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## Effect of perceptive enrichment on the efficiency of simulated contexts: Comparing virtual reality and immersive room settings

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# Food Research International

## Effect of perceptive enrichment on the efficiency of simulated contexts: Comparing Virtual reality and Immersive room settings

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<b>Abstract:</b>	<p>In sensory sciences, the conventional consumer tests (CLT, HUT), offer either a high internal or external validity but not both together. In recent years, immersive approaches have been developed to achieve both internal and external validity at the same time, i.e., environments close to real-life consumption settings with controlled variables. Virtual reality is one of the most promising ones. This article presents a cross-setups study, involving more than 270 consumers. We assessed here the internal and external validity of two different immersive setups simulating the consumption episode 'eating a sandwich for lunch in a park'. These two experimental conditions were a context room (N=57) and a VR environment (N=55). We added two control conditions: a real park in summer (N=56) and scenario-only in sensory booths (duplicated condition, N1=59, N2=52). For each condition, four sandwich recipes were evaluated in a between-participants design. One of the recipes was duplicated for a reliability assessment. Participants were thus given five samples presented in a sequential monadic order, evaluated on hedonic criteria. And they closed the experiment with a questionnaire measuring their level of immersion. We hypothesized that the two immersive setups would achieve a higher immersive capacity than the scenario-only condition. As expected, these immersive setups showed strong external validity, participants being more immersed and engaged than in sensory booths, while maintaining an internal validity as efficient as in the control conditions.</p>
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**HIGHLIGHTS – ‘Effect of perceptive enrichment on the efficiency of simulated contexts: Comparing Virtual reality and Immersive room settings’**

- Scenario projection can maintain product evaluation, but keep immersive weaknesses.
- Virtual reality and immersive room can provide strong immersion close to real-life.
- Immersion in virtual reality outperformed immersive room with outdoor simulation.

# 1 **Effect of perceptive enrichment on the efficiency of simulated** 2 **contexts: Comparing Virtual reality and Immersive room settings**

3  
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5  
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## 11 **HIGHLIGHTS**

- 12     ▪ Scenario projection can maintain product evaluation but keep immersive weaknesses.
- 13
- 14     ▪ Virtual reality and immersive room can provide strong immersion close to real-life.
- 15
- 16     ▪ Immersion in virtual reality outperformed immersive room with outdoor simulation.
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- 18
- 19
- 20

## 21 **ABSTRACT**

22  
23         This study was designed within the methodological framework of sensory and consumer  
24 sciences, where conventionally internal and external validity are approached separately (e.g. CLT vs  
25 HUT). **Here is explored the added value of new immersive strategies, such as virtual reality, on their**  
26 **ability to achieve both: internal and external validity. This article presents a comparative study between**  
27 **different experimental setups the positioning of new immersive strategies, such as virtual reality, in the**  
28 **search for a junction between internal and external validity. This article presents a cross setups study,**  
29 **involving** more than 270 consumers. Two different immersive setups were appraised, simulating the  
30 consumption episode 'eating a sandwich for lunch in a park': a context room (N=57) and a VR  
31 environment (N=55). We added two control conditions: a real park in summer (N=56) and scenario-  
32 only in sensory booths (duplicated condition, N1=59, N2=52). A set of sandwiches were evaluated in a  
33 between-participants design, with one duplicated recipe for a reliability assessment. Participants  
34 evaluated samples on hedonic criteria and closed the experiment with a questionnaire measuring their  
35 level of immersion. After classification of the questionnaire variables, seven underlying dimensions

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36 were identified, with significant differences between conditions on the credibility of the environment  
37 and the scenario. As expected, with strong external validity, the simulated environments ~~are~~ were more  
38 immersive than the conventional booth with scenario and less immersive than a real-life environment.  
39 Although the immersive conditions did not stand out from the other conditions on the product evaluation  
40 performance, all the conditions revealed a high level of internal validity. Mean scores and rankings of  
41 the products, participants' repeatability and discriminatory power remained comparable to the real park  
42 environment indices.

43

44 **Key words:** Virtual reality, immersion, context, scenario, park, sandwich.

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45 **1. INTRODUCTION**

46

47 Many studies have shown that context influences food consumption experience (Edwards et al.,  
48 2003; Meiselman, 2019). To appraise a consumer's hedonic and emotional perceptions, it is therefore  
49 important to consider the consumption context (Köster, 2003). In sensory sciences, the quality of  
50 measurements is expressed in terms of internal and external validity (Jaeger & Porcherot, 2017). Internal  
51 validity refers to the comparison of different products, and to whether observed differences are truly due  
52 to the nature of the products, and not influenced by the experimental conditions. Internal validity is  
53 emphasized in the Central Location Test (CLT). By contrast, external validity refers to the ability of an  
54 experimental setup to faithfully reproduce reality. It depends on the stimulus presented, the context of  
55 evaluation, and the participant's task (Schmuckler, 2001). The Home Use Test (HUT) emphasizes the  
56 external validity of a measurement, i.e., its ability to reflect how a consumer feels in real-life  
57 consumption conditions. There is therefore a conceptual opposition between the CLT and the HUT, each  
58 emphasizing one type of validity at the expense of the other, and so yielding often conflicting results  
59 (Delarue & Boutrolle, 2010).

60

61 The contextualization of sensory measurement aims to propose setups that simultaneously offer  
62 high levels of both internal and external validity. Various contextualization setups are described in the  
63 literature (Porcherot et al., 2018). They range from a simple scenario presented in a conventional sensory  
64 booth, to studies in an ecological environment such as an experimental or real restaurant. In recent years,  
65 virtual reality (VR) setups have proved promising (Ischer et al., 2014; Persky et al., 2018; Siegrist et al.,  
66 2019; Ung et al., 2018) for developing sensory measurements presenting both high internal and high  
67 external validity.

68

69 VR enables participants to engage in a sensorimotor activity in a digitally created environment  
70 (Fuchs et al., 2006). Comparative studies of immersive setups have underlined the importance of the  
71 interactions that occur between the participant and the recreated environment (Bangcuyo et al., 2015;  
72 Hathaway & Simons, 2017; Porcherot et al., 2018). Sinesio et al. (2019) conducted a study on beers,  
73 comparing several immersive setups that simulated a context of consumption in a pub. They carried out  
74 tests (1) in an immersive room, (2) with a 360° video projection, (3) using VR, comparing them with  
75 tests in sensory booths and in a real-life situation in a pub. The results of this first large-scale study were  
76 similar for VR, the immersive room and the real situation relative to the 360° video and the booth tests.  
77 These findings suggest that environments recreated either in immersive rooms (Sester et al., 2013;  
78 Sinesio et al., 2018), or by VR (Ischer et al., 2014; Persky et al., 2018; Siegrist et al., 2019; Ung et al.,  
79 2018), are promising setups for contextualizing sensory studies. The recent studies of Hannum et al.  
80 (2019), Hannum et al. (2020), and Lichters et al. (2021) add to these results in support of  
81 contextualization in an immersive room, relative to the conventional booth and the real-life situation, in

82 wine bar, pub, and coffeehouse settings. At the individual level (intra-individual comparisons)  
83 immersive rooms seemed to bring evaluations of wines (Hannum et al., 2019; Hannum et al., 2020),  
84 beers and cappuccinos (Lichters et al., 2021) closer to those made in real-life settings. However, studies  
85 comparing the potential of contextualization setups are still few in number. Until now, setups have been  
86 studied as wholes, in a comparison of conditions “with” vs “without” contextualization (setups vs CLT),  
87 although their effects may derive from separate factors, such as evocation and perceptive stimulation.  
88 We will try here to explore more on the perceptual added value of these devices, beyond the conceptual  
89 contribution of the context, which can already be introduced out of perceptive stimulation (e.g. scenario  
90 in booths).

91  
92 A context groups a set of variables that describe the physical, social and temporal environment  
93 of a consumption act. These variables, which are external to the individual, acquire meaning through  
94 the individual’s own ‘frame of interpretation’ determined by their system of beliefs and values, prior  
95 experience, level of expertise, physiological and emotional state at the time, and motivations. Bisogni  
96 et al. (2007) report that in daily life, external and internal variables do not vary independently, but are  
97 organized in specific patterns, termed ‘consumption episodes’. They correspond to a particular situation  
98 where a given type of product is usually consumed to meet a specific need (nutritional, affective, social,  
99 etc.) (Bisogni et al., 2007; Blake et al., 2007; Cruwys et al., 2015; Jaeger et al., 2011). Piqueras-Fiszman  
100 & Spence (2015) suggest that a consumption episode is a memorized representation of a set of  
101 external and internal variables, together with foods that are frequently experienced together, a sort of  
102 prototypical situation. The contextualization of sensory tests should aim to reactivate the representation  
103 of the consumption episode in participant mind, including the expectations generated by the  
104 consumption context. In an immersive situation, the experience a participant has with the product of  
105 interest should be close to that in real everyday life. The reactivation of the consumption episode can be  
106 induced by a conceptual evocation. This is the scenario method, where a participant imagines a  
107 consumption episode from a verbal description of a situation. A consumption episode can also be  
108 reactivated by the presentation of a set of perceptive indices congruent with the consumption episode.  
109 These are immersive setups in which variables such as place, atmosphere, time of day, social setting,  
110 etc. relevant to the consumption episode in question are recreated and presented for the participant.  
111 These indices will thus channel the participant toward the closest remembered consumption episode,  
112 which will be reactivated. However, the presence of perceptive indices can have an inherent utility:  
113 according to Dinh et al. (1999), perceptive enrichment enhances the ‘feeling of presence’.

114  
115 Therefore, our aim was to study the effect of the perceptive enrichment provided by two setups,  
116 a context room (CR) and a virtual reality system (VR), in addition to the effect induced by mere  
117 evocation of the consumption episode. Our hypothesis was that the real environment would be more  
118 immersive than the sensory booths and that the two immersive setups would be intermediate.

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## 119 2. MATERIALS & METHODS

120  
121 The perceptive enrichment of the setups studied was explored through the consumption episode  
122 ‘eating a sandwich in a park in summer during lunch break’. Four sandwich recipes were evaluated in  
123 this context, adopting a conventional CLT strategy, i.e., a sequential monadic evaluation of a sample of  
124 each product. The two immersive setups tested were compared to two reference situations: (i) a CLT  
125 carried out in sensory booths, and (ii) a test carried out in a real park. We note that this was not strictly  
126 an HUT, which would have entailed offering a single sandwich to be consumed as a complete lunch in  
127 the park. To ensure that the same consumption episode was evoked for all four setups, a scenario was  
128 given to the participants in all the experimental conditions at the start of the test – booth included.  
129 Consistent with the consumption episode evoked, all the tests took place on a weekday at lunchtime.

### 130 131 *2.1. Participants*

132  
133 In all, 279 adult volunteers, aged 18–67 years (median age 30 years, 34% males, 66% females),  
134 used to eating sandwiches, were split into five test contexts: Park ( $N = 56$ ), Context Room ( $N = 57$ ),  
135 Virtual Reality ( $N = 55$ ) and sensory booths repeated in parallel to the two simulated contexts (Booth 1,  
136  $N = 59$ ; Booth 2,  $N = 52$ ). Since the two immersive devices are located at two different geographical  
137 locations, we duplicated the booths condition, in order to ensure the comparability of the recruited  
138 populations.

139  
140 The study was carried out in accordance with the international ethical guidelines for research  
141 involving humans established in the Declaration of Helsinki, as well as in accordance with a  
142 longstanding internal code of conduct for sensory science. Data were collected following the EU General  
143 Data Protection Regulation (EU 2016/679).

144  
145 Upon arrival at the laboratory, participants read and signed an informed consent form. They  
146 were acknowledged at the end of the session with a sack lunch.

### 147 148 *2.2. Products*

149  
150 The products were industrial deep-frozen mini sandwiches. Fillings were goat’s cheese and  
151 tomato, cured ham and butter, smoked salmon and lemon, and grilled vegetables and cumin ( $\times 2$ ) (**Figure**  
152 **1**). They were thawed on the day before the experiment at 4°C for 24 h according to the manufacturer’s  
153 instructions.

154



155 The samples were packed individually, labeled with a three-digit code and placed for each  
156 participant in a lunchbox, stored at 14°C until use.

157

158 “Insert Fig.1 here”

159

### 160 2.3. Identification of the consumption episode

161

162 The consumption episode was built from the responses to prior questions asked in interviews  
163 lasting 5–10 min ( $N = 15$ , naïve subjects): “If I say, ‘sandwich’ what occasion do you think of? Now, if  
164 I say, ‘eating a sandwich in a park’, describe the picture you have in mind”. We constructed the scenario  
165 and the contexts from these responses; these are presented in **Table 1**. This study took place in 2019.

166

167 “Insert Table 1 here”

168

### 169 2.4. Performance criteria

170

171 Comparing the environments meant choosing performance criteria beforehand. In studies  
172 designed to compare experimental contextualization setups, criteria most often concern product  
173 evaluation. As these are the most important aspects for products evaluation and products development,  
174 these criteria comprise mean liking scores either absolute values or product ranking, level of product  
175 discrimination and intra- or inter-session repeatability (Galiñanes Plaza et al., 2019). We explored these  
176 criteria for the experimental setups tested. And to reach the direct effect of the setups on the participants'  
177 feelings, we also measured individual immersion.

178

179 In the literature, immersion is a complex concept. Slater & Wilbur (1997) define it as the  
180 description of the technology and the extent to which it produces an illusion of reality. Fuchs et al.  
181 (2003) add that combined with the interaction, immersion produces a ‘feeling of presence’, of ‘being  
182 there’. However, as the concept of immersion is not completely stable, there is still no firm consensus  
183 on its measurement, which may be behavioral, physiological or declarative. Among the declarative  
184 measurements, there are multiple questionnaire variants, emphasizing the concept of presence and  
185 mental representation of the space in the VR literature, and the concept of engagement and situational  
186 consistency in the sensory and consumer literature, using a ranging number of items according to the  
187 study. The diversity of disciplines of application of presence models (technologies, psychology,  
188 marketing, ...) and the diversity of functioning of immersive media (books, TV, VR, ...) explain the  
189 variability of vocabulary, of approaches in the detailed explanation of the processes and the non-  
190 consensus on the measurement methods developed. In the present study, in an attempt to be as  
191 exhaustive as possible, we drew up a questionnaire of 35 items (**Appendix A**) selected from the VR and

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192 sensory and consumer ‘immersion’ literature (Bangcuyo et al., 2015; Hathaway & Simons, 2017; Hein  
193 et al., 2010, 2012; IPQ, 2016; Lusk et al., 2015; O’Brien & Toms, 2010; Sinesio et al., 2019; Slater et  
194 al., 1995; Usoh et al., 2000; Witmer & Singer, 1998), with the aim of including as much information as  
195 possible consistent with our application case. This questionnaire construction started with discussions  
196 between experts of the field, to identify the processes underlying the construction of presence  
197 (**Appendix B**), common or not between the different models in the literature. We then sought to  
198 crosscheck as many validated questionnaires as possible to best encompass these different notions,  
199 eliminating redundancies and we homogenized the remaining questions in their sentence construction  
200 and rating scale size (9-points).

201

## 202 **2.5. Procedure**

203 Individual sessions lasting 30 minutes were run (*up to 45 minutes in VR, which were longer*  
204 *owing to the oral evaluation and two-stage eating phase*) in the time interval 11 a.m. to 2 p.m. to  
205 correspond to the consumption episode evoked. The participants first entered a waiting room where they  
206 read the instructions and the scenario evoking the consumption episode ‘eating a sandwich in a park’,  
207 described with the following narrative (full written scenario): “*Great weather today! It’s near midday,*  
208 *you’re getting hungry, and you feel you need a break. You decide to go to fetch a sandwich, and you*  
209 *enjoy half an hour in a park, sitting on a bench facing the greenery, eating quickly while enjoying*  
210 *landscape... ”.*

211

212 The participant then entered the test context (Park, Context Room, Virtual Reality or Booth) to  
213 evaluate the samples: four recipes, one of which was duplicated (grilled vegetables and cumin) to  
214 evaluate intra-session repeatability. The five samples were evaluated in a sequential monadic manner in  
215 a Williams Latin square, for overall liking on the nine-point hedonic scale of **Peryam and Pilgrim**  
216 **(1957)** (adopted by Hein et al., (2012), Jaeger et al., (2017), **Hathaway and Simons**, (2017), Sinesio et  
217 al., (2019), and Hannum et al. (2019)). The participants ended their session with a declarative evaluation  
218 of the immersive test environment (**Appendix A**): 35-item questionnaire, nine-point scales, based on  
219 the questions of **Witmer and Singer**, (1998), **O’Brien and Toms** (2010), and Hein et al. (2010)  
220 (adopted by Hein et al. (2012), Lusk et al. (2015), **Hathaway and Simons** (2017), and Sinesio et al.  
221 (2019)).

222

223 The data was collected in writing, in the different environments, with the exception of the tasting  
224 phase in VR, where the questions/answers were provided orally. The participant did not have to remove  
225 the head-mounted display, in order not to interfere with the immersion feeling. The food products were  
226 also visible in the virtual environment (see contexts design in **Table 1**).

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228 **2.6. Data processing**

229

230 **2.6.1. Engagement and presence analysis**

231

232 In the objective to approach the setups external validity, through the measurement of immersion and  
233 presence feelings, several statistical hypotheses were tested. As we drew up a specific questionnaire to  
234 capture this wide concept, compiling questions from different literature origins, we first checked the  
235 structure underlying this measurement (H1). We then look at how the different conditions of context  
236 presentation are positioned to each other on these dimensions underlying immersion (H2).

237

238 **H1:** There is only one underlying dimension in the questionnaire characterizing the conditions of  
239 context presentation.

240 **H2:** Whatever the number of dimensions in the questionnaire, the conditions of context presentation  
241 are all evaluated at the same level.

242

243 The data analysis comprised two phases:

- 244 1. An exploratory phase to identify the number of underlying dimensions in the engagement and  
245 presence variables. This phase was carried out by classification of variables under JMP15®. It was  
246 completed with a principal component analysis (PCA) on the scores of these dimensions for all the  
247 participants (H1).
- 248 2. The scores of the observations on the new variables derived from the classification then underwent  
249 an ANOVA (H2). Each Condition was then compared with the reference, Park, using a Dunnett test.

250

251  $Scores_{jm} = \mu + \beta_j + \varepsilon_{jm}$  (**Equation 1**)

252

253  $\beta_j$ : effect of Condition  $j, j = 1 \dots 5$

254 with  $\varepsilon_{jm} \overset{iid}{\rightarrow} N(0, \sigma^2)$

255

256 **2.6.2. Product evaluation analysis**

257

258 In parallel, several statistical hypotheses were tested to approach setups' internal validity (assessment  
259 discrepancy, repeatability, products discrimination).

260

261 **H3:** The average hedonic scores, all products combined, are the same irrespective of the conditions of  
262 context presentation.

263

264 **H4:** The products are evaluated in a similar way from one condition of context presentation to another.

265

266 To support or refute these hypotheses, we performed an analysis of variance (ANOVA) on the hedonic  
267 scores with the effects of Product, Condition, Subject, Order and all the interactions that could be  
268 estimated.

269

270  $Y_{ijklm} = \mu + \alpha_i + \beta_j + \gamma_{k(j)} + \delta_l + \alpha\beta_{ij} + \alpha\delta_{il} + \beta\delta_{jl} + \alpha\beta\delta_{ijl} + \varepsilon_{ijklm}$  (**Equation 2**)

271

272  $\alpha_i$ : effect of Product  $i, i = 1 \dots 5$

273  $\beta_j$ : effect of Condition  $j, j = 1 \dots 5$

274  $\gamma_{k(j)}$ : effect of Subject  $k$  inside effect of Condition,  $k = 1 \dots 59$

275  $\delta_l$ : effect of Order  $l, l = 1 \dots 5$

276  $\alpha\beta_{ij}$ : interaction Product  $i \times$  Condition  $j$

277  $\alpha\delta_{il}$ : interaction Product  $i \times$  Order  $l$

278  $\beta\delta_{jl}$ : interaction Condition  $j \times$  Order  $l$

279  $\alpha\beta\delta_{ijl}$ : interaction Product  $i \times$  Condition  $j \times$  Order  $l$

280 with  $\varepsilon_{ijklm} \stackrel{iid}{\rightarrow} N(0, \sigma^2)$

281

282 If H3 is true, then the effect of Condition will not be significant.

283 If H4 is true, then the interaction Product  $\times$  Condition will not be significant.

284

285 **H5:** The products are discriminated in a similar manner, from a hedonic point of view, in each  
286 condition of context presentation.

287

288 To support or refute hypothesis H5, we performed an ANOVA for each condition of context  
289 presentation on the hedonic scores with the effects of Product, Subject, Order and the interaction  
290 Product  $\times$  Order.

291

292  $Y_{iklm} = \mu + \alpha_i + \gamma_k + \delta_l + \alpha\delta_{il} + \varepsilon_{iklm}$  (**Equation 3**)

293

294  $\alpha_i$ : effect of Product  $i, i = 1 \dots 5$

295  $\gamma_k$ : effect of Subject  $k$

296  $\delta_l$ : effect of Order  $l, l = 1 \dots 5$

297  $\alpha\delta_{il}$ : interaction Product  $i \times$  Ordre  $l$

298 with  $\varepsilon_{iklm} \stackrel{iid}{\rightarrow} N(0, \sigma^2)$

299

300 If  $H_5$  is true, then the Fisher statistics observed for the Product effect will be similar from one  
301 condition of context presentation to another.

302 **3. RESULTS**

303

304 **3.1. Environment and presence results**

305

306 *Underlying dimensions of questionnaire*

307

308 After classification of variables in the questionnaire, seven underlying dimensions were identified:

- 309 1. Credibility of the environment (Q09, Q18, Q19, Q20, Q21, Q22, Q23, Q29, Q30, Q31)
- 310 2. Credibility of the scenario (Q01, Q02, Q06, Q07, Q08, Q16, Q17)
- 311 3. Attractiveness of the test experience (Q03, Q04, Q05, Q10, Q11)
- 312 4. Environment discomfort (Q15, Q25, Q26, Q27, Q35)
- 313 5. Non-disconnection/ connection-awareness (Q14, Q28)
- 314 6. Novelty (Q12, Q24)
- 315 7. Experience encountered (Q13, Q32, Q33, Q34) (**Appendix A**).

316

317 Interestingly, the question numbers in each cluster show that these seven dimensions were  
318 evenly distributed in the questionnaire, ruling out a halo effect, and attesting to a high concentration of  
319 the participants right through to the end of the questionnaire.

320

321 Looking now at the proximity of our seven dimensions (**Figure 2**), we observe a first clear  
322 separation between attractiveness of the setup (positive feeling, represented by five dimensions) and  
323 discomfort liable to disturb the task (represented by two dimensions). Lastly, a final separation between  
324 the two dimensions ‘credibility of the environment’ and ‘credibility of the scenario’ shows their  
325 proximity. These were also the clusters that best discriminated the conditions (*F* conditions ‘credibility  
326 of the environment’ = 55.80,  $p \leq 0.0001$ , *F* conditions ‘credibility of the scenario’ = 17.69,  $p \leq$   
327  $0.0001$ , **Table 2**).

328

329

“Insert Fig.2 here”

330

331 *Discrimination of environments*

332

333 The differentiation of the conditions of context presentation was not at the same level according  
334 to the dimension considered in the questionnaire (**Table 2**), refuting our hypothesis H2. For example,  
335 the differences between the conditions context of presentation were very marked for the dimension  
336 ‘Environment credibility’ but very small for ‘Environment discomfort’.

337

338

“Insert Table 2 here”

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Although the participants in each condition were different, it is interesting to observe that the real environment (Park) was the most credible one (Figure 3), highlighting the power and sensitivity of the questionnaire.

“Insert Fig.3 here”

“Insert Fig.4 here”

Because experimental design varied the condition in which the location of the evoked consumption episode was presented, it is hardly surprising that the dimension ‘credibility of the environment’ ( $F = 55.80, p < 0.001$ ) ranked first for discriminating the conditions. However, as regards scenario, all five conditions were accompanied by the same scenario. The second place of the dimension ‘credibility of the scenario’ ( $F = 17.769, p < 0.001$ ) in the discrimination of conditions thus reveals an influence of the environment on the credibility of the scenario.

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For the dimensions that best discriminated our test environments, namely ‘credibility of the environment’ and ‘credibility of the scenario’, Virtual Reality came closest to the Park condition, followed by the Context Room (Figure 4).

This first finding attests to the credibility of the simulated environments and their support for immersion in the evoked scenario, with nevertheless some discrepancies between virtual reality and context room. This difference might be explained by the type of context studied. It may be easier with virtual reality to give an impression of open space for an outdoor context (park, green spaces), than with a context room where walls remain perceptible and may limit the immersion.

For the dimensions ‘connection – awareness of the environment’ and ‘experience encountered’, the two simulated environments (context room and virtual reality) came close to the real environment, whereas the neutral environments (scenario-only in a booth) differed significantly from the park.

Though close to the park in the dimension ‘connection – awareness of the environment’, the central position of virtual reality, not significantly different from the other four conditions, point to an ambiguity reported by the participants in session feedback. The existence in the virtual immersion process of successive phases of ‘departure’ from the real world and of ‘arrival’ in the virtual one (Kim & Biocca, 1997), could explain the central position of the virtual reality, biased by the ambiguity of the questions asked on connection to the environment and awareness of surrounding items, which could refer to either forgetting reality or acting in the virtual world (“Q14. How aware were you of the events

376 *in the real world around you (sounds, ambient temperature, other persons, etc.)?” and “Q28. How*  
377 *disconnected were you from the test environment?”).*

378  
379 The booths ranked last for overall immersive capacity, distinct from the real park, with  
380 equivalent levels. There were nonetheless some nuances on the credibility of the environment and the  
381 attractiveness of the test experience, where a discrepancy appeared, marking off the Booth-2, possibly  
382 because the projection was out of season (so less credible, less appealing).

383  
384 Besides these dimensions, making a deeper unidimensional analysis of the questionnaire items  
385 (**Appendix C**), it was surprising to find, for olfactive engagement, a stronger demarcation of the  
386 stimulated environments (VR and Context Room – both odorless) from the park, compared with the  
387 booths (odorless as well). The absence of odor seemed to have more weight in an already perceptively  
388 enriched environment than in one not enriched, as an attentional focus on missing items (*individual*  
389 *ANOVA “Q24. How much did the olfactive aspects of the test environment engage you?”:  $F = 5.50, p <$*   
390  *$0.001$   $p < 0.000$ ).*

391  
392 Different levels of sensitivity of the VR setup were also observed. For most of the participants  
393 (67%) no negative effect was reported. For the others, negative effects ranged from simple discomfort  
394 (24% – visual discomfort, uncomfortable headset, or disturbance from the interaction with the product  
395 and the glass of water) to dizziness or headaches (9%).

### 396 397 **3.2. Product evaluation results**

398  
399 The terms of the ANOVA (**Equation 2**) were not all significant (**Table 3**). The model was  
400 simplified by removing the non-significant terms one by one, starting with the interactions.

401  
402 **“Insert Table 3 here”**

403  
404 The duplicated presence of vegetable sandwiches in the same groups of *post hoc* significance  
405 of the interaction Condition × Product in this five-factor ANOVA (**Table 4**) confirmed the good  
406 repeatability of the participants in the evaluation of the overall liking of our products and attested to an  
407 equivalent level between the different test conditions.

408  
409 **“Insert Table 4 here”**

410  
411 For the final model, only the effects of Product, Condition and Subject were significant  
412 (**Table 5**).

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“Insert Table 5 here”

H3 is thus refuted because the effect of Condition was significant. The significance of the test comes from the difference in the means of the hedonic scores between Context Room and one of the booths conditions (Scenario Booth-2). However, no Condition had a mean significantly different from that of Park (Figure 5).

“Insert Fig.5 here”

H4 is supported because the interaction Product × Condition was not significant. There were no significant differences between the means of the hedonic evaluations of the same sandwich in different conditions of context presentation (Table 5).

Concerning the evaluation of the products themselves, the salmon sandwich was the most liked, followed by the cheese and ham sandwiches (no significant difference), and then the repeated vegetable sandwich (duplicate) (Figure 6).

“Insert Fig.6 here”

The discrepancies between the conditions of context presentation (Condition effect:  $F = 3.63$ ,  $p = 0.0061$  before clean-up of model vs.  $F = 3.57$ ,  $p = 0.0066$  after clean-up), and their strength of interaction with product evaluation (interaction Product\*Condition:  $F = 0.97$ ,  $p = 0.4909$  = NS), were low relative to the strength of discrimination among the products themselves (Product effect:  $F = 33.43$ ,  $p < 0.0001$  before clean-up vs.  $F = 34.19$ ,  $p < 0.0001$  after clean-up). This difference in weight between discrimination among products and discrimination among conditions of context presentation shows ease of identifying the products in all the conditions, probably owing to their distinct flavors. Smaller perceptive differences in the product set might conceivably have yielded different results. For example, a set of more similar flavors, such as several salmon sandwich recipes, might have given more weight to the discrimination among conditions of context presentation.

As regards product discriminatory power, we examined the  $F$  values for the Product effects of individual ANOVA by Condition (Equation 3 and Table 6).

“Insert Table 6 here”

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449 First, the range of  $F_{\text{product}}$  values, taken into account as an indicator of the discrimination of the  
450 products with the hedonic scores, is quite narrow (from 6.02 to 8.439) (Table 6). The hedonic  
451 differences between the products are not reduced or increased from condition to condition, which  
452 supports H5. For each condition, we calculated the ratio of  $F_{\text{product}}$  for this condition by  $F_{\text{product}}$  for the  
453 park condition. The ratio is higher than 1 for Context Room and both cases of Scenario: these conditions  
454 result in a higher discrimination of the product than in the reference condition (the park). The ratio is  
455 lower than 1 for Virtual Reality, the products are less discriminated in this condition than in the reference  
456 condition (Table 7).

457  
458 The important question is whether we would like (i) the best possible discrimination, or  
459 (ii) discrimination closest to the real situation. In the first case, the  $F_{\text{product}}$  of the scenario (Booth-2)  
460 condition would argue for neutral environments, whereas in the second case, the dynamics of the VR  
461 condition support simulated environments. Neutral environments do allow a stronger discrimination  
462 among products, but simulated environments come closest to the level of discrimination obtained in a  
463 real environment.

464

465

“Insert Table 7 here”

466 **4. DISCUSSION**

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468 *IMMERSIVE CAPACITY*

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For the immersive capacity of the simulated environments: a context room and a virtual reality system, we hypothesized to find setups at an intermediate level between neutral (booths) and real (park) environments (*test H2*). Our hypothesis was supported. As expected, overall, the immersive capacity of the simulated environments lay between the immersive capacity of the conventional booth with scenario and that of a real-life environment. Even so, simulated environments came closer to the latter than to the former. These results are in line with those reported in the literature (Sinesio et al. (2019) for beers in a bar context; Banguyo et al. (2015) for coffees in a coffeehouse context; Hathaway & Simons (2017) for cookies in a kitchen context; Lichters et al. (2021) for beers and cappuccinos in bar and coffeehouse contexts, respectively). In these studies, conventional sensory rooms had a lower immersive capacity than simulated environments as measured by self-administered questionnaires, derived from Witmer & Singer's presence questionnaire (Witmer & Singer, 1998) and O'Brien & Toms' engagement questionnaire (O'Brien & Toms, 2010). These results also provide additional information on the capacity of virtual reality, less studied than the context room setup.

Simulated environments have immersive capacities close to real-life environments. This is in line with Sinesio et al. (2019) (equivalent to the real situation) and Lichters et al. (2021) (slightly lower than in real conditions). In the present study, the VR setup especially led to a 'feeling of presence' close to the real-life environment, closer than the context room. This finding could be context dependent. For our depicted outdoor environment, the VR setup may help build the illusion of an open landscape. The eye-screen proximity of the head-mounted display helps the participant forget the technology responsible for perceptual stimulation ('illusion of non-mediation' – Lombard et al., 2000). Also, whatever the gaze direction, no limit to the environment is detected. The theatrical strategy of the context room, with a dim light and black walls, draws attention to the represented scene and blurs its limits. However, these limits do remain perceptible. The illusion can be disturbed when a participant looks away from the screen or even by elements within their peripheral field of vision. This limit could be less problematic for indoor than for outdoor environments. For instance, in a bar environment, Sinesio et al. (2019) found that the context room was more efficient than a 3D-VR setup. However, as stated by the authors themselves, the way the social environment was simulated and the difficulty of including an avatar in VR may also account for this result.

Overall, the hypothesis concerning the impact of perceptive enrichment was supported. According to Dinh et al. (1999) perceptive enrichment increases feeling of presence. Giving participants more perceptual cues is thus likely to increase the immersive power of the setup, leading to a stronger

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503 feeling of presence, although less desirable effects may occur, such as potential deviations of attentional  
504 focus on the perceptual dimension.

505  
506 Comparison between immersive setups is complex. The ultimate goal of an immersive setup is  
507 to cause participants to experience a 'feeling of presence'. The expected differences between setups are  
508 subtle and may affect only one or another of the presence dimensions (*test H1*). Inter-individual  
509 differences are also to be considered. For instance, participants prone to simulator sickness may  
510 experience a very different pattern of immersion efficiency from other participants because simulator  
511 sickness negatively affects the feeling of presence (Witmer & Singer, 1998). In the same line, Sinesio  
512 et al. (2018) reported divergent opinion on the distraction dimension for their immersive setup.  
513 Participants may be variably sensitive to perceptual stimulation originating from the environment and  
514 this may then differently affect the attention they pay to the tested products. Finally, as previously stated,  
515 setup efficiency may depend on the consumption episode. For instance, ~~Hathaway & Simons~~  
516 (2017) **Hathaway and Simons (2017)** pointed out that the distraction brought about by the immersive  
517 setup was different in the coffee-house and kitchen environments for the evaluation of coffee and  
518 cookies, respectively.

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519  
520 There are relatively few studies reporting immersive assessments of immersive setups, and the  
521 number of items used to assess immersion ranges from 4 to 21. Moreover, comparison across studies is  
522 difficult, as explored dimensions are not systematically the same from one study to another, and when  
523 they are the same, are sometimes assessed with different items. To gain a better understanding of the  
524 immersive processes in play and how setups modulate product experience and their evaluation, there is  
525 a need for a validated questionnaire, specifically adapted to consumer studies. This would require a  
526 clarification of the immersion, presence, and engagement concepts and how they interact. One challenge  
527 is to develop questionnaires adapted to any kind of experimental setup to enable ready comparison.  
528 Meanwhile, information on how participants get acquainted with each specific device are also crucial,  
529 as this process is central in any immersive experience (Auvray, 2004). With the aim of understanding  
530 devices and immersion phenomena, we have sought here for an exhaustive questionnaire, otherwise in  
531 a more applied objective of having a method for quickly verifying consumers feelings, new synthetic  
532 questionnaires are being developed (Hannum & Simons, 2020).

## 533 534 PRODUCT EVALUATION

535  
536 Although this study targeted the exploration of the external validity (ecological validity) of the  
537 devices of the experience contextualization (immersion measurements), we also checked the internal  
538 validity (on the products evaluation), for which booths are more commonly used (*tests H3, H4, H5*).

539

540 Irrespective of the experimental conditions, the mean scores of the products, their ranking,  
541 repeatability and the discriminatory power of the group of participants, were of the same order as in the  
542 real environment (park). Performance in simulated environments (virtual reality and context room) was  
543 thus no different from that with a scenario in a booth as regards liking. The perceptive enrichment  
544 proposed by the immersive setups did not increase the validity of the measurement (internal validity),  
545 however this one was already very high as shown by the level of intra-session repeatability (duplicated  
546 sample) in all the conditions, and the reproducibility between the groups of participants in the booths.

547

548 Comparisons between sensory booths (CLT) and real-life situation (HUT) generally show  
549 discrepancies in product evaluation (Delarue & Boutrolle, 2010). Our study found no such discrepancy.  
550 This can be partly explained by a ceiling effect: the liking of the test sandwiches ranged very widely.  
551 As reported by other authors (Delarue et al., 2019), the amplitude of the differences in the product space  
552 is a key factor in comparing the experimental setups. The product space may thus have been too large  
553 in terms of sensations and/or liking, alongside the modulations induced by the immersion. Also, the  
554 perceived proximity of the two sandwiches with the same recipe is influenced by their distance from the  
555 other products of the set. More proximity within the product space, as it would be in the application  
556 framework of the improvement of the same recipe, could also accentuate differences between contextual  
557 conditions on this point. Nevertheless, it is important to note that in our case study the difficulty is to  
558 differentiate here the perceptual integration, from the conceptual evocation "only" of the context. In fact,  
559 it must be emphasized that in the studies reported in the literature, the booth condition does not generally  
560 include the presentation of a scenario. The products were chosen here for their congruence with the  
561 context of 'lunchbreak sandwich in a park in summer', an effect of this context was expected in  
562 comparison to other product uses, but the strength of the evocation alone facing this effect has been  
563 underestimated. The scenario presented systematically, including in booths, may increase external  
564 validity in all the conditions and helped reduce the discrepancies usually observed. The gap between  
565 booths and real environment is also more nuanced here by the fact that our real-life situation did not  
566 fully correspond to the classical HUT: the participant had several samples to evaluate instead of  
567 consuming a whole sandwich as a meal before evaluating it. Here too, the experimental setup may have  
568 helped diminish the difference from the booth condition.

569

570 Our study showed no significant difference between booths (CLT) and immersive environments  
571 for average liking of the products, liking pattern or repeatability. Two studies conducted respectively on  
572 coffees and cookies (Bangcuyo et al., 2015; Hathaway & Simons, 2017) showed overall higher liking  
573 scores in the contextual environment (immersive room with projection of a coffee-house scene and  
574 cookie-making at home, respectively). The authors explain the evaluation discrepancy by the fact that  
575 the environment in an immersive room was preferred to that of a booth, which would induce a higher

576 liking score for the products through a halo effect. However, in these studies, the booth condition had  
577 been set up without a scenario, so without evocation of a particular consumption episode. As underlined  
578 by Lichters et al. (2021), in conventional CLT (without contextualization by a scenario) consumers can  
579 have different consumption episodes in mind when they evaluate a product. Episodes may thus differ  
580 from one consumer to another and may differ from that evoked by contextualization in immersive setups.  
581 The results of Hannum et al. (2019) for wines evaluated in a real wine bar, immersion, or non-  
582 contextualized booth, support this view. The authors report that for intention to order wines in a ‘wine  
583 bar - restaurant’, the participants discriminated among the wines and desired them more when immersed  
584 in a ‘wine bar’ context, whereas they reported no significant difference when the evaluation was carried  
585 out in a booth. We can assume that the differences observed in immersion derive from a closer agreement  
586 among the participants, who can easily refer to the same consumption episode when they are immersed  
587 in a bar. In a booth, the participants may have more difficulty imagining a consumption episode in a bar  
588 or else can imagine various occasions included in the ‘bar-restaurant’ category. When asked if they  
589 would purchase the same wine to drink at home, wines were not discriminated either in a booth or in an  
590 immersive situation. As the question (consumption in the private sphere) did not refer to a consumption  
591 episode linked to the context evoked by the immersive setup (bar) the environment did not guide the  
592 participants toward one consumption episode rather than another. It may thus be that the discrepancy  
593 observed between CLT and immersive conditions comes from consumption episodes imagined by the  
594 participants. These will be more heterogeneous in a booth where no clue is given, than in an immersive  
595 situation where the environment points to a more specific situation. Our results are consistent with this  
596 hypothesis. The scenario presented at the start of the session in each experimental condition led the  
597 participants to evoke the same consumption episode in all the conditions. Because the scenario described  
598 a very precise episode, it probably left little room for inter-individual variations.

599  
600 Overall, and irrespective of the condition of context presentation, highly significant differences  
601 were observed between samples. However, comparison of levels of discrimination between  
602 experimental conditions showed a slightly higher discrimination in booths than in the other conditions.  
603 This result was expected, since the booth condition is deliberately designed to optimize the internal  
604 validity of measurements, of which discriminatory power is one. This highlights that a higher  
605 discriminatory power does not necessarily mean a better external validity. As underlined by Jaeger &  
606 and Porcherot (2017), differences in discrimination between CLT and immersive environments are not  
607 systematic. The literature shows conflicting results on this point. Bangcuyo et al. (2015) and Hathaway  
608 and Simons (2017) observed a higher discrimination in an immersive situation than in booths (CLT).  
609 By contrast, Andersen et al. (2019) found no difference in discrimination for liking of sun cream odors  
610 between booths (CLT) and a ‘beach’ context given by either a photograph or a VR-360 setup. Even so,  
611 the immersion was effective, as the desire for cold vs. hot drinks was more marked in the ‘beach’ context  
612 that in the booths. Lastly, Sinesio et al. (2018) observed that for perceived vegetable freshness,

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613 conventional booths produced greater discrimination than an immersive room (garden-patio  
614 environment). For Sinesio et al. (2019) the link between discrimination and immersion may depend on  
615 the product category and the context evoked. However, the underlying mechanism is unclear. A first  
616 explanation may lie in the nature of the products. Lichters et al. (2021) suggest that the strength of the  
617 contextual effect on the product perception may depend on how well the product is anchored in the  
618 consumption episode. Thus De Graaf et al. (2005) report context-stable liking (sensory laboratory vs.  
619 army field study) of sweet snacks, whereas familiar meals were more context-sensitive. Product  
620 versatility (Cardello & Schutz, 1996) is a key characteristic. It may modulate the impact of the context  
621 according to the perceived congruence between product and context (Dacremont & Sester, 2019). For  
622 versatile products like snacks, practically all contexts are perceived as appropriate, sensory booth  
623 included, whereas for meals, which are less versatile, the booth condition may be perceived as non-  
624 congruent. Another possible explanation may lie in the nature of the task required of the participants  
625 during the test and its degree of ecological validity (Galiñanes-Plaza, 2019). The attention paid to a  
626 product can thus vary widely according to the consumption episode considered. It can be central, like  
627 when a beer is being drunk in a beer cellar, or largely secondary, such as when the beer is drunk watching  
628 a match with friends. The task required of the participants in CLT, through drawing attention to the  
629 product, may thus come closer to what a consumer experiences in the first situation than in the second.  
630 All these factors indicate that the link between discriminatory power and external validity is complex  
631 and needs more thorough study. This argues for pursuing the exploration of immersive setups as  
632 simulators of real-life situations with indices other than evaluation performance measurements. For  
633 example, Lichters et al. (2021) considered the consumer segmentation revealed in different contexts for  
634 beers and cappuccinos. They highlighted a closer similarity between simulated and real environments,  
635 compared with the booth condition (CLT).

636  
637 Beyond virtual reality, other technologies are gradually being rolled-out in sensory and  
638 consumer sciences, such as augmented mixed reality devices (MR, AR), a new methodological  
639 competitor for the context room and the virtual reality (Wang et al., 2021). As presented by Low et al.  
640 (2021), through the positioning of an augmented mixed reality device facing booths and a real situation  
641 of chocolate snacks consumption in a coffeehouse, this augmented mixed reality tool appears promising  
642 to bring the tasting experience closer to reality. These new technological interests invite toward new  
643 comparative studies.

644

645

## 646 **5. CONCLUSION**

647

648 Evoking a consumption episode by a scenario presented in a booth has limited immersive  
649 capacity. The perceptive enrichment provided by recreated or real environments improves not only the

650 credibility of the environment, as expected, but also the credibility of the evoked consumption episode.  
651 The enhanced immersive capacity of our simulated environments had little impact on product  
652 evaluation. Performance in terms of repeatability and discrimination was very high, irrespective of the  
653 experimental setup. This result may be due to a ceiling effect. Overlarge differences in the product set  
654 make differences in evaluation between setups harder to evidence. Overall, the simulated environments  
655 presented a good level of internal validity and a strong potential to attain the external validity aimed for.  
656 The perceptive enrichment of the environment seems to be an important factor in reaching this objective.  
657

658 Evaluating the effectiveness and utility of an immersive setup calls on a number of criteria. A  
659 first one is the ratio of the expected differences between the various products of interest to the  
660 modulations that the context is liable to induce. This is difficult to assess because the differences are not  
661 necessarily known beforehand. A second one concerns the nature of the consumption episode and its  
662 relevance to the type of product to be evaluated. This concerns both the products and the setups. A  
663 product of interest can be anchored to ranging degrees in a consumption episode, and so be perceived  
664 as variably congruent with the environment, ultimately affecting its perception. The setup can also  
665 simulate important aspects of the chosen consumption episode with ranging degrees of effectiveness.  
666 VR allows a strong interaction with the simulated environment and so is advantageous for situations in  
667 which action is an integral part of the situation. Conversely, it can be less effective when the technology  
668 imposes limits as in the case of avatars to simulate a social environment. A last criterion concerns the  
669 right dimensions to assess the immersive capacity of a setup and the complex relations linking the steps  
670 in the immersion process with the feeling of presence in the environment and engagement in the task.  
671 On these methodological points, we still lack the perspective needed to fully describe and compare  
672 different immersive setups.

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674

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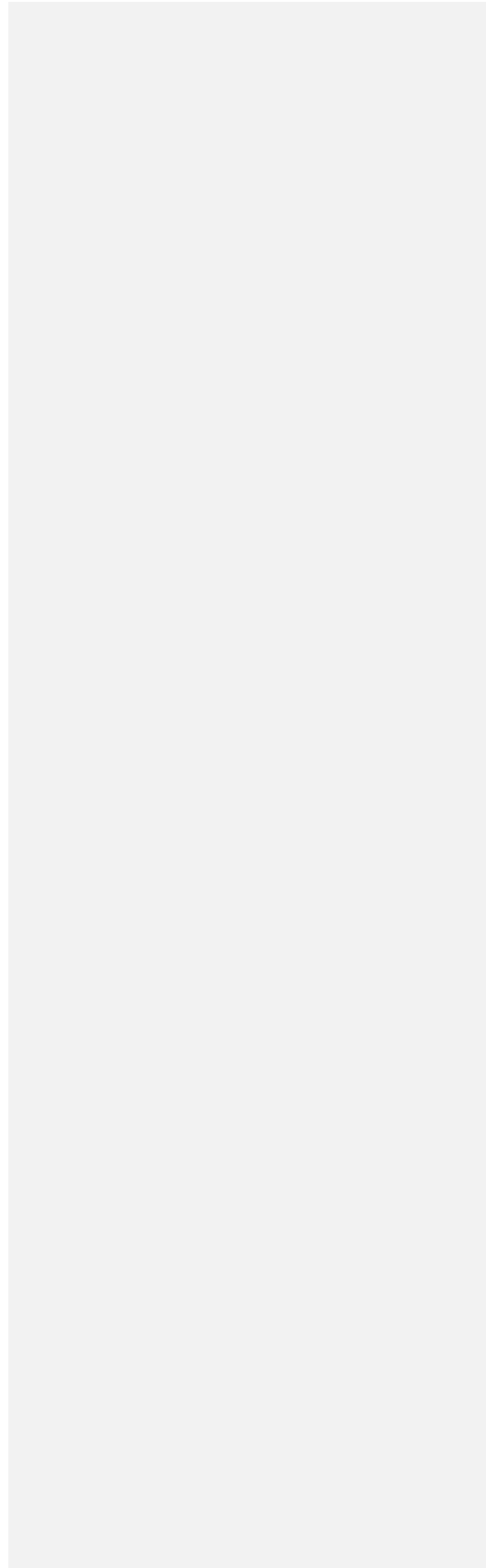
843 **8. APPENDIX**

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**CHEESE**



**SALMON**

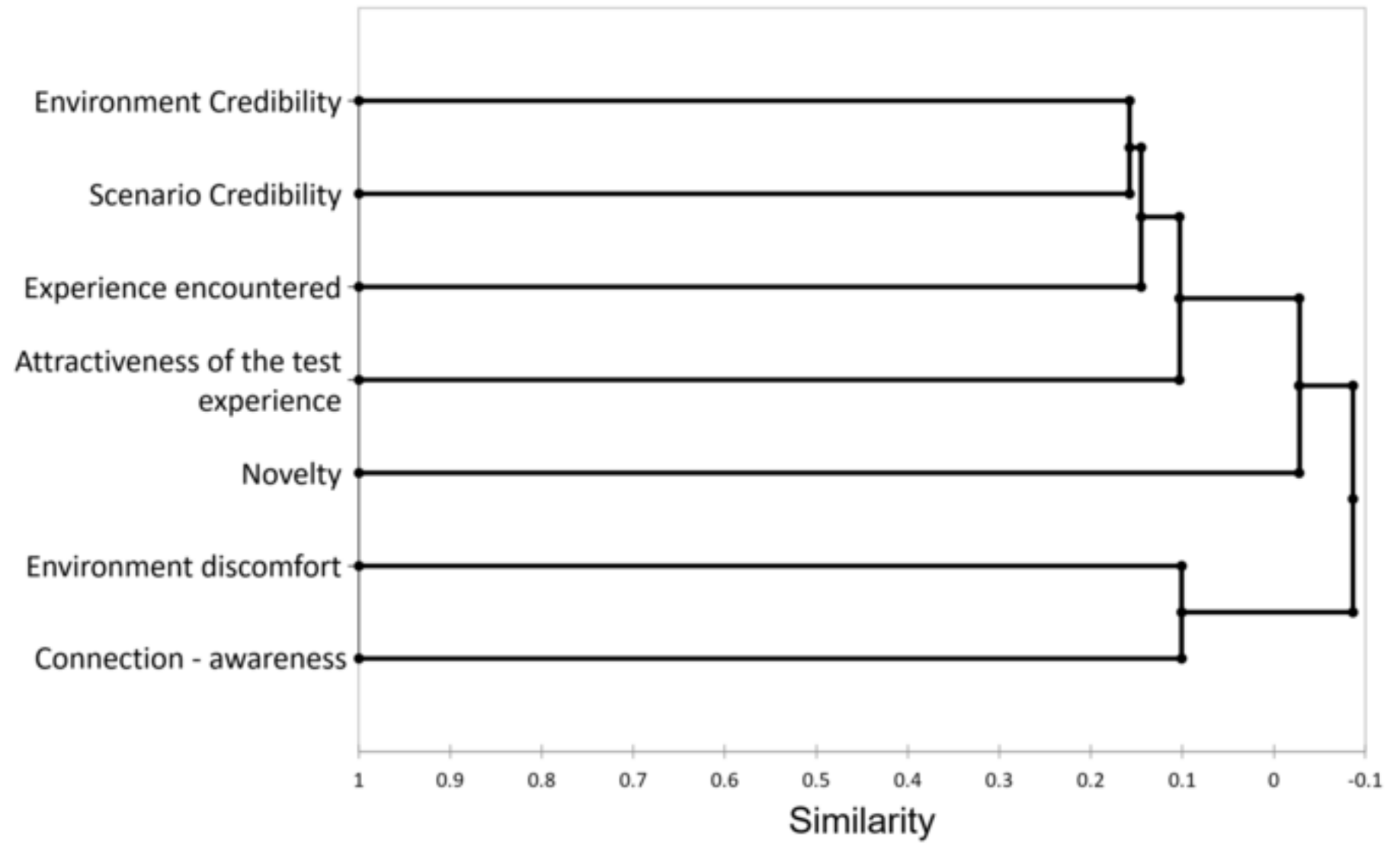


**HAM**



**VEGETABLES**







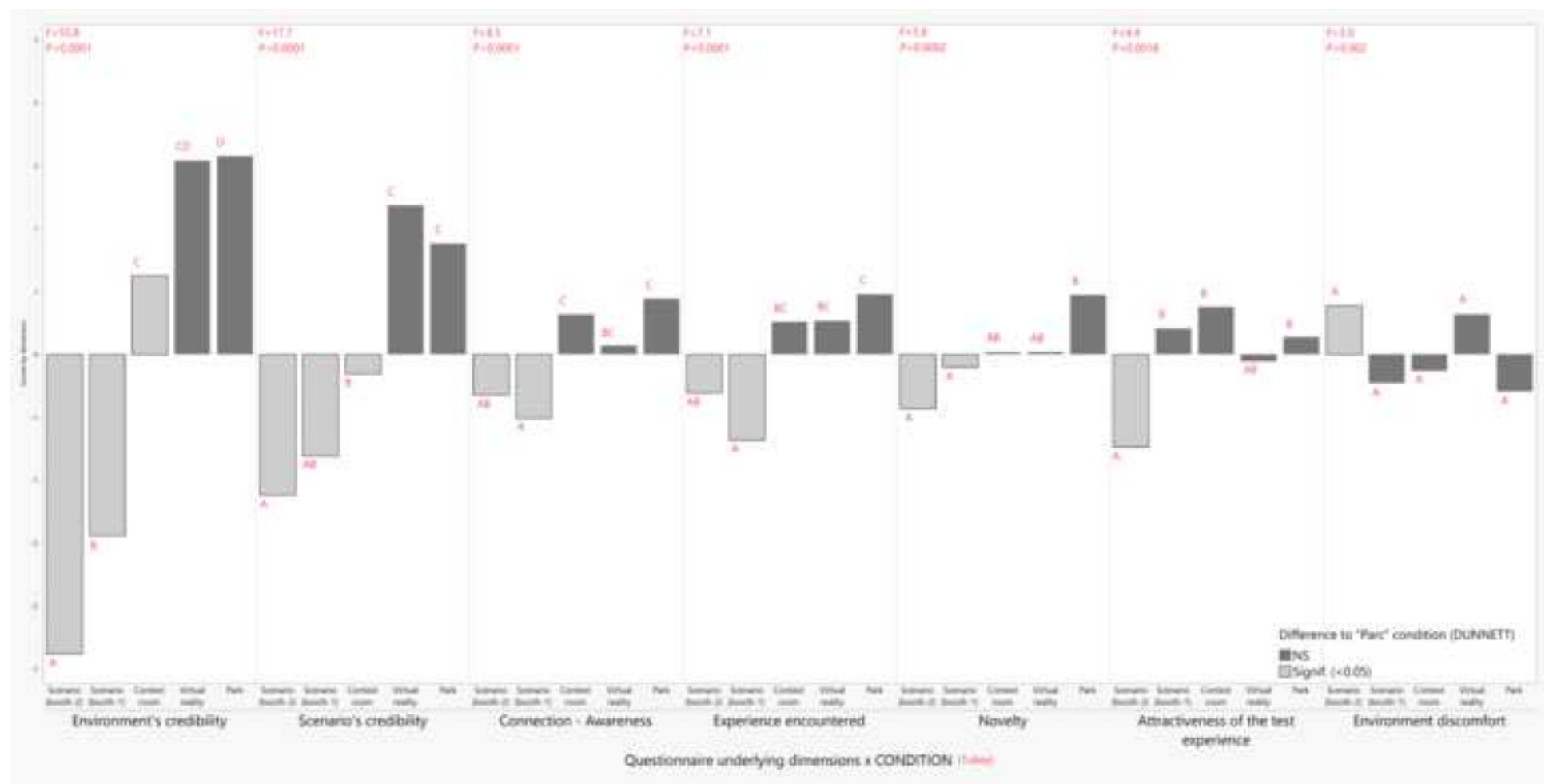


Figure 5

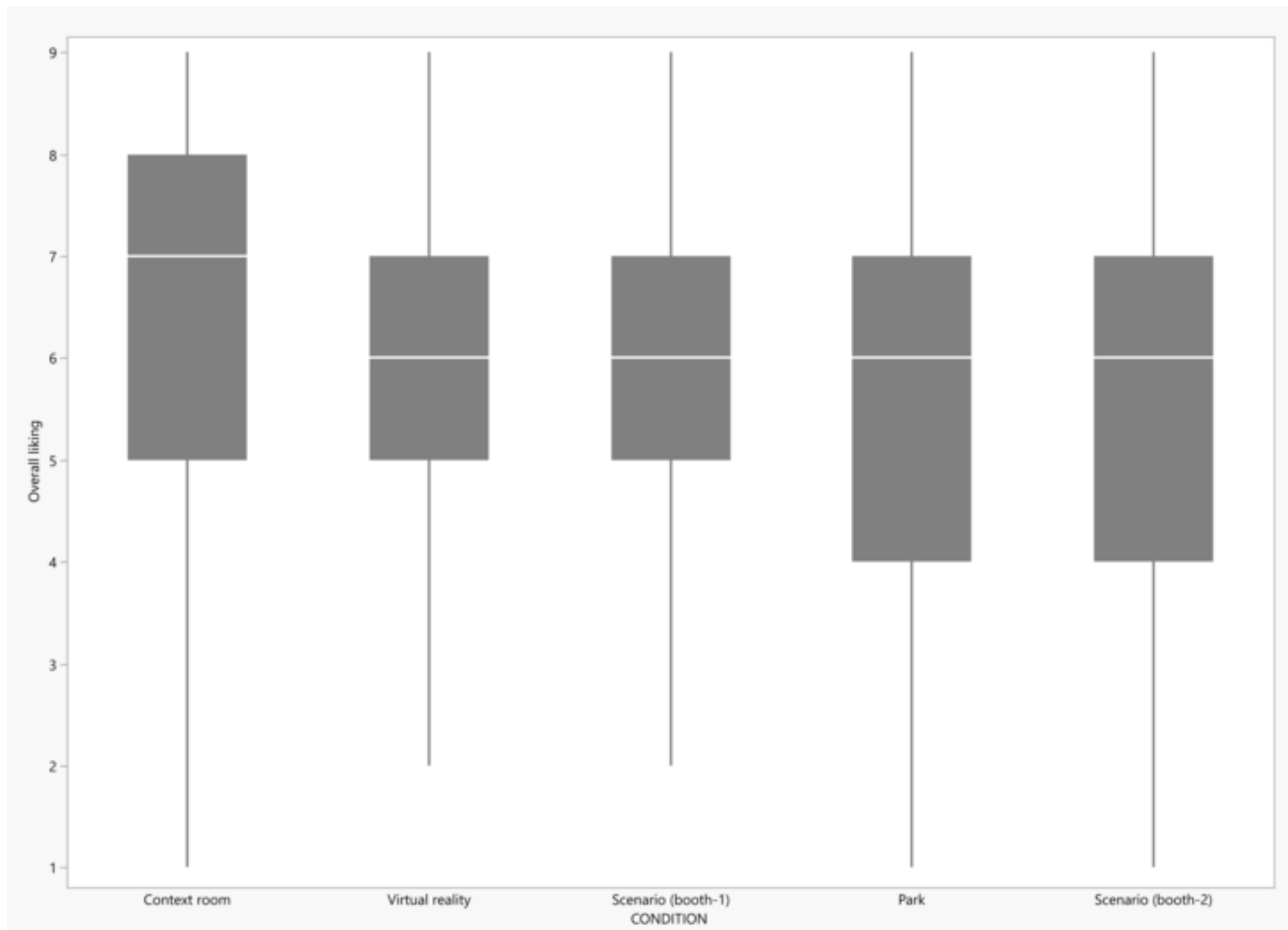
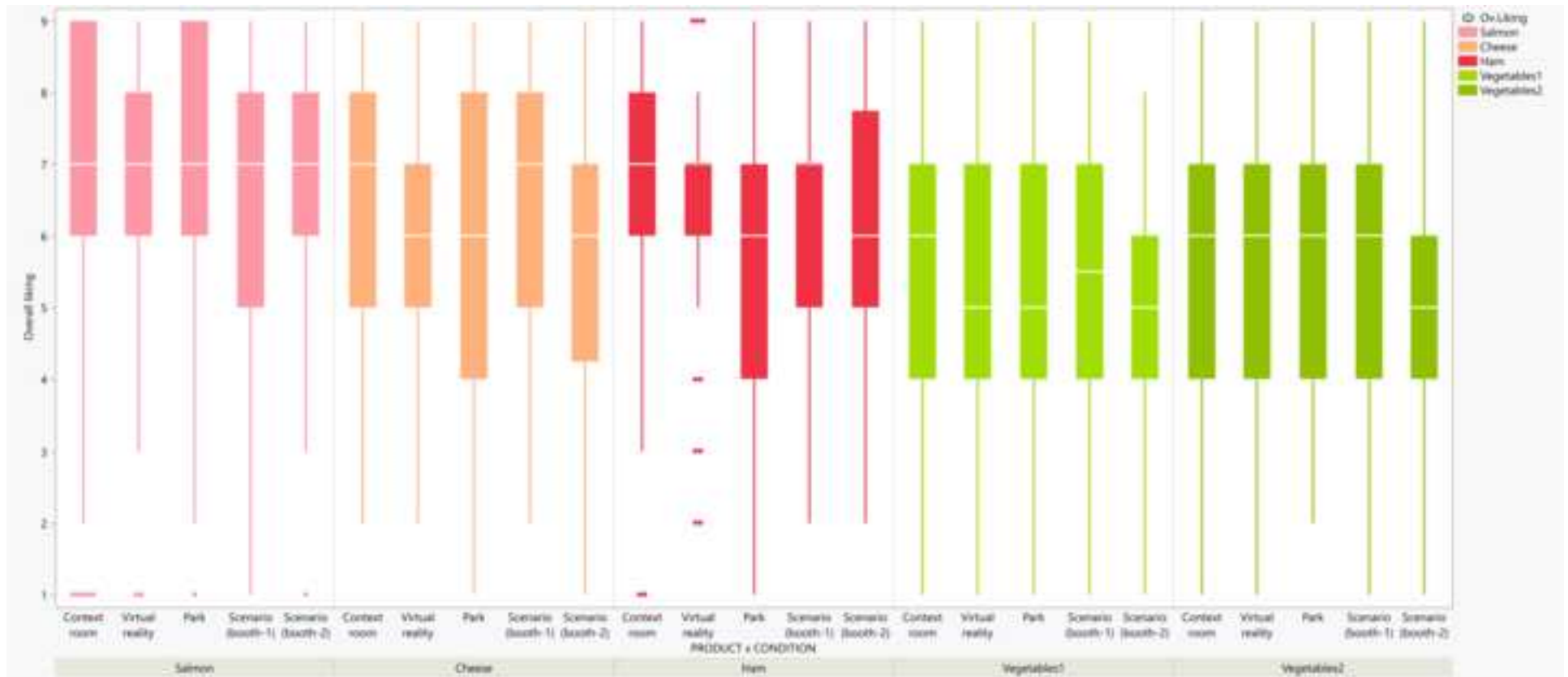
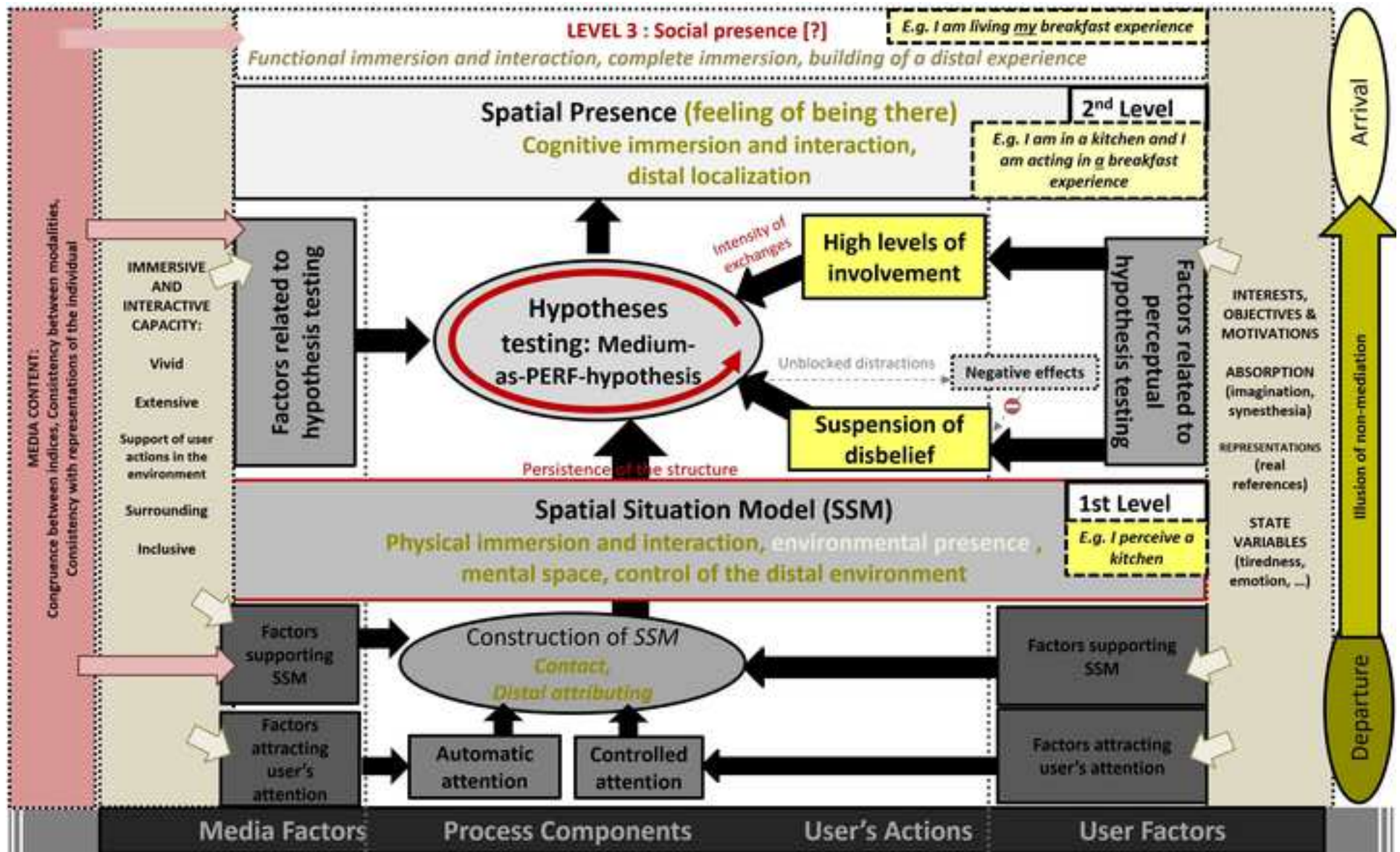


Figure 6





## FIGURES TITLES – ‘Effect of perceptive enrichment on the efficiency of simulated contexts: Comparing Virtual reality and Immersive room settings’

**Figure 1.** Photographic illustration of the four sample sandwich recipes tasted~~Sample sandwiches.~~

**Figure 2.** Classification of the seven dimensions underlying the immersion questionnaire, established according to the proximity matrix obtained with classification of the variables (items).~~Similarity of underlying dimensions in questionnaire.~~

**Figure 3.** Presentation of the main axes (1-2) of the principal component analysis (PCA), run on the average immersive scores per underlying dimension for all participants. Left: relative positioning of the experimental conditions (setups) and individual positioning of the participants under each condition; Right: Correlation between the underlying dimensions of the immersion questionnaire.~~PCA of the scores of all participants in the seven dimensions.~~

**Figure 4.** Scores by dimension (according to the analysis coordinates of the 7 dimensions underlying the immersion questionnaire) for each of the experimental conditions (5 setups). Red writing: ANOVA F and p values of condition effect. Tukey test connection letters; Dark gray filling: Proximity to the Park condition according to a Dunnett test.~~Condition effect (ANOVA, Tukey, Dunnett) on scores by dimension, per questionnaire underlying dimension.~~

**Figure 5.** Box plot by condition (5 experimental setups), on the overall liking data of the sandwich samples, all products combined.~~Comparison of means by Condition, all products combined.~~

**Figure 6.** Box plot by condition (5 setups) and by sandwich (5 samples), on the overall product liking data (Ov.Liking).~~Comparison of mean sandwich liking by Condition.~~

**Figure Appendix B.** Presence model based on the model of Wirth et al. (2007), enriched with the notions of Auvray (2004), Barfield and Hendrix (1995), Fuchs et al. (2003, 2006), Heeter (1992), T. Kim and Biocca (1997), Lombard et al. (2000), Lombard and Ditton (1997), Schubert et al. (1999a, 1999b), Sheridan (1992), Slater and Wilbur (1997), Zahorik and Jenison (1998).~~Presence model based on literature.~~

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## TABLES – ‘Effect of perceptive enrichment on the efficiency of simulated contexts: Comparing Virtual reality and Immersive room settings’

**Table 1.** Condition of presentation of the consumption episode “eating a sandwich in a park in summer during lunch break”.

<b>NARRATIVE</b> (in common for all setups)	<p style="text-align: center;"><i>SCENARIO (written): “Great weather today! It’s near midday, you’re getting hungry, and you feel you need a break. You decide to go to fetch a sandwich, and you enjoy half an hour in a park, sitting on a bench facing the greenery, eating quickly while enjoying landscape...”</i></p>			
<b>ENVIRONMENT</b>	<p><b>Park</b></p> 	<p><b>Context Room</b></p> 	<p><b>Virtual Reality</b></p> 	<p><b>Sensory Booths</b></p>  <p>(×2)</p>
<b>SPECIFIC CONTENT</b>	<p>In the park adjoining the laboratory building, three garden benches are arranged in an arc in the shade of a tree, looking onto greenery.</p> <p>Condition in Dijon, France.</p>	<p>The same three benches are arranged in an arc on an artificial lawn opposite a large screen onto which is projected a film made in the real park (at the same angle, opposite tall trees whose branches, on which birds are perched, move in the wind). The room is ventilated to give the impression of a breeze matching the movement of the branches. A soundtrack of birdsong is played.</p> <p>Condition in Dijon, France.</p>	<p>The real park and the three garden benches arranged in an arc are digitally reproduced on Unity® (version LTS 2017.4.28f1). They are viewed with an HTC Vive headset (first version). The same soundtrack of birdsong is played. Synchronization of the virtual position of the middle bench with that of an identical real bench connects the real and virtual worlds by haptic feedback to facilitate the eating experience. A lunchbox is in a synchronized real-virtual location. A Vive tracker is used to follow the position of the glass of water drunk from before and between each sample.</p> <p>The participant arrives in the virtual context with no foreknowledge of the real room, goes directly, with the headset on, to the middle virtual bench, and sits down. This favors interaction and facilitates the ‘departure’ stage (Kim &amp; Biocca, 1997). The sandwich eating phase has two stages: (i) observation of the virtual 3D copy of the product, which is handled with a controller (cf. scan method – Gouton et al., 2021, with optimization of light settings ‘smoothness’ and ‘normalmap’), and (ii) blind eating of the real product placed in the lunchbox. Instructions, questions and responses are all oral.</p> <p>Condition at Massy, France.</p>	<p>Sensory evaluation booth, white light, temperature 21–26 °C according to the season.</p> <p><i>Condition duplicated for best comparison with context room and virtual reality despite the change in location.</i></p> <p>Condition <u>Booth-1</u> in Dijon, France. Condition <u>Booth-2</u> at Massy, France.</p>



**Table 2.** Results of ANOVA for all the dimensions.

Y	Source	DF	Sum of squares	F ratio	Prob > F
Environment credibility	CONDITION	4	709.21	55.80	<del>0.0010</del> < 0.0001
Scenario credibility	CONDITION	4	225.47	17.69	<del>0.0010</del> < 0.0001
Attractiveness of the test experience	CONDITION	4	39.84	4.43	0.0018
Environment discomfort	CONDITION	4	22.30	2.98	0.0196
Connection – awareness	CONDITION	4	37.49	8.52	<del>0.0010</del> < 0.0001
Novelty	CONDITION	4	22.69	5.65	<del>0.0010</del> < 0.0002
Experience encountered	CONDITION	4	52.64	7.05	<del>0.0010</del> < 0.0001

**Table 3.** Effect tests for Equation 2 before model simplification.

Source	DF	Sum of squares	F ratio	Prob > F
PRODUCT	4	386.5702	33.4315	< 0.0001
CONDITION	4	41.9396	3.6270	0.0061
ORDER	4	4.6323	0.4006	0.8083
SUBJECT[CONDITION]	274	1689.7299	2.1333	< 0.0001
PRODUCT*CONDITION	16	44.7371	0.9672	0.4909
PRODUCT*ORDER	16	37.5902	0.8127	0.6720
CONDITION*ORDER	16	67.0174	1.4490	0.1117
PRODUCT*CONDITION*ORDER	64	158.7408	0.8580	0.7783

**Table 4.** HSD Tukey's connection letters of interaction Product\*Condition – overall liking, highlighting repeatability of vegetable sandwich evaluation (5%).

PRODUCT	CONDITION					Least squares mean
Cheese	Context Room	A	B	C		6.43
Ham	Context Room	A	B	C		6.42
Salmon	Context Room	A				6.79
Vegetables1	Context Room			C	D	5.31
Vegetables2	Context Room		B	C	D	5.56
Cheese	Park	A	B	C	D	5.75
Ham	Park			C	D	5.39
Salmon	Park	A				6.83
Vegetables1	Park			C	D	5.25
Vegetables2	Park		B	C	D	5.58
Cheese	Scenario (Booth 1)	A	B	C		6.35
Ham	Scenario (Booth 1)	A	B	C		6.31
Salmon	Scenario (Booth 1)	A	B			6.65
Vegetables1	Scenario (Booth 1)			C	D	5.46
Vegetables2	Scenario (Booth 1)			C	D	5.36
Cheese	Scenario (Booth 2)	A	B	C	D	5.80
Ham	Scenario (Booth 2)	A	B	C	D	5.90
Salmon	Scenario (Booth 2)	A	B			6.70
Vegetables1	Scenario (Booth 2)				D	5.00
Vegetables2	Scenario (Booth 2)				D	4.93
Cheese	Virtual Reality	A	B	C	D	6.07
Ham	Virtual Reality	A	B	C		6.35
Salmon	Virtual Reality	A				6.85
Vegetables1	Virtual Reality		B	C	D	5.53
Vegetables2	Virtual Reality		B	C	D	5.55

**Table 5.** Effect tests for Equation 1 after model simplification.

Source	DF	Sum of squares	F ratio	Prob > F
PRODUCT	4	392.5101	34.18589	<0.0001
CONDITION	4	41.0363	3.5741	0.00667
SUBJECT[CONDITION]	274	1759.3851	2.23740	<0.0001

**Table 6.** *F*-Ratio by source of individual ANOVA by Condition, before and after clean-up of the models.

	1-Before	2-After
<b>Context Room</b>		
ORDER	0.78	
PRODUCT	7.44	7.83
PRODUCT*ORDER	0.73	
SUBJECT	2.84	3.08
<b>Park</b>		
ORDER	2.65	2.61
PRODUCT	6.34	6.52
PRODUCT*ORDER	0.69	
SUBJECT	1.64	1.75
<b>Scenario (Booth 11)</b>		
ORDER	1.39	
PRODUCT	8.56	8.39
PRODUCT*ORDER	1.20	
SUBJECT	2.77	2.73
<b>Scenario (Booth 22)</b>		
ORDER	0.56	
PRODUCT	9.02	9.36
PRODUCT*ORDER	0.61	
SUBJECT	1.80	1.90
<b>Virtual Reality</b>		
ORDER	0.65	
PRODUCT	6.02	6.02
PRODUCT*ORDER	1.15	
SUBJECT	1.84	1.84

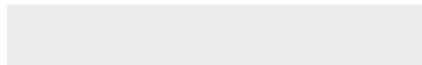
**Table 7.** Product *F*-ratio per Condition from individual ANOVA after clean-up of the models, and relation to Product in Park *F*-ratio.

	$F_{\text{product}}$	$\frac{F_{\text{product}} \text{ Condition}}{F_{\text{product}} \text{ Park}}$
<b>Virtual Reality</b>	6.02	6.02/6.52=0.92
<b>Park</b>	6.52	6.52/6.52=1.00
<b>Context Room</b>	7.83	7.83/6.52=1.20
<b>Scenario (Booth 11)</b>	8.39	8.39/6.52=1.29
<b>Scenario (Booth 22)</b>	9.36	9.36/6.52=1.44



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**Supplementary material for online publication only**  
2023 01 07 Appendix.docx



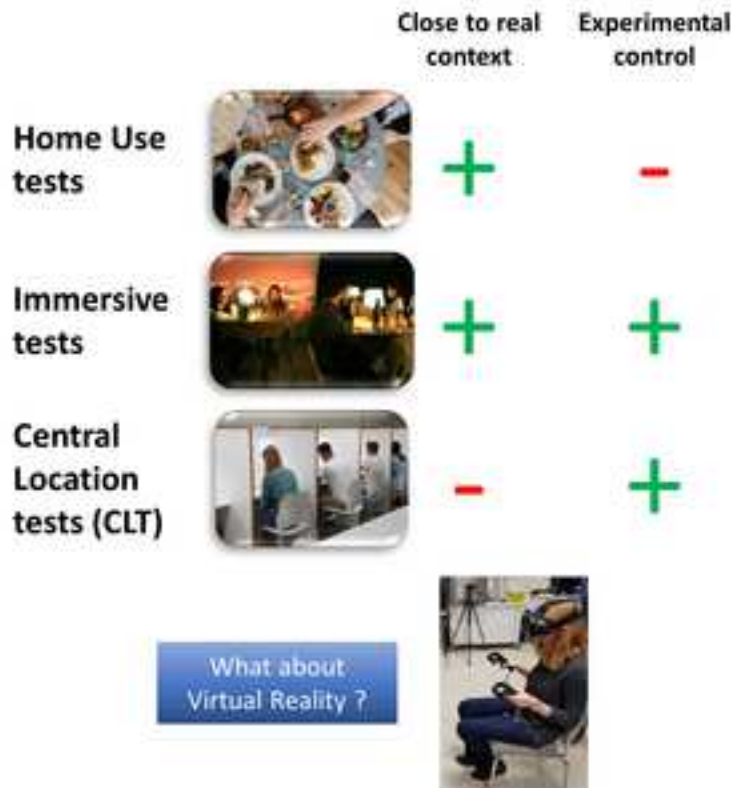
How to improve hedonic tests accuracy with the use of context in Sensory Science ?



How to help consumers to better understand the context of the evaluation ?

**Our experiment**  
 1) to compare internal and external validity of hedonic tests in one context but several setups  
 2) To test a new questionnaire on immersion

**Our Results**



**Real park**  
  
 56 consumers

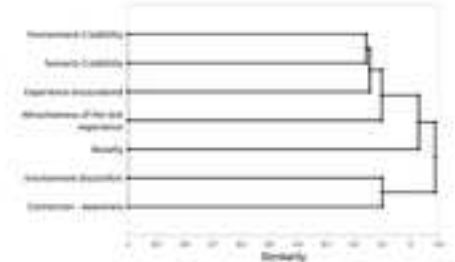
**Immersion**  
  
**CLT with scenario**  
  
 111 consumers

**Virtual Reality**  
  
 55 consumers

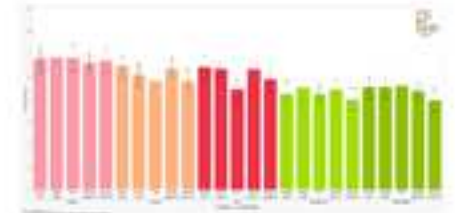
**Immersive Room**  
  
 57 consumers

7 dimensions on immersion with the questionnaire

Differences between setups according to several dimensions



Differences between products hedonic scores but small differences between setups



**AUTHOR STATEMENT** – “Effect of perceptive enrichment on the efficiency of simulated contexts: Comparing Virtual reality and Immersive room settings”

**Maëlle-Ahou Gouton:** Conceptualization, Methodology, Investigation, Formal analysis, Visualization, Writing - original draft. **Catherine Dacremont:** Conceptualization, Methodology, Writing - review & editing. **Gilles Trystram:** Conceptualization, Methodology, Writing - review & editing. **David Blumenthal:** Conceptualization, Methodology, Formal analysis, Visualization, Writing - review & editing.

**CONFLICT OF INTEREST** – “Effect of perceptive enrichment on the efficiency of simulated contexts: Comparing Virtual reality and Immersive room settings”

We declare no conflicts of interest.

Maëlle-Ahou Gouton, Catherine Dacremont, Gilles Trystram and David Blumenthal

This piece of the submission is being sent via mail.