Taste and Sound

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Throughout history, food has been associated with music. However, only recently have researchers started to consider the impact of what we hear on the experience of eating and drinking, be it consumption sounds, soundscapes or music. Crossmodal correspondences between taste and sound have been used to modify the experience of many different food and drink products by changing the music or soundscape that people listen to. Chefs and musicians are also becoming increasingly interested in exploiting the expressive potential of combining music and food. This so-called “sonic seasoning” can be boosted by the use of specially designed sensory apps.

Food has been associated with music since Antiquity: think of Trimalchio’s dinner in the Satyricon by Petronius, where meat is carved to the rhythm of music, or of the references to music in The Physiology of Taste by Brillat-Savarin (2009), where it is stated that “music and song were made to increase the pleasures of the table”; in Thomas More’s Utopia (1965), the ideal city should have music played during evening suppers to aid digestion. Beyond these and many other literary references, let us also mention the long and important tradition of Tafelmusik (literally, “table-music”) that developed from the late Medieval period through the Enlightenment, in which music accompanied meals of all types (Zohn, 2016).

Food-Intrinsic Sounds

However, only recently have researchers, chefs and musicians started to consider in a systematic way the impact of what we hear on the experience of eating and drinking, be it consumption sounds, soundscapes or music. In one of the most-cited studies in this area of research, Zampini and Spence (2004) showed that mastication sounds affect the perception of crispness and freshness of potato chips. They put earphones on the participants of their study and manipulated their biting noises in real time while they ate Pringles’ potato chips, so that for some chips, the participants heard the actual noises, while for others, the sound volume and the high-frequency components were boosted or attenuated. Their key finding was that boosting volume and/or high frequencies enhanced participants’ ratings of crispness and freshness. Another study (Dematté et al., 2014) showed similar results for the crispness and hardness of apples. Textural qualities such as creaminess seem to depend in part on subtle perceptions of sounds coming from the interior of the mouth (Van Aken, 2013): if you rub the tongue against the palate after drinking coffee with cream, it will sound different than if you do the same after drinking just black coffee. Perhaps our brains use such auditory cues in order to ascertain the texture of that which we have put into our mouths.

Of course, the experimental method of Zampini and Spence can be used creatively to deliver any kind of pre-recorded sounds in synchrony with mastication, as has been done by Japanese researchers (Masuda and Okajima, 2011). They played back over headphones the sounds of mastication of crunchy and sticky textures to people eating a variety of foods, resulting in altered texture perception in all cases.

Food-Extrinsic Sounds

Besides the sound of food in the mouth, loud noise has also been shown to affect taste perception. In a study in which participants sampled solutions of five prototypic tastants, and where conditions of airplane cabin noise were simulated with broad spectrum auditory stimulation, perception of sweetness was suppressed when the participants were exposed to 85 dB of noise intensity, while the taste of umami was rated as more intense instead (Yan and Dando, 2015). Note, however, that there is some conflicting evidence on this matter (Spence, 2014). Moreover, the pleasantness of food-related odours can be diminished by the presence of noise (Velasco et al., 2014). Also, loud background music or noise in a bar can stimulate drinking (but impair the perception of the alcohol content of drinks) (Spence et al., 2019). This observation has been explained by means of an “arousal hypothesis”: louder music tends to produce greater levels of emotional arousal, which in turn increases consumption (Guéguen et al., 2008). The arousal hypothesis may also help to explain the effect of high musical tempo on consumer behaviour. Researchers have observed that high-tempo music, which tends to increase arousal (Husain et al., 2002), may make people drink more rapidly (Spence et al., 2019). On the other hand, slow-tempo music may induce customers to linger for
longer in a bar (Spence et al., 2019). Music style and genre can also exert a marked effect on food evaluation by priming certain aspects of the taste experience. Classical music has been shown to increase the purchased amount of food and beverages in several real-world cases (see, for instance, North and Hargreaves, 1998; North et al., 2003), an effect that has been explained by the semantic connection that customers may make between classical music and notions of high quality and class. In other cases, music is able to bias judgments on specific aspects of taste, as in a study by North (2012) showing that playing “Carmina Burana” by Karl Orff to a group of university students while they tasted a red or a white wine made both wines taste more “powerful and heavy”, while playing “Just Can’t Get Enough” by Depeche Mode made the wines more “zingy and refreshing”.

**Sonic Ingredients**

These findings have stimulated culinary creativity, and some chefs, such as Heston Blumenthal in his dish named “Sound of the Sea”, have used soundscapes as an essential ingredient: in this dish, “seafood, seaweed and edible ‘sand’ are used to create what looks like the edge of the seashore, all of which is accompanied by an iPod and earphones so that the diner can hear the sounds of the waves lapping up against the shore while eating” (Spence and Piqueras-Fiszman, 2014). In an experimental tasting conducted by Blumenthal and Spence, they had two groups of people eating a bacon and egg ice-cream; one group simultaneously listened to the sounds of bacon sizzling in the pan, the other to the sounds of chickens clucking; in each case, sound intensified the congruent flavour (Spence and Piqueras-Fiszman, 2014).

Other chefs, like Grant Achatz of Chicago’s Alinea, are now starting to consider having a musician come into the restaurant to play something to accompany one of the dishes on the menu (Ulla, 2011). In his collaborative gastronomic project “Kitchen Theory”, Jozef Youssef organizes multisensory dinners where he uses soundscapes to enhance particular dishes, for example liquid nitrogen-poached grapefruit and vodka meringues, made at the table and served to the sound of rustling wind. Interestingly, he has also experimented with changing the music while diners consumed a dish entitled “Believe Nothing of What you Hear”, playing first a glitchy and distorted song and then a more consonant and melodic piece. He reports that “when consulted, the guests consistently reported that the glitchy music brought out the more bitter (cocoa), sour (passion fruit) and crunchy (crumble) elements of the dish, whereas the more melodic music brought out the sweeter and creamier (mango chocolate ganache) elements” (Youssef, 2015).

**Technology for “Sonic Seasoning”**

The expression “sonic seasoning” refers to altering people’s taste experiences by the use of sound. This can be boosted by the use of specially designed sensory apps. For instance, a device built by Japanese designers called the “Chewing Jockey” can detect when a user’s jaws move while eating and play back a pre-recorded sound in synchrony (Spence and Piqueras-Fiszman, 2014). As said before, this can have an effect on texture perception and also on the pleasure or surprise while eating – think of matching mastication to the sounds of thunder or a breaking glass. At our lab, we made an analogue device for drinks: a wine glass equipped with sensors that are able to detect three main gestures of the user: when the glass is taken by the hand, when the wine is aired, and when the liquid contacts the mouth while drinking (Figure 85.1). At a recent presentation, we used these glasses with a young and an aged wine to synchronize sounds designed to match the age of the wine (Mesz et al., 2017a; Mesz, 2019).

The musical spoons by food designers Sam Bompad and Harry Parr (Anonymous, 2013), with tiny mp3 players embedded in them, are specifically for Heinz baked beans. Each baked bean flavour gets a different type of music, which is heard via bone conduction to the ear when users bite the spoons – for instance, cheddar cheese gets an Elgar-inspired sound, while garlic and herb has a track made by rustling garlic skins together. The SmartPlate by designer Julian Caraulani (Seth, 2012) is a conceptual project of a plate that detects the ingredients of the food placed over it and generates a musical composition based on each of them.

For reviews on sound technology for “sonic seasoning”, see Velasco et al. (2016; 2018); see also Spence (2019) on sensory apps for musical augmentation of the wine drinking experience.

**Crossmodal Correspondences between Taste and Sound**

Crossmodal correspondences refer to the associations that many of us appear to make between seemingly unrelated attributes, features or dimensions in two or more different senses, as, in our case, taste and hearing (Spence, 2011). Empirical research shows that sweet taste tends to be matched with sounds that are high in pitch, with slow-tempo music that is “legato” in articulation (i.e., continuous and without separation between successive sounds) and soft in dynamics, and with consonant harmonies (Mesz et al.,

**FIGURE 85.1** Interactive wine glasses.
(Mesz et al., 2017)
TABLE 85.1
Summary of Crossmodal Correspondences between Basic Tastes and Sound Dimensions in the Literature to Date

<table>
<thead>
<tr>
<th></th>
<th>Sweet</th>
<th>Acid</th>
<th>Salty</th>
<th>Bitter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch</td>
<td>Medium</td>
<td>Very high</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Articulation</td>
<td>Medium-high</td>
<td>Mean</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Consonance</td>
<td>Legato</td>
<td>Low (dissonant)</td>
<td>Staccato</td>
<td>Legato</td>
</tr>
<tr>
<td>Pitch range (ambiitus)</td>
<td>High</td>
<td>Low (dissonant)</td>
<td>Medium</td>
<td>Low (dissonant)</td>
</tr>
<tr>
<td>Rhythm</td>
<td>Regular</td>
<td>Large</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Tempo</td>
<td>Slow</td>
<td>Fast</td>
<td>Medium</td>
<td>Slow</td>
</tr>
<tr>
<td>Sharpness (high-frequency content)</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>

2011; Bronner et al., 2012). By contrast, sour taste tends to be matched with extremely high-pitched sounds, fast tempo and dissonant music. Bitter taste is matched with sounds that are low in pitch and more likely to be brassy (Crisinel and Spence, 2012; Wang et al., 2015). Salty taste is mostly associated with “staccato” music (i.e., music with clearly detached successive notes) (Mesz et al., 2011; Kööfkerle and Spence, 2012) (Table 85.1).

Interestingly, the same correspondences have been documented in non-Western cultures (Knoeferle et al., 2015).

Importantly, these preferred pairings of taste and sound, when presented together, tend to enhance the pleasure of what one is tasting (Spence et al., 2014b; Wang and Spence, 2015). A growing body of empirical research now shows that our experience of many different food and drink products can be modified by changing the music or soundscape that people listen to (Crisinel et al., 2012; Spence and Deroy, 2013; Velasco et al., 2013; Spence et al., 2014a; Reinoso-Carvalho et al., 2015a,b; Wang and Spence, 2015a,b; Wang and Spence, 2016; Hauck and Hecht, 2019); see a summary of recent studies on this subject in Spence et al. (2019).

These effects of “sonic seasoning” tend to be more pronounced for foods with complex flavours, which could be explained by an attentional account. According to this approach, taste-congruent soundtracks work by drawing the listener’s attention towards the taste/flavour that happens to correspond to the soundtrack rather than to another taste/flavour. Attention can enhance the salience of the attended stimulus/feature relative to when the same stimulus/feature is unattended, and the effects of attention on awareness tend to become more pronounced as the perceptual input becomes more challenging or complex (Wang, 2017). Note that “sonic seasoning” may also work comparatively better with unfamiliar food products, in which case the role of memories of previous experiences with their taste/flavour will presumably not dominate over the actual tasting situation.

Besides attentional biases, there are several other plausible mechanisms accounting for the effect of sound in taste perception/evaluation (Wang, 2017), such as emotion and sensation transference. The idea of emotion transference is that “if you like the music more, you like the food more”: people will prefer a food or drink consumed while listening to music they enjoy in comparison to eating/drinking it with music they don’t; that is, preference for the music is transferred to taste preferences. In fact, several studies have shown precisely this for a variety of products such as fruit juice, chocolate and beer (Reinoso-Carvalho et al., 2015a,b; Wang, 2017; Reinoso-Carvalho et al., 2019).

More generally, sensation transference happens when what we think about what we hear (and the ideas/concepts primed by such music or soundscapes) is transferred to whatever it is we happen to be tasting. For instance, in the already-mentioned study by North on music and wine (North, 2012), a music that is judged as heavy and powerful can make a wine taste more heavy and powerful. It is worth bearing in mind that such effects may depend on the whole service environment; a music that is judged congruent with the environment can improve customers’ evaluation of its quality (Demoulin, 2011), and in turn, this sensation can be transferred to food evaluations (Spence et al., 2019). Of course, these influences of auditory stimuli on food perception also operate in the kitchen and may affect how food and drinks are seasoned and prepared (Kontukoski et al., 2015).

A favourite pairing in the literature on crossmodal matching and multisensory perception of sound and taste is combining music with wine (Spence and Wang, 2015a,b,c). The existing research shows that sweetness, acidity, fruitiness, astringency and length of the flavour sensation can all be modified by playing appropriate musical selections.

Since music and the consumer experience of food/drink are both time-varying in nature, it would seem appropriate to take temporality into account when studying the impact of music on the eating/drinking experience. A recent study used a time-based method of sensory analysis called time-intensity to measure temporal changes in sweetness and sourness evaluations of an off-dry white wine when the music stimulus changed from a soundtrack commonly associated with sweetness to one associated with sourness instead, and vice versa (Wang et al., 2017a). The results revealed that a change of soundtrack results in a change in taste intensity (for both sweetness and sourness) in the same direction as the change in the soundtrack. More specifically, a switch from the sweet to the sour soundtrack enhanced the intensity of sourness, whereas a switch from the sour to the sweet soundtrack enhanced the perceived intensity of sweetness (this experiment is similar to Youssef’s idea of changing music while savouring a dish). More complex shifts in the taste of red wine presented together with classical and pop music were measured with the method of temporal dominance of sensations (Wang et al., 2019).
For considerations on the aesthetics of temporal sequences in cuisine and music, see Rozin and Rozin (2018).

**Multisensory Gastromusical Art**

Inspired in part by the growing research on the effects of sound on taste perception, musicians and chefs are increasingly interested in exploiting the expressive potential of combining music and food.

Irene and Per Moneeo are Swedish composers of electronic art music that create “Taste of Sound Dinner Experiences”; these spectacles, which they have been presenting since 2012, are large-scale dinners for all the senses with sound, music, food, drinks, fragrances and other sensory stimuli (Moneeo and Moneeo, 2020). The music works like a soundtrack to a movie, enhancing the taste of the dishes and creating specific atmospheres (Figure 85.2).

Ben Houge, professor at Berklee College of Music in Boston, together with designer Jutta Friedrichs, has been developing a “food opera” project (Houge and Friedrichs, 2018a). They distribute sound among diners using individual speakers at each seat in the dining area, or by networked mobile devices, which allows them to use real-time software to render a customized soundtrack based on each diner’s behaviour. They have also been working with sensors for systems of networked plates and glasses to increase the extent to which diners’ activities and gestures can influence the music that accompanies a meal. Some recent performances of the project were a dinner at Symphony Hall in Boston (Arnett, 2018) and the “XX aniversario” dish at Mugaritz restaurant in Spain (Houge and Friedrichs, 2018b).

Jo Burzynska is an Australasia-based sound artist and wine writer whose work in these areas has increasingly converged in the production of multisensory art. Her work “Carbonic Oscillation” in the Mishearings exhibition at the Auricle Sonic Arts Gallery in Christchurch, New Zealand was an immersive chamber in which sparkling wine formed the focus of a fusion of all the senses. An effervescent environment was created through “a sound work made from recordings of fizzing wine reinforced by a bubbling light projection and the taste and tactile elements of the sparkling wine consumed within it” (Burzynska, 2015). “Amazuppai” is a work that sets out to sonically modulate the sensory and conceptual perception of sweet and sour in wine, which was first exhibited at the Auricle in Christchurch in 2017 (Burzynska, 2017). Her “Risonanze di Vino” project, conducted in Campania in 2018 during the vintage, was a cultural study that used winegrowers’ sensory responses to guide the six wine and sound compositions that resulted (Burzynska, 2018).

Composer and chef Ysanne Spevack creates sensorial events called “Yntegriti”. In one of them, she presented “Cacao in E Major,” “an immersive five-course symphony of chocolate syn-aesthesis designed to inspire deep inner happiness” (Halter, 2016). Each of the courses included single-estate raw cacao from Ecuador, and Spevack served the dinner to the sounds of a very primal place, the rainforest, together with her own compositions and those of Billy Corgan (Smashing Pumpkins) and Shepard Fairey (Noise) (Spevack, 2017).

In “Cena Emocional” (Emotional Dinner), María Zegna, Janice Wang and Bruno Mesz built four scenes where food, smells and music responded to different emotional states: “Narcotic” (music: “Clair de lune” by Gabriel Fauré, food: “arroz con leche”, smell: roses), “Irritant” (music: “Child of Tree” by John Cage, food: spicy bread served on the spines of a cactus, smell: an irritant monomolecular odour), “Depressive” (music: sound texture by Mesz, food: blueberries floating in fish tanks containing icy water that people had to catch with their hands, dance by Zegna, smell: humidity and earth) and “Stimulant” (music: “Rebonds B” by Iannis Xenakis, drink: champagne mixed with Fanta Orange Soda) (Zegna et al., 2015). Other performances by Zegna and Mesz (MoT and ToM) were organized in four parts corresponding to the basic tastes bitter, sweet, sour and salty. In each part, a piece of contemporary art music was presented together with...
visual live performance and dance, while at a given moment (indicated on a screen) the spectators had to eat a small canape of the corresponding taste, made from ingredients used by the originary people of Latin America (MoT) or typically Finnish (ToM) (Mesz, 2012a,b). The music for each taste was selected on the basis of crossmodal taste–music correspondences.

Artist and researcher Janice Wang has directed many performances and multisensory dinners combining music and gastronomy (Wang, 2019a). In “Aros far from home multisensory dinner”, five courses were served in the Aros museum restaurant in Aarhus, Denmark. Each course emphasized the role of one particular sense in flavour perception, while the overall progression of the evening took the diners further from home. Each dish was served with an assortment of accompaniments including beverages, lighting, sound and aroma (Wang, 2019b).

**Conclusion**

Sound is often described as the forgotten flavour sense (Spence et al., 2011); however, there is now a large volume of research on auditory contributions to the experience of eating and drinking. These investigations show that the effects of sound and music on taste perception and consumer behaviour related to food are surprising and profound; this fact, documented both in the laboratory and in real-world contexts, offers exciting opportunities to conceive new kinds of multisensory gastronomic events. It can be expected that multisensory technologies and apps will have a relevant role to play in enriching dining experiences, in aspects such as the selection and control of sound events for “sonic seasoning” (Spence, 2019) or the synchronization of the music with the act of eating/drinking.

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