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Running head: *How loud is your coffee?*

Title: The effects of noise control in coffee tasting experiences

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Abstract

The present research investigates the general effect of noise control in individual's eating and drinking experiences. In particular, the study applied passive vs active commercial headphone noise control techniques to an urban drinking situation. Here, each participant drank twice the same coffee while exposed to a louder (~ 85 dBA) vs less loud (- 20 dBs) version of the same background noise of a food court in busy hours. Note that by loud, louder, and less loud, we are referring to differences in the sound level of the noise.

Results suggest that consumers tend to be less sensitive to specific sensory and hedonic attributes of the coffee under louder noise (sweetness, bitterness, acidity, flavor/aroma intensity, flavor-liking, sound-liking, flavor-sound-matching) and less willing to pay and purchase the coffee, relative to less loud sounds. This was more evident concerning the perceived bitterness and aroma intensity of the coffee. The effects reported are mainly attributed to the differences in noise level during taste, and discussed based on theory on crossmodal correspondences, and attention (e.g., louder noise may diminish the ability to attend to specific elements of the experience). When thinking of public health, for example, these results suggest that differences in urban noise level may moderate behavior during food/drink situations (e.g., potentially modulating sugar intake).

Keywords: Coffee, consumer behavior, flavor, noise control.

1. Introduction

What is heard at more or less the same time that we eat or drink can influence the way in which we experience taste and flavor (e.g., see North et al., 1997, 1999; Zellner et al., 2017). There is a growing body of studies assessing the impact of food intrinsic sounds, such as those related to food/beverage preparation (Wheeler, 1938; see Knöferle & Spence, in press, for a recent review), food packaging manipulation (i.e., being opened; Spence & Wang, 2015a, 2017), and the consumption of food (such as mastication, e.g., Youssef et al., 2017; Zampini & Spence, 2004; see Spence, 2015, for a review), on people's sensory, hedonic, and purchasing evaluations of different foods/drinks. Importantly, there is also a growing body of research on product-extrinsic auditory contributions to food perception and consumer behavior (see Spence et al., 2019, for a review). Extrinsic sounds are not specific to the food or food packaging but instead are detached from the food object itself, while occurring at more or less the same time of a food/drink experience (think of music and/or noise).

In the present study, the effects of extrinsic sounds on product experiences, and in particular, concerning the effect of noise in tasting experiences, were studied. Contrary to music, for example, noise is usually present in daily situations, and is not typically subject to any particular customization, unless people have access to noise control (e.g., via headphones). From a listener's perspective, noise is commonly framed as a kind of unwanted sound, being usually perceived as unpleasant, while potentially judged as disruptive to hearing (Goines & Hagler, 2007). That said, researchers have been considering and investigating the implications that noise can have when it comes to eating and drinking since the late 1950's (i.e., Crocker, 1950; Pettit, 1958). For instance, Petit (1958) reflected on the role that noise can play in restaurants, while Crocker (1950) suggested that loud noise can work as a distractor from tasting (cf. the latter with Peynaud, 1987).

Overall, understanding the role of noise in eating/drinking environments is important (e.g., Lebo et al., 1994; Novak et al., 2010; see Spence, 2014, for a review), considering that many people all over the world are exposed to noise in one way or another, and in many cases to unhealthy levels of it (Hänninen et al., 2014; Rusnock & Bush, 2012; WHO, 2011). Studying noise, and its influence on food perception and behavior, is not only relevant considering its ubiquitous nature in human environments, but also given the number of new technologies and sound developments that now facilitate noise control and sound delivery (Brown & Evans, 2011). Smartphones, for instance, usually come equipped with noise suppression technology

(Poddar, 2018; see also **note 4).** In this sense, if food and beverage firms look to effectively manage noise as part of their individual customer experience design strategies, the technology that the customer carries (such as headphones) may be used to facilitate the experiences that they want to deliver.

Intriguingly, compared to the growing literature on the effects that customized sounds, such as music, can bring to the multisensory tasting experience (e.g., Crisinel et al., 2012; Kantono et al., 2016a, b, c, 2018, 2019; Reinoso-Carvalho et al., 2019; Reinoso Carvalho et al., 2015, 2016, 2017; Wang & Spence, 2018; Ziv, 2018, just to mention a few), only a handful of studies have been conducted to better understand the specific effects that noise can prompt in tasting experiences (e.g., Alamir et al., 2020; Biswas et al., 2019; Havermans & Hendriks, 2019; Stafford et al., 2013; Woods et al., 2011; Yan and Dando, 2015).

1.1.Theoretical framework

1.1.1. The role of noise in the experience of foods and drinks

Research suggests that loud noise can influence specific aspects of a tasting experience (e.g., Rahne et al., 2018; Trautmann et al., 2017). For example, using different everyday snacks (such as chips), Woods et al. (2011) showed that the perception of sweet and salty tastes, as well as the perception of crunchy food, is reduced under the influence of loud white noise (in this case, presented over headphones at around 80-85 dB). Yan and Dando (2015), inspired by early predictions forwarded by Spence et al. (2014), reported that sweetness and umami perception, tends to be affected by noise associated with commercial airplanes (80-85 dB). In this study, it was further confirmed the idea that noise can actually diminish sweetness perception and enhance umami perception (cf. Velasco et al., 2014). Stafford et al. (2013) also suggested that noise can diminish the ability to discriminate alcohol strength. In the latter study, noise was framed as distraction produced by either music, some kind of storytelling (namely shadow auditory stimulus), and a mix of both. More recently, Alamir et al. (2020) further suggested that non-acoustic factors (gender, noise sensitivity, and age) can have an impact on the liking of the food in the presence of background noise.

But why would noise influence food experiences, and in particular, taste perception? If one thinks of loud noise as something that distracts, or even irritates (when compared to a pleasant sound), it could hypothesized that loud noise can somehow affect cognitive processes, such as attention (Brocolini et al., 2016; Chandler & Sweller, 1992; Hygge et al., 2002; Sweller, 1988), while acting as a crossmodal distractor, or masking stimulus (e.g., see Hockey, 1970; Kou et al., 2018; Plailly et al., 2008; Spence, 2014; Spence & Wang, 2015b; Wesson & Wilson, 2010, 2011). Stafford et al. (2012), for instance, suggested that alcohol strength discrimination is impaired by those that tend to be distracted by sounds. Wine tasters also argue that hearing can potentially interfere with the other senses, where silent environments are considered necessary for concentration. Wine tasters actually suggest avoiding high levels of noise, since noise can divert attention while tasting (Peynaud, 1987; Spence & Wang, 2015b).

In light of the above considerations, in the present study, it was decided to assess the effects that noise can trigger in the tasting experience, where a clear research gap is being addressed for the first time. Previous literature has indeed addressed the role of noise in the experience of food/drink products. However, most of these previous studies have either compared some kind of noise-related distractive condition versus 'silence' (Yan & Dando, 2015), different versions of different noises (Stafford et al., 2012; 2013), music vs noise (Biswas et al., 2019), or noises that do not actually represent, say, eating/drinking realistic situations - e.g., MRI noise (Havermans & Hendriks, 2019), or white noise (Woods et al., 2011). Hence, in the present study it was hypothesized, first, that sensory and hedonic aspects of a tasting experience would be different when being stimulated by a louder, as compared to a less loud, and controlled, eating/drinking realistic version of the same noise (by loud, louder, and less loud, we are referring to differences in the sound level of the noise.). In particular, in H1, it was hypothesized that *the participants would tend to be less sensitive to specific taste and flavor characteristics of a particular tasting experience (e.g., the bitterness, sweetness, acidity, and aroma of coffee) when there is a louder noise, as compared to being stimulated by the less loud version of the same noise. Such lack of sensitivity would also affect how much people end-up liking the tasting experience, their willingness to pay, and purchase intention, for the food/drink at stake.*

Since there are, in fact, different ways to control and, consequently, reduce noise exposure, as a second part of the research question of this assessment, it was decided to narrow the scope of the study by comparing commercial/available noise control techniques applied individually to the listener.

1.1.2. Noise control and taste/flavor perception

Noise control is commonly used to reduce the impact of urban noise on people (see Harris, 1957, for an early reference on the topic). There is a wide range of noise control solutions, where the impact of noise can be measured and/or controlled from the most various perspectives (i.e., via sounds barriers/baffles; Kutz, 2004; room acoustics; Kuttruff, 2016;

environmental approaches; Alamir et al., 2019; applied individually to the listener by means of earplugs and/or safety earmuffs; see Hänsler & Schmidt, 2006, for an overview).

In this study, it was decided to compare noise control techniques applied individually to the listener. When considering such noise control techniques, it may be of essence to not only to understand the way people generally experience noise directly from their environment, but also how that happens through earphones/headphones (from now onwards both will be referred as simply headphones). Even though headphones do not allow the exposure of the whole body to noise, the use of headphones is growing exponentially. The latter is mainly driven by the increase use of portable audio systems such as smartphones, tablets, and portable music players (see **note 1**). This market as a whole has grown during the last decade and is forecasted to almost double its size by 2025, when compared to 2018 (Flynt, 2019; see also **note 2**).

In summary, although there may be different ways to control noise, here, it was decided to rely on commercial headphones as means to achieve noise control for the individual listener in a common eating/drinking urban situation. Headphones can actually be thought as an affordable solution to provide a controlled reduction of external noise during parts of the food/drink individual customer journey (Lemon & Verhoef, 2016). Noise cancelling techniques applied to headphones have become a common feature in commercial audiovisual electronics (Møller at al., 1995), where passive (mostly block-out based) and/or active (based on electro-acoustic circuits that eliminate the physical soundwave before it hits the ear; Elliott & Nelson, 1993; Kuo & Morgan, 1999) technologies are used for such purposes.

Whereas passive noise control is efficient for eliminating high-frequencies, active noise control is efficient for eliminating low-frequencies instead. Therefore, one could assume that, if each of these solutions is applied independently via headphones as, e.g., a mean for attenuating an existing loud noise while eating/drinking (say, in a bar, café, or restaurant), the resultant controlled noises would be somehow opposite in terms of audible frequency range. Based on the literature of crossmodal correspondences (that is, the associations that people make between features across the senses; Spence, 2011), the latter may potentially trigger different perceptual effects on a multisensory tasting experience, which may also rise the possibility for further sound/noise customization (Knöferle & Spence, 2012; Spence et al., 2019). In fact, several studies have demonstrated that different frequency ranges tend to be associated with specific taste/flavors, such as sweetness, bitterness, acidity, and even the strength of alcohol (e.g., Holt-Hansen, 1968, 1976; Reinoso Carvalho et al., 2016; Rudmin & Capelli, 1983; Winter et al., 2019). In particular, high frequencies have been shown to enhance the perceived sweetness, whereas low frequencies tend to enhance perceived bitterness of different food/drink products, such as beers (e.g., Reinoso Carvalho et al., 2016), and chocolates (e.g., Reinoso Carvalho et al., 2015; 2017).

Therefore, as H2, it was hypothesized that *passive noise control applied to the individual listener, via headphones, to reduce the sound level of urban noise (as being efficient for eliminating high-frequencies) may influence specific taste parameters of a tasting experience, such as bitterness. Active noise control applied in the same way, and to the same urban noise (as being efficient for eliminating low-frequencies), may influence other tastes such as sweetness.*

1.2 The present study

In the present research, the effects of listening to a loud vs a less-loud versions of the same noise on the tasting experience were studied. These effects were assessed via commercial and available headphone noise control techniques (passive vs active), applied into the individual listener in a common eating/drinking urban situation (in this case, the typical background noise of a food court in busy hours). Here, coffee was used as tasting stimuli. Coffee was chosen as a type of drink that is widely consumed individually, and across different urban situations involving headphones (think of general travelling/displacement, shopping, bars/restaurants, entertainment, work, etc.). What is more, to our knowledge, this is the first-time coffee is being used as tasting stimuli while assessing the effects of noise in the multisensory tasting experience.

2. Materials and methods

2.1.Participants

A total of 384 participants between 18 and 65 years old (Mean of age = 32 years old, SD = 10) joined the study (56 % males, and 44 % females), which took place in a room inside the campus of Universidad de las Américas (Quito, Ecuador) between July and September, 2019. The participants were selected by means of convenience sampling, and randomly assigned to one of the two existing experimental conditions (n = 192 on each condition). The sample size was determined *a priori* via power analysis, using Friedman's simplified determinations of statistical power (see Friedman, 1982). Considering 95% confidence (α=0.05), effect size of 0.20, and a power effect of at least 0.8, the suggested sample size, per condition, would be approximately 190 participants.

2.2. Apparatus and materials

2.2.1. Tasting stimulus

The coffee sample (tasting stimulus) was a blended Arabica green beans, medium roasted, and at medium grinding, harvested from the Ecuadorian highlands (at 1500 – 2100 meters above sea level; Type A: cupping 84/100). It was supplied by Galletti coffee house (http://www.cafegalletti.com/). The coffee brew preparation was carried out by a professional barista from Galletti, using an 11L percolator with ozonized water. 40 g of ground coffee per liter of water were used, without added sugar. The water was heated up until 85 °C. Once the percolator finished the brew, the mixture was allowed to rest for 5 minutes, and was settled into two vacuum thermoses, in order to keep the temperature and flavor stables during the experimental hours (maximum 4 experimental hours a day).

2.2.2. Sound stimuli

Three different versions of the same noise (sound stimuli) were produced before the experiment for this study (baseline unfiltered noise - UBN; passive-controlled noise - PBN, and active-controlled noise - ABN). Each of these three sounds had approximately 1-minute length. For the production of these sounds, urban ambient noise samples and equivalent sound pressure levels (SPL, measured in L_{Aeq}) were recorded and registered simultaneously at the food court of a shopping mall in high occupancy hours (e.g., lunch-time), using a NH4 ZOOM recorder, and NTI-Audio XL2 sound level meter. Specific fragments of such recordings were chosen and mixed using Avid Pro Tools 10.

A baseline version of this audio mix was chosen as the baseline background noise (UBN). Waves Q10 equalizing filters were further applied to this baseline mix, in order to simulate – and produce – two extra background noise approaches before the experiment took place (PBN and ABN). The equalization baseline for PBN was the rough-average frequency response of a standardized wearable passive absorbing material (https://www.3m.com/3M/en_US/worker-health-safety-us/personal-protective-equipment/foam-earplugs/ , retrieved on January 16th, 2020). The equalization baseline for ABN was the frequency response information from a well-known commercial headphones brand (Sennheiser; see **note 3**), along with more technical details extracted from the corresponding literature (e.g., Elliot & Nelson, 1993; Kuo & Morgan, 1999). In summary, the passive noise control technique was simulated by mostly reducing sound level, along with extra subtle reductions at mid-high frequencies. The active noise control technique was simulated by reducing low frequencies instead, while keeping it at somewhat similar intensity as the passive one (see **Table B**, in the Annex, for details on the equalization that was applied).

The UBN was used as referential point for the calibration of the experimental hearing systems and set at approximately 85 +/- 6 dBA. The value of 85 dBA was defined following different healthcare indicators which suggest that long exposure to sounds above such SPL can be harmful and provoke hearing loss (Blahd et al., 2018; see also http://dangerousdecibels.org/education/information-center/noise-induced-hearing-loss/ , retrieved on January 16th, 2020). Note also that, while 85 dBA is somewhat loud (e.g., typically associated with heavy traffic), it is not uncommon for consumers to eat and drink in such contexts (just imagine a busy restaurant or bar street, and/or a crowded gathering with live music playing).

The calibration process was conducted in a quiet room using a Neumann KU100 artificial/dummy head. During calibration, the three experimental noise stimuli were loaded in the on-line experimental questionnaire to be used during the experiment (via Qualtrics). This questionnaire was accessed via Wi-Fi network on the GUI – Graphical user interface (in this case, a Samsung Galaxi Tab A6). All the headphones to be used during the experiment (Sennheiser HD 280 PRO) were connected to the GUI's sound output. These headphones were set in the dummy head, and the inner microphones of such dummy head were connected to the NTI-Audio XL2 sound level meter. The equivalent A-weighted sound pressure level (L_{Aeq}) - which was simultaneously measured while performing the recordings at the food court with a free-field microphone and class 1 measurement equipment - was used to adjust the sound volume in the experimental reproduction GUI setting. Once the sound volume performed the expected 85 +/- 6 dBA setting level (which was being monitored via the aforementioned sound level meter), the volume control of the GUI was turned-off, and locked, in order to ensure that all participants had the same level during the experiment (see **Figure C**, in the Annex, for a visual inspection of the calibration setting).

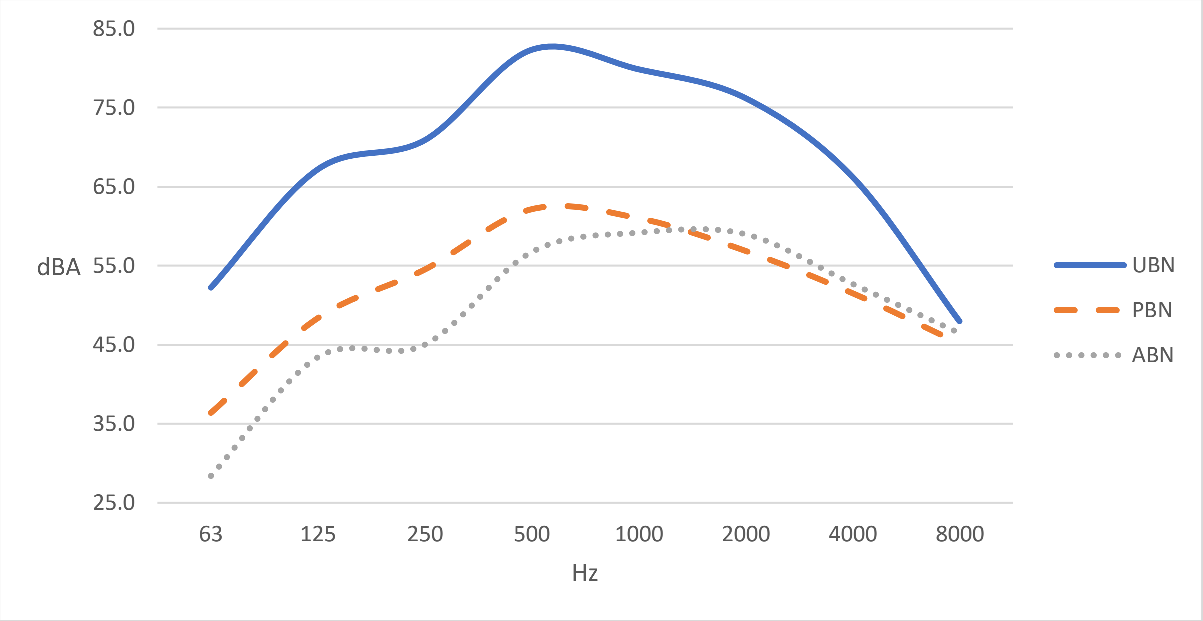
The average SPL of the UBN was expected to be approximately 20 +/- 6 dBs louder than the PBN, and ABN, SPLs. Considering that it is usually necessary to add 6-10 dBs to double the SPL intensity of a sound source (Poulton & Stevens, 1955), one could assume that the UBN would be perceived, at least, between 2 to 4 times louder than the PBN/ABN ones. During the experiment, these sounds were played without any extra active noise cancelling technique via headphones.

The overall levels of the acoustic descriptors such as Leq, L10 and L90 (the three in dBA), and the loudness parameter related to SPL (obtained using PsySound3 software) are shown in **Table 1**. The spectral content of the three experimental sounds, as they were heard from the headphones during the experiment (including calibration) are shown in **Figure 1**. The sounds, as they were played in the experiment (except for calibration), can be accessed via the following link https://soundcloud.com/sonictaste/sets/background-noise-experiments.

Table 1. Main SPL acoustic/psychoacoustic descriptors for each experimental noise, extracted during calibration. Here, it is possible to appreciate that the main differences are between the UBA (in bold), and the other two.

Descriptor	UBN Baseline unfiltered noise	PBN Passive-controlled noise	ABN Active-controlled noise
LAeq (equivalent continuous sound level in dBA)	**85.1**	65.6	62.9
L10 (sound level exceeded 10% of the time of the measurement period in dBA)	**87.4**	67.7	64.7
L90 (sound level exceeded 90% of the time of the measurement period in dBA)	**72.5**	63.0	57.8
Loudness (Subjective perception of sound pressure - Sone)	**70.9**	34.6	30.4

Figure 1. Spectral content of the three experimental sounds in octave bands (UBN, PBN, ABN), as they were heard from the headphones during the experiment and including calibration. Y-axis shows values in dBA, whereas X-axis shows values in Hertz (Hz).



2.3. Design and procedure

At all times, all of the participants were exposed to similar controlled environmental conditions, including comfortable room temperature, low background noise (~ 40 dBA), and stable lighting (see **Figure A**, in the annex, for visual inspection of the experimental room). Those people that were passing near the study area during experimental hours, were invited to take part in the study. As an incentive to join, they were told that they would be participating in a short experiment involving tasting coffee and listening to sounds. There were 6-8 experimental booths operating at all times, where participants were able to work individually. The experimental setting was organized in order for the participants to not be able to listen to each other. The participants were also instructed to perform the experiment individually. The experiment lasted no more than 10 minutes in total.

One batch of experimental coffee was prepared for each experimental day, following the exact same procedure. During experimental hours, the coffee was kept inside two vacuum thermoses. In order to keep the temperature and flavor of the coffee stable, the participants had access to each cup of coffee a few seconds prior they had to start the tasting process.

Prior to and after tasting each coffee sample, the participants were instructed to clean their palates with tap water. During the experiment, the participants tasted the same coffee twice from a cup (in total, no more than two experimental doses of around 5 cl each; all experimental cups were identical). They were not informed that they were actually tasting the same coffee twice. During each tasting, they listened to the unfiltered (UBN) version of the noise vs one of the two available filtered versions (passive – PBN – or active – ABN – controlled, depending on which condition they were randomly assigned to). Hence, all participants were exposed to the unfiltered version of the baseline noise, but only half to each of the two filtered version ones. The decision of presenting a contrasting pair of auditory stimuli in a within-participants design was based on the often-relative nature of crossmodal correspondences, where contrast is often crucial to capture the relative compatibility of the stimuli (Parise & Spence, 2013; Spence 2019b). Note also that the participants were randomly assigned to each of these two conditions (1 = UBN vs PBN, or 2 = UBN vs ABN). Prior to the tasting process, the participants were also advised to focus on the most evident flavor attributes of the coffee while listening to each sound.

The tasting evaluation was based on a self-report questionnaire implemented electronically via Qualtrics (https://www.qualtrics.com/). While designing this questionnaire, potential tendency of survey respondents to answer questions in a way that they think it should be answered (Furnham, 1986; Nederhof, 1985) were tackled by subdividing the questionnaire into two main tasks, with the first evaluative task focusing on ratings, and the second on sorting (Harzing et al., 2009). By offering two different tasks to participants (sorting vs ranking), we would be potentially reducing such type of response bias, by having 2 different tools to assess the consistency on the answers of the participants. In the first task (rating), after each coffee tasting, the participants were asked to answer questions related to such coffee-sound experience based on continuous rating scales. Variables assessed by the questionnaire involved hedonic (coffee liking, sound liking, matching between sound and coffee flavor), sensory (flavor attributes of coffee, such as sweetness, bitterness, acidity, flavor intensity, aroma intensity, temperature), and purchasing (purchase intention, willingness to pay – WTP) aspects of the experience. In the second task of the questionnaire (sorting), the participants were asked to compare both coffee tastings. That is, after tasting both samples, the participants had to contrast both experiences by sorting which of the variables mentioned above were more/less/equally present on both tastings. The questionnaire also requested the participants to report basic demographical data (see **Table D**, in the Annex, for a more detailed description of the questionnaire).

The presentation of the sounds was randomized and coded with combinations of alphabetical letters, in order to avoid order bias effects (Stone et al., 2012). The order of presentation of the questions, and of the choices of the multiple-choice type of answers, were also fully randomized.

2.4. Data analysis

The analysis of the sorting task was based on a descriptive overview of the frequencies chosen by the participants. The rating task data were analyzed by means of a mixed design multivariate analysis of variance (MANOVA), with the two combinations of experimental sounds – louder vs less loud noises (1=UBN vs PBN; 2=UBN vs ABN) as between-participant factors, and type of noise (UBN vs PBN/ABN), as within participants factors. The dependent variables included hedonic (coffee liking, sound liking, matching between sound and coffee flavor), and sensory (flavor attributes of coffee, such as sweetness, bitterness, acidity, aroma intensity) dimensions. Four main control factors were also considered during the analysis, and included as covariates (age, gender, coffee liking, and order of the presentation of the sounds).

The control for age was used since the age range of the sample was wide. Moreover, it has been acknowledged that taste/flavor sensitivities tend to evolve over a lifespan (Cowart, 1981; Spence, 2012). Age-related hearing loss is also widespread knowledge (Newman et al., 1990). Gender was also controlled since it has been recently suggested that there are gender differences in olfactory abilities (Sorokowski et al., 2019; though, see also Spence, 2019a), being smell a key sense in flavor perception (e.g., Stevenson et al., 2000). Note also that there are differences on the morphology of the ear of women vs men (Sullivan et al., 2010), and differences in the resonating frequency of a women and men’s ear canal (Staab, 2014). There seem to exist certain gender differences in age-related hearing loss as well (Sharashenidze et al., 2007; see also Almir et al., 2020, for an extra overview on how some of these non-acoustic factors can affect hedonic response to food when accompanied by noise).

Coffee liking was controlled, considering the between participant factor, as well as while assuming that people that do not like coffee, do not usually drink it. Hence, such consumers would be potentially less aware of its flavor attributes (or perhaps less biased by it), when compared to those that like, and drink coffee (e.g., Masi et al., 2015).

The palate suffers from desensitization effects, where first position preference bias is recurrent (Dean, 1980). Moreover, and since the presentation of the stimuli was randomized, but not counter-balanced, the order of the presentation of the sounds was controlled during analysis as well. Bonferroni corrections were applied for the corresponding post-hoc analyses. All the aforementioned analyses were conducted using SPSS 26.

3. Results

3.1. General comparative rankings of both coffee tastings

More than twice the amount of the participants sorted the coffee under the influence of PBN/ABN as the better and more expensive alternative, when compared to the same coffee while listening to UBN (see H1). Moreover, when asked under which sound specific characteristics of the coffee were more present, once again, more than 50% of the participants chose PBN/ABN, over UBN (see H1). The only rankings that did not achieve more than 50% of agreement in choices were temperature and sweetness. In the case of sweetness, such outcome may be related to the fact that the coffee did not contain added sugar, providing no sweetness threshold to begin with. **Tables 2A/2B** shows more details on these ratings.

Table 2A. Frequencies of comparative multiple-choice rankings (after both tastings) in condition UBN vs PBN. Frequencies in bold are those that achieved more than 50% of agreement in choices.

Variable		Frequency (%)		
		Coffee with UBN	Coffee with PBN	Equally in both tastings
Which coffee do you think was better?		19.8	**64.6**	15.6
Which coffee do you think is the most expensive one?		20.8	**58.3**	20.8
Please select which characteristics of the experience were more present during the coffee tasting	Quality of flavor	21.4	**64.1**	14.6
	Sweetness	19.3	50.0	30.0
	Bitterness	28.6	**56.3**	15.1
	Acidity	24.0	**54.7**	21.4
	Flavor intensity	22.9	**60.9**	16.1
	Aroma intensity	24.5	**59.9**	15.6
	Temperature	17.7	43.8	38.5
	Quality of sound	24.5	**62**	13.5
	A better association between sound and coffee flavor	16.1	**64.1**	19.8

Table 2B. Frequencies of comparative multiple-choice rankings (after both tastings) in condition UBN vs ABN. Frequencies in bold are those that achieved more than 50% of agreement in choices.

Variable		Frequency (%)		
		Coffee with UBN	Coffee with ABN	Present equally in both tastings
Which coffee do you think was better?		18.6	**62.9**	18.6
Which coffee do you think is the most expensive one?		15.5	**54.1**	30.4
Please select which characteristics of the experience	Quality of flavor	21.6	**63.4**	14.4
	Sweetness	**19.6**	47.9	32.5

were more present during the coffee tasting	Bitterness	29.9	**52.6**	17.5
	Acidity	23.7	**52.6**	23.7
	Flavor intensity	23.2	**61.3**	15.5
	Aroma intensity	22.7	**56.7**	20.6
	Temperature	**21.1**	38.7	40.2
	Quality of sound	26.3	**60.8**	12.9
	A better association between sound and coffee flavor	20.6	**63.9**	15.5

3.2. Particular ratings after each coffee tasting

Table 3 shows all the details on the general results of the multivariate test. In general, the multivariate tests show a main effect ($p \leq 0.001$), with an interaction effect with age ($p \leq 0.001$) at between-participants level (see **note 5** for details on age effect). In general, the coffee was averagely rated as low in sweetness (M = 22.86, SD = 3.76), medium in bitterness (M = 54.18, SD = 3.63), acidity (M = 42.16, SD = 3.71), flavor intensity (M = 56.57, SD = 3.54), aroma intensity (M = 52.67, SD = 3.67), and high in temperature (M = 70.08, SD = 3.77). The coffee liking average rating was M = 52.09, SD = 3.88, sound liking was M = 42.45, SD = 4.19, flavor-sound matching was M = 51.48, SD = 4.00, purchase intention was M = 47.48, SD = 3.70, and WTP was M = 1.70, SD = 0.15 (the latter in local currency, meaning US dollars).

A main effect of type of noise was also detected ($p = 0.026$), but no effects were observed at for the interaction of type of noise with the combination of the noises ($p = 0.778$). The aforementioned results suggest that there were significant differences between UBN vs PBN/ABN ratings (see H1), but no differences between PBN vs ABN ratings (see H2). No effects were observed for the interaction of type of noise with age ($p = 0.100$), gender ($p = 0.070$), coffee liking ($p = 0.559$), nor order of the presentation of sounds ($p = 0.146$).

Table 3. Summary of the results of the multivariate test of the mixed design MANOVA, with the two combinations of experimental sounds – intercept (1=UBN vs PBN; 2=UBN vs ABN) as between-participant factors, and type of noise (UBN vs PBN/ABN), as within participants factors, including controls for gender, age, coffee liking, and order of the presentation of sounds effects (only Pillai's trace test being reported). Values in bold indicate a significant different at 95% confidence.

Multivariate Tests[a]

		F	Sig. (p)	Partial Eta Squared
Between participants	Gender	0.531^b	0.882	0.016
	Age	$\mathbf{3.153^b}$	**<0.001**	**0.086**
	Coffee liking	1.238^b	0.260	0.036
	Order of presentation of sounds	1.391^b	0.175	0.040
	Combination of noises (1=UBN vs PBN; 2=UBN vs ABN)	1.089^b	0.369	0.032
Within participants	**Type of Noise (UBN vs PBN/ABN)**	$\mathbf{2.014^b}$	**0.026**	**0.057**
	Noise * Gender	1.706^b	0.070	0.049
	Noise * Age	1.588^b	0.100	0.045
	Noise * Coffee liking	$.881^b$	0.559	0.026
	Noise * Order of presentation of sounds	1.456^b	0.146	0.042
	Type of noise * Combination of noises (1=UBN vs PBN; 2=UBN vs ABN)	0.659^b	0.778	0.019

a. Design: Intercept + Gender + Age + Coffee liking + Order of presentation of sounds + Combination of noises (1=UBN vs PBN; 2=UBN vs ABN). Within participants design: Noise

b. Exact statistic

c. Computed using alpha = .05

Overall, the participants rated the coffee as more bitter (p = 0.020), and as having a more intense aroma (p = 0.045), while listening to the filtered versions of the noise (either PBN or ABN), when compared to UBN. The intercepts related to such differences in bitterness ($\text{Mean}_{\text{PBN}} - \text{Mean}_{\text{UBN}} = 10.105$, SD = 6.709; $\text{Mean}_{\text{ABN}} - \text{Mean}_{\text{UBN}} = 8.102$, SD = 6.709), and in aroma intensity ($\text{Mean}_{\text{PBN}} - \text{Mean}_{\text{UBN}} = 10.313$, SD = 6.494; $\text{Mean}_{\text{ABN}} - \text{Mean}_{\text{UBN}} = 9.275$, SD = 6.494) indicate an average of 8-10% difference in ratings. The analysis also suggests a significant difference in terms of temperature (p = 0.006, $\text{Mean}_{\text{PBN}} - \text{Mean}_{\text{UBN}} = 2.503$, SD = 6.518; $\text{Mean}_{\text{ABN}} - \text{Mean}_{\text{UBN}} = - 0.388$, SD = 6.518). Note that such significance is obtained after including the control variables in the model and thus the small intercept (see **Table E,** in the Annex, for an overview of the preliminary results obtained without considering the effects of the covariates). None of the other differences achieved statistical significance (see **Table 4** for more details). **Table 5** also summarizes all of the corresponding Means, SE, and intercepts.

Table 4. Summary of the results of the univariate tests for within-participants effects, including all the dependent variables that were measured (sphericity assumed; Field, 2013). Values in bold indicate a significant difference at 95% confidence.

Univariate Tests				
		F	Sig. (p)	Partial Eta Squared
Type of Noise (UBN vs PBN/ABN)	Flavor liking	2.301	0.130	0.006
	Sweetness	0.116	0.733	0.000
	Bitterness	**5.462**	**0.020**	**0.014**
	Acidity	0.137	0.712	0.000
	Flavor intensity	2.821	0.094	0.007
	Aroma Intensity	**4.060**	**0.045**	**0.011**
	Temperature	**7.689**	**0.006**	**0.020**
	Sound liking	3.344	0.068	0.009
	Flavor sound matching	1.762	0.185	0.005
	Purchase intention	1.232	0.268	0.003
	WTP	0.557	0.456	0.001

a. Computed using alpha = .05

Table 5. Mean with corresponding 95% confidence interval, and intercept ($\text{Mean}_{\text{PBN/ABN}}$ - Mean_{UBN}) of the ratings of each dependent variable. Values in bold indicate a significant difference within the corresponding PBN/ABN vs UBN ratings, and at 95% confidence.

				95% Confidence interval		
DEPENDENT VARIABLE	*CONDITION*	*SOUND*	*MEAN*	*LOWER*	*UPPER*	*INTERCEPT*
Sweetness	UBN vs PBN	UBN	19.716	16.773	22.659	5.644
		PBN	25.360	21.687	29.033	
	UBN vs ABN	UBN	21.201	18.258	24.143	3.976
		ABN	25.177	21.503	28.850	
Bitterness	**UBN vs PBN**	**UBN**	**48.669**	**45.314**	**52.023**	**10.105**
		PBN	**58.774**	**55.468**	**62.081**	
	UBN vs ABN	**UBN**	**50.587**	**47.232**	**53.941**	**8.102**
		ABN	**58.689**	**55.383**	**61.996**	
Acidity	UBN vs PBN	UBN	40.031	36.765	43.297	6.581

		PBN	46.612	43.248	49.977	
	UBN vs ABN	UBN	38.803	35.536	42.069	4.371
		ABN	43.174	39.810	46.538	
Flavor intensity	UBN vs PBN	UBN	48.084	44.649	51.519	16.246
		PBN	64.330	61.185	67.475	
	UBN vs ABN	UBN	51.713	48.278	55.148	10.452
		ABN	62.165	59.020	65.310	
Flavor liking	UBN vs PBN	UBN	46.434	42.981	49.888	12.669
		PBN	59.103	55.557	62.649	
	UBN vs ABN	UBN	46.649	43.195	50.102	9.545
		ABN	56.194	52.648	59.740	
Coffee temperature	**UBN vs PBN**	**UBN**	**67.331**	**64.072**	**70.590**	**2.503**
		PBN	**69.834**	**66.663**	**73.005**	
	UBN vs ABN	**UBN**	**71.778**	**68.519**	**75.037**	**-0.388**
		ABN	**71.390**	**68.219**	**74.561**	
Aroma intensity	**UBN vs PBN**	**UBN**	**47.777**	**44.530**	**51.024**	**10.313**
		PBN	**58.090**	**54.719**	**61.461**	
	UBN vs ABN	**UBN**	**47.760**	**44.513**	**51.007**	**9.275**
		ABN	**57.035**	**53.664**	**60.406**	
Sound liking	UBN vs PBN	UBN	33.806	30.276	37.335	19.211
		PBN	53.017	49.152	56.883	
	UBN vs ABN	UBN	33.205	29.675	36.734	16.559
		ABN	49.764	45.898	53.629	
Sound-flavor matching	UBN vs PBN	UBN	45.863	42.201	49.526	10.242
		PBN	56.105	52.588	59.623	
	UBN vs ABN	UBN	48.199	44.537	51.861	7.571
		ABN	55.770	52.252	59.287	
Purchase intention	UBN vs PBN	UBN	41.143	37.821	44.465	13.065
		PBN	54.208	50.831	57.585	
	UBN vs ABN	UBN	41.414	38.092	44.736	11.727
		ABN	53.141	49.764	56.518	
WTP	UBN vs PBN	UBN	1.522	1.411	1.634	0.248
		PBN	1.770	1.641	1.899	
	UBN vs ABN	UBN	1.616	1.504	1.728	0.286
		ABN	1.902	1.774	2.031	

4. Discussion

In this study, for the first time, the effect of two very common, commercial, and different, headphone noise control techniques (active vs passive), on taste/flavor perception of coffee, while under the influence of stereotypical urban noise (in this case, the noise of a food court in busy hours), were analyzed.

4.1. Louder vs less loud background noise (H1)

In general, when the same participants were asked to compare both coffee experiences (under the influence of the louder noise, vs under the influence of the controlled and less-loud one), more than half of the participants perceived the coffee as better and more expensive under the influence of the less-loud and controlled version of the same noise. Similarly, specific sensory, hedonic, and purchasing aspects were thought to be less present with the louder noise by more than half of the population (think of sweetness, bitterness, acidity, flavor/aroma intensity of the coffee; see **Tables 2A/2B**).

In addition, when the participants were asked to rate each coffee tasting experience, individually, they tended to rate the same coffee as significantly less bitter, and as having a less intense aroma, when tasted with the louder noise, as compared to the less-loud and controlled noise ratings (presumably the two most evident sensations during the coffee tasting; see **Table 5)**.

The obtained results suggest that a loud noise tend to reduce the overall sensitivity of the coffee experience, and this is most clear concerning the bitterness and aroma intensity (see H1). While the sorting task suggests that the louder noise tends to reduce the overall sensitivity of the coffee experience in most of the attributes being here evaluated relative to the other conditions, the rating task suggests that the most evident coffee sensations tend to outstand under the less-loud-controlled version of the noise, (see H1).

But how to interpret the differences between the results of the rating task and the sorting task? Considering that the sorting task focused on contrasting the two coffees as a function of a given dimension, this task automatically involved a reference point. In that sense, the judgements became relative to the two coffee conditions at hand. The rating task, on the other hand, may be typically based on the participant’s own, internal, reference point (see Sherif et al., 1958, for an early reference on contrast/assimilation theory, and on how internal reference points influence judgements depending on external anchors). This would also be in line with the theory on crossmodal correspondences which suggests that contrast, or more specifically relative compatibility, is often crucial for correspondences. In other words, it has been argued that crossmodal correspondences tend to arise from relative compatibility rather than absolute judgements (Parise & Spence, 2013; Spence 2019b).

Considering the literature on noise and perception, we hypothesize that the aforementioned effects principally rised from noise triggering distraction and/or masking effects (Hockey, 1970; Kou et al., 2018; Plailly et al., 2008; Spence, 2014; Wesson & Wilson, 2010, 2011). Results related to H1 suggest that the effects being reported may be directly related to cognitive load as well (e.g., Robinson, 2020). For instance, loud noise could be affecting the cognitive performance of the brain by creating heavy cognitive load that potentially reduces the overall brain response towards, in this case, a tasting experience (Le Van Quyen, 2019). As a matter of fact, it has been previously reported that memory load influences taste and flavor sensitivity (Hoffmann-Hensel et al., 2017; Liang et al., 2018). Ling et al.'s assessment (2018), for example, suggests that the higher the memory load, less is the taste sensitivity.

It is also plausible to hypothesize that the differences in attention via noise can mediate sensation transference effects (Spence & Shankar, 2010; see also Cheskin, 1972, for a notion on sensation transference). As suggested by the results presented in **Tables 2A/2B**, most participants ranked the same coffee as better, and as more expensive, when accompanied by the less-loud versions of the noise. In parallel, the less-loud noise was also evaluated as a better-quality type of sound by the majority, and as a sound that matched best with the coffee's flavor.

4.2 Active vs passive noise control techniques applied via headphones (H2)

Part of the present research also intended to see if passive vs active headphone commercial noise-controlling techniques would prompt distinct perceptual effects on the coffee tasting experience (see H2). This does not seem to be the case, as the differences observed across the effects triggered by PBN and ABN were not statistically significant (see **Table 3**). Hence, we did not find evidence in our data to back H2. The fact that H2 was not supported may have to do with the fact that, contrary to music, noise is not something that people usually pay attention to, unless it becomes potentially distracting/disturbing (as it seems to be the case with UBN). In this sense, one could argue that neither of the noise-related sounds were actually drawing the participants' attention toward specific aspects of the coffee experience in order to, e.g., trigger observable crossmodal correspondences (cf., Reinoso-Carvalho et al., 2015, 2016, 2017; Wang & Spence, 2016; Wang et al., 2017). In other words, in this study, noise may have acted as a task irrelevant sound effect (see Beaman, 2005; Felicia, 2011; Macken et al., 1999), whereas crossmodal correspondences seem to demand some kind of meaning from the different sensory signals to begin with (as in semantic priming; see McNamara, 2005). Another plausible element that may have influenced the null results of H2, which future research could consider, is how noticeable the different noise control techniques were perceived by the user via headphones, when compared to each other and, e.g., via loudspeakers. If one is far more noticeable than the other, perhaps this may contribute to guide the effects being reported.

As the main contributions of this article, first, it is suggested that loud noise affects attention, while triggering distraction and consequently reducing the overall sensitivity of a tasting experience. This is here being reported and measured from a perceptual perspective, using specific sensory, hedonic, and purchasing indicators. Secondly, this study also suggests that commercial noise-controlling techniques, commonly available through headphones (being headphones more and more common during individual urban experiences), can be effectively applied to mitigate the negative effects that a loud urban noise may trigger in the individual experience of foods/drinks (in this case, coffee).

4.3. Practical implications

Loud noise might be constantly bringing negative effects in usual food/drink experiences. The results here obtained show tangible and generalizable consequences concerning how urban and noisy soundscapes that customers may experience can affect an important part of the food/drink individual customer journey, and in this particular case, the flavor experience of coffee (cf. Keller & Spence, 2017; Liu et al., 2018; Mamalaki et al., 2017, where complementary results have been tested for different food/drinks, and different scenarios of consumption). Interestingly, the particular market for headphones that include environmental noise suppression technology (Poddar, 2018; see also **note 6**) is expected to continue gaining a bigger cut of the whole headphones market (Mulligan, 2018; Sohail, 2019; Wood, 2020). Therefore, one could think that the further adoption of such headphones by the general population could allow us to rethink the way coffee – and other food/drink – experiences can be better customized and, why not, enhanced. When thinking of public health, for example, these results suggest that loud vs less loud urban noise can moderate behavior during food/drink situations. For instance, a person that is constantly – and perhaps unaware – under the influence of a very noisy urban environment while drinking coffee, may unconsciously be driven towards consuming a potentially unnecessary stronger coffee, with excessive added sugar. In fact, excessive sugar consumption is a major health problem (Lustig et al., 2012).

Practical food managerial implications could also be explored in this sense. Food/drink coffee brands could, for instance, strategically rely on noise-control solutions while thinking about the experience of their customers, since the growing market of headphones suggests that such audio systems tend to be more and more present during different situations of individual coffee consumption. Here, music customization with crossmodal correspondences in minds could also play a complementary and interesting role, where a ‘sweet’ or a ‘bitter’ song may prompt more robust multisensory effects when accompanied by the quiet environment that such gadgets are able to provide to the individual listener (Blecken, 2017; Lowe et al., 2017, 2018; Spence, 2017).

Interesting to note as well that the bitterness and the aroma of the coffee were principally and significantly affected when coffee was tasted and evaluated in environments where there was no noise control vs when there was noise control (see **Tables 4 and 5**). The latter results may have implications for cafes, roasters, and others stakeholders in the business of coffee experiences, who may want to consider noise as a possible element to control during the customer experience. There are, for instance, more particular exercises involving baristas, roaster, and others usually performing tasting where they rate coffee quality and sensory attributes, and who may want to consider noise as a necessary element to control.

The results associated with the task in which participants had to sort the coffees as a function of the different dimensions being assessed may also inspire the different stakeholders involved of coffee experiences. The latter, actually, may not be limited to experts since there seems to be a general growing interest among certain groups to explore the different varieties of specialty coffee (Johnson, 2019). If those professionals and consumers look to have neater evaluations based on sorting different coffees against each other, they may consider the role of noise, and encourage noise control during tasting (something that wine tasters already seem to be aware of; Peynaud, 1987; Spence & Wang, 2015b).

4.4. Limitations and future work

The coffee used in this study did not contain added sugar. Since coffee is a product that a large proportion of consumers drink with added sugar, future similar studies could look for to replicate these findings with different coffee formulas, recipes, and/or even different food/drink products. The results obtained could also be further replicated with different types of noises being controlled by the same active/passive techniques. Future studies could try to reassess the obtained findings without headphones as well by, e.g., using a system of loudspeakers. This could also be further analyzed across rooms with different types of acoustic performances. The participants also seem to have perceived some changes in the appreciation of the temperature of the coffee. However, overall results suggest that such differences in appreciation of temperature were not conclusive (cf. temperature ratings in **Table 5** vs those in **Tables 2A/2B**). Even though the coffee temperature was controlled during experimental hours, such control may not have been enough. Perhaps a future similar study could look into better ways to assess such variable (e.g., by means of a cup that has a temperature control). In this study there were no direct measurements of cognitive performance in order to robustly validate that the effects being reported could be directly related to cognitive load (e.g., Robinson, 2020). Nevertheless, future similar works could explore such insights by complementing behavioral data with physiological measurements, such as task-invoked pupillary response and/or skin conductance (cf., Granhholm et al., 1996; Hoffman-Hensel et al., 2017; Skulmowski & Rey, 2017). Finally, in this study, the participants were asked to rate the sound, and this may have facilitated the obtained effects. Future studies could indagate similar research questions while not asking ratings on the sounds, in order to further reflect on how noise would affect perception in such tasting contexts in a more naturalistic fashion.

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Ethical statement

This study was carried out in accordance with the recommendations posed by the ethics committee of research with human beings – CEISH/UDLA (Memorandum of January 28th, 2020). All of the participants gave their written informed consent prior to starting the study.

Conflict of interest

This study involved the payment for the material and services provision of Galletti coffee house.

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Notes

[1] https://www.ameriresearch.com/product/earphones-headphones-market/ , retrieved on January 16th, 2020.

[2] https://www.marketwatch.com/press-release/at-78-cagr-earphones-and-headphones-market-size-is-expected-to-exhibit-us-26500-million-by-2025-2019-10-04 , retrieved on January 16th, 2020.

[3] https://en-us.sennheiser.com/news-a-whole-new-world-at-the-touch-of-a-button-sennheisers-noisegard-technology , retrieved on January 16th, 2020.

[4] A significant interaction effect at between-participants level, as a function of age, was found for flavor liking ($p = 0.010$), purchase intention ($p <= 0$), and WTP ($p = 0.001$) general ratings.

[5] http://www.digitaljournal.com/pr/2998914 , retrieved on January 16th, 2020.

[6] https://support.apple.com/en-us/HT210643 , retrieved on January 16th, 2020.

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Annex

Figure A. Visual inspection of the room where the study was carried out.

Table B. Details on the equalization parameters that were applied for the simulation of PBN and ABN (equalization applied via Waves Q10 plug-in). The original sound source was the UBN.

Main Input (dB)		Type of Filter		Gain (dB)		Frequency band (Hz)	
PBN	ABN	PBN	ABN	PBN	ABN	PBN	ABN
-24	-18	Low-pass	Low-cut	10	-12	125	31
		Bell	Low-pass	6	-4	250	62
		Bell	Bell	1	-4	500	125
		Bell	Bell	1	-4	1000	250
		Bell	Bell	4	-4	2000	500
		Bell	Bell	2	-3	2100	800
		Bell	Deactivated	2	Deactivated	4000	Deactivated
		Bell	Deactivated	0	Deactivated	8000	Deactivated
		Hi-cut	Deactivated	0	Deactivated	16000	Deactivated

Figure C. Visual inspection of the calibration setting, considering the signal flow – GUI (A), the experimental headphones being calibrated (B), the dummy head (C), and sound level meter (D).

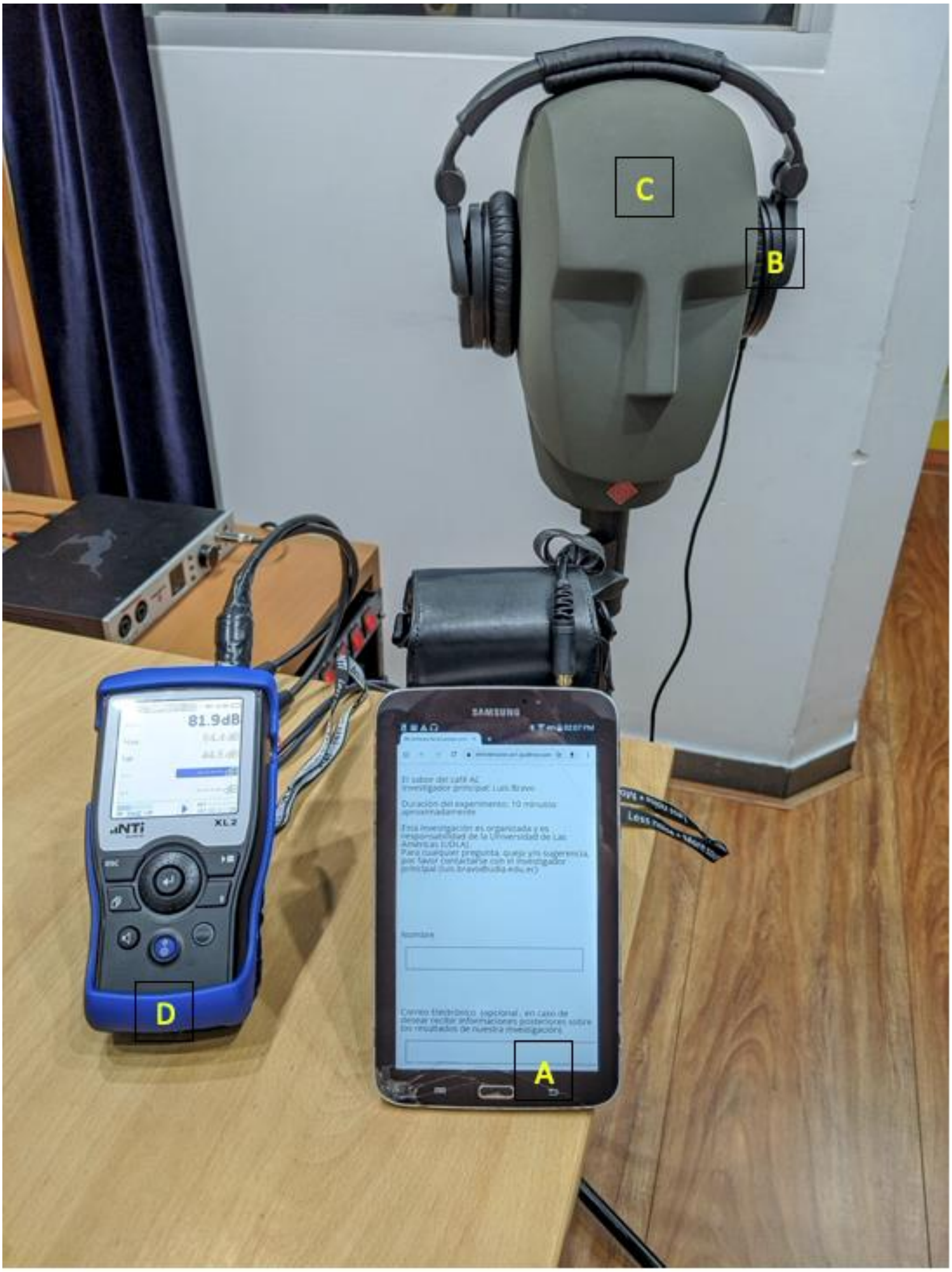

Table D. Details of the questionnaire, including the variables that were sampled, and the system that was used to measure each variable.

Section of Questionnaire	Variable	Measurement system
1. Demographics & basic coffee habits (prior both tastings)	Age	Open numerical
	Gender	1=Male; 2=Female
	Do you like coffee?	1=Yes; 2=No
2A. Ratings Scales (After tasting each coffee)	Flavor liking of coffee	100-point continuous rating scale (horizontal slide), with 1 being 'not at all / very low', and 100 being 'very much / a lot'.
	Sweetness of coffee	
	Bitterness of coffee	
	Acidity of coffee	
	Flavor intensity	
	Aroma intensity of coffee	
	Coffee temperature	
	Sound liking	
	Sound-flavor matching	
	Purchase intention	
2B. Open question (After tasting each coffee)	Willingness to pay (WTP)	Open numerical in local currency (in this case, US dollars), including message with local reference.
3. Contrasting multiple-choices (After tasting both coffees)	Which coffee do you think was better?	1=UBN; 2=PBN/ABN; 3=both equally good.
	Which coffee do you think is the most expensive one?	1=UBN; 2=PBN/ABN; 3=both equally expensive.
	Please select which characteristics of the experience were more present during the coffee tasting Quality of flavor Sweetness Bitterness Acidity Flavor intensity Aroma intensity Temperature Quality of sound A better association between sound and coffee flavor	1=More present with UBN; 2=More present with PBN/ABN; 3=Equally present in both coffees

Table E. Summary of the results of the multivariate (top) and univariate (bottom) tests of the mixed design MANOVA, with the two combinations of experimental sounds – intercept (1=UBN vs PBN; 2=UBN vs ABN) as between-participant factors, and type of noise (UBN vs PBN/ABN), as within participants factors, without controls for gender, age, coffee liking, and order of the presentation of sounds effects (only Pillai's trace test being reported, and sphericity is being assumed). Values in bold indicate a significant different at 95% confidence interval. Note that, in this case, the values related to temperature (in the Univariate tests) are non-significant (cf. **Table 3**, where temperature results are significant). There may be, at least, two possible explanations for the changes in these temperature results. First, the groups being compared were different on the covariate, and the estimated scores on the dependent variable are now sufficiently far apart to be statistically significant. Secondly, the inclusion of the covariate may have removed some of what otherwise would have gone as unexplained variation in the dependent variable, making the error term smaller (e.g., MacKinnon et al., 2000).

Multivariate Tests[a]

		F	Sig. (p)	Partial Eta Squared
Between participants	**Intercept**	**997.665 [b]**	**0.000**	**0.967**
	Combination of noises (1=UBN vs PBN; 2=UBN vs ABN)	1.275[b]	0.237	0.036
Within participants	**Type of Noise (UBN vs PBN/ABN)**	**17.681[b]**	**0.000**	**0.342**
	Type of noise * Combination of noises (1=UBN vs PBN; 2=UBN vs ABN)	0.582[b]	0.843	0.017

a. Design: Intercept + Gender + Age + Coffee liking + Order of presentation of sounds + Combination of noises (1=UBN vs PBN; 2=UBN vs ABN). Within participants design: Noise

b. Exact statistic

c. Computed using alpha = .05

Univariate Tests

	F	Sig. (p)	Partial Eta Squared
Flavor liking	**49.180**	**0.000**	**0.114**

Type of Noise (UBN vs PBN/ABN)	**Sweetness**	**11.180**	**0.001**	**0.028**
	Bitterness	**34.920**	**0.000**	**0.083**
	Acidity	**13.712**	**0.000**	**0.034**
	Flavor intensity	**71.414**	**0.000**	**0.157**
	Aroma Intensity	**41.450**	**0.000**	**0.097**
	Temperature	0.595	0.441	0.002
	Sound liking	**127.987**	**0.000**	**0.250**
	Flavor sound matching	**31.262**	**0.000**	**0.075**
	Purchase intention	**67.207**	**0.000**	**0.149**
	WTP	**36.352**	**0.000**	**0.086**

a. Computed using alpha = .05