press.
- James, W. (1887). The perception of space (part I). *Mind*, 12, 1-30.
- Juravle, G., Olari, E.-L., & Spence, C. (2022). A taste of beauty: Crossmodal correspondences from geometric shapes to temperature, texture, and taste. *i-Perception*, 13(5), 1-19. <https://doi.org/10.1177/20416695221120948>.
- Knöferle, K., & Spence, C. (2012). Crossmodal correspondences between sounds and tastes. *Psychonomic Bulletin & Review*, 19, 992-1006. DOI 10.3758/s13423-012-0321-z.
- Lee, I. F. (2018). *Joyful: The surprising power of ordinary things to create extraordinary happiness*. London, UK: Rider.
- Liang, P., Biswas, P., Vinnakota, S., Fu, L., Chen, M., Quan, Y., Zhan, Y., Zhang, G., & Roy, S. (2016). Invariant effect of vision on taste across two Asian cultures: India and China. *Journal of Sensory Studies*. 31(5). DOI: 10.1111/joss.12225
- Michel, C., Velasco, C., Gatti, E., & Spence, C. (2014). A taste of Kandinsky: Assessing the influence of the artistic visual presentation of food on the dining experience. *Flavour*, 3:7. doi:10.1186/2044-7248-3-7.
- Michel, C., Woods, A. T., Neuhäuser, M., Landgraf, A., & Spence, C. (2015). Rotating plates: Online study demonstrates the importance of orientation in the plating of food. *Food Quality & Preference*, 44, 194-202. <http://dx.doi.org/10.1016/j.foodqual.2015.04.015>.
- Motoki, K., Saito, T., & Velasco, C. (in press). Spontaneous crossmodal correspondences grounded in contexts. *Food Quality and Preference*.
- Motoki, K., Takahashi, A., & Spence, C. (2021). Tasting atmospherics: Taste associations with colour parameters of coffee shop interiors. *Food Quality and Preference*, 94:104315. <http://dx.doi.org/10.1016/j.foodqual.2021.104315>.
- Motoki, K., & Velasco, C. (2021). Taste-shape correspondences in context. *Food Quality and Preference*, 88:104082. <https://doi.org/10.1016/j.foodqual.2020.104082>.
- Otterbring, T., Rolschau, K., Furrebøe, E. F., & Nyhus, E. K. (2022). Crossmodal correspondences between typefaces and food preferences drive congruent choices but not among young consumers. *Food Quality and Preference*, 96:104376. <https://doi.org/10.1016/j.foodqual.2021.104376>.
- Overbeeke, C. J., & Peters, M. E. (1991). *The taste of desserts' packages*. *Perceptual and Motor Skills*, 73, 575-580.
- Peynaud, E. (1987). *The taste of wine: The art and science of wine appreciation* (Trans. M. Schuster). London, UK: Macdonald & Co.
- Spence, C. (2011). Crossmodal correspondences: A tutorial review. *Attention, Perception, & Psychophysics*, 73, 971-995. DOI 10.3758/s13414-010-0073-7.
- Spence, C. (2017). *Gastrophysics: The new science of eating*. London, UK: Viking Penguin.
- Spence, C. (2020a). Designing for the multisensory mind. *Architectural Design: Neuroarchitecture: Designing with the Mind*

in Mind, December, 42-49.

Spence, C. (2021). *Sensehacking: How to use the power of your senses for happier, healthier living*. London, UK: Viking Penguin.

Spence, C., & Deroy, O. (2012). On the shapes of tastes and flavours. *Petits Propos Culinaires*, 97, 75-108.

Spence, C., & Deroy, O. (2013a). Crossmodal mental imagery. In S. Lacey & R. Lawson (Eds.), *Multisensory imagery: Theory and applications* (pp. 157-183). New York, NY: Springer.

Spence, C., & Deroy, O. (2013b). On the shapes of flavours: A review of four hypotheses. *Theoria et Historia Scientiarum*, 10, 207-238.

Spence, C., & Ngo, M. (2012). Assessing the shape symbolism of the taste, flavour, and texture of foods and beverages. *Flavour*, 1:12. doi:10.1186/2044-7248-1-12.

Spence, C., Velasco, C., & Knoeferle, K. (2014). A large sample study on the influence of the multisensory environment on the wine drinking experience. *Flavour*, 3:8. doi:10.1186/2044-7248-3-8.

Spence, C., Wan, X., Woods, A., Velasco, C., Deng, J., Yousef, J., & Deroy, O. (2015). On tasty colours and colourful tastes? Assessing, explaining, and utilizing crossmodal correspondences between colours and basic tastes. *Flavour*, 4:23. DOI 10.1186/s13411-015-0033-1.

Thömmes, K., & Hübner, R. (2018). Instagram likes for architectural photos can be predicted by quantitative balance measures and curvature. *Frontiers in Psychology: Perception Science*, 9:1050. doi: 10.3389/fpsyg.2018.01050.

Vartanian, O., Navarrete, G., Chatterjee, A., Fich, L. B., Leder, H., Modroño, C., Nadal, M., Rostrup, N., & Skov, M. (2013). Impact of contour on aesthetic judgments and approach-avoidance decisions in architecture. *Proceedings of the National Academy of Sciences of the USA*, 110 (Supple 2), 10446-10453.

Velasco, C., Hyndman, S., & Spence, C. (2018). The role of typeface curvilinearity on taste expectations and perception. *International Journal of Gastronomy & Food Science*, 11, 63-74. https://doi.org/10.1016/j.ijgfs.2017.11.007.

Velasco, C., Jones, R., King, S., & Spence, C. (2013). Assessing the influence of the multisensory environment on the whisky drinking experience. *Flavour*, 2:23. doi:10.1186/2044-7248-2-23.

Velasco, C., Michel, C., Woods, A., & Spence, C. (2016). On the importance of balance to aesthetic plating. *International Journal of Gastronomy and Food Science*, 5-6, 10-16. http://dx.doi.org/10.1016/j.ijgfs.2016.08.001.

Velasco, C., Salgado-Montejo, A., Marmolejo-Ramos, F., & Spence, C. (2014). Predictive packaging design: Tasting shapes, typographies, names, and sounds. *Food Quality & Preference*, 34, 88-95. http://dx.doi.

org/10.1016/j.foodqual.2013.12.005.

Velasco, C., & Spence, C. (2019). The role of typeface in packaging design. In C. Velasco & C. Spence (Eds.), *Multisensory packaging: Designing new product experiences* (pp. 79-101). Cham, Switzerland: Palgrave MacMillan.

Velasco, C., Woods, A., Liu, J., & Spence, C. (2016). Assessing the role of taste intensity and hedonics in taste-shape correspondences. *Multisensory Research*, 29, 209-221. DOI:10.1163/22134808-00002489.

Velasco, C., Woods, A. T., Petit, O., Cheok, A. D., & Spence, C. (2016). Crossmodal correspondences between taste and shape, and their implications for product packaging: A review. *Food Quality & Preference*, 52, 17-26.

Velasco, C., Woods, A., Deroy, O., & Spence, C. (2015). Hedonic mediation of the crossmodal correspondence between taste and shape. *Food Quality & Preference*, 41, 151-158.

Velasco, C., Woods, A. T., Hyndman, S., & Spence, C. (2015). The taste of typeface. *i-Perception*, 6(4), 1-10.

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. DOI: 10.1177/2041669516663750.

Woods, A. T., Michel, C., & Spence, C. (2016). Odd versus even: A scientific study of the 'rules' of plating. *PeerJ*, 4:e1526. https://doi.org/10.7717/peerj.1526.

Woods, A. T., & Spence, C. (2016). Using single colours and colour pairs to communicate basic tastes. *i-Perception*, 7:4. DOI: 10.1177/2041669516658817.

Woods, A. T., Spence, C., Butcher, N., & Deroy, O. (2013). Fast lemons and sour boulders: Testing the semantic hypothesis of crossmodal correspondences using an internet-based testing methodology. *i-Perception*, 4, 365-369.

NOTES

¹This synaesthete is unusual in that the shape-taste synaesthesia only emerged in his twenties. When cooking "He then adjusts seasonings (at times by trial and error) to alter the taste's shape, making it "rounder," giving it more "inclination," "sharpening up" the corners, or unwinding the "curlicues." " (Cytowic & Woods, 1982, pp. 37-38).

²The oenologist Emile Peynaud (1987, p. 221) writes that: "I have searched through numerous texts and have encountered all the expressions that I mention here at least once, but can I be sure of having picked them all up? A wine is formless if its image on the palate is unclear. The following words immediately evoke simple forms: spherical, round, rounded, oblong, flat, threadlike, rectilinear, lanky or long limbed, square, angular, sharp, pointed, twisted, corked concave, convex."

³The poet and fellow Balliol Scholar, Matthew Arnold, once described the 'sweet vista of the city' of Oxford (<https://www.poetryfoundation.org/poems/43608/thyrsis-a-monody-to-commemorate-the-authors-friend-arthur-hugh-clough>).

⁴Confusing matters somewhat, though, synaesthetes are presumably likely to experience many of the same crossmodal correspondences as the rest of us non-synaesthetes, hence perhaps explaining the angularity-acidity connection picked-up in the responses of the synaesthete in Cytowic and Woods' (1982) study.

⁵Given that umami and kokumi are both associated with mouth-filling sensations (Devenyns, 2019), it might be expected that they would be linked with more voluminous forms. Interestingly, kokumi is often described as adding roundness to the taste/flavour of foods (Devenyns, 2019). That said, these newer taste qualities have yet to make it into research on the crossmodal correspondences. One challenge perhaps being that kokumi substances have no taste in and of themselves, but add 'roundness' and 'length' to sweet, salty, and umami taste sensations.

⁶It remains, though, an open question as to how a viewer's/diner's handedness may influence their preference for the orientation, position, and layout of food (as when served on a plate). This might be expected to interact with culture, e.g., in the differing ways in which cutlery is used to bring the food from plate to mouth. However, once again, more research is needed.

⁷According to personal correspondence with Joshua Berger of Sydney (May 27th, 2022): "The peak taste of a lemon is a fleeting sensation (perhaps because the components are hydrophilic/acidic and disperse in saliva/your mouth quickly) - in comparison with say peanut butter, which being a butter is, of course, lipophilic and 'sticks around' and could be imagined or associated with a 'slow' taste. That's a plausible statistical contingency that COULD explain the propensity for fast and slow tastes."

⁸Were this spatiotemporal account to be correct, then it might predict that different sweeteners would be associated with different shapes, since they have been documented to exhibit very different temporal profiles in consumer experience.

⁹Konrad Lorenz first introduced the term introduced the notion of imprinting in 1935. Tinbergen subsequently went on to demonstrate that newly-hatched ducklings would form a special attachment and follow around whatever visual stimulus they were first exposed to. In humans neonates, one might thus consider the imprinting possibilities associated with the pink aureole and nipple for breast-fed children

¹⁰Favre and November (1979) combine different colours and shape properties in order to convey taste qualities in their marketing book on the use of colour in communication.