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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 ± 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**

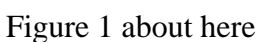
195 same time, the participants could taste or listen to the stimuli one at a time in a random order.
196 During the second step, the participants said out loud their descriptors and the experimenter
197 wrote them down on a white board, allowing every participant to have a look at the
198 enunciated 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 ± 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 χ^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 α -
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 α -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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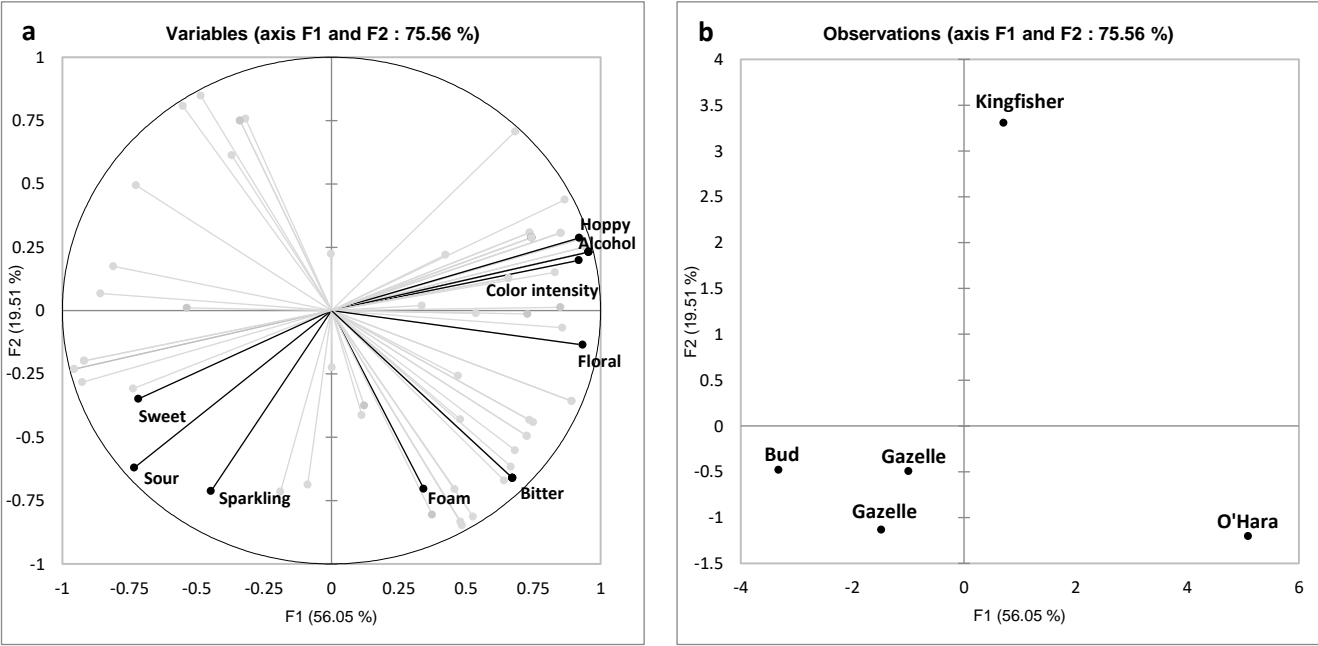
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704

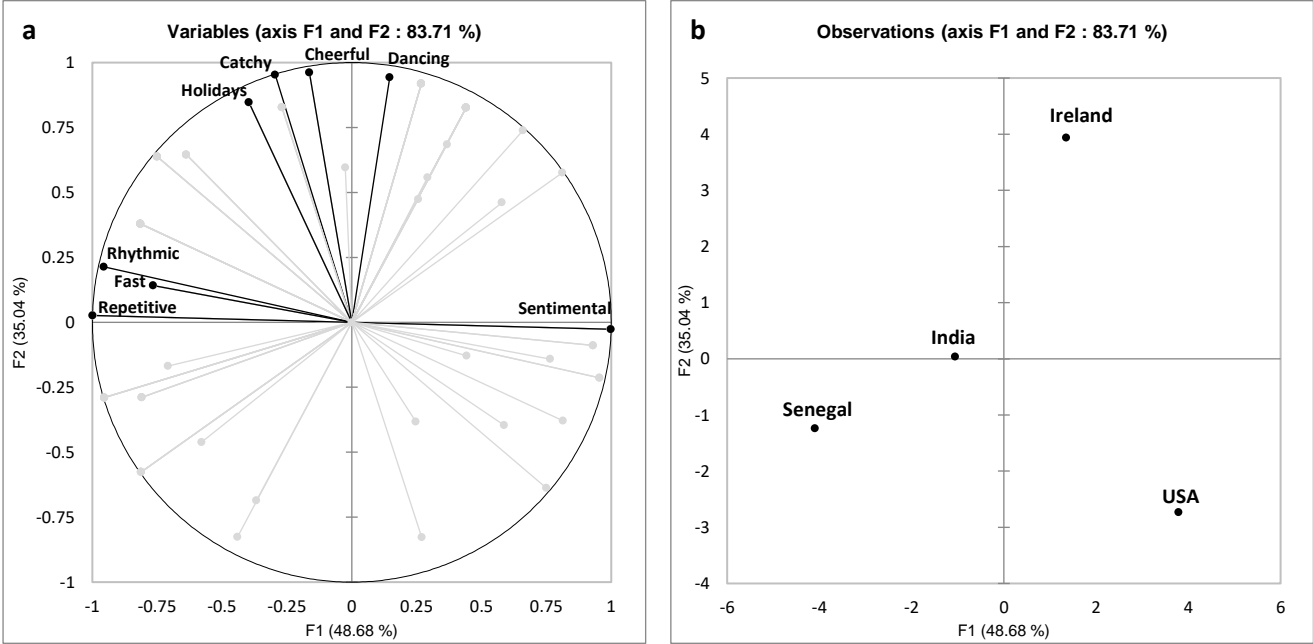
705

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



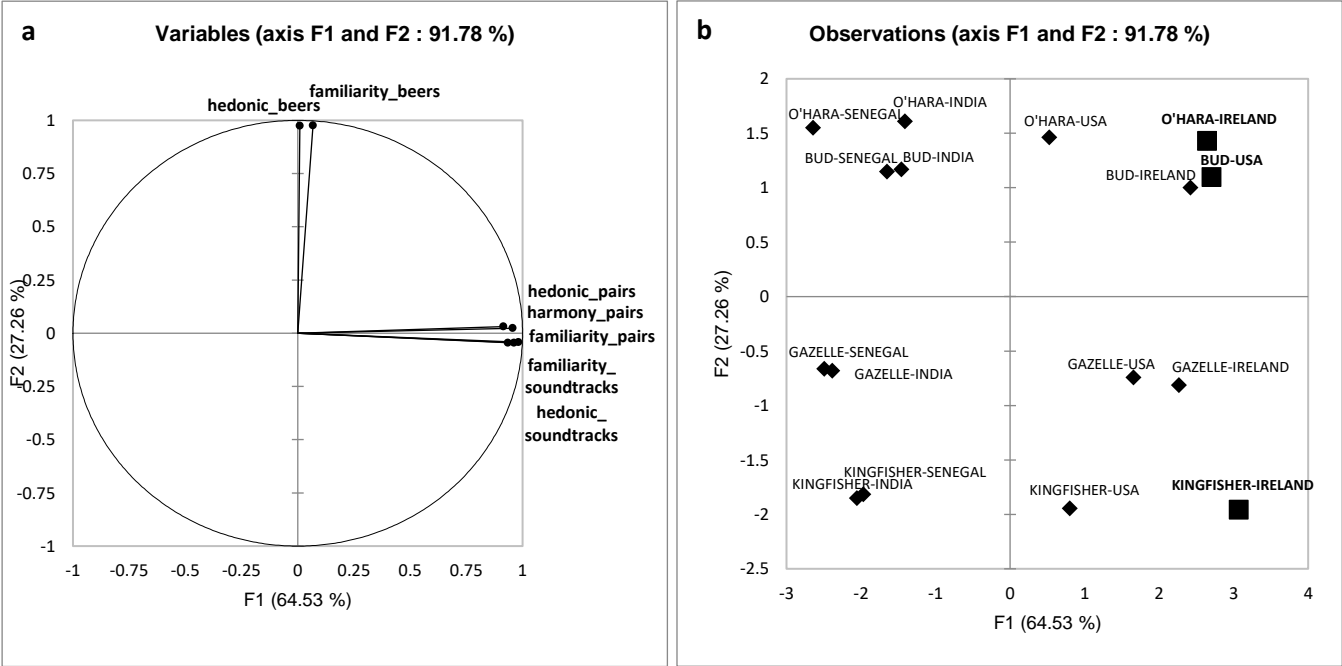
Only relevant descriptors are presented in figure 1a: either descriptors that were cited at least by three different participants and whose contribution is greater than the mean contribution of all descriptors or having a $\cos^2 > 0.5$.

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



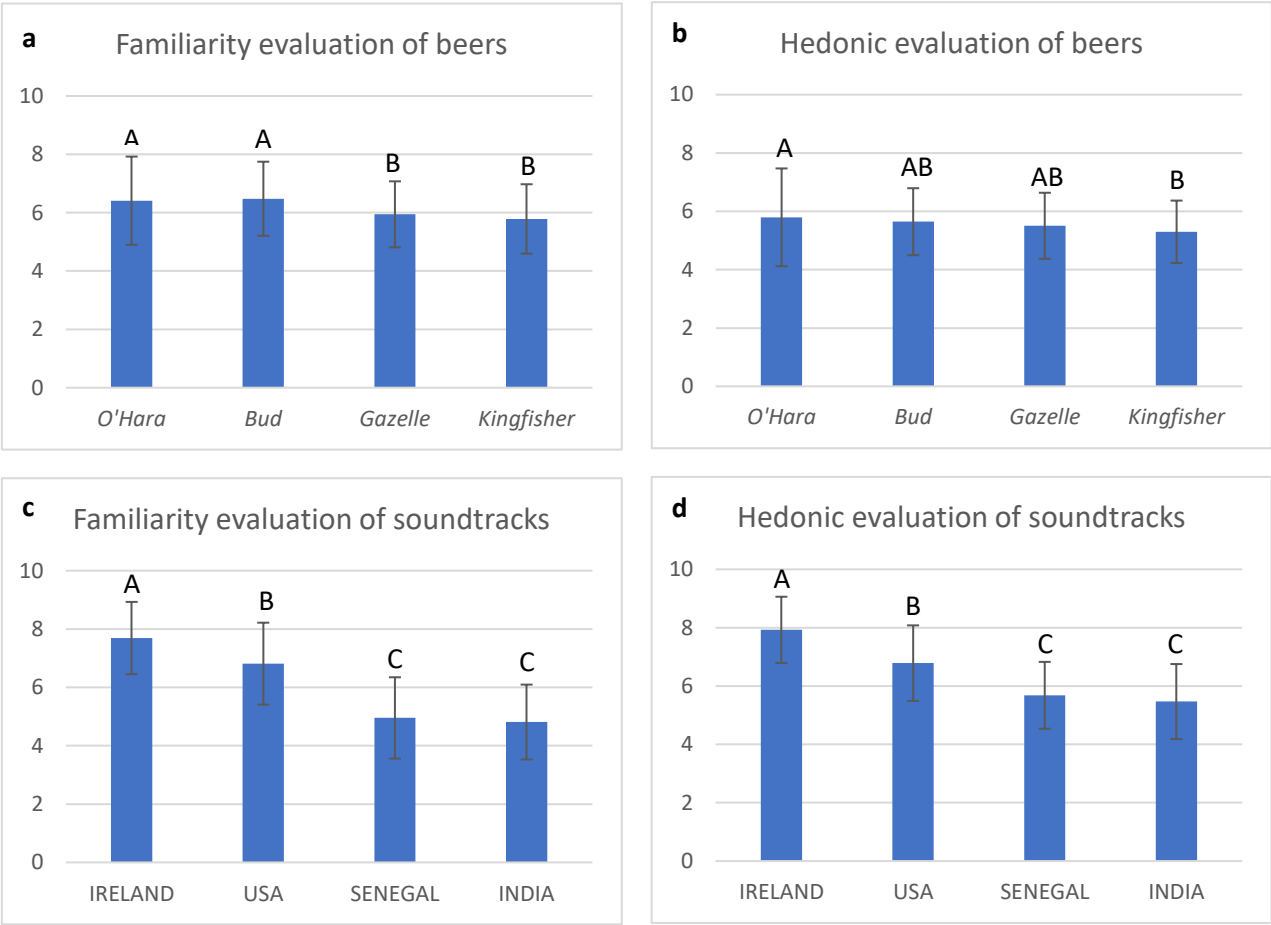
Only relevant descriptors are presented in figure 2a: either descriptors that were cited at least by three different participants and whose contribution is greater than the mean contribution of all descriptors or having a $\cos^2 > 0.5$.

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	https://www.youtube.com/watch?v=ozZQZvi2vDA	Ireland
Back in the day	Daniel Robinson	0'00	https://www.youtube.com/watch?v=10VQM9pgTcs&ab_channel=DanielRobinson	USA
Koukou	Orchestre Africa Djembé	1'31	https://www.youtube.com/watch?v=TaTWtRCXN4E&ab_channel=MemoriesofMusic	Senegal
Deewani Mastani	Shreya Ghoshal	1'48	https://www.youtube.com/watch?v=Pu-fhMmzATY&ab_channel=SaraswatiFutureFilmsSaraswatiFutureFilms	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.