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### ► To cite this version:

Mathilde Vandenberghe-Descamps, Arthur Paté, Sylvie Chollet. Pairing a beer with a soundtrack: Is it guided by geographical identity?. *Food Quality and Preference*, 2022, 96, pp.104432. 10.1016/j.foodqual.2021.104432 . hal-03561433

**HAL Id: hal-03561433**

**<https://hal.science/hal-03561433v1>**

Submitted on 5 Jan 2024

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# 1 PAIRING A BEER WITH A SOUNDTRACK: IS IT GUIDED BY GEOGRAPHICAL 2 IDENTITY?

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## 8 **Abstract:**

9 In French gastronomy, food and beverage pairing is a traditional practice set down by pairing  
10 principles. Among these, some studies highlighted the principle of “geographical identity”:  
11 pairing two products related to the same area. While this concept has been explored for food-  
12 food and food-beverage pairing, there is less investigation across different senses e.g. auditory  
13 and **flavory**; specifically when **flavory** stimuli belong to the same food **category**. Yet it is well  
14 known that the auditory environment interacts with food behavior. We can wonder whether  
15 the pairing principles identified for food and beverage are relevant for a soundtrack and a  
16 beverage and more precisely whether the shared geographical identity of a beverage and a  
17 soundtrack drive their association. The aim of the present study is to explore **multisensory**  
18 interaction through the investigation of geographical identity association between a complex  
19 beverage – **a beer** – and a complex soundtrack (**i.e. stimuli with a perceived complexity**). The  
20 results showed that familiarity and hedonic evaluation of pairs as well as of soundtracks were  
21 strongly correlated to harmony evaluation of pairs while familiarity and hedonic evaluation of  
22 beers were correlated together. In addition, the results seem to highlight that soundtracks  
23 **dominate** the evaluation of pairs. The present study attempts to demonstrate that **pairing**  
24 **multisensory stimuli is complex and the related principles refer** to some of the already

25 highlighted pairing principles for food-food pairing: geographical identity but also perceptual  
26 principles.

27

28 **Keywords:** Beverage, music, pairing, interaction, multisensory perception

## 29 **Highlights**

- 30 • Some food-food pairing principles are relevant for multisensory pairing
- 31 • Pairs are more harmonious when stimuli show similar sensory characteristics
- 32 • Soundtrack familiarity and liking drive harmony evaluation of beer-soundtrack pairs

## 33 **INTRODUCTION**

34 Why do we drink wine when eating cheese? In gastronomy, food-beverage or food-food  
35 pairing is a traditional practice set down by pairing principles (Anastasia Eschevins, 2018;  
36 Harrington, 2008; Herz & Conley, 2015; Paulsen, Rognså, & Hersleth, 2015). According to  
37 Paulsen et al. (2015) and Harrington (2008), the most often cited principles refer to balanced  
38 intensities of tastes, body, flavor, and aftertaste; aromatic similarity between products and  
39 contrasts such as association of fatty food with acidic or tannic wine. In their work,  
40 Eschevins, Giboreau, Allard, & Dacremont (2018) classified the pairing principles into three  
41 categories: perceptual, conceptual and affective pairing principles. According to the authors,  
42 perceptual pairing comprises the sensory characteristics of the products, including balance in  
43 intensity and enhancement or decrease of sensory properties. The second category, conceptual  
44 pairing, involves the extrinsic properties of the products such as the terroir or quality level, the  
45 context of consumption and the concept of tradition including geographical identity. This  
46 category is commonly encountered in food and wine pairing. Finally, the third category  
47 relates to affective pairing and comprises consumer's preference and emotions such as a  
48 pairing that "deliberately breaks the rules" generating the surprise. In a recent literature

49 review, Galmarini (2020) investigated the topic and scanned the articles that aim at  
50 understanding pairing principle in food-food or food-beverage associations. The author  
51 confirms that aromatic compound similarity – included in the perceptual pairing concept  
52 defined by Eschevins et al. (2018) – is one of the reasons why a beverage and a food or two  
53 foods are matched together; but other reasons were also highlighted. Indeed, according to the  
54 author, harmony, balance, sensory similarities, tradition or even geographic origin could be a  
55 reason of matching, depending on the food and the beverage. Furthermore, it has been  
56 highlighted in this review that principles for pairing a beverage and a food or two foods could  
57 be different across the world. Indeed, in a cross-cultural study on food pairing (Ahn, Ahnert,  
58 & Bagrow, 2011), the authors showed that North American and Western European tend to  
59 match foods that share flavor compounds, while East Asian tend to match foods that are  
60 different in terms of flavor compounds. In another study, Tallab & Alrazgan (2016)  
61 investigated the pairing principles in four Eastern Mediterranean countries: Syria, Lebanon,  
62 Palestine and Jordan. The results showed that in those four countries the aroma compound  
63 similarity principle is a valid principle. **However, this principle is not so clear-cut and may not**  
64 **be working in terms of predicting food or ingredients pairing (Spence, 2020; Spence, Wang,**  
65 **& Youssef, 2017).**

66 While some pairing principles have been largely explored such as the aromatic similarity  
67 principle (Galmarini, 2020), others have, to the best of our knowledge, scarcely been  
68 investigated. Among these is the “geographical identity”: pairing two products related to the  
69 same area (Anastasia Eschevins, 2018). One **may ask** whether people associate two products  
70 from the same geographical area because they read the labels and make a word association, or  
71 whether even in blinded condition people would associate two products coming from the  
72 same area. **Zellner, Geller, Lyons, Pyper, & Riaz (2017) investigated this topic, they asked the**  
73 **participants of their study to choose between a Spanish or an Italian dish while listening to**

74 either a Spanish or an Italian music. The results showed a significant effect of the music on  
75 food choice. In addition, the association of two products from the same area could be related  
76 to the evaluation of familiarity: when two products are presented simultaneously, one gets  
77 used to the association and gets familiar with those two products together, which could  
78 possibly lead to an increase in harmony evaluation over time. A parallel could be made for  
79 odor perception: some odors are described as being sweet because an association is made  
80 between the smelled odor and the expected taste of the product through a learning process  
81 (Stevenson, Prescott, & Boakes, 1995). Furthermore, as it is well known that familiarity  
82 increases the liking (Legendre, Jo, Jang, & Kim, 2019; Nacef, Lelièvre-desmas, Symoneaux,  
83 & Jombart, 2019; Stein, Nagai, Nakagawa, & Beauchamp, 2003), it could be hypothesized  
84 that a pair of products that are familiar when presented together has a greater hedonic rating  
85 compared to a pair of two products that are not commonly presented together. From this  
86 hypothesis, it is possible to wonder whether this geographical identity principle can be  
87 applicable to other objects than food and more generally in cross-modal associations such as  
88 taste and sound for example.

89 For several years now, studies have been conducted to investigate the association between  
90 food stimuli and auditory stimuli. Indeed, a few authors investigated the associations between  
91 flavor and music (Reinoso Carvalho, Wang, de Causmaecker, et al., 2016; Reinoso Carvalho,  
92 Wang, van Ee, & Spence, 2016, Felipe Reinoso-Carvalho, Wang, van Ee, Persoone, &  
93 Spence, 2017; Wang, Keller, & Spence, 2017; see Spence (2020) for a review). Crisinel &  
94 Spence (2010) showed that basic tastes such as sweet, salty or even bitter can be associated  
95 with a pitch. The results showed that high-pitched sounds tend to be associated with sweet  
96 and sour tastes, while low-pitched sounds tend to be associated with bitter taste. In another  
97 study (Simner, Cuskley, & Kirby, 2010), the authors assessed a cross-modal mapping with  
98 taste and sounds. The results show that participants systematically associate basic tastes and

99 the frequency aspects of synthesized speech sounds (the frequency location of the first two  
100 formants, which are zones of higher sound level in the speech spectrum, these formants being  
101 responsible for the identification of vowels; the vowel discontinuity in time; the spectral  
102 balance, i.e., the shape of the frequency spectrum, highlighting either treble or bass  
103 frequencies). Moreover, the authors highlight the fact that bitter tastes were associated with  
104 sounds having a higher (respectively lower) first formant and a lower (respectively higher)  
105 spectral balance than sour (respectively sweet) tastes. However, in this study the participants  
106 were given a drop of tastant solution on their tongue before choosing the sound that best  
107 matches the taste according to them. This protocol is far from real-life situation as only basic  
108 tastes were studied and tasting procedure is intrusive; on the auditory side the stimuli were ad-  
109 hoc synthesized sounds, not recordings of existing music. In a more ecological way, Guetta &  
110 Loui (2017) investigated the cross-modal associations between complex sound and complex  
111 taste. Four pieces of music were composed and recorded, representing the four basic tastes  
112 according to previously published studies (Crisinel et al., 2012; Crisinel & Spence, 2010,  
113 2011). The pieces of music were presented to the participants, as well as four chocolate  
114 ganache: a sweet ganache, a salty ganache, a bitter ganache and a sour ganache. The results  
115 showed that the participants associated sound and chocolate ganache that represent the same  
116 basic taste. In addition, the authors highlighted the fact that preference ratings for music and  
117 chocolate ganache were correlated. Indeed, the participants who preferred the salty sound also  
118 preferred the salty chocolate ganache (Guetta & Loui, 2017). Also, some authors investigated  
119 the influence of music on food perception and showed that participants evaluated food as  
120 sweeter and more intense in taste while listening a music that conveyed positive emotion  
121 compared to music that conveyed negative emotion (Reinoso-Carvalho, Dakduk, Wagemans,  
122 & Spence, 2019; Reinoso-Carvalho, Gunn, Horst, & Spence, 2020; Reinoso-Carvalho, Gunn,  
123 Molina, et al., 2020). We can notice that most of the studies that investigated the association

124 between sound and flavor were only based on taste association - more precisely on the four  
125 basic tastes: sweetness, sourness, saltiness and bitterness – or liking (see Spence (2020) for a  
126 review), but very few evaluated the link between familiarity and liking on pairs evaluation. In  
127 real life, foods, beverages and sonic environments are always very complex; we can wonder  
128 whether those studies reflect real-life situations and whether the principles highlighted in the  
129 laboratory are still valid in real life. Furthermore, it is well known that the auditory  
130 environment interacts with food behavior (Kantono et al., 2016; North, 2012; Reinoso  
131 Carvalho, Velasco, van Ee, Leboeuf, & Spence, 2016); see Dacremont & Sester (2019) and  
132 Spence, Reinoso Carvalho, Velasco, & Wang (2019) for reviews). Accordingly, we propose  
133 to investigate pairing principles across different senses, e.g., auditory and gustatory stimuli.  
134 Yet one **may ask** whether the pairing principles identified for food and beverage or food and  
135 food are relevant for a soundtrack and a beverage and more precisely whether the shared  
136 geographical identity of a beverage and a soundtrack drive **the evaluation of pairs**.  
137 Therefore, the aim of the present study is to explore **multisensory** interaction through the  
138 investigation of geographical identity association between a complex beverage and a complex  
139 soundtrack. More precisely, the harmony of a beer and a soundtrack pairing is investigated  
140 **through** familiarity and hedonic evaluation of pairs, beers and soundtracks. Those three  
141 components were shown to be relevant when investigating food-beverage associations  
142 (Eschevins et al., 2018). The present article is divided into two experiments. In the first  
143 experiment, the beverages and the soundtracks are characterized using the flash profile  
144 method, in order to identify descriptors relevant to characterize both stimuli. **The flash profile**  
145 **is a descriptive method combining food choice profiling (participants are free to use their own**  
146 **words) and ranking. It allows to provide a quick access to the relative sensory positioning of a**  
147 **set of products (Dairou & Sieffermann, 2002).** In the second experiment, we investigate the

148 association between the beverages and the soundtracks using three components: harmony,  
149 familiarity and hedonic evaluation.

## 150 **I. EXPERIMENT 1. CHARACTERIZATION OF THE BEVERAGES AND OF THE** 151 **AUDITORY STIMULI USING FLASH PROFILE**

152 The aim of experiment 1 is to characterize the selected beers and soundtracks. The choice was  
153 made to perform a flash profile as participants do not need to be trained to assess the stimuli  
154 (Valentin, Chollet, Lelièvre, & Abdi, 2012).

### 155 **1) Materials and methods**

#### 156 **Participants**

157 Nine participants (5 women and 4 men) aged between 26 and 47 years participated in this  
158 study (mean age =  $36.4 \pm 7.6$  year old). The participants are part of the University staff and  
159 were recruited through email advertisement. They were invited to participate in two sessions:  
160 one for beers and one for soundtracks. The sessions took place at 12:15 PM on two separate  
161 days one week apart. The participants were not trained at evaluating neither beer nor music.

#### 162 **Stimuli**

163 Four beers and four soundtracks were used in this experiment. In order to identify the four  
164 beers, some pre-tests were conducted. The aim was to identify four beers that are issued from  
165 four different parts of the world, typical from their country and different from each other. To  
166 do so, a free sorting task and a tasting session to evaluate typicality were conducted with 20  
167 participants, on 18 beers from 12 different countries. The analysis of the typicality test and the  
168 free sorting task led us to select the four following beers: *O'Hara* from Ireland, *Bud* from the  
169 USA, *Gazelle* from Senegal and *Kingfisher* from India. Once the four beers were selected,  
170 three soundtracks from each corresponding country were selected (i.e. Ireland, the USA,



171 Senegal and India) and a listening session to evaluate their typicality was conducted with 20  
172 **French participants that are considered as non-native listeners**. The most typical soundtrack  
173 from where the beers originate were selected.

#### 174 *Beers*

175 Table 1 presents the four selected beers for the experiment. The beers were stored in a  
176 refrigerator at +4°C 24h before the session and were taken out of the refrigerator 30 minutes  
177 before each session in order to be served at tasting temperature (6-7°C). The samples were  
178 served in 20cl transparent plastic cup in order to allow visual evaluation. About 4cl of each  
179 beer was poured in the cups, this quantity assures that the blood-alcohol maximum level  
180 cannot be reached.

181 [Table 1 about here](#)

#### 182 *Soundtracks*

183 Table 2 presents the four soundtracks selected for the experiment. The soundtracks  
184 correspond either **to a movie original soundtrack or a song**. Twenty seconds of each  
185 soundtrack were extracted and presented to the participants. Participants could listen to  
186 soundtracks using headphones Tellememore® connected to a computer.

187 [Table 2 about here](#)

#### 188 **Procedure**

189 Two flash profile sessions took place: one on beers and one on auditory stimuli. Each session  
190 consisted of three steps.

191 During the first step, the participants were asked to taste the beers or listen to the soundtracks  
192 as many times as they wanted, and write down every descriptor that could, according to them,  
193 discriminate the samples or the soundtracks. The beers and the soundtracks were presented  
194 simultaneously: **all the beers or all the soundtracks were presented to the participants at the**

195 same time, the participants could taste or listen to the stimuli one at a time in a random order.  
196 During the second step, the participants said out loud their descriptors and the experimenter  
197 wrote them down on a white board, allowing every participant to have a look at the  
198 enunciated descriptors. Then, the participants were asked to focus on their own list and were  
199 allowed to add as many descriptors from the other participants as they wanted. Finally, the  
200 third step consisted in the evaluation session. The participants were asked to rank the five  
201 beers or the four soundtracks on a 10cm linear scale for each descriptor they had on their list.  
202 Ties were allowed and the participants could taste the beers or listen to the soundtracks as  
203 many times as they wanted. Again, the beers and the soundtracks were presented  
204 simultaneously. Spring water was available and the participants were free to drink water  
205 during the sessions. In total, every session lasted approximately 75 minutes. For beer session  
206 only, and during the third step of flash profile, one of the four beers was repeated to assess  
207 participant's reliability and assess the data: *Gazelle* from Senegal. This procedure was not  
208 setup for soundtracks as the soundtracks were easily recognizable.

## 209 **Data analysis**

210 For each participant and each descriptor, the data were coded as rank: the lowest intensity  
211 corresponding to the rank 1 and the highest intensity to the highest rank. For each participant  
212 one data frame was obtained with 5 lines for beers, 4 lines for soundtracks and x columns  
213 corresponding to descriptors (as participants could use as many descriptors as they wanted).  
214 Then, two separate Multiple Factor Analyses (MFA) were conducted to analyze the data for  
215 beers and soundtracks. Both analyses were performed using XLSTAT® software version  
216 2020-3.1.

## 217 2) RESULTS

218 *Beer characterization.* Figure 1 presents the first two dimensions of MFA map of the flash  
219 profile of beers (75.56 % of the variance). It has to be noted that both repetitions of *Gazelle*  
220 beer are very close on the map confirming that participants' assessment was reliable. The first  
221 dimension of the results of the MFA opposes the *Bud* beer (the USA) which was considered  
222 as having an intense sour taste and a low intensity color, to the *O'Hara* beer (Ireland) which  
223 was rated as having a greater color intensity, a greater taste intensity and an intense floral,  
224 hoppy, bitter and alcoholic flavor. On the second dimension, the *Kingfisher* beer (India) was  
225 considered as having neither a sour or bitter taste, not sparkling and has not a great amount of  
226 foam. Finally, the *Gazelle* beer (Senegal) is well represented on the third dimension (data not  
227 shown) and was rated as being sparkling and having a sweet taste.

228 Figure 1 about here

229 *Soundtrack characterization.* Figure 2 presents the first two dimensions of the MFA map of  
230 the flash profile of soundtracks (83.71% of variance). Results show that the first dimension  
231 opposes the Senegalese soundtrack which was considered as being fast, rhythmic, repetitive,  
232 and containing drums, to the American music which was evaluated as being a sentimental  
233 soundtrack. The Irish soundtrack is well represented on the second dimension, this soundtrack  
234 was considered as being a **catchy** and dancing soundtrack, cheerful, with high pitch notes,  
235 reminding of holidays, but without the presence of drums. Finally, the Indian soundtrack is  
236 well represented on the third dimension (data not shown) and was considered as being a  
237 rhythmic, complex and oriental soundtrack by the participants.

238 Figure 2 about here

## 239 II. EXPERIMENT 2. PAIRING EVALUATION

240 The aim of experiment 2 is to investigate whether geographical identity impacts pairing  
241 evaluation on cross-modal associations. To do so, the harmony of beers and soundtrack

242 pairing will be investigated throughout familiarity and hedonic evaluation of pairs, beers and  
243 soundtracks.

## 244 **1) Materials and methods**

### 245 **Participants**

246 A hundred and seven participants (41 women and 66 men) aged between 18 to 27 years  
247 participated in this study (mean age =  $20.44 \pm 1.9$  year old). Participants were students from  
248 one university based in Lille (France). **As it is well known that age have an influence on food  
249 and music perception (Kremer, Bult, Mojet, & Kroeze, 2007; Stothart & Kazanina, 2016), the**  
250 choice was made to recruit students, a homogeneous group of beer drinkers and music  
251 listeners. They were recruited throughout recruitment posters and social media's  
252 advertisement. The trials were carried out from 11AM to 5PM, participants were free to come  
253 to the laboratory anytime during this time slot.

### 254 **Stimuli**

#### 255 *Beers*

256 The four beers of Experiment 1 were served in Experiment 2, i.e. *O'Hara* (Irish beer), *Bud*  
257 (American beer), *Gazelle* (Senegalese beer) and *Kingfisher* (Indian beer) (see Stimuli of  
258 experiment 1 and table 1). Beers were stored in a refrigerator at +4°C 24h before the session  
259 then were taken out of the refrigerator 30 minutes before each session in order to be served at  
260 tasting temperature (6-7°C). The samples were served in a 20cl transparent plastic cup in  
261 order to allow visual evaluation. About 2cl of each beer was poured in the cups, this quantity  
262 assures that the blood-alcohol maximum level cannot be reached **according to French**  
263 **legislation.**

#### 264 *Soundtracks*

265 The four soundtracks of Experiment 1 were used for Experiment 2 (see Stimuli of Experiment  
266 1 and table 2). Participants could listen to musical extracts using headphones (Tellememore®)  
267 connected to a computer.

## 268 **Procedure**

269 The pairing evaluation was divided into three steps: 1) the evaluation of beer-soundtrack  
270 associations; 2a) the evaluation of beers; 2b) the evaluation of soundtracks; 3) the socio-  
271 demographic questionnaire. For the first step, the pairs were evaluated according to harmony,  
272 familiarity and hedonic components. For the second step, beers and soundtracks were  
273 evaluated on the familiarity and hedonic components.

274 *Evaluation of the association beer-soundtrack.* Participants performed the harmony,  
275 familiarity and hedonic evaluation of each pair using a 10-point scale (from *not at all* to *very*  
276 *much*). For those three components, the pair was evaluated as an entity in itself. Beers and  
277 soundtracks were presented as pairs to the participants, following a William Latin square  
278 design. Each beer was presented with each soundtrack; therefore each participant evaluated 16  
279 pairs. Participants could listen to the soundtrack and taste the beers as many times as they  
280 wanted. They were asked to rinse their mouth between each pair's evaluation using bottled  
281 spring water.

282 Then, participants were asked to evaluate the beers and soundtracks separately. Half of the  
283 participants started with beer evaluation, the other half with soundtrack evaluation.

284 *Evaluation of beers.* The four beers were presented one at a time to the participants following  
285 a William Latin square design. Participants performed the familiarity and hedonic evaluation  
286 of each beer using a 10-point scale (from *not at all* to *very much*). They were asked to rinse  
287 their mouth between each beer evaluation using bottled spring water.

288 *Evaluation of soundtracks.* The four soundtracks were presented one at a time to the  
289 participants following a William Latin square design. Participants performed familiarity and

290 hedonic evaluation of soundtracks using a 10-point scale (from *not at all* to *very much*), they  
291 could listen to the soundtrack as many times as they wanted.

292 *Socio-demographic questionnaire.* At the end of the session, participants were invited to  
293 answer socio-demographic questions as well as questions regarding beer consumption  
294 frequency, musical practice and music listening frequency. Among the socio-demographic  
295 questions, the number of years of musical experience as well as instrument practice was asked  
296 to the participants.

297 The sessions were conducted in a sensory room designed according to ISO guidelines (ISO  
298 International Organization for Standardization, 2007). Tasting was conducted in individual  
299 sensory booths under white light at a room temperature of  $20^{\circ}\text{C} \pm 0.5$ . The beers and  
300 soundtracks were coded with different three-digit numbers.

### 301 **Data analysis**

302  $\chi^2$  tests were performed to analyze the study population. To analyze cross-modal association,  
303 an analysis of variance (ANOVA) was carried out considering the beer and the soundtrack as  
304 factors and the harmony, familiarity and hedonic scores as dependent variable. When a  
305 significant effect was found, a Newman Keuls pair comparison test was performed with a  $\alpha$ -  
306 level at 5%. For familiarity and hedonic evaluation of beers and soundtracks, an ANOVA was  
307 carried out with beer or soundtrack as factor and familiarity and liking scores as dependent  
308 variables. When a significant effect was found, a Newman Keuls pair comparison test was  
309 performed with a  $\alpha$ -level at 5%. Finally, an Principal Component Analysis (PCA) was  
310 performed on the 16 associations and on the seven variables issued from the results: harmony,  
311 familiarity and hedonic evaluation of beer-soundtrack pairs, familiarity and hedonic  
312 evaluation of beers, as well as familiarity and hedonic evaluation of soundtracks.

313 Statistical analyses were performed using XLSTAT® software version 2020-3.1.

## 314 2) RESULTS

### 315 Study population

316 Table 3 shows the characteristics of the study population. No significant differences were  
317 observed regarding age distribution between men and women ( $\chi^2=3.6$ ; ns), as well as travels  
318 abroad ( $\chi^2=0.006$ , ns), number of years of music training ( $\chi^2=2.6$ , ns), practice of an  
319 instrument ( $\chi^2=2.2$ , ns) and frequency of listening to music ( $\chi^2=6.9$ , ns). However, a  
320 significant difference was observed regarding beer frequency consumption: women consume  
321 beer less often than men as they are more likely to consume beer once a month or several  
322 times a month while men are more likely to consume beer several times a week ( $\chi^2=18.9$ ,  
323  $p=0.002$ ). The study population may therefore be considered as being balanced.

324 Table 3 about here

### 325 Beer-soundtrack pairing

326 The two-way ANOVA shows a significant effect of soundtrack but no effect of beers on  
327 harmony, familiarity and hedonic evaluation ( $p<0.001$  for the three variables regarding  
328 soundtrack). Indeed, regardless of the beers, the average scores of harmony, familiarity and  
329 liking are greater for pairs containing Irish or American soundtrack than for pairs containing  
330 Senegalese or Indian soundtrack (Table 4).

331 Table 4 about here

332 Furthermore, we can see a tendency for the interaction between beers and soundtracks for  
333 harmony evaluation: the two pairs considered as most harmonious according to the  
334 participants were the pairs *Bud*-USA ( $M = 6.6 \pm 2.5$ ) and *Kingfisher*-IRELAND ( $M = 6.4 \pm$   
335  $2.6$ ). It has to be noted that the *O'hara*-IRELAND arrives in third position in terms of  
336 harmony evaluation ( $M = 6.1 \pm 2.8$ ). On the contrary, the two pairs that were considered as  
337 less harmonious according to the participants were the pairs *Gazelle*-SENEGAL ( $M = 4.8 \pm$   
338  $2.6$ ) and the pair *O'Hara*-SENEGAL ( $M = 4.8 \pm 3.0$ ) pair. In general, pairs containing either

339 the Irish of the American soundtrack are considered as more harmonious compared to the  
340 other pairs (Table 5).

341 Concerning familiarity and hedonic evaluation, no interaction has been highlighted. The  
342 scores of familiarity show that the pairs containing the Irish of the American soundtracks are  
343 more familiar than the pairs containing either the Senegalese of the Indian soundtrack,  
344 whatever the beer. Regarding hedonic scores, as for the familiarity evaluation, pairs  
345 containing either the Irish or the American soundtracks are more liked whatever the beer,  
346 except for the pair *O'Hara* – USA. Again, the pairs containing either the Senegalese of the  
347 Indian soundtrack are less liked.

348 No difference was observed depending on socio-demographic data: The evaluation does not  
349 differ depending on gender, beer frequency consumption, music frequency exposition or years  
350 of music experience.

351 Table 5 about here

352 Figure 3 presents the first two dimensions of the PCA maps explaining 91.78% of the  
353 variance. Results show that familiarity and hedonic evaluation of pairs as well as familiarity  
354 and hedonic evaluation of soundtrack are strongly correlated to harmony evaluation of pairs  
355 ( $R=0.86, p<0.001$ ;  $R=0.96, p<0.001$ ;  $R=0.78, p=0.001$  and  $R=0.74, p<0.001$  respectively).  
356 Familiarity and hedonic evaluation of beers are correlated together ( $R=0.90, p<0.001$ ).  
357 Regarding beer-soundtrack pairs (Figure 3b), the first dimension opposes pairs containing  
358 either the Irish or the American soundtrack, which are more familiar and more liked,  
359 compared to the pairs containing either the Senegalese or the Indian soundtrack, which are  
360 less familiar and less liked. The second dimension opposes pairs containing the beers *O'Hara*  
361 or *Bud* which are more familiar and more liked, compared to the pairs containing either  
362 *Kingfisher* or *Gazelle* which are less familiar and less liked.

363 Figures 3a and 3b about here



364 **Beer evaluation**

365 Figures 4a and 4b show the results of the one-way ANOVA on beers for familiarity and  
366 hedonic evaluations respectively. A significant effect was observed on both variables  
367 ( $p < 0.0001$  and  $p = 0.03$  respectively). For familiarity evaluation, *O'Hara* and *Bud* are  
368 significantly more familiar than *Gazelle* and *Kingfisher*. Regarding the hedonic evaluation,  
369 *O'Hara* is the most preferred beer while *Kingfisher* is the less preferred beer.

370 **Soundtrack evaluation**

371 Figures 4c and 4d show the results of the one-way ANOVA on soundtrack evaluation for  
372 familiarity and hedonic evaluations respectively. A significant effect was observed on both  
373 variables ( $p < 0.0001$  for both variables). Similar results are observed for both variables: the  
374 Irish soundtrack is the most familiar and most liked while Senegalese and Indian soundtracks  
375 are the less familiar and less liked. Besides, whether it is for familiarity or hedonic evaluation,  
376 Irish and American soundtracks were rated as significantly different while Senegalese and  
377 Indian soundtracks were not rated as significantly different.

378 

379 **III. DISCUSSION**

380 The aim of the present study was to explore **multisensory** interaction through the investigation  
381 of geographical identity association between a complex beverage and a complex soundtrack.  
382 More precisely, the harmony of beverage and soundtrack pairing was investigated throughout  
383 familiarity and hedonic evaluations of pairs, beverages and soundtracks.

384 Overall, the results showed that familiarity and hedonic evaluation of pairs as well as of  
385 soundtracks were strongly correlated to harmony evaluation of pairs while familiarity and  
386 hedonic evaluation of beers were correlated together. In addition, results showed that  
387 whatever the beer, pairs containing either the Irish or the American soundtrack were

388 considered as being more harmonious, more familiar and more liked compared to the pairs  
389 containing the Senegalese or the Indian soundtrack. As Reinoso Carvalho, Wang, de  
390 Causmaecker, et al. (2016), our results highlight link between auditory and olfactory and  
391 **flavory** stimuli. These authors explain this result based on physical properties: Most salient  
392 taste attribute, degree of alcohol and range of pitch. In the present study, we suggest a  
393 complementary explanation: The link between auditory and olfactory and gustatory stimuli  
394 could also be due to the concept of harmony and familiarity of both beers and soundtracks.

395 **Several hypotheses could explain the results of the present study. First, our results could be**  
396 **explained by the sensory dominance of judgment. Some studies highlighted that when two**  
397 **stimuli are presented simultaneously – one visual and one auditory – there is a prepotency of**  
398 **the visual over the auditory stimulus (Colavita, 1974). One can wonder whether this concept**  
399 **is applicable for auditory and flavory stimuli. Also, as the soundtracks are clearly different**  
400 **and recognizable whereas the beers present less differences and are probably not recognizable**  
401 **when blinded, people may simply ignore the minor differences in beer and only focus on**  
402 **music to evaluate pairs. Consequently, it is possible that in absence of bottom-up**  
403 **differentiation of beers based on flavor, participants based their judgements on top-down**  
404 **information coming from music identification.**

405 Second, it could be hypothesized that participants evaluated the pairs as more harmonious  
406 when the two stimuli present similar sensory characteristics, i.e. when both stimuli have  
407 strong sensory characteristics or on the contrary when they seem to have a less pronounced  
408 identity. According to Eschevins et al. (2018), this hypothesis refers to one of the three  
409 enunciated pairing principles: the perceptual principle. Therefore, two stimuli with similar  
410 sensory characteristics could go well together and be perceived as harmonious, as it was  
411 observed for food-food associations where shared aromatic compounds or sensory

412 characteristics lead to a preferred association (Galmarini, 2020). This pairing principle could  
413 therefore be considered as universal whatever the involved senses.

414 Third, it could be hypothesized that familiarity and hedonic evaluation have an impact on the  
415 evaluation of pairs. Indeed, the pairs that were rated as the most harmonious seem to contain  
416 either a beer or a soundtrack that was rated as the most familiar and the most liked by the  
417 participants. In addition, it has to be noted that the pairs that were rated as more harmonious  
418 compared to the others contained both a beer that was familiar and liked and a soundtrack that  
419 was familiar and liked. This leads us to believe that two stimuli that are either familiar or  
420 liked go well together, and the pair containing those two stimuli is harmonious. It is also  
421 possible (and might be tested in further studies) that the monomodal familiarity and/or  
422 hedonic evaluation of beers and soundtracks predict well the **multisensory** harmony  
423 evaluation of the beer/soundtrack pairs. This hypothesis goes in line with the fact that  
424 familiarity increases the liking: two products presented together have a greater hedonic rating  
425 when they are familiar compared to two products that are not commonly presented together  
426 (Legendre et al., 2019; Nacef et al., 2019; Stein et al., 2003). Also, some authors  
427 demonstrated that familiarity and hedonic ratings are positively correlated in various domains  
428 such as vision (Zajonc, 1968), odors (Chrea, Valentin, Sulmont-Rossé, Nguyen, & Abdi,  
429 2005; Engen, 1982) or food (Nicklaus, Boggio, Chabanet, & Issanchou, 2004; Sulmont,  
430 2000). Finally, the impact of hedonic evaluation seems to have its importance for both beers  
431 and soundtracks. It could be hypothesized that the “*flavor-flavor learning*” concept may be  
432 relevant for beer and soundtrack: when a new flavor is presented in a repetitive manner and  
433 associated with a liked flavor, the new flavor is well liked. On the contrary, when a new  
434 flavor is associated with an unliked flavor, it becomes unliked (D. A. Zellner, Rozin, Aron, &  
435 Kulish, 1983). Here, presenting whether a new beer or a new soundtrack with a soundtrack or

436 a beer that are already liked would increase the hedonic rating of the new beer or the new  
437 soundtrack.

438 In order to confirm those hypotheses, several leads may be considered. First of all, only four  
439 beers and four soundtracks were presented to the participants, even though many others could  
440 have been studied. It is difficult to fully represent the geographical identity of one country in a  
441 single beer or a single music, it would be interesting to present a set of various stimuli issued  
442 from one country to better investigate the effect of geographical area on pairing. However, as  
443 the tasted products are alcoholic products, it was important not to serve too much beer in  
444 order to make sure that the legal alcoholic level was not reached by any of the participants. In  
445 addition, it is necessary to pour enough beer for participants to answer to all the questions.  
446 Therefore, the number of served beers was restrictive and the authors of the present study  
447 found that four beers was a reasonable number of products as 16 samples were served in total:  
448 the 4 beers x the 4 soundtracks. Furthermore, beer is a very complex matrix **containing more**  
449 **than 3000 different compounds** (Anderson, Santos, Hildenbrand, & Schug, 2019). Indeed, the  
450 more beers are presented to the participants, the more difficult the task is to assess the beers.  
451 Serving more than four beers to the participants may increase cognitive load and tiredness  
452 during the test (Sharif, Butt, Sharif, & Nasir, 2017). Therefore, it is strategic not to serve too  
453 many samples of beers to the participants.

454 Second, regarding geographical associations, the choice was made to perform the association  
455 assessment task asking only French students, the students were asked to assess four beers that  
456 are not originated from France. This way, we made sure that all the participants had the same  
457 understanding of the questions and the same background culturally speaking. However, it  
458 would be interesting to investigate whether American, Indian, Irish or Senegalese students  
459 assess the beer-soundtrack associations the same way or not, and whether French students  
460 assess the French beers differently as they were more exposed to French beers and therefore

461 are more familiar with them as compared to the other beers. An idea would be to add a fifth  
462 beer in the study: a typical French beer. That way, we could investigate the influence of  
463 cultural background on harmony, familiarity and hedonic assessment of beer-soundtrack  
464 pairs. In addition, it would be interesting to assess cultural knowledge of the participants to  
465 evaluate whether the participants are familiar with the culture of the countries where the beers  
466 and soundtracks are originated. Knowing whether the participants have already been to these  
467 countries, tasted the beers and are familiar with the soundtracks of those specific countries  
468 would give clues to understand the impact of familiarity on pairs evaluation.

469 Third, the results showed that while the four soundtracks are all different in terms of  
470 characteristics, the Irish beer is very different from the other beers (see figure 1b, axis F1).  
471 That is to say, the soundtracks are well divided in terms of difference compared to the beers.  
472 Indeed, the Irish beer is the one having the most intense taste in general and the most  
473 pronounced characteristics according to the participants of the flash profiling task, while the  
474 other beers had a less intense taste. Also, the Irish beer was the only one having an amber  
475 color, the three other beers were blond beers. It would have been interesting to select four  
476 beers with four distinct characteristics as it was the case for the soundtracks: a very sweet  
477 beer, a very hoppy beer, a very sour beer and a very bitter beer for example. That way, the  
478 four beers would have had four distinct profiles and be closer to the four soundtracks who  
479 were very distinguishable between each other. Additionally, it is possible that our choice of  
480 soundtracks spans a broader range of diversity than our choice of beers do. In other words, we  
481 might have chosen soundtracks that are more different from each other than beers are from  
482 each other. Having exposed the participants to auditory stimuli that were more diverse than  
483 gustatory stimuli might explain why the beer/soundtrack harmony seems to be driven by  
484 soundtrack familiarity and liking (see above and figure 3a, axis F1).

485 Finally, it has to be noted that the participants evaluated the associations in a standardized  
486 laboratory, using headphones to listen to the soundtracks. It is now well known that context  
487 has a significant impact on food perception and liking. Many studies have indeed investigated  
488 the topic, comparing various contexts with several degree of immersion – i.e. sensory  
489 laboratory, virtual reality, immersive room or in-home tests (Bangcuayo et al., 2015; Boutrolle,  
490 Arranz, Rogeaux, & Delarue, 2005; Boutrolle, Delarue, Arranz, Rogeaux, & Köster, 2007; De  
491 Wijk et al., 2019; Hannum, Forzley, Popper, & Simons, 2019; Hathaway & Simons, 2017;  
492 Hehn, Lutsch, & Pessel, 2019; Lichters, Möslein, Sarstedt, & Scharf, 2021; Liu, Hannum, &  
493 Simons, 2019; Schouteten, Gellynck, & Slabbinck, 2019; Stelick & Dando, 2018). Whereas  
494 the results of the studies do not always lead towards the same conclusions, all results show an  
495 increase in participant's engagement. Thus, when one drinks a beer while listening to music, it  
496 is commonly in a pub or at home with family and friends. In addition, when drinking a beer in  
497 a pub, the customers do not need to wear headphones as the music is diffused using  
498 loudspeakers. Therefore, this laboratory situation is not the most ecological situation, when  
499 talking about beer consumption and music listening (Galiñanes Plaza, Delarue, & Saulais,  
500 2019). It would be interesting to perform such a task in a more ecological environment, such  
501 as an immersive room or in a real pub for example. Indeed, in a recent study investigating the  
502 influence of environment on beer consumption (Delarue, Brassat, Jarrot, & Abiven, 2019), the  
503 authors highlighted the fact that the immersive situation could reduce the effect of time  
504 assessment. Indeed, their results showed that the difference between morning and afternoon  
505 sessions was significant in the non-immersive condition but not significant in the immersive  
506 condition. Therefore, it could help the participants to immerse themselves into a more realistic  
507 situation.

## 508 **CONCLUSION**

509 The present study aimed at investigating **multisensory** interaction through the evaluation of  
510 beer-soundtrack associations. Harmony, familiarity and liking of pairs, beers and soundtracks  
511 were assessed in order to investigate whether geographical identity is a relevant pairing  
512 principle for beer-soundtrack associations. As a result, the present study attempts to  
513 demonstrate that pairing **multisensory stimuli is complex** and refers to some of the already  
514 highlighted pairing principles for food-food pairing: geographical identity but also perceptual  
515 principles. In order to deeply investigate the influence of geographical identity on associations  
516 assessment, it could be interesting to study products that are traditionally associated together,  
517 for example wine with cheese, and see if, blinded, the participants still consider this  
518 association as harmonious, liked and familiar.

## 519 **Ethical Statements**

520 The authors declare that they do not have any conflicts of interest.

## 521 **Acknowledgements**

522 The authors thank Salamata Baldé for the work she did on the tasting sessions, and all the  
523 participants of the present study.

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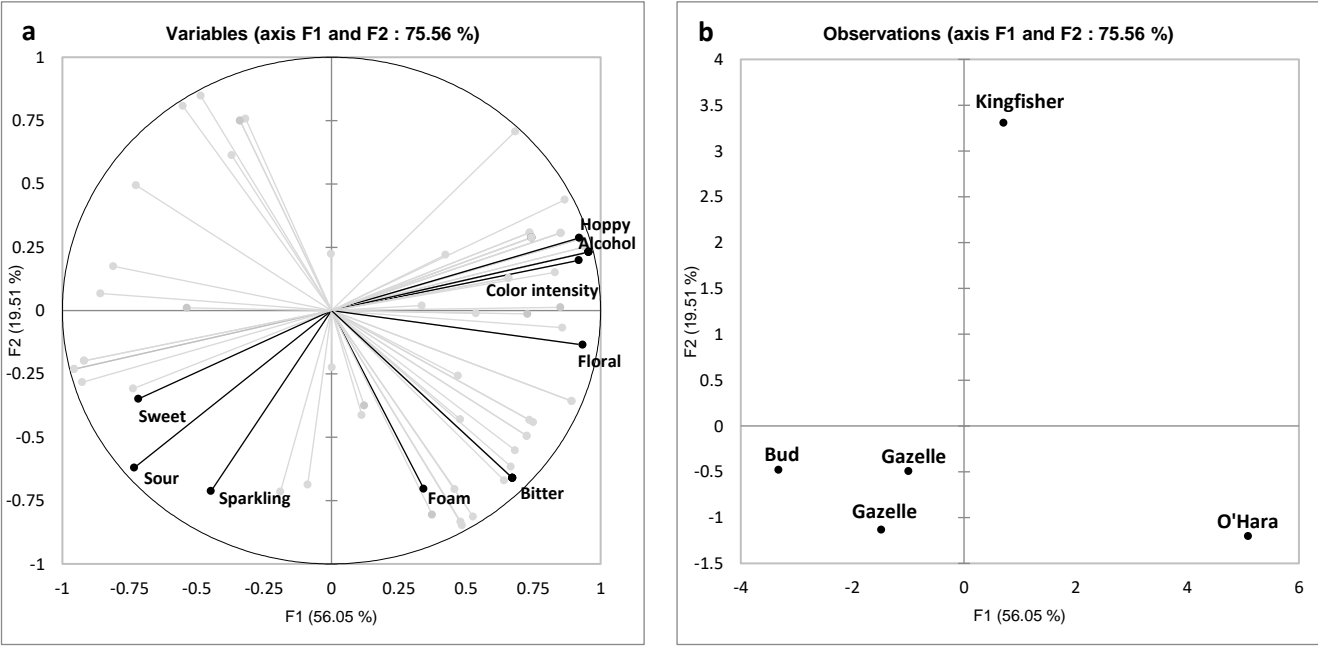
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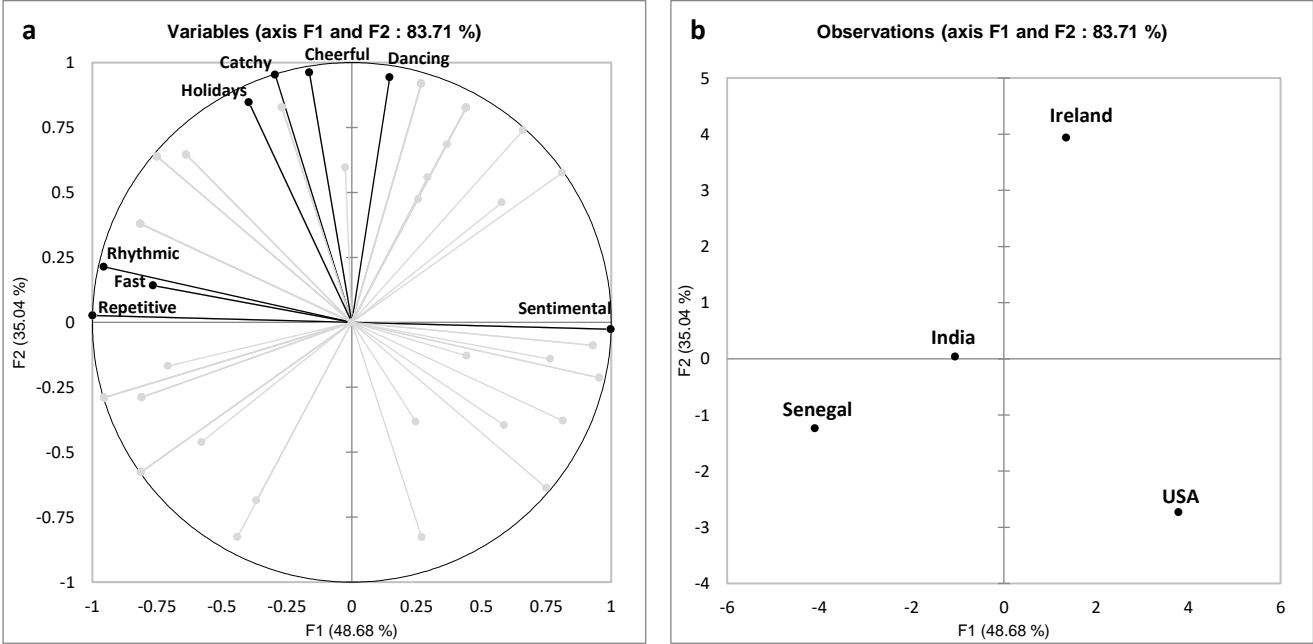
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Figure 1. Multiple Factor Analysis (MFA) plots of flash profile data on beers for dimensions 1 and 2 (1a: descriptors; 1b: Beer map).



Only relevant descriptors are presented in figure 1a: either descriptors that were cited at least by three different participants and whose contribution is greater than the mean contribution of all descriptors or having a  $\cos^2 > 0.5$ .

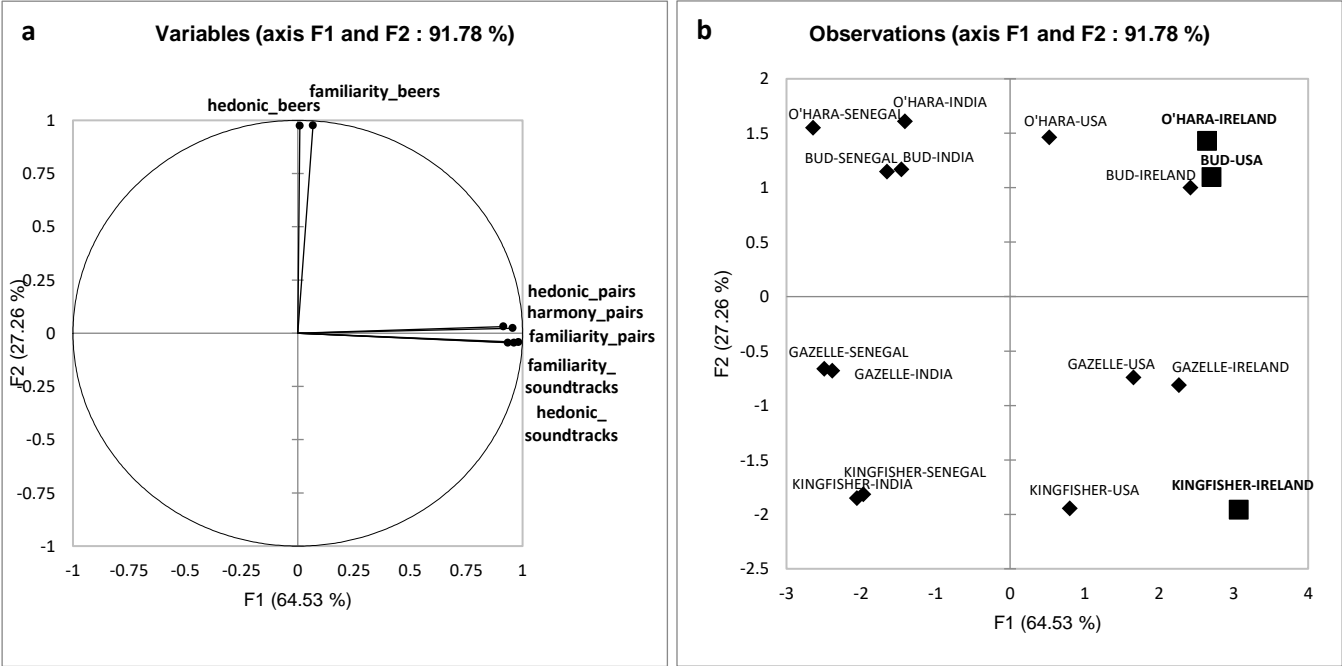
Figure 2. Multiple Factor Analysis (MFA) plots of flash profile data on soundtracks for dimensions 1 and 2 (2a: descriptors; 2b: soundtracks map).



Only relevant descriptors are presented in figure 2a: either descriptors that were cited at least by three different participants and whose contribution is greater than the mean contribution of all descriptors or having a  $\cos^2 > 0.5$ .

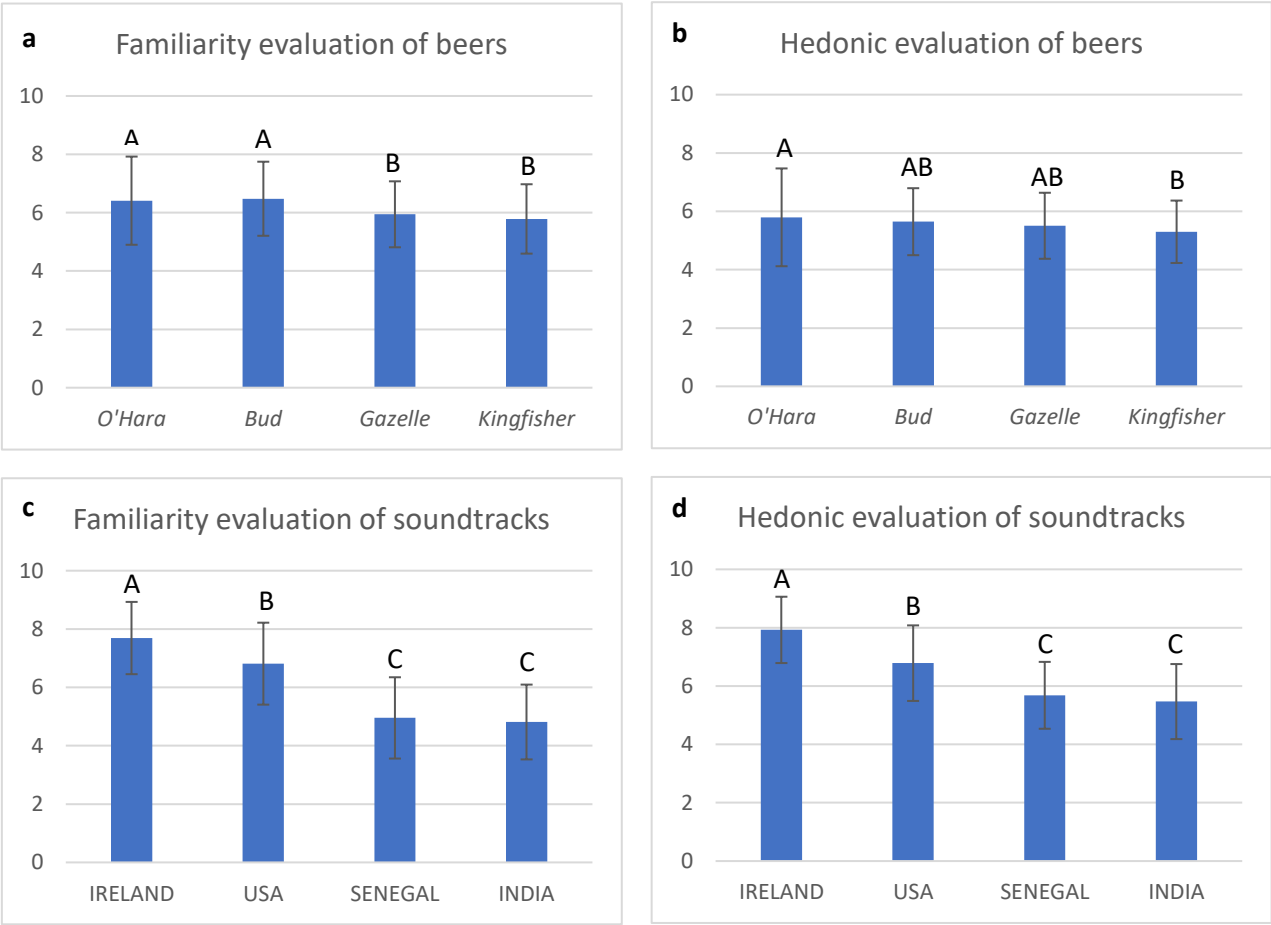


Figure 3. Principal Component Analysis (PCA) for dimensions 1 and 2: 3a evaluation variables; 3b beer-soundtrack pairs.



The squared shapes in the stimuli map indicates the three pairs that were evaluated as more harmonious.

Figure 4. Representation of familiarity and hedonic evaluation for beers (4a and 4b respectively) and soundtracks (4c and 4d respectively).



The error bars correspond to the standard deviations. For each variable, the means with a different letter are significantly different ( $p < 0.05$ ).

Table 1. Selected Beers and their characteristics

Beer	Characteristics of the beers	Illustration	Country of origin
<i>O'Hara Irish Pale Ale</i>	Category: Pale Ale Packaging: bottles of 33cl Degree of alcohol: 5.2° Color of the beer: Amber		Ireland
<i>Bud</i>	Category: Pale Lager Packaging: bottles of 25cl Degree of alcohol: 5.0° Color of the beer: Blond		USA
<i>Gazelle</i>	Category: Pale lager Packaging: bottles of 50cl Degree of alcohol: 4.2° Color of the beer: Blond		Senegal
<i>Kingfisher Premium</i>	Category: Pale Lager Packaging: bottles of 33cl Degree of alcohol: 4.8° Color of the beer: blond		India

Table 2. Selected soundtracks and their characteristics

Name of the song	Artist	Beginning of the 20 seconds extract	Reference	Country
Farmer Macdog	Petunes	0'50	<a href="https://www.youtube.com/watch?v=ozZQZvi2vDA">https://www.youtube.com/watch?v=ozZQZvi2vDA</a>	Ireland
Back in the day	Daniel Robinson	0'00	<a href="https://www.youtube.com/watch?v=10VQM9pgTcs&amp;ab_channel=DanielRobinson">https://www.youtube.com/watch?v=10VQM9pgTcs&amp;ab_channel=DanielRobinson</a>	USA
Koukou	Orchestre Africa Djembé	1'31	<a href="https://www.youtube.com/watch?v=TaTWtRCXN4E&amp;ab_channel=MemoriesofMusic">https://www.youtube.com/watch?v=TaTWtRCXN4E&amp;ab_channel=MemoriesofMusic</a>	Senegal
Deewani Mastani	Shreya Ghoshal	1'48	<a href="https://www.youtube.com/watch?v=Pu-fhMmzATY&amp;ab_channel=SaraswatiFutureFilmsSaraswatiFutureFilms">https://www.youtube.com/watch?v=Pu-fhMmzATY&amp;ab_channel=SaraswatiFutureFilmsSaraswatiFutureFilms</a>	India

Table 3. characteristics of the study population

Number of participants	107 participants
Mean age (years)	20.4 ± 1.8
Gender (% female)	38.3%
Has already traveled abroad (% yes)	95.3%
Frequency consumption of beer	
1/month	3.7%
Several times/month	11.2%
1/week	21.5%
Several times/week	58.9%
1/day	3.7%
Several times/day	1.0%
Frequency listening of music	
1/month	0%
Several times/month	0%
1/week	1.9%
Several times/week	10.3%
1/day	11.2%
Several times/day	76.6%
Number of years of musical training	
Never	58.9%
1-5 years	28.0%
6-10 years	11.2%
More than 10 years	1.9%
Number of years of instrument practice	
Never	48.6%
1-5 years	30.8%
6-10 years	13.1%
More than 10 years	7.5%

Table 4. Means and standard deviations of harmony, familiarity and hedonic evaluation of pairs

	Harmony of pairs	Familiarity of pairs	Hedonic of pairs
IRELAND	6.100 ± 2.7 a	5.210 ± 3.0 a	6.166 ± 2.9 a
USA	5.932 ± 2.8 a	5.063 ± 3.2a	5.972 ± 3.0 a
SENEGAL	4.972 ± 2.7 c	3.208 ± 2.6 b	4.871 ± 2.8 b
INDIA	5.360 ± 2.8 b	3.227 ± 2.6 b	5.126 ± 2.8 b

For each variable, means in the same column with different letters are significantly different ( $p < 0.05$ ) according to the Newman Keuls test.

Table 5. Means and standard deviations for beer-soundtrack pairs on harmony, familiarity and hedonic evaluation

Beer-music	Harmony of pairs		Familiarity of pairs		Liking of pairs	
<i>Bud</i> - USA	6.6 ± 2.5	a	5.5 ± 2.8	a	6.7 ± 2.7	a
<i>Kingfisher</i> - IRELAND	6.4 ± 2.6	ab	5.3 ± 3.1	a	6.4 ± 2.8	ab
<i>O'Hara</i> - IRELAND	6.1 ± 2.8	abc	5.3 ± 3.0	a	6.2 ± 3.0	abc
<i>Gazelle</i> - USA	6.0 ± 2.6	abcd	5.1 ± 3.1	a	6.2 ± 2.7	abc
<i>Gazelle</i> - IRELAND	5.9 ± 2.8	abcde	5.1 ± 3.0	a	6.0 ± 3.0	abcd
<i>Bud</i> - IRELAND	5.9 ± 2.7	abcde	5.2 ± 2.8	a	6.1 ± 2.8	abcd
<i>O'Hara</i> - INDIA	5.8 ± 2.9	abcde	3.2 ± 2.5	b	5.2 ± 3.1	cde
<i>Kingfisher</i> - USA	5.6 ± 2.7	abcde	5.0 ± 3.0	a	5.6 ± 2.9	abcde
<i>O'Hara</i> - USA	5.5 ± 3.1	bcde	4.7 ± 3.0	a	5.4 ± 3.4	bcde
<i>Kingfisher</i> - INDIA	5.3 ± 2.7	bcde	3.1 ± 2.6	b	5.1 ± 2.6	cde
<i>Bud</i> - INDIA	5.3 ± 2.6	bcde	3.5 ± 2.7	b	5.4 ± 2.6	bcde
<i>Bud</i> - SENEGAL	5.2 ± 2.4	cde	3.4 ± 2.7	b	5.2 ± 2.5	cde
<i>Kingfisher</i> - SENEGAL	5.1 ± 2.7	cde	3.4 ± 2.7	b	4.9 ± 2.7	de
<i>Gazelle</i> - INDIA	5.0 ± 2.8	cde	3.1 ± 2.7	b	4.8 ± 3.0	e
<i>Gazelle</i> - SENEGAL	4.8 ± 2.6	de	3.1 ± 2.6	b	4.8 ± 2.8	e
<i>O'Hara</i> - SENEGAL	4.8 ± 3.0	e	2.9 ± 2.6	b	4.5 ± 3.1	e

For each variable, means in the same column with different letters are significantly different ( $p < 0.05$ ) according to the Newman Keuls test.