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

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Abstract:

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

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

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

Highlights

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

INTRODUCTION

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

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

While some pairing principles have been largely explored such as the aromatic similarity principle (Galmarini, 2020), others have, to the best of our knowledge, scarcely been investigated. Among these is the “geographical identity”: pairing two products related to the same area (Anastasia Eschevins, 2018). One may ask whether people associate two products from the same geographical area because they read the labels and make a word association, or whether even in blinded condition people would associate two products coming from the same area. Zellner, Geller, Lyons, Pyper, & Riaz (2017) investigated this topic, they asked the 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

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

I. EXPERIMENT 1. CHARACTERIZATION OF THE BEVERAGES AND OF THE AUDITORY STIMULI USING FLASH PROFILE

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

1) Materials and methods

Participants

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

Stimuli

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

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

Beers

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

Table 1 about here

Soundtracks

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

Table 2 about here

Procedure

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

During the first step, the participants were asked to taste the beers or listen to the soundtracks as many times as they wanted, and write down every descriptor that could, according to them, discriminate the samples or the soundtracks. The beers and the soundtracks were presented 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.

2) RESULTS

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

Figure 1 about here

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

Figure 2 about here

II. EXPERIMENT 2. PAIRING EVALUATION

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

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

1) Materials and methods

Participants

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

Stimuli

Beers

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

Soundtracks

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

Procedure

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

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

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

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

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

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

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

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

Data analysis

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

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

2) RESULTS

Study population

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

Table 3 about here

Beer-soundtrack pairing

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

Table 4 about here

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

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

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

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

Table 5 about here

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

Figures 3a and 3b about here

Beer evaluation

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

Soundtrack evaluation

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

Figures 4a, 4b, 4c and 4d about here

III. DISCUSSION

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

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

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

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

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

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

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

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

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

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

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

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

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

CONCLUSION

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

Ethical Statements

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

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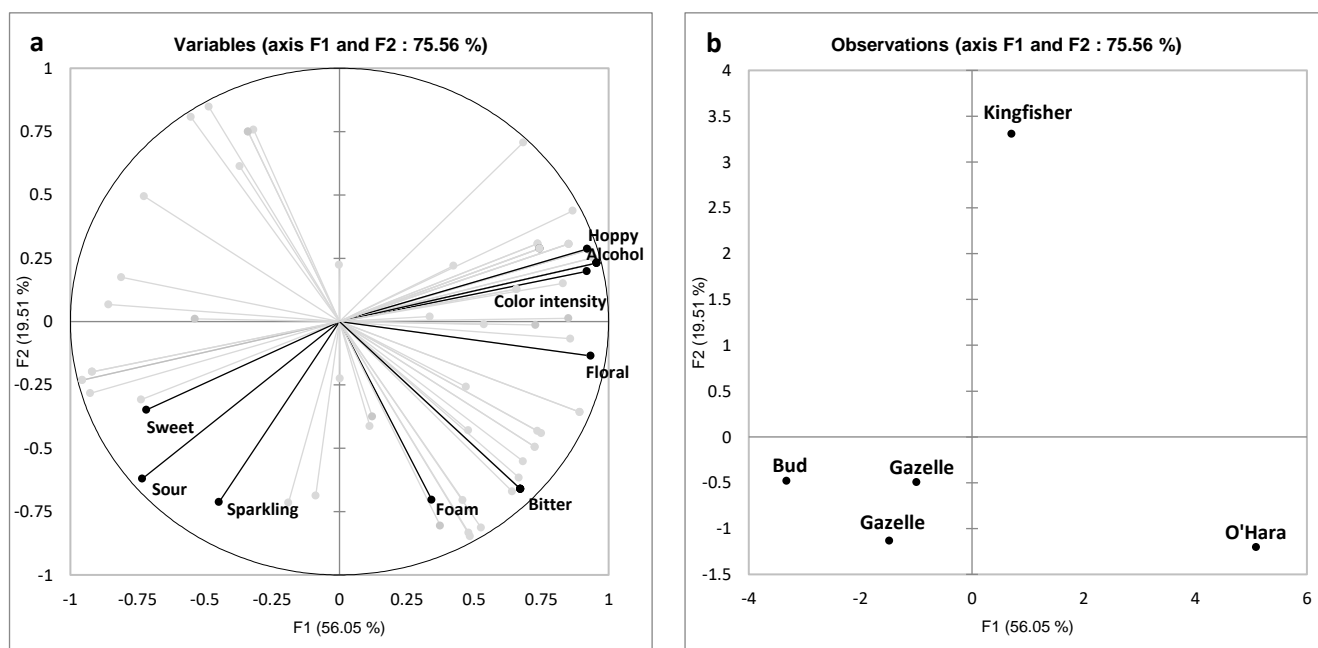
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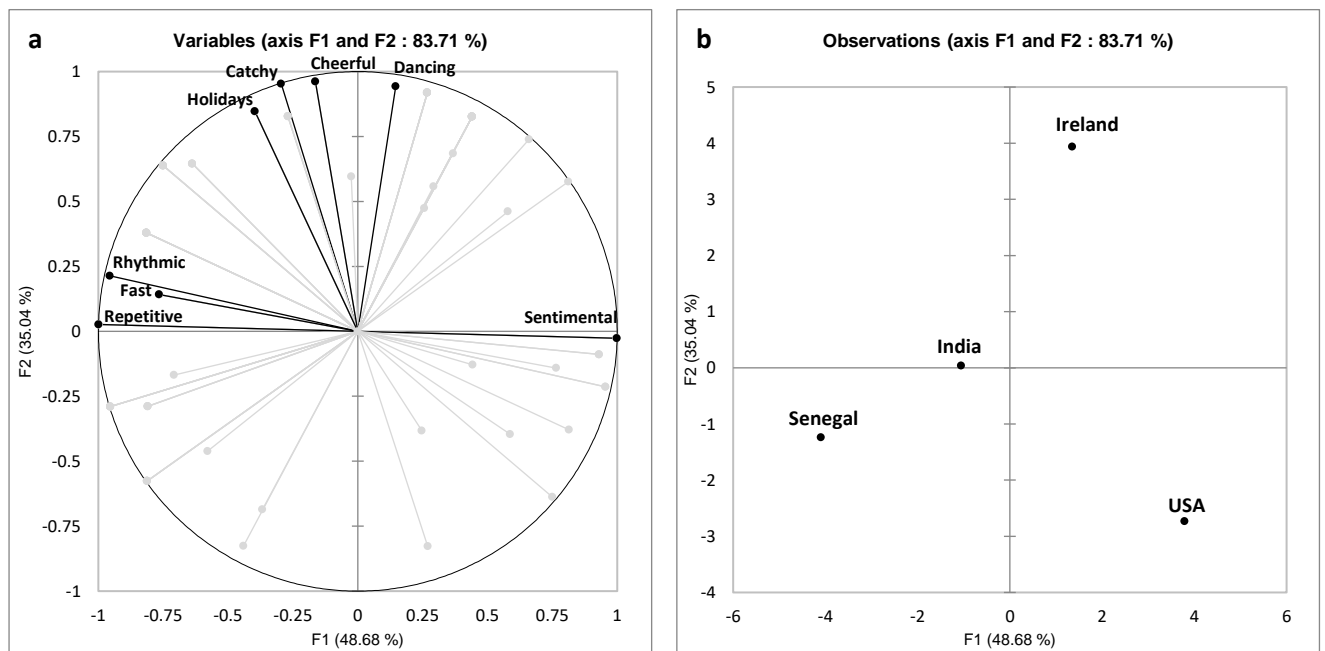
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Figure 1. Multiple Factor Analysis (MFA) plots of flash profile data on beers for dimensions 1 and 2 (1a: descriptors; 1b: Beer map).



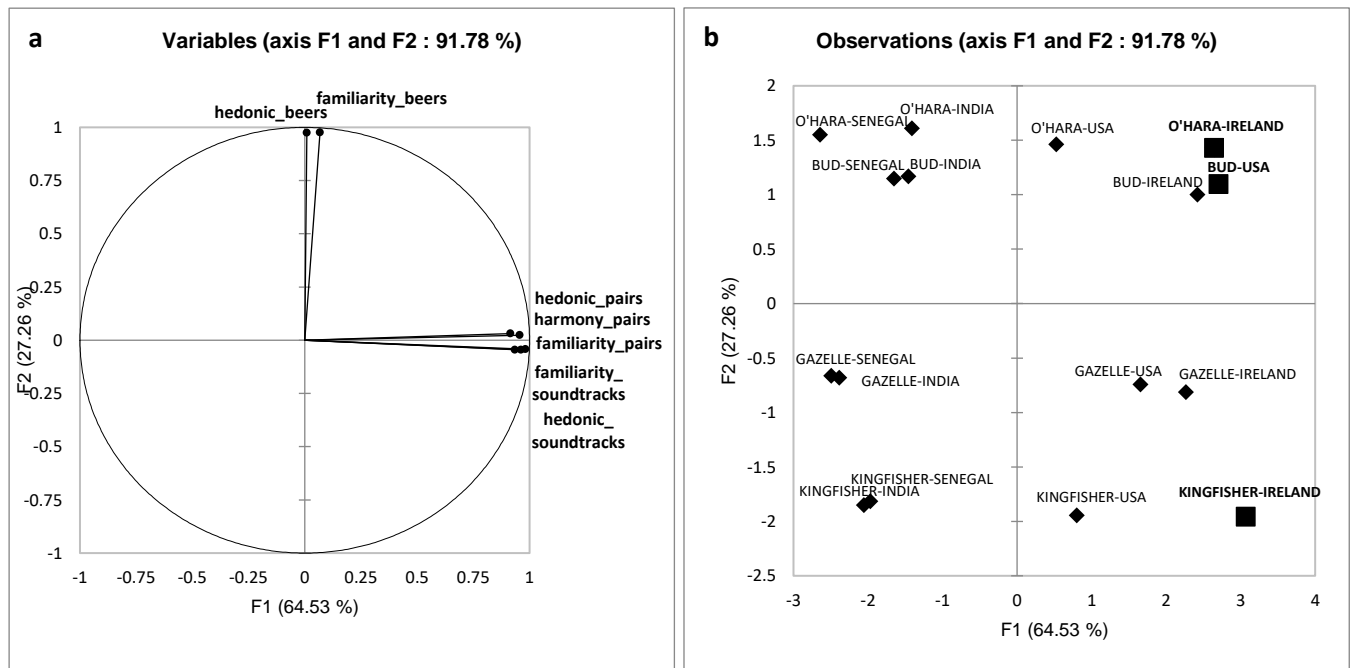
Only relevant descriptors are presented in figure 1a: either descriptors that were cited at least by three different participants and whose contribution is greater than the mean contribution of all descriptors or having a $\cos^2 > 0.5$.

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



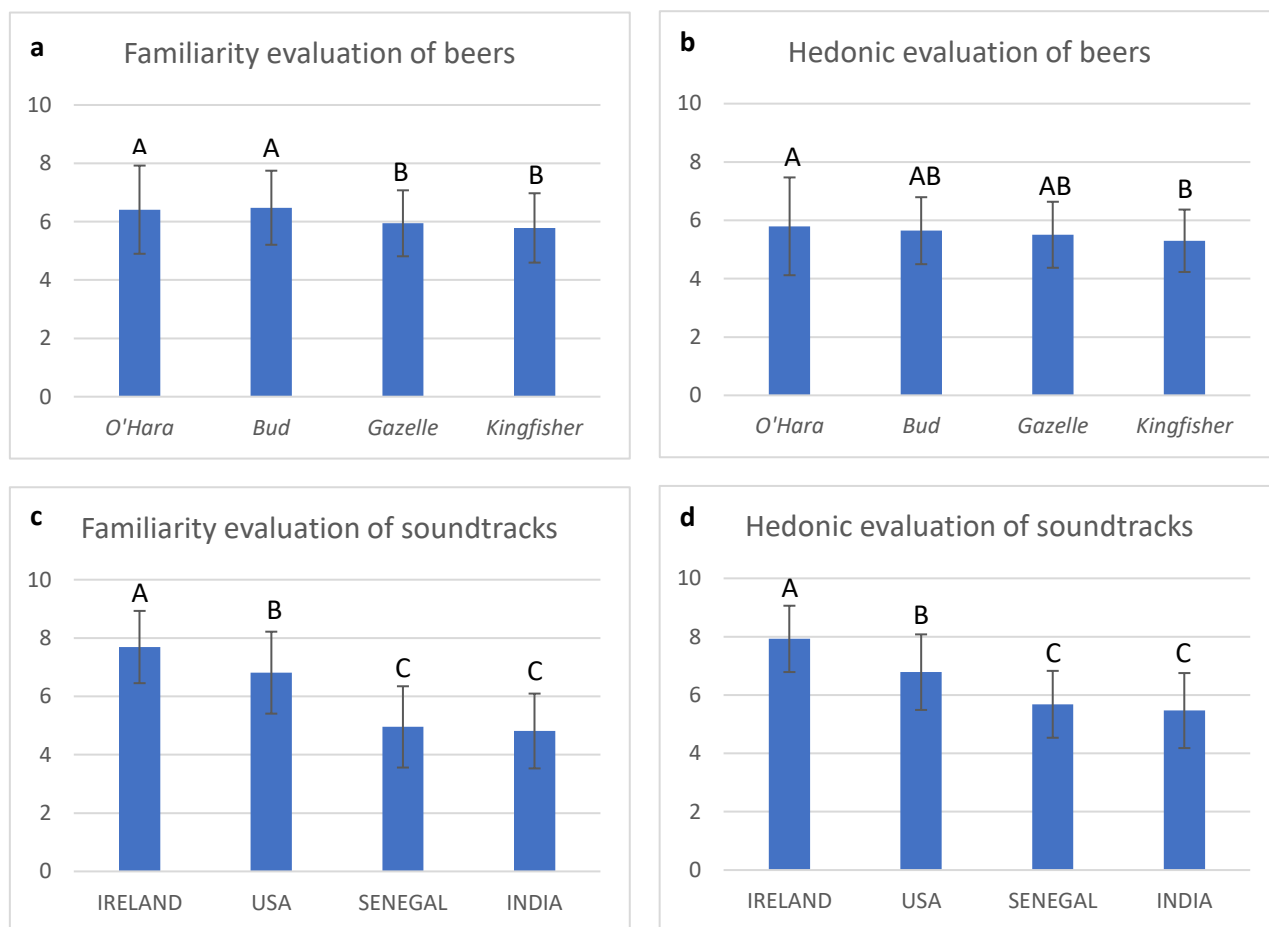
Only relevant descriptors are presented in figure 2a: either descriptors that were cited at least by three different participants and whose contribution is greater than the mean contribution of all descriptors or having a $\cos^2 > 0.5$.

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	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.