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The influence of music on the perception of taste

Joana Campinho [a], Paulo Sousa [b,*], Paulina Mata [a]

[a] REQUIMTE - LAQV, Department of Chemistry, NOVA School of Science and Technology, NOVA University of Lisboa, 2829-516, Caparica, Portugal

[b] Gastronomy Undergraduate Program, Culture and Art Institute, Federal University of Ceara, Brazil

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ABSTRACT

The auditory characteristics of a musical composition can be matched in a congruent manner with the basic tastes affecting the way consumers perceive them. Based on this evidence, the present study was developed to extend the understanding of crossmodal interactions between gustatory and auditory stimuli—namely, the influence of music on sweet and sour basic tastes intensity. For this purpose, two musical compositions congruent with sweet and sour basic tastes were selected. The gustatory stimulus chosen was a real food (passion fruit mousse) having these two basic tastes. Sensory tests were performed upon a participants screening using basic tastes recognition tests and familiarization with the used scale. Each participant experienced the same dessert in three different conditions, in random order: *i)* control, in which the dessert was tasted in silence; *ii)* condition A, in which the dessert was tasted while listening to *sweet* music, that expectably would enhance the sweet taste and *iii)* condition B, in which the dessert was tasted while listening to *sour* music, that expectably would enhance the sour taste. Results demonstrated that the same dessert was perceived differently when participants were exposed to different auditory stimuli, validating the music's influence on the tasting experience. Furthermore, it was verified that crossmodal music-taste correspondences with the sour taste were stronger and showed a significant effect. *Sweet* music, by contrast, did not increase the sweet taste of the dessert. However, it decreased the intensity of sour taste, suggesting a different approach to crossmodal correspondences between music and taste.

1. Introduction

Food perception is one of the most representative multisensory experiences. A large body of research has shown the deep effect of music on food behaviour, choices, perception of food sensory attributes and the overall experience. These findings awaken people's interest in matching music to specific tastes, flavours, and textures to enhance the experience (Knöferle and Spence, 2012; Spence, 2011; 2012; Spence and Piqueras-Fiszman, 2014; Spence et al., 2019).

The idea that gustatory attributes can describe music is not new. Some metaphors, such as a "*sour note*" or a "*sweet voice*" implied taste-sound correspondences. In musical lexis, the Italian term *dolce* (sweet) describes soft, gentle, and delicate playing (Knöferle and Spence, 2012; Mesz et al., 2012).

Recently research has been conducted to evaluate these sound-taste crossmodal associations. It consistently showed specific musical parameters correspondences with the different tastes/flavours/textures (Bronner et al., 2012; Carvalho et al., 2017; Crisinel et al., 2012; Crisinel & Spence, 2009, 2010, 2010, 2011, 2010; Guetta and Loui, 2017; Knoeferle et al., 2015; Knöferle and Spence, 2012; Kontukoski et al., 2015; Mesz et al., 2011; Wang and Spence, 2018).

The main musical dimensions targeted in the research were: *pitch* - the auditory sensation based on vibrations' frequency; *duration* - the time's length of a note; *articulation* – the continuity degree between successive notes (*legato* without breaks and *staccato* with each note detached); *loudness* - the sound's volume; *degree of dissonance (gradus)* – dissonance related to unpleasant or unstable sounds and consonance with pleasant sounds (Mesz et al., 2011) and *timbre* - the sound's quality that allows to distinguishing different musical instrument or voices.

A correspondence was established between sour taste and high-pitched, fast, articulated (high discontinuity), and dissonant sounds (Crisinel and Spence, 2009, 2010; Crisinel et al., 2012; Mesz et al., 2011). The sweet taste was associated with medium-high-pitched, consonant, slow, soft, low articulated (low in discontinuity), and low loudness sounds (Mesz et al., 2011). Furthermore, sweet tastes were mapped to piano sounds (rated as pleasant) (Crisinel and Spence, 2010; Wang and Spence, 2018).

Based on the previous findings, a body of research focused on

* Corresponding author. Av. Jovita Feitosa 3300 ap, 801B Sul, 60455-410, Fortaleza, CE, Brazil.
E-mail address: phmachado@ufc.br (P. Sousa).

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assessing the influence of music on the intensity of basic tastes in food showed a congruency effect between them (Crisinel et al., 2012; Höchenberger and Ohla, 2019).

Kontukoski et al. (2015) explored how sweet and sour music influences food preparation. The results showed that listening to sweet music resulted in drinks with higher sugar content in a free choice of ingredients, whereas sour music generated drinks with higher acidity. This suggests that music can also influence the creation of culinary dishes (Kontukoski et al., 2015).

Based on these insights, the present study aimed to understand the influence of congruent music on taste perception intensity. More specifically, whether *sweet music* (medium-high pitch, low dissonance, low speed, soft, low articulation (*legato*), low loudness and low psychoacoustic roughness) and *sour music* (high-pitch, high speed, high articulation, high dissonance and high psychoacoustic roughness) would enhance the perceived intensity of the sweet and sour basic tastes, respectively, in a dessert.

2. Materials and methods

2.1. Food stimulus

A real dessert, having two main basic tastes, sweet and sour, was chosen for food stimulus. A passion fruit mousse was selected because it met all the requirements (see appendix 1). pH (measured using a pH meter Checker by Hanna®) was 5.2, and soluble solid content was above 30 ^{o}Brix (the limit for the hand refractometer available - series 300 by Zuzi®). The mousse was prepared according to the recipe in Fig. A1. One batch was prepared with the required amount of the mousse, which was equally distributed between 180 coded plastic containers (approximately 20 g each). Samples were served at 8 ± 1 °C.

2.2. Auditory stimuli

2.2.1. Musical pieces' pre-selection

A professional musician pre-selected two *sweet* and two *sour* pieces of music based on crossmodal correspondences between basic tastes and sonic elements proposed by Mesz et al. (2011). The selected *sweet* pieces of music were *Nocturne Op.9 No.2 in E flat major*, by *Fryderyk Chopin,* played in piano (M1), and *Piano Concert No.21 Andante in C major* by *Wolfgang Amadeus Mozart* played by orchestra and piano (M2). The selected *sour* pieces of music were *Capriccio No.24 in A minor,* by *Niccolò Paganini* played on violin (M3) and *The flight of the bumblebee*, by *Nikolai Rimsky-Korsakov* played by the orchestra (M4). From these, the two pieces of music having stronger congruence with sweet and sour tastes were selected by a focus group.

2.2.2. Focus group

The focus group was formed by volunteer professional musicians having solid knowledge of the musical features to be evaluated. It was composed of five females aged between 20 and 54 years old. Participants were informed about the research aim and the importance of choosing the most congruent musical pieces for each basic taste of the dessert. They knew the dessert was exactly the same across the experiment, and the only changeable element would be music. However, they were not informed about how each piece of music was supposed to influence taste perception.

Free associations between basic tastes and musical characteristics were initially made, and a sensory test with the dessert was performed. Each participant was instructed to taste each sample sequentially in silence while listening to the four pieces of music (in the order – M1, M2, M3, and M4) and to mark on 9 cm unstructured scales the intensity perceived for each one of the two tastes.

All participants felt a great difference in taste perception with music. This difference was congruent with the crossmodal correspondences between music and taste referred in literature.

Information about other researchers findings on crossmodal correspondences between basic tastes and sonic elements was presented upon the sensory tests. The musical sheets for each piece were handed out to promote a more conscious discussion.

For the two *sweet* pieces of music, all participants perceived a stronger sweet taste intensity with M1 than with M2. The two *sour* pieces of music raised divergent perceptions. Both were carefully analyzed and all participants agreed M3 was the best option for *sour* music.

With a consensual opinion, the musical pieces selected were:

- M1 - *Nocturne Op.9 No.2 in E flat major, by Fryderyk Chopin,* played on piano for sweet taste;
- M3 - *Capriccio No.24 in A minor – Niccolò Paganini* played in violin for sour taste.

2.3. Sensory analysis

2.3.1. Participants and recruitment

Volunteer participants were recruited at NOVA School of Science and Technology (FCT NOVA) campus. They knew that they would taste passion fruit mousses, but they were never informed about the purpose of the study to avoid bias. There was no screening of the volunteers considering gender, age, ethnicity, musical training, or other aspects. Participants were allocated in groups for each session and instructed about good sensory analysis practices beforehand. They started the session by signing informed consent and reported not having any senses' impairment at the time or any intolerance or allergy.

2.3.2. Participants' screening

A participant screening was performed, through the application of pre-tests, to ensure more accuracy (Stoer et al., 2002). Three criteria were considered for excluding participants: *i)* The ability to recognize basic tastes. All participants who failed to recognize either sweet or sour tastes were excluded. *ii)* The ability to correctly perceive and mark different intensities of sweet and sour taste of samples made available on an unstructured scale. *iii)* The ability to identify when tasting the mousse, the sweet and sour tastes.

2.3.2.1. Recognition of basic tastes test. Four basic tastes solutions were prepared: sweet (sucrose 24 g/L), salty (sodium chloride 4 g/L), sour (citric acid 1g/L) and bitter (denatonium benzoate in concentration number 3 from *Coffee consulate*®) (Faria and Yotsuyanagi, 2018). Samples (30 ml) were given in six coded containers with the same appearance and placed randomly. Four of them had the four basic taste solutions, one with pure water and another with a repetition of one of the basic taste solutions.

Participants were instructed to taste each sample and fill out a form with the basic tastes perceived.

2.3.2.2. Familiarization with the scale. Before starting the sensory tests, training with an unstructured 9 cm scale was performed. 30 ml samples of two solutions for each sweet and sour basic tastes were given in coded containers with the same appearance. The solutions were tasted in an increasing intensity order. First, the sweet ones (14 g sucrose/L vs. 51 g sucrose/L), followed by the sour ones (0.5 g citric acid/L vs. 1.5 g citric acid/L). Participants were asked to taste each sample and mark the perceived intensity on the correspondent line scale.

2.3.3. Instruments

An unstructured 9 cm scale was used to quantify the sweet and sour taste intensity, with increasing values from left to right. Participants were informed they could mark any part of the line. This scale was chosen since it is considered more accurate in detecting small differences in intensity perception (Greene et al., 2006).

2.3.4. Sensory tests

Sensory tests took place at FCT NOVA. Participants were seated at one per table, preventing them to face each other. A comfortable environment regarding temperature, humidity, ventilation and illumination was guaranteed and the ambiance was as noise-free as possible to avoid interference with the auditory stimuli.

The sensory tests were performed immediately after pre-tests. Each participant sequentially experienced three different moments in random order:

- Control – participants tasted the dessert in silence.
- Condition A – participants tasted the dessert while listening to music that expectably would enhance sweet taste – M1 (*Nocturne Op.9 No.2 in E flat major*, by *Fryderyk Chopin*)
- Condition B – participants tasted the dessert while listening to music that expectably would enhance the sour taste – M3 (*Capriccio No.24 in A minor,* by *Niccolò Paganini*)

Background music was used (no headphones were involved). The sound source was a laptop and the volume was measured with the app *"Decibel X":* 71 dB for M1 and 76 dB for M3.

Six sessions were organized in different slots along the same day, each one with a different sequence of the auditory stimuli: 1) Control – Condition A – Condition B; 2) Control – Condition B – Condition A; 3) Condition A – Control – Condition B; 4) Condition A – Condition B – Control; 5) Condition B – Control – Condition A; 6) Condition B – Condition A – Control.

The number of participants for each session was balanced (approximately 10 tasters). All tests occurred under exactly the same conditions. New dessert samples and sensory forms were provided for each test.

2.3.5. Statistical analysis

The sensory analysis data were submitted to analysis of variance (ANOVA) at 5% probability by Tukey's multiple comparison test ($p \leq 0.05$).

All the statistical analyses were performed by the XLSTAT 2017.6.48089 software version 0.7 for Windows (Adinsoft, Paris, France).

3. Results and discussion

3.1. Sensory tests

3.1.1. Panel characterization

Based on the pre-test results, from the initial 60 participants, 11 (18%) were excluded from this study (four failed basic taste recognition, three could not correctly use the scale, and four rated the dessert as not sweet or sour).

Of the 49 participants whose tests were considered, 65% were females, and 35% were males. 10% were under 25 years old, 23% were between 25 and 34 years old, 35% were between 35 and 45 years old, 14% were between 46 and 55 years old, and 18% were above 55 years old.

Table 1
Mean values for the sensory evaluation results of sweetness and sourness perception with different auditory stimuli using a 9 cm unstructured scale (n = 49).

Auditory stimuli	Sweetness	Sourness
Sour Music	5.0 A	4.5 A
Silence	5.0 A	4.2 AB
Sweet Music	4.9 A	3.6 B

Values for each attribute with at least one equal letter, do not differ at the 5% level of significance, by Tukey's test.

3.1.2. Sensory acceptancy

Results in Table 1 show that only sourness intensity while listening to the *sweet* and *sour* pieces of music presented significant differences for Duncan's range test.

Results show that in silence, participants considered the dessert sweeter (5.0 ± 2.4) than the sour (4.2 ± 2.8). This pattern did not change with auditory stimuli. No significant differences were encountered in the sweetness perception (4.9 ± 2.4 while listening to *sweet* music and 5.0 ± 2.4 with *sour* music). Participants considered, with statistical significance, the dessert sourer with the *sour* music (4.5 ± 2.8) than with the *sweet* music (3.6 ± 2.8). Although the *sweet* music did not increase the sweet taste perception, the results showed that it influenced the decrease of sour perception of dessert (3.6 ± 2.8) when compared with *sour* music (4.5 ± 2.8) or silence (4.1 ± 2.8).

3.2. Discussion

Results show that music congruency had a significant influence on sour taste perception. Although the specific mechanisms behind these associations are yet unclear (Guetta and Loui, 2017; Knöferle and Spence, 2012; Mesz et al., 2011; Spence and Deroy, 2013), some possible causes can be proposed.

Music may activate superordinate knowledge structures that then prime a feature being perceived simultaneously. Therefore, the *sour* symbolic connotation of *Paganini*'s piece of music primes a mental content linked with the sourness, triggering an increase in this taste perception in dessert (Kontukoski et al., 2015; Spence and Deroy, 2013).

Another hypothesis is the emotional valence of sound and taste stimuli as mediators (Guetta and Loui, 2017; North, 2012; Reinoso-Carvalho et al., 2019, 2020a, 2020b).

People match unpleasant sounds with tastes similarly unpleasant (Guetta and Loui, 2017; Reinoso-Carvalho et al., 2020a). As *sour* music and sour taste can be considered unpleasant, a transference effect could occur, whereby unpleasant sensations caused by *sour* music reinforce and intensify the perception of a similarly unpleasant taste in the dessert (Carvalho et al., 2017; Guetta and Loui, 2017; Kontukoski et al., 2015).

Another conjecture is related to the dessert's colour. There is a connection between the colours and the basic tastes, being green and yellow colours associated with sour taste (Spence, 2017; Spence et al., 2010; Spence and Piqueras-Fiszman, 2014). In the experiment, when a yellow dessert was offered while listening to *sour* music, the senses were combined congruently, providing a higher effect (Spence, 2017) on the intensification of sour taste perception.

The sweetness perception of the dessert was not increased with sweet music. These results are incongruent with music-taste crossmodal correspondence findings (Bronner et al., 2012; Crisinel et al., 2012; Crisinel & Spence, 2009, 2010, 2011, 2012; Knöferle and Spence, 2012; Kontukoski et al., 2015; Mesz et al., 2011, 2012; Wang et al., 2015). Some possible causes can be hypothesized.

The high sweetness of the dessert, proved by the total soluble solids content, and the fact that participants considered the dessert sweeter than sourer, could mask the effect of the auditory stimuli on the perception of the sweet taste.

Despite *sweet* music did not increase the sweet taste perception, it decreased the sour taste perception. These results suggest a different approach, whereby crossmodal studies should focus on the congruent music impact on the same taste and the opposite taste. In this experiment, a polarity between sweet and sour tastes and their musical patterns allowed this understanding. Based on the decrease in the sour perception, one may imply that, even with no increase in sweet taste perception, the *sweet* music influenced the overall sweetness perception through the balance with sourness perception.

The fact that the gustatory stimuli was a dessert could also bias the responses. The name of a food might influence the perception of its taste by building up expectations and capturing people's attention (Schifferstein, 2001; Spence and Piqueras-Fiszman, 2014; Yeomans et al., 2008).

Participants were aware that they would be tasting a dessert, thus expecting sweetness. This could have affected the perception of this taste and jeopardized the influence played by the *sweet* music.

Another possibility is related to the fact that most people have a natural propensity to enjoy sweet food and its strong presence in food habits (Spence and Piqueras-Fiszman, 2014). Background *sweet* music during food consumption is also common. Thus, possible habituation could make participants less sensitive to sweet perception differences than sour perception ones.

Although most people in the focus group and sensory tests found the dessert sweeter than sour, the influence of the auditory stimuli on the perception of basic tastes was remarkably different. In the focus group, the auditory stimuli greatly influenced taste perception, congruently with the crossmodal correspondences for both tastes. Moreover, the impact of music on decreasing the opposite taste intensity perception was also noted (Fig. 1). This difference can be related to participants' profiles. Although everyone can map auditory and gustatory stimuli, the role of musical training could increase the aptitude to associate sounds with corresponding tastes (Guetta and Loui, 2017). Besides, the musicians in the focus group were aware of the study goal, being more focused on music conditions while tasting the dessert.

3.3. Suggestions for future work and methodology improvement

Participants' subjectivity can hinder understanding of the truly drivers of participants' responses (Spence and Piqueras-Fiszman, 2014). Despite some common patterns, a big range of intensity perception for the basic tastes was observed in this study.

This subjectivity can result from differences in the senses' physiology. Taste is the sense with the largest individual differences (Shepherd, 2011; Spence and Piqueras-Fiszman, 2014). Moreover, different expositions to certain basic tastes can alter people's sensitivity (Crisinel and Spence, 2010), reinforcing variability in their perception of the intensity.

Robuster results could be achieved by having a larger number of participants. Also, it would be insightful to analyse results individually to understand better the subjectivity extent of the attribute perception with different auditory stimuli. Using a less sweet dessert could also be interesting, having a better balance between sweetness and sourness.

Measurement accuracy can also be a challenge. It was found that the results would not follow the same pattern if the excluded participants were considered. This highlights the importance of testing basic taste recognition, training participants, and familiarizing them with the scales (Stoer et al., 2002). Additionally, qualitative data could be included in future researches. A meeting with participants to explore their feelings and qualitative perceptions regarding the experiment could be promoted.

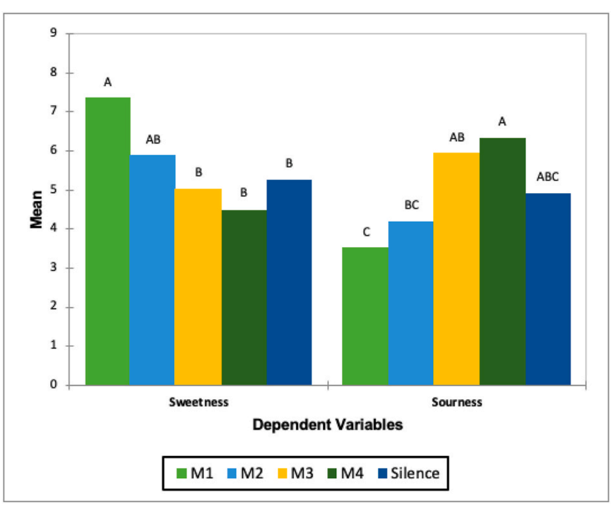

Fig. 1. Impact of music on sweetness and sourness perception of the dessert by the Focus Group. M1 - *Nocturne Op.9 No.2 in E flat major, by Fryderyk Chopin*; M2 - *Concert No.21 Andante in C major*, by *Wolfgang Amadeus Mozart;* M3 - *Capriccio No.24 in A minor,* by *Niccolò Paganini;* M4 - *The flight of the bumblebee,* by *Nikolai Rimsky-Korsakov.* Values for each attribute with at least one equal letter do not differ at the 5% level of significance. n = 5. Scale 0–9 cm.

A previous assessment of the relationship between participants and music could be relevant for analyzing the results (Kantono et al., 2016). Particularly the familiarity with the repertoire (Spence et al., 2013). Even without technical musical knowledge, it is likely that participants who appreciate classical music could be more sensitive to its effect on taste perception. Besides, a previous musical background could be an influential factor, as suggested by the focus group results. Further research should be conducted to explore the role of culture, location, memory and preferences about gustatory and auditory stimuli in crossmodal matches. (Guetta and Loui, 2017; Knoeferle et al., 2015; Knöferle and Spence, 2012; Spence, 2011).

Since each piece of music was not entirely used to avoid fatigue, the excerpts used could also have influenced the results (Wang et al., 2015). Weakness might have been introduced if the used frame was not the most adequate for the desired taste matching. The difference in the eating speed could also mean different parts of the music playing in the background.

Perhaps the music should have been introduced a while before the sample tasting to make participants more comfortable with the auditory stimuli. It could probably be easier to notice the sensory attributes because it was not necessary to process all the new information at once.

To minimize subjectivity, this experiment should be replicated with an extensive music repertoire for each taste (Kontukoski et al., 2015). Also, as the auditory stimuli chosen were simple musical compositions, it could be noteworthy to conduct a similar study with more complex stimuli, having more instrumental layers and/or more sound effects aligned with real food consumption environments (Carvalho et al., 2017; Kantono et al., 2016).

This study was conducted in a laboratory to eliminate all unrelated variables. However, this does not correspond to the natural atmosphere of food consumption. It could be interesting to repeat this experiment using a more realistic setting, such as a cafe or a restaurant, and compare the results (Kantono et al., 2016; Spence and Piqueras-Fiszman, 2014).

As in similar studies, this one followed the within-participants experimental design (Spence and Piqueras-Fiszman, 2014), in which each participant was exposed to every possible condition. Although participants had experienced all conditions, they did not experience them in the same order. It might be interesting to understand the order effect on perception. Aware of music effect on emotions, mood, and judgments (Spence, 2017; Spence and Piqueras-Fiszman, 2014), the music order of each test could be considered a possible bias.

4. Conclusion

The study described, using as a food stimulus, a dessert having two main basic tastes, sweet and sour. As auditory stimuli, one *sweet* and one *sour* piece of music showed that participants did not perceive the dessert in the same way when exposed to different musical stimuli, which validates music influence on the tasting experience. It was observed that music congruency with the taste was stronger regarding sour taste, with a significant effect. *Sweet* music did not increase the sweetness of the dessert. However, it decreased the intensity of sourness, suggesting a different approach to these studies not found in previous research.

This study represents a small step in the path of discovery about food perception. These findings can be useful in designing and building new multisensory gastronomic experiences by food businesses and restaurant entrepreneurs.

Author statement

Joana Campinho, Paulo Sousa and Paulina Mata conceived and designed the experiments; Joana Campinho performed the experiments; Joana Campinho e Paulo Sousa analyzed the data and wrote the paper. All authors have read and agreed to the published version of the manuscript.

Implications for gastronomy

The present study might have great potential in designing and building new multisensory gastronomic experiences using music to enhance consumer experiences. The reported achievements can be applied by food businesses and in health related contexts. Specific music could highlight/mask certain taste perceptions, increasing the eating pleasure of people with gustatory restrictions. These "perception tricks" could be useful to alter the sweetness/sourness perception without adding sugar. Based on the emotional valence liking, also presented in this study results, the consumption of healthier but disliked foods could be increased by combining them with pleasant music.

Declaration of competing interest

All authors declare that they gave no know competing for financial or personal interest that could have appeared to influence the word reported in this paper.

Data availability

Data will be made available on request.

Appendix 1

Passion Fruit Recipe.

INGREDIENTS	PREPARATION
. 3 packages of frozen passion fruit pulp (300 g);	1. Heat the passion fruit pulp (60–70 °C) and hydrate the gelatin leaves in cold water.
. 3 colourless gelatin sheets (6 g);	2. Remove the water excess from the gelatin and dissolve it in the heated passion fruit pulp.
. 2 packages of cream (400 g).	3. Reserve and let cool. In the meantime, lightly whip the cream (it shouldn't be as firm as Chantilly)
. 1 can of condensed milk (400 g);	4. Using a wire whisk, blend the condensed milk with the passion fruit pulp.
	5. Make sure that the previous preparation is completely cool and then gently incorporate the whipped cream.
	6. Transfer the preparation to disposable cups and put it in the refrigerator at least 3 h before serving.

References

Bronner, K., Frieler, K., Bruhn, H., Hirt, R., Piper, D., 2012. What is the sound of citrus? Research on the correspondences between the perception of sound and flavour. In: Proceedings of the 12th International Conference of Music Perception and Cognition (ICMPC) and the 8th Triennial Conference of the. European Society for the Cognitive Sciences of Music (ESCOM), pp. 142–148.

Carvalho, F.R., Wang, Q.J., Van Ee, R., Persoone, D., Spence, C., 2017. Smooth operator": music modulates the perceived creaminess, sweetness, and bitterness of chocolate. Appetite 108, 383–390. https://doi.org/10.1016/j.appet.2016.10.026.

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 Qual. Prefer. 24 (1), 201–204. https://doi.org/10.1016/j.foodqual.2011.08.009.

Crisinel, A.-S., Spence, C., 2009. Implicit association between basic tastes and pitch. Neurosci. Lett. 464 (1), 39–42. https://doi.org/10.1016/j.neulet.2009.08.016.

Crisinel, A.-S., Spence, C., 2010. A sweet sound? Food names reveal implicit associations between taste and pitch. Perception 39 (3), 417–425. https://doi.org/10.1068/p6574.

Crisinel, A.-S., Spence, C., 2011. Crossmodal associations between flavoured milk solutions and musical notes. Acta Psychol. 138 (1), 155–161. https://doi.org/10.1016/j.actpsy.2011.05.018.

Crisinel, A.-S., Spence, C., 2012. The impact of pleasantness ratings on crossmodal associations between food samples and musical notes. Food Qual. Prefer. 24 (1), 136–140. https://doi.org/10.1016/j.foodqual.2011.10.007.

Faria, V., Yotsuyanagi, K., 2018. In: Campinas, I.T.A.L. (Ed.), Técnica de Análise Sensorial, 2 ed. for Standardization, I. O. (2008). ISO 5492: 2008.

Guetta, R., Loui, P., 2017. When music is salty: the crossmodal associations between sound and taste. PLoS One 12 (3), 1–14. https://doi.org/10.1371/journal.pone.0173366.

Höchenberger, R., Ohla, K., 2019. A bittersweet symphony: evidence for taste-sound correspondences without effects on taste quality-specific perception. J. Neurosci. Res. 97 (3), 267–275.

Kantono, K., Hamid, N., Shepherd, D., Yoo, M.J., Carr, B.T., Grazioli, G., 2016. The effect of background music on food pleasantness ratings. Psychol. Music 44 (5), 1111–1125. https://doi.org/10.1177/0305735615613149.

Knoeferle, K.M., Woods, A., Käppler, F., Spence, C., 2015. That sounds sweet: using cross-modal correspondences to communicate gustatory attributes. Psychol. Market. 32 (1), 107–120.

Knöferle, K., Spence, C., 2012. Crossmodal correspondences between sounds and tastes. Psychonomic Bull. Rev. 1–15. https://doi.org/10.3758/s13423-012-0321-z.

Kontukoski, M., Luomala, H., Mesz, B., Sigman, M., Trevisan, M., Rotola-Pukkila, M., Hopia, A.I., 2015. Sweet and sour: music and taste associations. Nutr. Food Sci. 45 (3), 357–376. https://doi.org/10.1108/NFS-01-2015-0005.

Mesz, B., Sigman, M., Trevisan, M.A., 2012. A composition algorithm based on crossmodal taste-music correspondences. Front. Hum. Neurosci. 6, 1–6. https://doi.org/10.3389/fnhum.2012.00071.

Mesz, B., Trevisan, M.A., Sigman, M., 2011. The taste of music. Perception 40 (2), 209–219. https://doi.org/10.1068/p6801.

North, A.C., 2012. The effect of background music on the taste of wine. Br. J. Psychol. 103 (3), 293–301. https://doi.org/10.1111/j.2044-8295.2011.02072.x.

Reinoso-Carvalho, F., Dakduk, S., Wagemans, J., Spence, C., 2019. Not just another pint! the role of emotion induced by music on the consumer's tasting experience. Multisensory Res. 32 (4–5), 367–400. https://doi.org/10.1163/22134808-20191374.

Reinoso-Carvalho, F., Gunn, L.H., Horst, E.T., Spence, C., 2020a. Blending emotions and cross-modality in sonic seasoning: towards greater applicability in the design of multisensory food experiences. Foods 9 (12), 1876. https://doi.org/10.3390/foods9121876.

Reinoso-Carvalho, F., Gunn, L., Molina, G., Narumi, T., Spence, C., Suzuki, Y., Ter Horst, E., Wagemans, J., 2020b. A sprinkle of emotions vs a pinch of crossmodality: towards globally meaningful sonic seasoning strategies for enhanced multisensory tasting experiences. J. Bus. Res. 117, 389–399. https://doi.org/10.1016/j.jbusres.2020.04.055.

Schifferstein, H.N., 2001. Effects of product beliefs on product perception and liking. In: Food, People and Society. Springer, Berlin, Heidelberg, pp. 73–96.

Shepherd, G.M., 2011. Neurogastronomy: How the Brain Creates Flavor and Why it Matters. Columbia University Press.

Spence, C., 2011. Crossmodal correspondences: a tutorial review. Attention, Perception. & Psychophysics 73 (4), 971–995. https://doi.org/10.3758/s13414-010-0073-7.

Spence, C., 2012. Auditory contributions to flavour perception and feeding behaviour. Physiol. Behav. 107 (4), 505–515. https://doi.org/10.1016/j.physbeh.2012.04.022.

Spence, C., 2017. Gastrophysics: the New Science of Eating. Penguin UK.

Spence, C., Deroy, O., 2013. On why music changes what (we think) we taste. I-Perception 4 (2), 137–140. https://doi.org/10.1068/i0577ic.

Spence, C., Levitan, C.A., Shankar, M.U., Zampini, M., 2010. Does food color influence taste and flavor perception in humans? Chemosensory Perception 3 (1), 68–84. https://doi.org/10.1007/s12078-010-9067-z.

Spence, C., Piqueras-Fiszman, B., 2014. The Perfect Meal: the Multisensory Science of Food and Dining. John Wiley & Sons.

Spence, C., Reinoso-Carvalho, F., Velasco, C., Wang, Q.J., 2019. Extrinsic auditory contributions to food perception & consumer behaviour: an interdisciplinary review. Multisensory Res. 32 (4–5), 275–318. https://doi.org/10.1163/22134808-20191403.

Spence, C., Richards, L., Kjellin, E., Huhnt, A.M., Daskal, V., Scheybeler, A., Velasco, C., Deroy, O., 2013. Looking for crossmodal correspondences between classical music and fine wine. Flavour 2 (1), 1–13. https://doi.org/10.1186/2044-7248-2-29.

Stoer, N., Rodriguez, M., Civille, G.V., 2002. New method for recruitment of descriptive analysis panelists. J. Sensory Stud. 17 (1), 77–88. https://doi.org/10.1111/j.1745-459X.2002.tb00333.x.

Wang, Q., Spence, C., 2018. Assessing the influence of music on wine perception among wine professionals. Food Sci. Nutr. 6 (2), 295–301. https://doi.org/10.1002/fsn3.554.

Wang, Q., Woods, A.T., Spence, C., 2015. What's your taste in music?" A comparison of the effectiveness of various soundscapes in evoking specific tastes. I-Perception 6 (6), 1–23. https://doi.org/10.1177/2041669515622001.

Yeomans, M.R., Chambers, L., Blumenthal, H., Blake, A., 2008. The role of expectancy in sensory and hedonic evaluation: the case of smoked salmon ice-cream. Food Qual. Prefer. 19 (6), 565–573. https://doi.org/10.1016/j.foodqual.2008.02.009.