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Impact of music on the dynamic perception of coffee and evoked emotions evaluated by Temporal Dominance of Sensations (TDS) and Emotions (TDE)

--Manuscript Draft--

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Abstract:	The aim of the present work was to study the temporal effect of music on sensory perception and on the emotional changes while drinking coffee. Two different commercial filter coffees were evaluated by a group of 48 consumers using the Temporal Dominance of Sensations (TDS) method with the attributes: sweet, bitter, astringent, acidic and toasty. The description was done in silence and also while listening to two different musical fragments: one with a “sweet” connotation and the other with a “bitter” one. Under the same conditions (drinking coffee with and without musical stimuli), a different group of 72 consumers evaluated their perceived emotions (joy, fear, neutral, rejection, disgust, surprise, sadness and anger) by Temporal Dominance of Emotions (TDE). Data was analyzed by dominance curves and by ANOVA and MANOVA of the durations of dominance (for emotions and sensations). Coffee perception, in both cases, was modified by the musical stimuli. The duration of dominance of bitter was increased in the presence of “bitter” music, while it decreased with the “sweet” music. Moreover, the sweet attribute was practically not chosen for describing the coffee on its own, but its choice and duration as dominant increased while listening to the “sweet” musical fragment. Music had even a higher impact on the perceived emotions. The “sweet” music was related to the emotion of joy, which was accompanied by surprise and also some sadness when drinking coffee (regardless of the type of coffee being drunk). The “bitter” music was described with the anger and fear emotions. The effect of “sonic seasoning” and translation of emotions with a familiar product was achieved.

Buenos Aires, 4th October 2021

Editorial Office

Editor-in-Chief; Dr. Sant'Ana

I am enclosing the revised version of the manuscript entitled, *"Impact of music on the dynamic perception of coffee and evoked emotions evaluated by Temporal Dominance of Sensations (TDS) and Emotions (TDE)"* by Galmarini, M.V., Silva Paz, R.J., Enciso Choquehuanca, D., Zamora, M.C. & Mesz, B. to be considered for publication in the special issue of *Food Research International - SenseLatam 2020*.

All comments and suggestions from the reviewers were taken into account and are detailed in the Response to Reviewers. We believe our manuscript has been considerably improved in the process and hope that will now be approved for publication.

Best regards,

Dr. Mara Virginia Galmarini

Dear Editor,

We would like to thank you and the reviewers for giving us the opportunity to improve our manuscript entitled “Impact of music on the dynamic perception of coffee and evoked emotions evaluated by Temporal Dominance of Sensations (TDS) and Emotions (TDE).”

You will find below a point-by-point response to the reviewers’ comments and concerns. Moreover, all changes are highlighted with the Word “track for changes” tool in the revised version.

Reviewer #1: General comments
The article is well written and the methodology is appropriate. However, the data analysis and result parts should be improved. Apart from that, I only noticed some points to be clarified and suggested some minor improvements.

Introduction:
Add recent missing references on influence of music on tasting (Zellner 2017, Spence 2018, Peng-Li 2020, De Paula 2020, etc.)
The suggested references have been added to the text.

We could not find a relevant reference in English corresponding to De Paula 2020, we added instead the paper “de Paula, S. C. S. E., Zuim, L., de Paula, M. C., Mota, M. F., Lima Filho, T., & Della Lucia, S. M. (2021). The influence of musical song and package labeling on the acceptance and purchase intention of craft and industrial beers: A case study. Food Quality and Preference, 89, 104139.”

L141/244: TimeSens software (INRA, Dijon, France)
The suggested change has been made in the revised version.

Material and methods:
Coffee samples: add, if possible, geographic origin of the coffee.
Unfortunately, the commercial brand does not include the geographic origin of the coffee beans in the label.

L147-148: "They were different in terms of intensity and aromatic profile" -> According to the description of the manufacturer, they were supposed different in terms of intensity and aromatic profile. One was defined as "intense" and the other one as "soft" (hereon coffee samples will be referred to as IC and SC respectively). (reverse order of sentences).
The order of the sentences and the phrase were modified according to the reviewer’s suggestion.

Music fragments: I suggest to add the 2 music framents as supplementary material in order to help the reader to understand what are sweet and bitter musics.
The musical fragments were added as supplementary material.

L169: How was it validated? Please say a little more about the online experiment.

More detail on the experiment was given in the revised version, as follows:

"Both the "sweet" and the "bitter" music were validated in an online experiment where a total of 24 musical fragments (6 intended to correspond to each taste category: bitter, salty, sour and sweet), were presented to 18 participants who were asked to determine, in a forced choice, to which of the taste category corresponded each fragment. For each "sweet" and "bitter" fragment, 83% or more of the participants associated the intended taste."

L181-182: Please add standard deviation. The panel is as always unbalanced, which is not a problem in a general case. But I do not know the literature about music influence, do you think than women can be more influenced by music than men?

The standard deviation for the panelist's ages was added.

To the extent of our knowledge, studies on crossmodal associations between taste and music have found no significant differences due to sex. With respect to the influence of sex on emotions perceived or induced by music, quoting a recent article, "previous studies do not allow firm conclusions. Perceived emotions, in general, appear unaffected by the sex of listener" [1] but other studies have shown psychophysiological differences, in particular, that women are more sensitive to aversive musical stimuli [2], but the difference is reflected in electrophysiological measures, not in psychological variables.

[1] Bullack, A., Büdenbender, N., Roden, I., & Kreutz, G. (2018). Psychophysiological responses to "happy" and "sad" music: A replication study. Music Perception: An Interdisciplinary Journal, 35(4), 502-517.

[2] Nater, U. M., Abbruzzese, E., Krebs, M., & Ehlert, U. (2006). Sex differences in emotional and psychophysiological responses to musical stimuli. International journal of psychophysiology, 62(2), 300-308.

L209: How did you explain the consumers to select "taste" attributes during the listening of the fragments. I find hard to imagine what a "toasted" music fragment could be. Wasn't it something like an association like sweet=pleasant to listen, bitter/astringent/sour=unpleasant?

The task was intended to be based on crossmodal sound-taste associations. We hypothesized that crossmodal associations of music with specific taste attributes, and not just psychoacoustic features of sound or subjective perceptions of music such as pleasant/unpleasant, would be transferred to the multisensory coffee+music experience, so we did not want to prescribe a specific way of selecting "taste" attributes for music based on purely music/sound features (e.g. if it is pleasant use "sweet" to describe it, if it is unpleasant use "bitter" or "astringent" or "sour" instead). Note that, for example, "bitter" and "astringent" but not "sour" have been selected consistently for the "bitter" music, indicating there are more specific taste-music associations at play than merely a correspondence along the pleasant/unpleasant axis. In other words, we wanted to see if "sweet" music makes coffee taste sweeter, or "bitter" music makes coffee taste more bitter, and not merely if pleasant/unpleasant music makes coffee taste more sweet/ more bitter-sour-astringent. The reviewer's intuition that "toasted" is difficult to associate with music is supported by the fact that this label was not consistently applied to our musical fragments; however, "astringent" appeared as a possible common attribute between taste and music (we try to explain this in the text, lines 266-271). The command was "if you were to describe this musical fragment with the given attributes: which ones would you use?". This was clarified in the revised manuscript, and we believe that having the fragments available, will make this part of the experiment easier to understand.

Data analysis

L248: did the music start as the same moment of the subject clicked on start? If yes, data are by construction left and right standardized, but as first times of citations have been analyzed I supposed it did not. So how did you handle that? Also, as you show later differences in first citations, why did you not left standardized data?

The music started at the same moment in which subjects clicked on Start. However, we wanted to analyze if the presence and the type of auditive stimulus had an impact on the time consumers took before choosing the first description. Could having another stimulus distract or change the way in which consumers carried out the TDS description? This is the main interest of Figure 2 (modified in the revised version for the purpose of clarity).

However, the reviewer is correct to point out that, after such an analysis, data should be standardized also to the left in order to reduce differences among subjects. This was done and modified in the revised manuscript. All TDS and TDE curves were modified in the revised version and standardized left and right.

L250-251: I'm not sure of the interest of this part. Consider removing here and in results. Otherwise replace post-hoc numbers by letters in figure 2 for the purpose of homogeneity with table 1.

In agreement with the reviewer's comment, the analysis of the number of descriptors used was removed. However, the time to first click seems a relevant indicator to see if the presence of music has an impact on the time before deciding on the first attribute.

The text on the data analysis and results sections, as well as Figure 2, have been changed accordingly in the revised manuscript.

Adding differences curves SC-SCSM, SC-SCBM and SCSM-SCBM and same with IC could help visualizing temporal differences in perceptions. It should replace figure 7, as you previously mentioned you were not interested in studying differences between the two coffees.

The aim of figure 7 (figure 8 in the revised manuscript) is to see how the impact of music is different on TDS and on TDE. Having the two coffees makes the comparison more robust. In TDS the impact of music is smaller and the description of the coffees with music is closer to that of coffee itself rather than to the musical fragment. On the other hand, on TDE, the emotions are more associated to the music than to the product itself. This was further explained in the revised manuscript.

Results/discussion

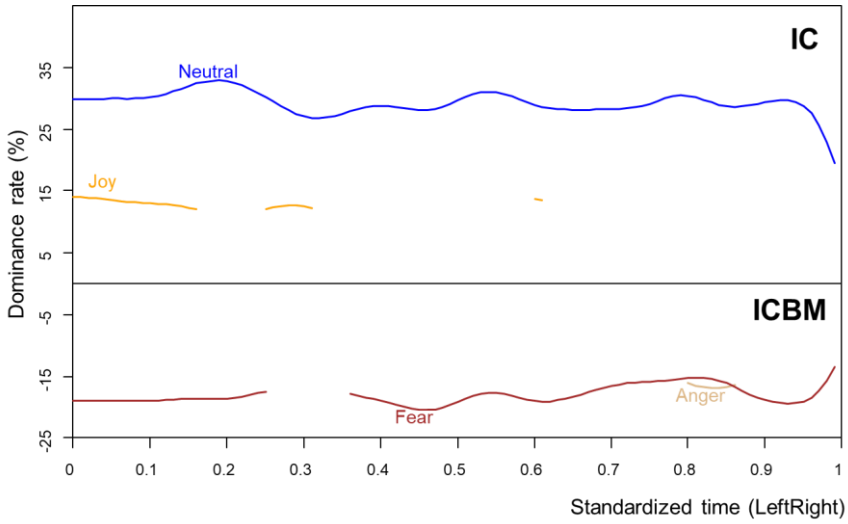
Table 1. There is no differences between SC and IC in terms of attribute durations, neither between SCSM and SCBM. Also, sweet music also increased bitterness duration in sweet coffee. How do you explain that? The results from this table deserves to be more discussed, and a table with the same analysis with emotions should be of interest.

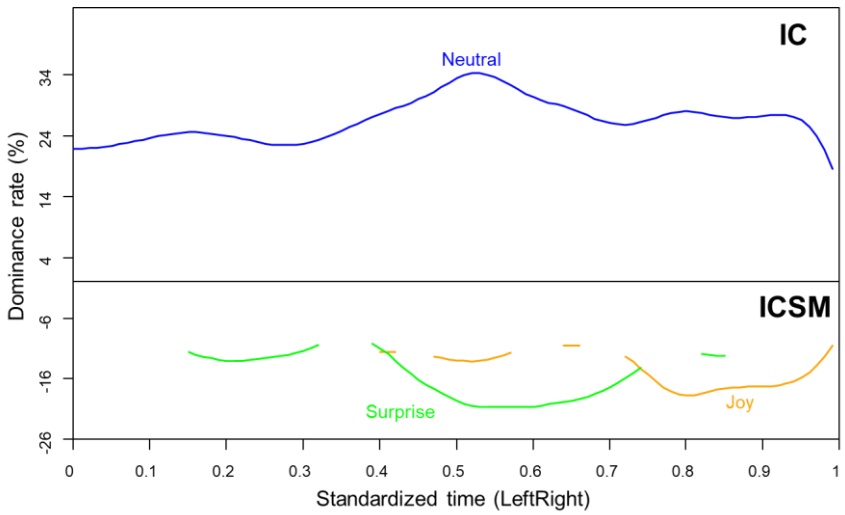
The lack of significant differences between SCSM and SCBM are probably due to the fact that the analysis was done comparing all 6 samples, which, in retrospective, is incorrect. When comparing, separately, the three conditions of IC and the three differences in dominance duration for sweet and bitter become significant. This was corrected in the revised version and further comments were added regarding the results presented in this table.

As suggested previously, adding difference curves could help visualizing the differences that seem relatively small. As an alternative, you could also represent 2 figures with TDS curves, one with IC, ICBM, ICSM, one with SC, SCBM, SCSM (same with TDE).

Small differences in temporality are usually not evidenced in difference curves. This was the case for the present TDS data. Therefore, TDS curves of all the samples are now presented in the revised version. Figure 3 (a and b), was changed and replaced by Figures 3 a,b, c and Figure 4 a,b,c were the TDS curves for IC and SC with the sweet music, the bitter music and no music are represented.

As for TDE, differences are bigger and continuous, therefore the TDE difference curves do not add much significant information. We have added the figures here for the reviewer to see them but we consider that with the CVA and the added ANOVA table, the effect of music and the differences among tasting conditions are clearer.





Example of difference curves for the Intense Coffee tasted with "bitter" musical fragment and with the "sweet" one.

L375-377 (and 428-430): Too strong assumption. It is a good idea for another experiment, but actual results do not "suggest" such a thing.
The expression was changed as follows in the revised version:

"This observation makes us hypothesize that, under given conditions, the appropriate sound stimuli could result in, for example, reduction of sugar ingestion by taking advantage of "sonic sweetening"."

L381-398: I think you can draw similar conclusions from table 1 and suggested table 2. As previoyusly mentioned, consider removing figure 7.
The purpose of figure 7 (now figure 8 in the revised version) was better explained.

Reviewer #2:
Overall, I would classify this as an interesting addition to the literature on sonic seasoning, using temporal dominance of sensations measures and linking to temporal dominance of emotions. There are, however, a number of minor issues to clarify/correct. However, I would imagine that a revision would be acceptable for publication.

Issues to address:
Text inconsistent 'toasty' in abstract 'toasted' in main text.
The revised text was checked for the word 'toasted' and this was not found.

One of first commercial uses of sonic seasoning reported by Spence, C. (2013). On crossmodal correspondences and the future of synaesthetic marketing: Matching music and soundscapes to tastes, flavours, and fragrance. In K. Bronner, R. Hirt, & C. Ringe (Eds.), (((ABA))) Audio Branding Academy Yearbook 2012/2013 (pp. 39-52). Baden-Baden: Nomos. Working with Starbucks.

The suggested reference was added in the revised version.

Does Bach's café cantata deserve a mention?
We think this is just a historical reference, Bach's cantata is a kind of miniature opera that would be difficult to relate to the article's subject, so we have not included a mention to the cantata in the revised text.

Several recent examples of commercial sonic seasoning with coffee mentioned in Spence, C., Wang, Q. J., Reinoso-Carvalho, F., & Keller, S. (in press). Commercializing sonic seasoning in multisensory offline experiential events and online tasting experiences. Frontiers in Psychology.
We have included this reference and modified the revised text accordingly.

References cited in text but missing from refs include:
Reinoso-Carvalho, F., Gunn, L., Molina, T., Narumi, T., Spence, C., Suzuki, Y., ter Horst, E., & Wagemans, J. (2020). A sprinkle of emotions vs a pinch of crossmodality: Towards globally meaningful sonic seasoning strategies for tasting experiences. Journal of Business Research, 117, 389-399.

Reinoso-Carvalho, F., Gunn, L. H., ter Horst, E., & Spence, C. (2020). Blending emotions and crossmodality in sonic seasoning: Towards greater applicability in multisensory food experience design. Foods, 9:1876. https://www.mdpi.com/2304-8158/9/12/1876/pdf.

References have been added in the corresponding section.

Highlights: 'was achieved' sounds odd. 'were translated' in what sense translated?
The term "achieved" was replaced by "observed" in the revised version.
The term "translated" was probably a bad translation from Spanish. This was changed in the revised version by "were transferred".

p.3 for the latest on salty auditory parameters, see: Wang, Q. J., Keller, S., & Spence, C. (2021). Metacognition and crossmodal correspondences between auditory attributes and saltiness in a large sample study. Multisensory Research DOI:10.1163/22134808-bja10055.
We added and commented on the reference.

Line 63 sweater - sweeter -and best ref for wine coloured lighting would be to include Spence et al. (2014) already in refs.
The typo and the reference were corrected.

76 - avoid using word 'done
This expression was changed in the revised manuscript.

86 account or approach - these seem different
The word "approach" has been deleted.

102 - Avoid starting sentence with 'Also'
The term "also" was replaced by "moreover" in the revised manuscript.

149-150 - delete 'between them'?

The suggested correction was made in the revised version.

174 How was sample size chosen? Why should we think it adequate to demonstrate effect? Power calculation?

*Sample size calculation was based on exploring the relationship between two musical fragments and the sensations (TDS) or emotions (TDE) to two samples of coffee using the software G*Power (version 3.13; Cardenas and Arancibia, 2014). Assuming two-sided tests with α = 0.05, power (1-β) = 0.80 and effect size f = 0.18, in TDS, the required sample size would be 44 to ensure a power >0.80, F [3, 129] = 2.674.*

For TDE, effect size f = 0.14, the required sample size would be 71 to ensure a power >0.80, F[3, 210] = 2.674

This has been clarified in the Materials and Methods section of the revised manuscript.

204-205 'astringent' isn't a basic taste as you seem to imply

The sentence was rewritten as follows: "…basic taste solutions for sweet, sour, bitter and for the mouthfeel sensation astringent…"

Results

317 'The same happened…' Ambiguous quite what this sentence means

The sentence was replaced by: "On the other hand, the duration of bitter was significantly longer when the coffee was evaluated while listening to the "bitter" music." in the revised manuscript.

362 /363 - you switch between taste and flavor
The reviewer is correct. The term we meant to use was taste and it has been modified in the revised version.

370 - 'might be expected to ' perhaps closer to what they say than 'tends to work' - Ie. I think it is just a speculation.
This has been changed accordingly in the revised version.

404 Spence, C., & Gallace, A. (2011). Multisensory design: Reaching out to touch the consumer. Psychology & Marketing, 28, 267-308. DOI: 10.1002/mar.20392. talk of hedonic ventriloquism for what is described here as emotion transference
We added this reference and also referred to Spence, C. (2020). Assessing the role of emotional mediation in explaining crossmodal correspondences involving musical stimuli. Multisensory Research, 33(1), 1-29.

413. Space too many
The space between the paragraphs was deleted in the revied version.

488 'point also' - reword and see Bravo-Moncayo, L., Reinoso-Carvalho, F., & Velasco, C. (2020). The effects of noise control in coffee tasting experiences. Food Quality and Preference, 86:104020.
We have reworded the sentence and added the reference.

References contain multiple inconsistencies / errors
Crisinel 2010 is actually Crisinel and Spence]
Drobna, why suddenly capitalize article title?
These were modified in the revised version.

Ekan, editors? Publisher?
We believe the reviewer refers to Ekman, and the reference has been modified.

Jager 32013 - missing end page number for article
Unfortunately, we don't understand which is the reference the reviewer is referring to. However, all of them were checked in the revised version.

Knoferle, failure to capitalize journal appropriately - same problem for several of subsequent references.
The mentioned references were modified in the revised manuscript.

554 missing space
Space was added in the revised version.

560'different numbers indicate' - was unclear which numbers you are referring to

Figure 2 was modified in the revised version. Numbers between brackets were replaced by lowercase letters.

Figure 3 - do these results suggest the marketers got the descriptions of soft and intense mixed up?
Not necessarily. The soft and intense description of the marketers could be related to the aromatic intensity, which was not evaluated by our consumers.

For the 3 CVA graphs. It might be good to add a couple of sentences on how to rad/interpret the figure for those who may be unfamiliar with the technique.

A reference on the CVA analysis was added and a short explanation was added in lines 402 – 404.

Peltier, C., Visalli, M., & Schlich, P. (2015). Canonical variate analysis of sensory profiling data. Journal of Sensory Studies, 30(4), 316-328.

Highlights

- Sonic seasoning was observed on a familiar product.
- Musical fragments changed coffee temporal perception.
- Emotions evoked by the music were transferred to the tasting.
- “Sweet” music reduced the dominance perception of bitter in coffee.

Impact of music on the dynamic perception of coffee and evoked emotions evaluated by Temporal Dominance of Sensations (TDS) and Emotions (TDE)

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Highlights

- Sonic seasoning was observ~~achiev~~ed on a familiar product.
- Musical fragments changed coffee temporal perception.
- Emotions evoked by the music were ~~translated~~ transferred ~~in~~to the tasting.
- “Sweet” music reduced the dominance perception of bitter in coffee.

Abstract

The aim of the present work was to study the temporal effect of music on sensory perception and on the emotional changes while drinking coffee. Two different commercial filter coffees were evaluated by a group of 48 consumers using the Temporal Dominance of Sensations (TDS) method ~~with the attributes: *sweet, bitter, astringent, acidic* and *toasty*~~. The description was done in silence and also while listening to two different musical fragments: one with a "sweet" connotation and the other with a "bitter" one. Under the same conditions (drinking coffee with and without musical stimuli), a different group of 72 consumers evaluated their perceived emotions (*joy, fear, neutral, rejection, disgust, surprise, sadness* and *anger*) by Temporal Dominance of Emotions (TDE). Data was analyzed by dominance curves and by ANOVA and MANOVA of the durations of dominance (for emotions and sensations). Coffee perception, in both cases, was modified by the musical stimuli. The duration of dominance of *bitter* was increased in the presence of "bitter" music, while it decreased with the "sweet" music. Moreover, the *sweet* attribute was practically not chosen for describing the coffee on its own, but its choice and duration as dominant increased while listening to the "sweet" musical fragment. Music had even a higher impact on the perceived emotions. The "sweet" music was related to the emotion of *joy*, which was accompanied by *surprise* and also some *sadness* when drinking coffee (regardless of the type of coffee being drunk). The "bitter" music was ~~described with~~linked to ~~the~~ the emotions *anger* and *fear* ~~emotions~~. The effect of "sonic seasoning" and translation of emotions with a familiar product was ~~achieved~~observed.

Keywords

Sonic seasoning, TDS, TDE, emotional translation

1. Introduction

Eating is a multisensory experience, even if sometimes we are not fully aware of it. Sight, sound, smell, taste and touch provide, in an integrated fashion, all the information we need before and during food and beverage consumption. Moreover, the different senses can be ~~further~~ stimulated by sensory cues coming from other than the food itself (e.g. context). In crossmodal interactions, what impacts one sense, influences what is experienced by another. These can go from the impact of illumination on taste (e.g. the use of a red light to make a wine taste fruitier and sw~~ea~~eeter, ~~(~~Spence et. al, 2014a~~(Spence, 2017))~~, to the influence of furniture in a bar on consumers' drink choice (Sester et al., 2013). In the present work, the impact of musical fragments on perceived temporal profile of coffee was studied.

Empirical research shows that there are correlations between music and basic tastes. Sweet taste tends to be conceptually 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), soft in dynamics and with consonant harmonies (Bronner et al., 2012, Mesz et al., 2011). By contrast, sour taste tends to be matched with extremely high-pitched sounds, fast tempo, and dissonant music. Bitter taste is associated with sounds that are low in pitch and more likely to be brassy (Crisinel and Spence, 2010, Wang et al., 2015). Salty taste is mostly related with *"staccato"* music (i.e. music with clearly detached successive notes) (Mesz et al., 2011, Knöferle and Spence, 2012, ~~).~~ Guetta and Loui, 2017), and with long decay time, high auditory roughness and a regular rhythm (Wang et al., 2021). Interestingly, the same correspondences have been documented in non-western cultures (Knöeferle et al., 2015).

Other r~~R~~esearch ~~has also been done~~ on the impact of music on food preference, ~~finding that~~showed that, when presented together, the music tends to enhance the pleasure

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of what one is tasting, ~~to~~ affects food selection and ~~to~~ orients visual attention to crossmodally congruent food items (Spence et al., 2014a, Wang et al., 2015, Zellner et al, 2017, Peng-Li et al, 2020, de Paula et al, 2021)~~(Zellner et al., 2017, Peng-Li et al., 2020, de Paula et al., 2021))~~. It has been shown that the experience of many different food and drink products can be modified by changing the music or soundscape that people listen to (Wang and Spence, 2015a, Wang and Spence, 2015b, Crisinel et al., 2012, Reinoso-Carvalho et al., 2015a, Reinoso-Carvalho et al., 2015b, Spence and Deroy, 2013, Spence et al., 2014b, Velasco et al., 2013, Hauck and Hecht, 2019); for a summary of recent studies on this subject see Spence et al. (2019).

This effect of music on taste perception and appreciation is known as "sonic seasoning" (Spence, 2013; Spence et al., 201~~9~~9) and it tends to be more pronounced for foods with complex flavors, this being explained by an attentional account. According to this ~~approach~~, taste-congruent soundtracks draw the listener's attention towards the taste that corresponds to the soundtrack enhancing the salience of the attended characteristic. "Sonic seasoning" is said to work comparatively better with unfamiliar food products (Spence et al., 2019), in which case the role of memories of previous experiences will presumably not dominate over the actual tasting situation, giving a higher predominance to the impact of sound. However, this effect has also been observed with familiar and frequently consumed produced such as cheese, chocolate, wine, beer, and most relevantly for the present study, coffee (Spence et al, 2021).

~~However, it would be most interesting to see if this effect can also be obtained with familiar and frequently consumed products.~~

Besides attentional biases, there are several other plausible mechanisms accounting for the effect of sound in taste perception and evaluation (Wang, 2017), such as

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transference. This is the case where the preference for the music is transferred to the preference on taste. People will like more a food or drink consumed while listening to music they enjoy in comparison to eating/drinking it with music they do not. In fact, several studies have shown this transference for a variety of products such as fruit juice, chocolate and beer (Reinoso-Carvalho et al., 2015a, Reinoso-Carvalho et al., 2015b, Wang, 2017, Reinoso-Carvalho et al., 2019). ~~Also~~Moreover, in a study by North (2012) on music and wine, it was found that characteristics from the music were transferred to the wine: music that was judged as heavy and powerful made a wine taste heavier and more powerful. However, no further research was done regarding the aspects of emotions evoked by music or soundscapes and their combination with food or beverage intake.

Since music and food consumption are both time-varying in nature, it would seem appropriate to use a temporal method for studying the impact of music on the perception of food and drink. A recent study used time-intensity (T-I) 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., 2017). Results revealed that a change of soundtrack resulted 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.

More complex shifts in the taste of red wine presented together with classical and pop music were measured with the method Temporal Dominance of Sensations (Wang et

al., 2019). Temporal Dominance of Sensations (TDS, Pineau (2003)) is a multi-dimensional dynamic technique which is easily used with consumers, allows description in an holistic way and has successfully been used to describe perception of coffee (Dinnella et al., 2013). Moreover, TDS description is based on pointing out (from a given list) the sensation that most catches the evaluator's attention at every moment of the tasting. It is a task of choice, based on attentional behavior and is not a descriptive technique based on quantifying the intensity of the perceived sensations. Therefore, it is adequate to see if music changes our attention in relation to basic taste when consuming a product, in this case, coffee. ~~Also~~In addition, this method has been easily adapted to obtain information on emotions (Temporal Dominance of Emotions, TDE, Jager et al. (2014)). In this way, the two methods based on temporal choice can be used to evaluate how: a) consumers perceive the coffee with and without musical stimuli and b) how consumers perceive and describe their own emotions while drinking coffee with and without the same musical stimuli.

It was the aim of the study to evaluate the dynamic impact of two different sound fragments on coffee tasting. Temporal changes in taste perception of coffee were evaluated by means of Temporal Dominance of Sensations (TDS) while the impact on autodeclared emotions was described by Temporal Dominance of Emotions (TDE).

2. Materials and Methods

The experiment took place in the sensory facilities of *the Facultad de Ingeniería y Ciencias Agrarias (Universidad Católica Argentina, Buenos Aires)* which has nine sensory booths equipped with special lighting and tablets using the TimeSens~~™~~ software (INRA, Dijon, France).

2.1. Coffee samples

Two different commercial filter coffees were used. They were bought at a local supermarket and were both of the same commercial brand (*Sensaciones* by *Bonafide,* made in Argentina). According to the description of the manufacturer, they were different in terms of intensity and aromatic profile. ~~They were different in terms of intensity and aromatic profile.~~ One was defined as "intense" and the other one as "soft" (hereon coffee samples will be referred to as IC and SC respectively). However, the aim of having two coffee samples was to verify the impact of the musical stimuli on coffee perception, not to compare them ~~samples between them~~.

Coffees were prepared according to the manufacturers' instructions: 12g of coffee every 200 ml of water using a traditional filter coffee machine. They were served at 52 ± 5 ºC in small thermal coded cups.

2.2. Music fragments

The musical stimuli consisted of two fragments of 20 seconds each, with "sweet" and "bitter" connotations.

The "sweet" fragment combined the beginning of Robert Schumann's Eusebius from his Carnaval Op. 9 and the beginning of the sweet soundtrack designed by Jialing Deng and Harlin Sun for Deng's Master of Arts thesis. The "bitter" audio was also a combination of two different soundtracks, a fragment from the beginning of the first movement of the Third Symphony by H. Górecki and a static low-register trombone chord. The audios were selected to satisfy criteria associated with sweetness and bitterness in the literature (Mesz et al., 2011, Knöferle and Spence, 2012). They were harmonically consonant, of medium to high pitch and of low psychoacoustic roughness in the case of "sweet" audio, and low-pitched and of high roughness in the case of "bitter" audio. Moreover, in the case of "sweet"

music, both the Schumann and the Deng fragments had been used in previous research and had shown to reliably evoke sweetness (Kontukoski et al., 2015, Wang et al., 2015). Both the "sweet" and the "bitter" music were validated in an online experiment where a total of 24 musical fragments (6 intended to correspond to each taste category: bitter, salty, sour and sweet), were presented to 18 participants who were asked to determine, in a forced choice, to which of the taste category corresponded each fragment. For each "sweet" and "bitter" fragment, 83% or more of the participants associated the intended taste. ~~The "bitter" music had been validated in an online experiment (N=18) where 83% of the participants associated both the Górecki and the trombone audios with bitter taste.~~

From hereon, musical stimuli will be referred to as SM, for the "sweet" fragment and BM, for the "bitter" fragment.

2.3. Consumer panels

A total of 120 frequent coffee ~~frequent~~ consumers were recruited by mail from the sensory analysis laboratory database. They were students and staff members of the *Universidad Católica Argentina* who consumed black coffee at least once a day, without any added sugar or sweetener.

Consumers were randomly assigned to the Temporal Dominance of Sensations (TDS) or the Temporal Dominance of Emotions (TDE) group. The final panels were conformed as follows: 48 consumers (72% women, mean age 32 years old, ± 11.8) for TDS and 72 consumers (72% women, mean age 29 years old, ± 10.6) for TDE.

Sample size calculation was based on exploring the relationship between two musical fragments and the sensations (TDS) or emotions (TDE) to two samples of coffee using the software G*Power (version 3.13; Cárdenas and Arancibia, 2014). Assuming two-sided tests with α = 0.05, power (1-β) = 0.80 and effect size f = 0.18, in TDS, a ~~the required~~ sample size of ~~would be~~ 44 ~~to~~ ensures a power >0.80, F [3, 129] = 2.674. For TDE, effect

size f = 0.14, the required sample size would be 71 to ensure a power >0.80, F[3, 210] = 2.674

More participants were allocated ~~We decided to allocate more participants~~ to the TDE study since there is more literature on the effect of music on taste sensations (Wang and Spence, 2015a,b, Wang et al. 2019, Reinoso Carvalho et al. 2015) than on its effect on emotions while consuming food or drink products.

2.4. Evaluation methods

2.4.1 Coffee description by Temporal Dominance of Sensations (TDS)

Consumers participated in a short training session and then evaluated all samples (coffee, music fragments and coffee+music fragment combinations) over a one-hour long session.

The training session was devoted to explaining the method and the proposed attributes. Participants were told that the aim of the evaluation was to register the dominant sensation at every moment of the tasting, the dominant sensation being the one that caught their attention, not necessarily the most intense one (Pineau et al., 2003). The panel leader emphasized that the evaluation was dynamic and that data was continuously recorded, from the moment they clicked on a start button until the end of the evaluation (from the first contact with the product in the mouth until after swallowing). Consumers were presented with a list of sensations which included: *sour, bitter, sweet, astringent* and *toasty*. Consumers were also told that they could choose only one attribute at a time, but that the dominant sensation could change as many times as desired. The same descriptor could be used more than once, and some might not be used at all. A live demonstration was carried out to make sure consumers understood the method.

In this training session participants also received basic taste solutions for *sweet*, *sour*, *bitter* and for the mouthfeel sensation *astringent* to ensure that they could identify and

differentiate them (specially the last three). Solutions were composed as follows: 2% sucrose (*sweet*), 0.05% citric acid (*sour*), 0.05% caffeine (*bitter*) (Meilgaard et al., 1991), 0.07% alum (*astringent*) (Drobna et al., 2004). For *astringent* they were also told that it is a sensation associated with dryness, puckering and rough mouthfeel.

In the evaluation session consumers were given first a warm-up sample (a third commercial coffee) to familiarize them with the computer program and the methodology. Then, samples were presented as follows: coffee without music (half consumers received IC first), the four combinations of coffee and music (IC+BM, IC+SM, SC+SM, SC+BM) presented in random order and, at the end of the session, consumers were asked to use the same list of attributes to describe the musical stimuli (half the panel began by the SM). For mus~~Mus~~ic description, consumers were simply asked the following: "if you were to describe this musical fragment with the given attributes: which ones would you use?". This was done at the end of the session in order not to bias consumers' responses when tasting the coffee together with the musical fragments. The order of the attributes presented on the screen was randomized across consumers to reduce potential bias due to attribute position (Pineau et al., 2012). However, for each participant, the order was kept across samples.

With each evaluation consumers were given a new coffee sample with a different number. In every case, they were asked to take one generous sip and the evaluation was stopped after 20 sec, in accordance with the duration of the musical fragment (this was the same in the absence of music).

2.4.2 Evoked emotions described by Temporal Dominance of Emotions (TDE)

The auto declared emotions while consuming the coffee with and without musical stimuli were evaluated by Temporal Dominance of Emotions (TDE) (Jager et al., 2013). The principle behind TDE is like that of TDS, therefore similar instructions were given to the group performing this evaluation. Moreover, consumers were instructed to focus on how

they felt at every moment, regardless of whether they felt like that because of the music or the coffee.

The list of emotions was reduced and included *joy, fear, neutral, rejection, disgust, surprise, sadness* and *anger.* These were based on Ekman's study on basic emotions (Ekman, 1999). Water was used as a baseline and warm-up sample for consumers to get acquainted with the software and method. Sample presentation followed the same order as in the TDS evaluation (only coffee, combinations of musical fragments + coffee, and musical fragments alone).

The order of the emotions on the screen was also randomized across consumers to reduce potential bias due to position (Pineau et al., 2012). For each participant, the order was kept across samples.

2.5. Data analysis

Data was mostly analyzed by means of the web based TimeSens~~TM~~ software (INRA, Dijon, France).

The effect of the presence of music on the TDS and TDE task was assessed by evaluating differences in time to first click (and consequently real duration) in all the evaluations.

The temporal description of the musical fragments and of the selected coffees was depicted by the construction of dominance curves (Pineau et al., 2009), displaying the proportion of the consumers who selected a certain attribute as dominant at a given moment. The same was done with the temporal data on emotions. Curves were standardized to the left to reduce differences among subjects and to the right, since all the evaluations ended after 20 sec, in agreement with the duration of the music fragment.

~~The number of descriptors used, the average time to the first click and the total duration of the evaluation were analyzed and compared to evaluate consumer performance.~~

Duration of sensations (and emotions) as dominant were analyzed (Galmarini et al., 2017) and compared, for each coffee tested under different conditions, using ANOVA by descriptor (or emotion), MANOVA, Hotelling Test and Canonical Variate Analysis (CVA, Peltier et al., 2015). The analysis on duration of dominance ~~was preferred because it can~~ reveals statistically significant differences among samples, which cannot be shown by ~~as opposed to~~ the visual inspection of temporal curves.

3. Results

3.1. Description of musical fragments

Figure 1 a and b show the obtained TDS curves for the musical fragments. It can be observed that they were described as expected, mainly by the terms *sweet* and *bitter*. It should be noted that the "bitter" music fragment was also described as *astringent* by some of the consumers. *Sour* and *toasty* were never significant. There was a high agreement (dominance rate over 60%) on the use of the term *sweet* for describing the "sweet" soundscape. For the "bitter" musical stimulus, the attribute *bitter* had the highest dominance rate, but consumers also used (in a smaller proportion) the term *astringent*. The use of this latter term could be explained by the high perceived roughness of the sound which also agreed with the definition given for *astringent* (sensation associated with dryness, puckering and rough mouthfeel, section 2.4.1). Also, rough timbre has been shown to be processed by the same neural substrates involved in feeling and talking about rough objects (Wallmark and Kendall, 2018).

- Insert Fig 1 a and b about here -

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Figure 2 shows a comparison on the mean time before the first click and the real duration of all the evaluations. It can be observed that consumers took the longest time to give the first click for the “sweet” music fragment and this was significantly different from the “bitter” music, to which they reacted faster (7.6 sec vs. 6.3 sec). ~~However, this time is in line with the time it took consumers to describe the coffee samples.~~ Even though consumers were probably surprised to use the taste attributes to describe only the music, they were perfectly capable of doing so.

- Insert Fig. 2 about here –

3.2 Coffee dynamic description without and with background musical stimuli

The temporal description of the ~~dominant~~ sequence of dominant sensations for the evaluation of coffees, ~~(~~without and with the different musical fragments, ~~)is~~ ~~is~~ presented in Figures 3 (a, b and c) and 4 (a, b and c) ~~(a and b)~~.

- Insert Fig 3 (a, b and c) and 4 (a, b and c) ~~a and b~~ about here-

-

The soft coffee (SC) (Fig. 3a) had a more complex profile with a higher agreement among consumers. The *bitter* taste was perceived as dominant at first, then ~~*sour* was dominant and afterwards~~ *toasty* called the consumers’ attention, ending with an *astringent* note. Sour was slightly dominant in the middle of the tasting. On the other hand, the intense coffee (IC) (Fig. 4a) was mostly characterized by *bitter*. Sour was also significant at the beginning (with a smaller dominance rate), and ~~*a A*~~*stringent*~~*, sour*~~ and *toasty* were chosen by the consumers, reaching the limit of significance, but *sweet* was practically not selected

as a dominant attribute. Even though it was not the aim of the experiment to compare the two coffee samples, it can be observed that they were different in terms of temporality.

The impact of the music on the sequentiality and on the dominance rate of the sensations can be observed in Figures 3 b and c for the SC and in Figures 4b and c for IC. When described with the "bitter" musical fragment, the dominance rate of *bitter* increased in both coffees and it even became the only attribute above significance all along the tasting (Figures 3 b and 4 b). The use of a "sweet" musical fragment had the opposite effect on bitterness reducing its dominance rate. This was more evident in the IC. Moreover, even though it did not reach significance, it can be observed that with the "sweet" music, the dominance rate of *sweet* increased in both coffees. In all cases the temporal profiles of the coffees changed under the three tasting conditions.

~~The number of descriptors used, the time to the first click and the total (real) duration of the evaluation were analyzed and compared for both samples and all conditions. In average, 2.5 descriptors were used to describe the coffees without background music and consumers took one second more to select the first descriptor when evaluating the coffee with music (average to first click 5.6 sec for the coffees without and 6.6 sec for coffees tested with background music, see Figure 2).~~

To find the impact of the auditory stimulus on small differences, the duration of dominance of the different attributes were also evaluated and represented with a Canonical Variate Analysis (Galmarini et al., 2017) comparing each coffee sample evaluated under the three different conditions. These are presented in Figure ~~4~~ 5 a and b.

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As it can be observed, coffee perception was modified by the musical fragments. The obtained description for each coffee was different under the three conditions (SC: F-MANOVA= 2.5, p= 0.008**; IC: F-MANOVA= 2.4, p=0.012*). In both cases the musical stimuli changed coffee perception mostly in the direction of the characteristic of the musical fragment. In this figure, the length of the vectors represent differences among samples, the longer the vector the bigger the difference in duration of dominance for this descriptor among the samples. The duration of *sweet* as dominant was significantly longer when the coffee was tasted while listening to the "sweet" music. On the other hand, the duration of *bitter* was significantly longer when the coffee was evaluated while listening to the "bitter" music. ~~The same happened for the duration of *bitter*. This can be further observed when comparing t~~The duration of each attribute (as a proportion of the evaluation) was also compared in an ANOVA, for each coffee under the three tasting conditions. This is presented in Table 1 (part a) comparisons for SC; part b) comparisons for IC)~~, as presented in Table 1~~.

- Insert Table 1 about here -

Table 1 (a and b) shows that, under the three tasting conditions, there were significant differences in the duration of dominance for the attributes *sweet, bitter* and *sour*. *Toasty* and *astringent* showed no significant differences in terms of total duration (though there were differences in dominance rate (panel agreement), see Figures 3 and 4).

In both coffees, there was a significant difference in the duration of *sweet* and the highest~~r~~ values were observed while listening to the "sweet" music. However, there was also a small effect of the "bitter" music ~~on~~increasing the duration of *sweet*, though it was not significantly different from the coffe with no music. Changes in *bitter* were higher while listening to the "bitter" musical fragment, but they were not the same in both coffees. Finally,

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the duration of *sour* was reduced in the presence of both musical fragments, probably due to the fact that the other sensations increased their duration and that there was no association with the musical fragments.

It should be noted that the nature of the musical fragment drives most of the changes in the description. However, there is probably also a music effect, regardless of the nature of the musical fragment.

~~A significantly longer duration of *sweet* was observed for both coffees when evaluated while listening to the "sweet" musical fragment. The *bitter* sensation was dominant for the longest period for the soft coffee evaluated in combination with the "bitter" musical fragment.~~

3.3 Description of evoked emotions

Emotions evoked by the two musical fragments were quite different. The corresponding TDE curves are presented in Figure ~~5~~ 6 a and b.

- Insert Fig ~~5~~ 6 a and b –

-

The "sweet" music fragment had an important dominance of *joy* and some *surprise*. On the other hand, the "bitter" fragment was associated with more negative emotions: mainly *fear*, and *disgust*. In the TDE curve for water (warm up sample, graphic not shown) the only evoked emotion was *neutral*, showing that consumers understood the method and that they were not projecting a previous emotion onto the evaluation.

The impact of the musical fragments on the perceived emotions while tasting each coffee was evaluated by analyzing the duration of dominance of the emotions as presented in Figure ~~6~~ 7 a and b.

- Insert Fig ~~6~~ 7 a and b about here –

-

The F-values for the MANOVA analysis (Figure ~~6~~ 7 a and b) show a greater discrimination for the samples when compared to the evaluations done by TDS. Moreover, results seem to, somehow, reflect the emotions evoked by the music. For both coffees it was found that the prevailing emotion when describing the coffee alone was *neutral* (that was the emotion that was dominant for a longer period of time). Also, when tasting the coffee with the "bitter" musical fragment the emotions of *fear* and *anger* were dominant for longer periods of time while with the "sweet" music *joy, surprise* and also *sadness* prevailed. This was similar for both coffees.

As complementary information, Table 2 (a and b) presents the comparison of the duration of dominance by emotion for each coffee tasted under the different conditions and the musical fragments.

- Insert Table 2 about here –

As it can be observed, there were significant differences in the duration of all emotions. Fear was not registered while tasting only coffee. This emotion was linked to the "bitter" musical fragment and the tasting of the coffees while listening to it (ICBM, SCBM) On the other hand, joy was dominant for a short period of time during the coffee evaluation without music, but its duration increased significantly while listening to the "sweet" music. The neutral emotion, which was registered as dominant for both coffees when there was no

auditive stimuli, was significantly reduced with the sonic seasoning. Music made evaluators prone to select other emotions mostly music related; ~~, but~~ they did not remain indifferent to the music.

4. Discussion

In the present work the impact of auditory stimuli (in the form of musical fragments with a "bitter" and "sweet" connotation) on the perception of the flavor of two different coffees as well as on the emotions experienced while drinking these coffees was evaluated using a temporal method based on the temporal dominance paradigm. Several interesting facts were observed.

First, it was found that consumers were able to describe the proposed musical fragments in a consistent way using the list ~~of taste~~ descriptors proposed for the coffee. M~~,~~ ~~that is to say, m~~usic was susceptible to be described in terms of ~~flavor~~ taste attributes, which shows how "natural" and common are these crossmodal associations.

Surprisingly, consumers were quicker for describing the "bitter" than the "sweet" music. This could be related to the intrinsic negative connotation of *bitter* taste which results in a fastest reaction time (Bianchi et al., 2018).

~~Another interesting result was that "sonic seasoning" was possible even with a familiar product such as coffee. According to Spence et al. (2019), this type of interaction tends to work better with unfamiliar food products where the role of memories of previous experiences will not dominate over the actual tasting situation. However, in the present study, consumers were frequent users of the evaluated product and, even so, their temporal taste perception was significantly changed by the addition of musical stimuli.~~ In both coffees, listening to the "sweet" music reduced the dominance of *bitter*~~*ness*~~ and increased the choice

of *sweet* as a dominant sensation. This observation makes us hypothesize that, under given conditions, the ~~suggests that including the~~ appropriate sound stimuli could result in, for example, reduction of sugar ingestion by taking advantage of “sonic sweetening”.

Moreover, the impact of music was higher on the perceived emotions than on taste. It was found that music drives emotions and that greater differences were expressed for a same coffee based on emotions than on taste ~~(see figures 6 a and b)~~. Figure 8 shows how different the impact of music is on perceived coffee sensations (part a, TDS) and on consumers’ emotions (part b, TDE). Even though it was not the aim of the experiment to compare the results between coffees, both are represented on the CVA’s to make the comparison more robust.

~~To better analyze the different impact of music on taste description and perceived emotions, figure 7 a and b integrate all the results obtained by TDS and TDE in terms of duration of dominance (musical fragments, coffees on their own and the coffees with the musical stimuli).~~

- Insert Figure ~~7~~ 8 a and b about here -

It can be observed that the duration of dominance of *sweet* in the “sweet” music was way more important than in any of the other sample~~s~~. Something similar, but to a lesser extent, was obtained for *bitter* and “bitter” music. Therefore, in the TDS experiment, the descriptions for the musical fragments are further apart than in the TDE study and are more differentiated from the description of the coffees and the coffees + musical fragments. In contrast, the duration of emotions evoked by the music are closer to those evoked to the combination of music and coffee, while the coffees without any musical stimuli are further

away from the other samples, and are described as *neutral*. In addition, “sweet” music was mostly described with *joy*, but tasting coffee also added a period of some *sadness*, together with *surprise*. In the case of “bitter” music, described mainly with *fear*, when tasting coffee some dominance of *anger* was added. In TDS the impact of music is smaller and the description of the coffees with music is closer to that of coffee itself rather than to the musical fragment. On the other hand, on TDE, the emotions are more associated to the music than to the product evaluated by itself. In this way, both music and taste contribute to the variety and complexity to the emotionality of the multisensory coffee experience.

There is extensive evidence supporting the hypothesis of “sensation transference” (Wang, 2017), that refers to the carrying over of the feelings about one stimulus to a different one experienced at the same time. This is possibly one of the mechanisms behind the effect of “sonic seasoning” found in this experiment.

In view of the above remarks, it seems relevant, in the present context, to distinguish between “sensorial transference” and “emotion transference” (Spence and Gallace, 2011; Spence, 2020) from the music stimulus. The latter effect appears much more important and clearer, while in contrast, from a sensory point of view, the driving stimulus appears to be coffee taste, and music only modulates taste perception to a limited extent. Importantly, however, it does so in a congruent way: “sweet” music increases the duration of dominance of *sweet* taste and reduces the duration of *bitter* in both coffees while “bitter” music enhances the duration of dominance of *bitter* taste (Figure 4, Table 1). So, our results provide evidence consistent with the hypothesis of crossmodal sensorial and emotional transfer from music to coffee, adding to the results on juices, beer, chocolate and wine referred to in the introduction.

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Working with chocolate, Reinoso-Carvalho et al., (2020b). also showed that “sonic seasoning” and sonic sensation transference could be combined and triggered concurrently, but that emotional influences were numerically larger than those reported for the sonic seasoning tracks. Ultimately, one of the aims of sonic seasoning research is to pick, or select, music combining elements carrying crossmodal flavor associations to enhance the desirable taste qualities, and capable also of enabling “emotional sonic sensation transfer” to enhance the overall multisensory experience (Spence, 2021).

5. Conclusion

Temporal dominance of sensations and emotions were efficient tools for describing and comparing the impact of music on the perceived taste and auto declared emotions during the coffee drinking experience.

The specific musical fragments had a significant effect in changing the flavor temporal perception of coffee, demonstrating that “sonic seasoning” can be achieved also with such a frequently consumed beverage. The obtained results show a promising use of music and auditory stimuli applied to, for example, reducing sugar intake. This could be of interest in contexts where people tend to over ingest sweeteners due to a significant coffee intake, such as office workers or university students.

Sensation transference from the music to the tasted coffee was observed, emphasizing that, in addition to the impact on taste, music can drive emotions and, in this way, define the tasting experience. This is also of great importance when generating a friendly or cozy environment for coffee consumption, as could be the case of a coffee shop (Spence 2017), for using music for enhancing the uplifting boost of a coffee cup in the morning (perhaps using special “gastrosonic” devices such as the sonic glass described in Mesz et al., 2017) or creating atmospheres for more hedonic and refined coffee experiences.

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More generally, our results indicate~~point~~ ~~also to~~ the importance of having a controlled sonic environment for performing sensory analysis studies and ~~also~~ the significance of ambient sound for food consumption in restaurants, bars and cafeterias. ~~(Bravo-Moncayo et al 2020).~~

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Table 1. Mean duration of dominance (expressed as a percentage of the evaluation, not in seconds) for TDS attributes. a) Comparison of the soft coffee tasted under the three conditions (no music, SC; ~~of each attribute for the two coffees tasted without music (SC and IC) and while listening to~~ "sweet" music (SCSM) and "bitter" music (SCBM). b) Comparison of the intense coffee tasted under the three conditions (no music, IC; "sweet" music (ICSM) and "bitter" music (ICBM). ~~musical fragments.~~

a)	SC	SCSM	SCBM
*Sweet**	3 (a)	11 (b)	7 (ab)
*Bitter**	29 (a)	37 (ab)	40 (b)
Astringent	18	10	15
*Sour**	20 (ab)	18 (ab)	12 (b)
Toasty	30	24	26
b)	IC	ICSM	ICBM
*Sweet**	1 (a)	11 (b)	6 (ab)
*Bitter**	30 (ab)	21 (a)	33 (b)
Astringent	21	12	20
*Sour**	25 (b)	26 (b)	16 (a)
Toasty	23	30	25

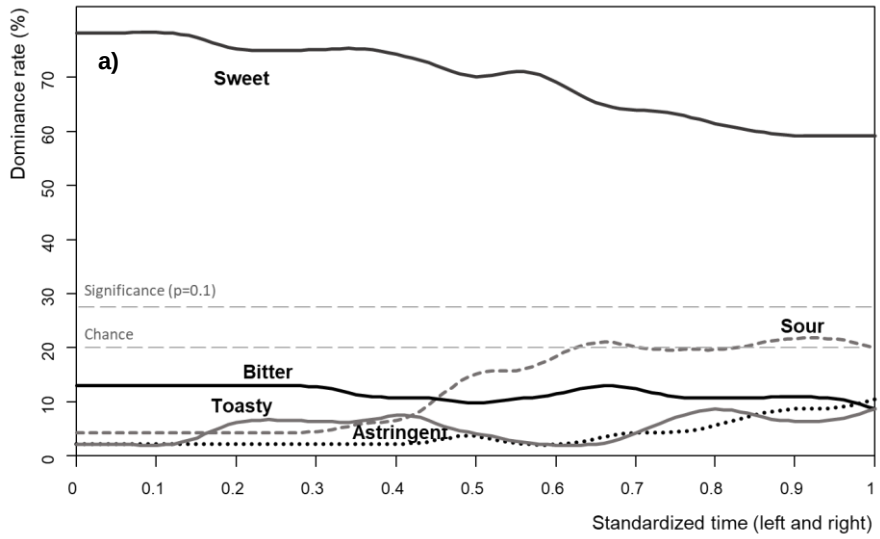
Different letters show significant differences among samples for the given attributes for Tukey test.
* p<0.05~~; **p<0.01~~

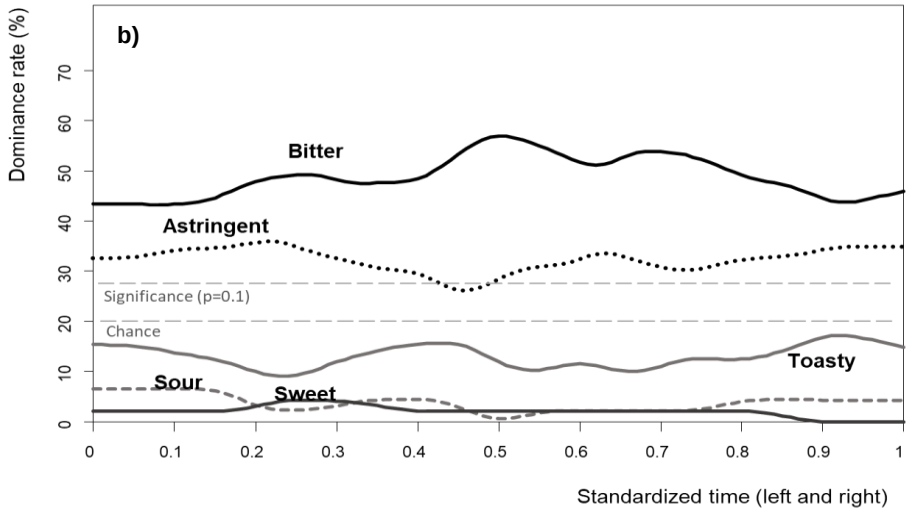
Table 2. Mean duration of dominance (expressed as a percentage of the evaluation, not in seconds) for the emotions evaluated by TDE attributes. a) Comparison of the intense coffee tasted under the three conditions: no music (IC); with "bitter" music (ICBM), with "sweet" music (ICSM) and the two musical fragments, "bitter" music (BM), with "sweet" music (SM). b) Comparison of the sweet coffee tasted under the three conditions (no music (SC); with "bitter" music (SCBM), with "sweet" music (SCSM) and the respective comparison with the different musical fragments.

a)	IC	ICBM	ICSM	BM	SM
Joy***	15 (ab)	4 (a)	27 (b)	3 (a)	53 (c)
Fear***	1 (a)	19 (b)	5 (a)	30 (b)	4 (a)
Neutral***	38 (b)	9 (a)	12 (a)	11 (a)	12 (a)
Anger***	1 (a)	14 (b)	1 (a)	10 (b)	1 (a)
Disgust***	19 (b)	22 (b)	12 (ab)	18 (b)	1 (a)
Surprise**	14 (a)	15 (a)	28 (b)	10 (a)	16 (ab)
Rejection**	10 (ab)	12 (b)	4 (ab)	12 (b)	1 (a)
Sadness**	2 (a)	4 (ab)	12 (b)	7 (ab)	11 (b)

b)	SC	SCBM	SCSM	BM	SM
Joy***	14 (a)	6 (a)	29 (b)	3 (a)	53 (c)
Fear***	2 (a)	32 (b)	4 (a)	30 (b)	4 (a)
Neutral***	43 (b)	13 (a)	18 (a)	11 (a)	12 (a)
Anger***	2 (ab)	8 (bc)	0 (a)	10 (c)	1 (ab)
Disgust***	12 (bc)	12 (abc)	7 (ab)	18 (c)	1 (a)
Surprise**	17 (ab)	11 (ab)	23 (b)	10 (a)	16 (ab)
Rejection***	7 (ab)	14 (b)	7 (ab)	12 (b)	1 (a)
Sadness**	3 (a)	5 (a)	11 (a)	7 (a)	11 (a)

Different letters show significant differences among samples for the given attributes for Tukey test.
* p<0.05, ** p<0.01, ***p<0.001


a)
Sweet
Sour
Bitter
Toasty
Astringent
Significance (p=0.1)
Chance
Dominance rate (%)
0
10
20
30
40
50
60
70
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Standardized time (left and right)


b)
Bitter
Astringent
Toasty
Sour
Sweet
Significance (p=0.1)
Chance
Dominance rate (%)
0
10
20
30
40
50
60
70
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Standardized time (left and right)

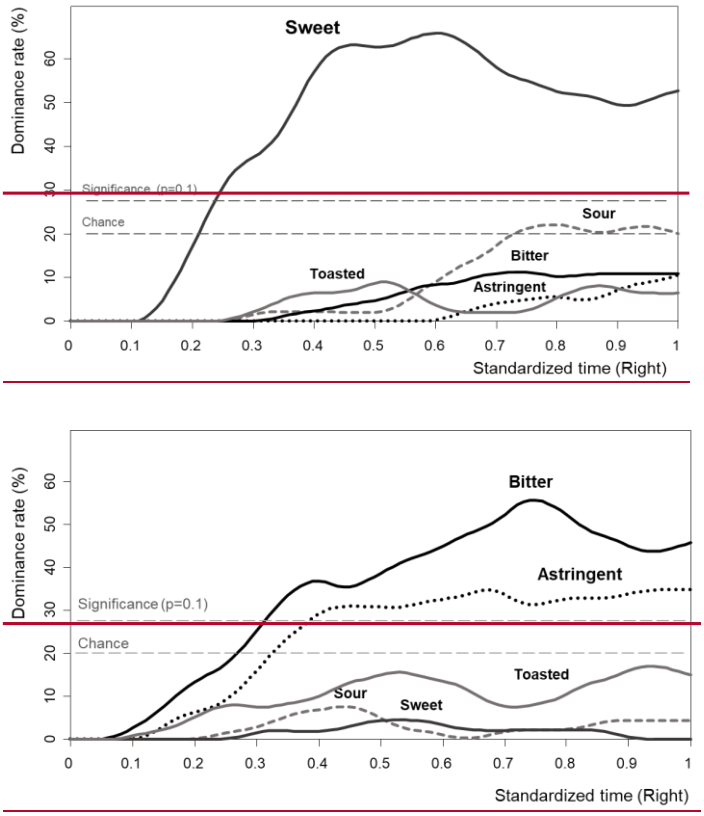
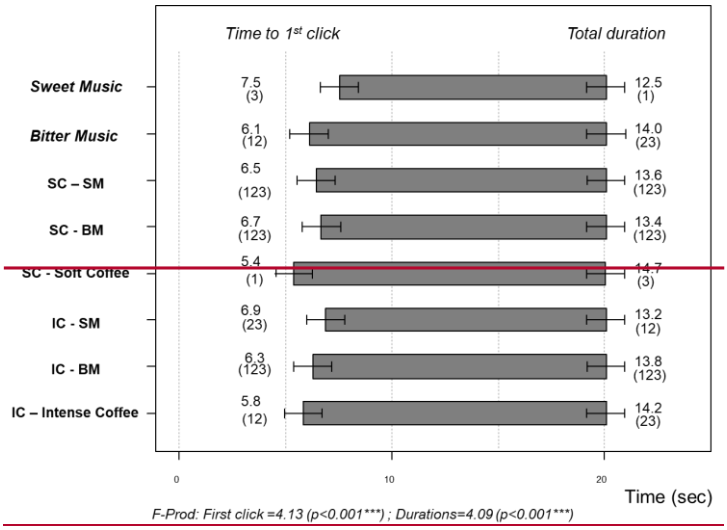


Figure1. TDS curves of the musical fragments. a) SM, “sweet” musical fragment; b) BM, “bitter” musical fragment.



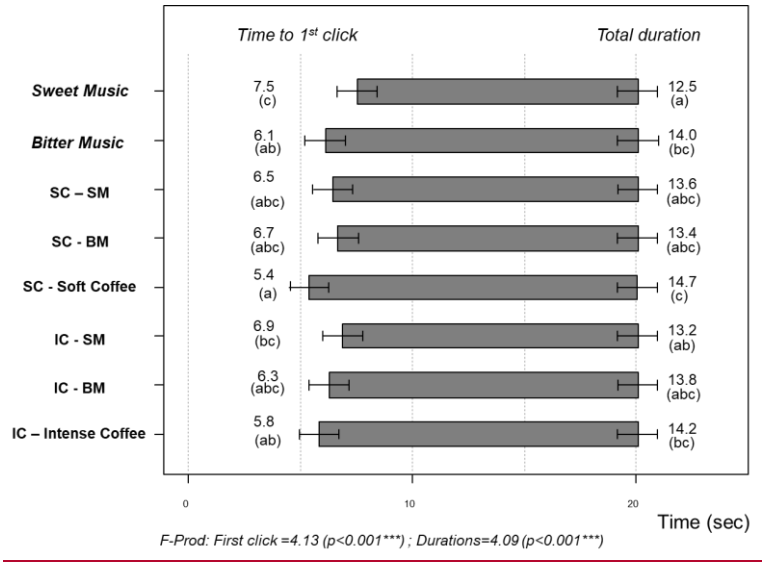
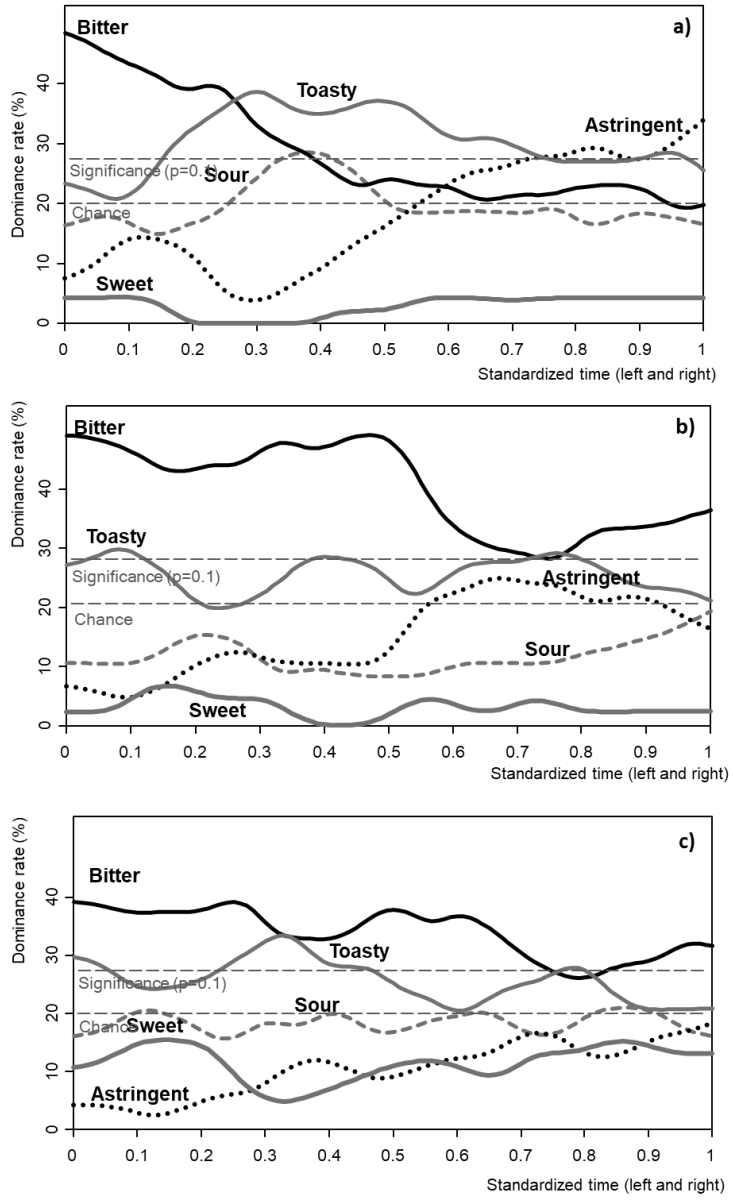


Figure 2. Time to first click and total duration of the evaluation for all the samples (musical fragments, coffees and coffees with musical stimuli). Different letters between brackets

indicate significant differences among samples for time to first click and total duration according to Tukey post-hoc test.


a)
Bitter
Toasty
Astringent
Sour
Sweet
Significance (p=0.1)
Chance
Dominance rate (%)
Standardized time (left and right)
b)
Bitter
Toasty
Astringent
Sour
Sweet
Significance (p=0.1)
Chance
Dominance rate (%)
Standardized time (left and right)
c)
Bitter
Toasty
Sour
Sweet
Astringent
Significance (p=0.1)
Chance
Dominance rate (%)
Standardized time (left and right)

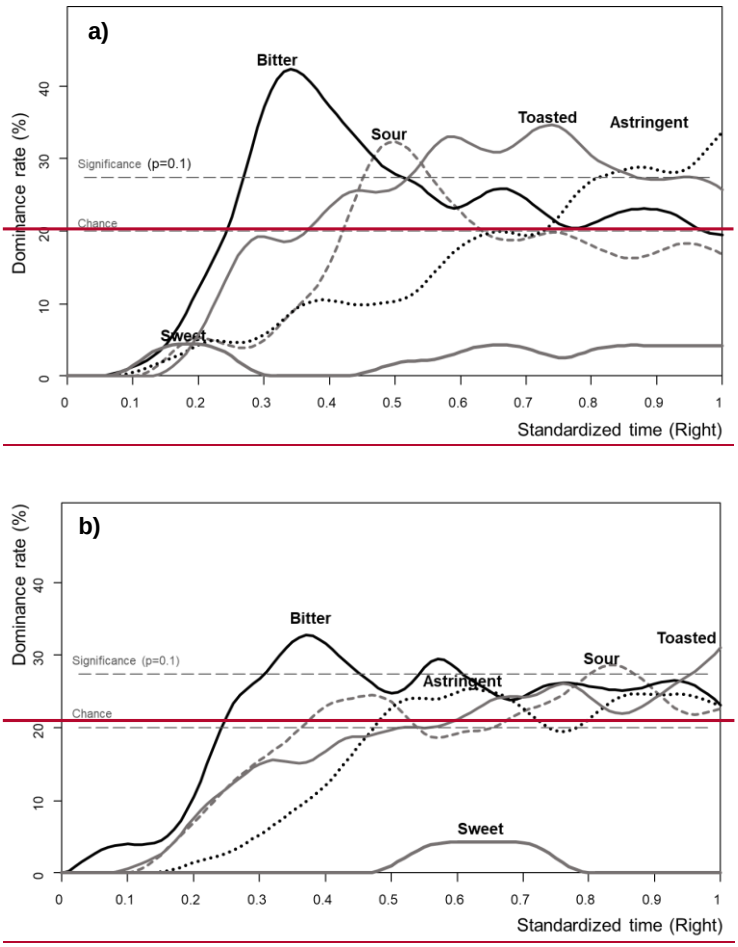


Figure 3. TDS curves for a) SC (soft coffee without music), ~~and~~ b) SCBM (soft coffee with bitter musical fragment) and c) SCSM (soft coffee with sweet musical fragments).~~IC (intense coffee).~~

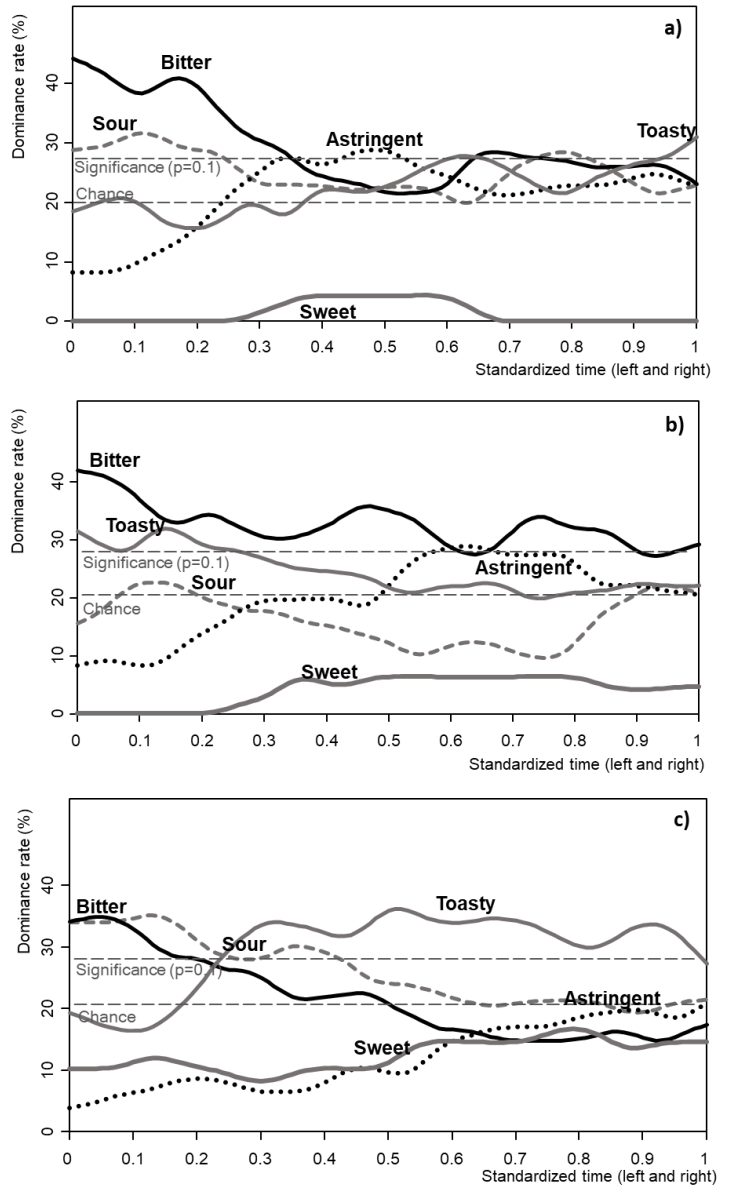
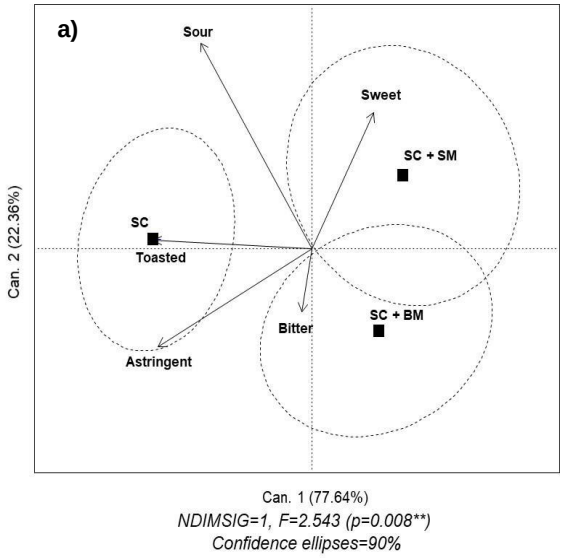


Figure 4. TDS curves for a) IC (intense coffee without music), b) ICBM (intense coffee with bitter musical fragment) and c) ICSM (intense coffee with sweet musical fragments).



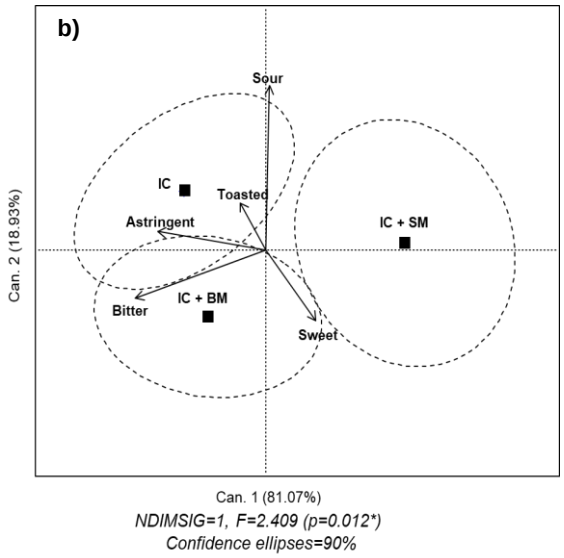
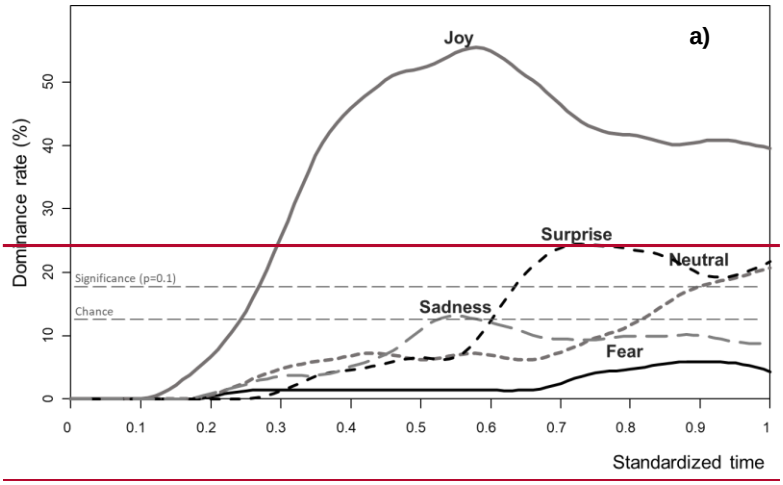
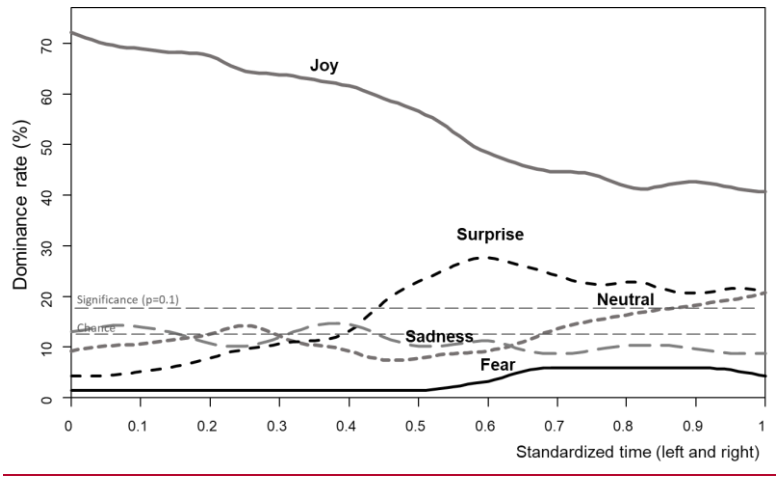


Figure 45. Canonical Variate Analysis (CVA) for: a) the soft coffee (SC) evaluated without and with musical fragments (SM and BM) and the same for b) the intense coffee (IC).





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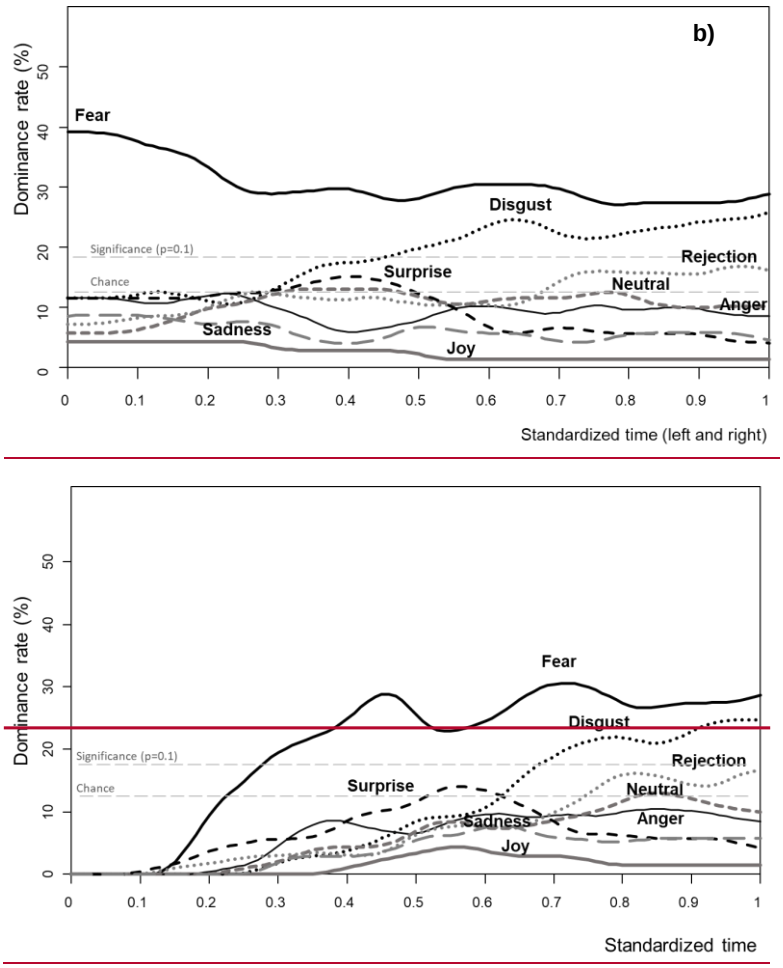
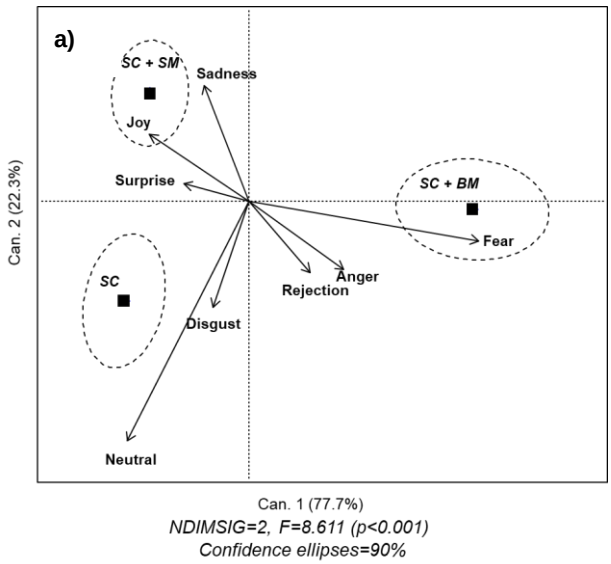


Figure ~~5~~6. TDE curves of the musical fragments. a) SM, “sweet” musical fragment; b) BM, “bitter” musical fragment.



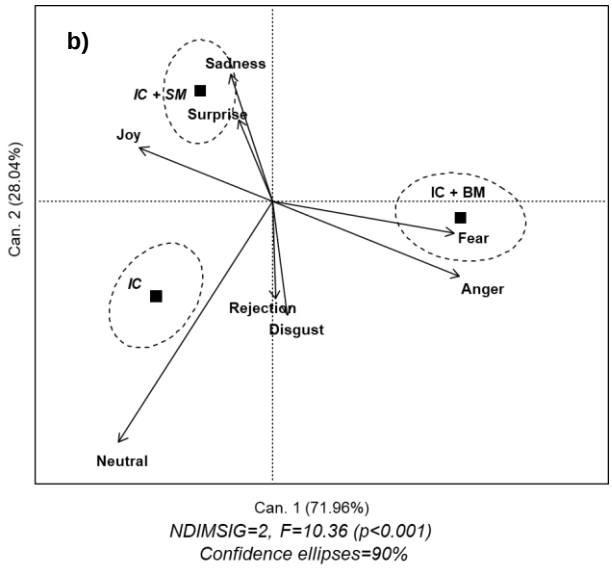
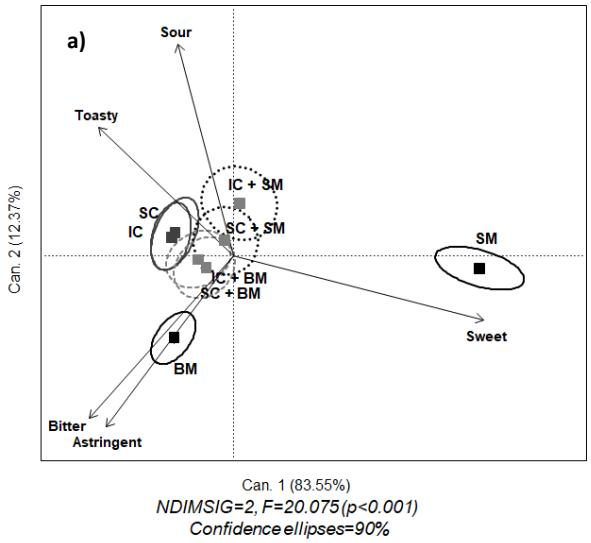


Figure ~~67~~. Canonical Variate Analysis (CVA) for the duration of dominance of the emotions: a) soft coffee (SC) evaluated without and with musical fragments, b) the intense coffee (IC) without and with musical fragments.



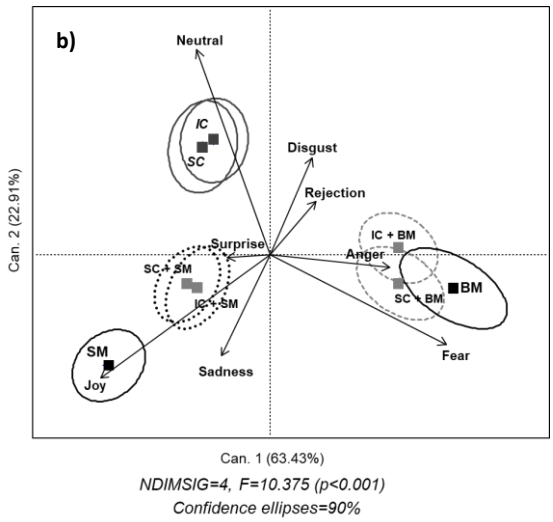
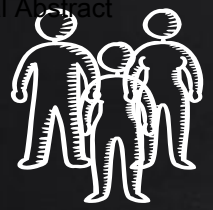


Figure ~~7~~8. a) Duration of dominance of flavor descriptors in music fragments, coffee and coffee tasted with music. b) Duration of dominance of emotions describing musical fragments, coffee and coffee tasted with music.

"bitter" music

"sweet" music

Graphical Abstract



consumers

2 types of coffee

Bitter music – Sweet music

Flavor perception described by TDS

SONIC SEASONING

Emotions described by TDE

EMOTIONAL TRANSLATION

Credit Author Statement

Galmarini, M.V.: conceptualization, methodology, software, formal analysis, investigation, resources, writing, visualization, supervision, Writing - Review & Editing

Silva Paz, R.J. : investigation, resources

Enciso Choquehuanca, D. : investigation, resources

Zamora, M.C.: Writing - Review & Editing

Mesz, B.: conceptualization, methodology, software, formal analysis, investigation, resources, writing, visualization, supervision, Writing - Review & Editing

Conflicts of Interest Statement

Manuscript title:

“Impact of music on the dynamic perception of coffee and evoked emotions evaluated by Temporal Dominance of Sensations (TDS) and Emotions (TDE)”

The authors whose names are listed immediately below certify that they have NO affi liations with or involvement in any organization or entity with any fi nancial interest (such as honoraria; educational grants; participation in speakers’ bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-fi nancial interest (such as personal or professional relationships, affi liations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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