

1 **Assessing the influence of the color of the plate on**
2 **the perception of a complex food in a restaurant setting**

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22 **Abstract**

23 Whenever we consume food and drink, we normally do so from some sort of
24 container/receptacle (e.g., such as a plate, bowl, cup, or product packaging).
25 More and more importance is being given nowadays to how the food or drink is
26 being presented. There are several reasons for this interest: With regard to the
27 color of the plate, several recent studies have demonstrated that identical foods
28 served on plates of different colors are often perceived differently (at both the
29 sensorial and hedonic levels). However, these effects have not been tested in
30 an ecologically-valid setting with a range of more complex foods in order to
31 assess the generalizability of the findings.

32 The aims of the present study were therefore to test the extent to which the
33 color of the plate may influence the gustatory and hedonic experiences of a
34 complex food. Specifically, we investigated diners' perception of three complex
35 desserts served on black or white plate in a between-participants experiment.

36 The results demonstrated that the color of the plate exerted a significant
37 influence on people's perception of the food, but that this effect varied as a
38 function of the type of dessert. Interestingly, the perceptual pattern for each
39 dessert was constant for each plate used, this is, for all the attributes rated, the
40 higher scores were obtained with the same plate, for all the desserts. These
41 results therefore confirm the importance of the color of the plate on people's
42 perception of food, even in realistic uncontrolled conditions, such as that of a
43 restaurant.

44

45 **Keywords:** *food perception; color influence; flavor intensity; liking; consumer*
46 *studies, restaurant setting, ecologically valid contexts*

47

48 **1. Introduction**

49 When we consume food or drink, we normally do so from certain
50 containers/receptacles (e.g., such as plates, bowls, cups, glasses or product
51 packaging such as a drinks can or a plastic yoghurt pot). More and more
52 importance is being given to how the food or drink is presented (Zellner,
53 Lankford, Ambrose, & Locher, 2010). There are several reasons for this growth
54 of interest. Researchers are interested in whether they can make the food or
55 drink more appealing, to give us the impression that the serving is larger, etc.).
56 It is becoming increasingly clear that our perception of food is affected not only
57 by the various sensory properties of the food itself, but also by our expectations
58 about it, not to mention all of the other contextual factors. A great deal of
59 research has been carried out over the years in order to investigate the
60 influence of all of these variables on the perception of both the sensory-
61 discriminative and hedonic attributes of a variety of different food and drink
62 items (see Spence, Harrar, & Piqueras-Fiszman, 2012, for a recent review).

63 With regard to the influence of the appearance of the food on people's
64 perception of its flavor, it is important to note that the color of a food or
65 beverage often dominates over other sources of information regarding the flavor
66 (Shankar, Levitan, & Spence, 2010; Spence, 2010). Numerous studies have
67 now demonstrated the profound role that the color of a food or beverage can
68 play in flavor perception across many different foods and drinks (e.g. see
69 Spence, Levitan, Shankar, & Zampini, 2010, for a review). What is more, the
70 containers from which we eat and drink, and, in particular, their color, can also
71 influence our perception of food and beverages and the overall consumption
72 experience to a greater extent than most of us are consciously aware of.

73 Focusing on a culinary context, several studies have demonstrated the effect of
74 the color of the surroundings in which food happens to be presented (i.e., cups,
75 plates, tablecloth, and even the ambient lighting) both on our perception of the
76 food and on the amount that people will serve not to mention consume (e.g.,
77 Guéguen, 2003; Harrar, Piqueras-Fiszman, & Spence, 2011; Oberfeld, Hecht,
78 Allendorf, & Wickelmaier, 2009; Ross, Bohlscheid, & Weller, 2008). For
79 example, Van Ittersum and Wansink (2012) recently demonstrated that the
80 color contrast between the plateware and the background color, be it the color

81 of the tablecloth or table, had a significant effect on serving sizes (and a
82 significant interaction effect with the plate size). They found that people with
83 white plates placed on a black tablecloth served 9.8% ($p < .01$) more than the
84 target serving size on the larger plate, and 13.5% ($p < .01$) less than the target
85 serving size on the smaller plate. However, this over/under-serving bias was
86 reduced for those participants with white plates situated on a white tablecloth.

87 In another study, Van Ittersum and Wansink (2012) tested the effect of color
88 contrast between the food and the plate on the serving size in a canteen (this
89 time keeping the size of the plate and table/tablecloth color constant). Their
90 results revealed that participants in the low color contrast condition (i.e., white-
91 pasta sauce on a white plate, or red pasta sauce on a red plate) served
92 themselves significantly ($p < .01$) more pasta than those in the high color
93 contrast condition (i.e., white pasta sauce on a red plate, or red pasta sauce on
94 a white plate). These two studies can potentially be framed in terms of the
95 Delboeuf illusion - the illusion whereby we see a central circle as smaller when
96 surrounded by a much larger concentric circle than when surrounded by a circle
97 that is only slightly larger. It has been shown that this illusion is enhanced by
98 color contrast, and it could thus provide a possible explanation for why and how
99 plate size might influence serving behavior in real-life situations.

100 With regard to this contrast effect between the color of food (i.e., the color of the
101 dish/cup, etc.) and the color of the plate, there are also mechanisms that may
102 help to explain our perception of certain "illusory", or more saturated, colors. For
103 instance, the orange of a carrot might well be intensified if it were to be served
104 on the same blue plate due to the phenomenon of simultaneous contrast, as
105 Hutchings (1994) reported as an anecdote. It might be expected that if the color
106 of the plate (or background) affects the way in which people perceive the color
107 of the food (Ekroll, Faul, & Niederée, 2004; Lyman, 1989; Hutchings, 1994), and
108 the color of the food is known to affect the perception of flavor, then the color of
109 the plate (and any contrast effect that it elicits) might be expected to influence
110 the perceived properties of the food (e.g., the flavor intensity, etc.). Piqueras-
111 Fiszman, Alcaide, Roura, and Spence (2012) studied this under laboratory
112 conditions, in a short within-subjects experiment using black and white plates.
113 Their results showed that an identical strawberry mousse (of homogeneous

114 color) tasted significantly more intense, sweeter, and was more liked when
115 served from the white plate, compared to when served from the black one.
116 However, though these interesting results were observed, they have not been
117 tested in a natural context and with more complex foods (varying in color,
118 texture, etc).

119 The aims of the present study were therefore to test the extent to which the
120 color of the plate influences the visual and gustatory experiences of different
121 complex foods (namely, desserts) served from them, and the extent to which
122 these effects can be generalized in natural conditions, such as those of a real
123 restaurant.

124

125 **2. Materials and methods**

126 The study was carried out at the experimental restaurant of the Institut Paul
127 Bocuse (Lyon, France). Three different desserts were served either on black or
128 white plates according to the balanced between-participants experimental
129 design showed in Figure 1.

130 **2.1. Food stimuli**

131 Berry-based desserts were served on either white glossy or black matt dishes.
132 Dessert A was a *fraisier* (main colors: yellow, white, and red), Dessert B was a
133 *Fraicheur* of raspberry and vanilla (Figure 2), and Dessert C consisted in a
134 *vacherin* glacé with vanilla, raspberry, and basil (mainly white and light pink).
135 Importantly, although it was intended that the desserts should have been
136 presented (and decorated) identically, this was impossible to control in this
137 realistic setting, so at the end, they were as similar as possible. A fixed menu
138 was kept constant throughout the two weeks the study lasted.

139 **2.2. Plates**

140 Black and white plates were used, since they are the most commonly used in
141 restaurant settings. They were of the same shape and size (rectangular, 30 x 26
142 cm), but, as mentioned before, the white plate had a glossy finish while the
143 black plate had a matt finish. Though, strictly-speaking, black and white are not
144 considered as colors, they will be referred to as such for ease of exposition.

145 **2.3. Participants**

146 Two hundred fifty-three people (nearly all of them French) participated in the
147 study, of which 142 were females (M= 43.4 years, SD=13.8). No recruitment
148 process was followed; the participants simply consisted of those people who
149 had chosen to book a table for lunch or dinner.

150 Detailed information concerning the breakdown of the participants (age and
151 gender) distributed for each day is shown in Table 1.

152 **2.4. Procedure**

153 Participants were welcomed to the experimental restaurant and it was explained
154 to them that a quick questionnaire would be delivered at the end of the meal in
155 order mainly to know what they thought about the dessert (so participants
156 thought the aim was to give some feedback to the trainee chefs). They were
157 told to read the questionnaire first, and then proceed with the dessert.

158 A5 pencil-and-paper questionnaires and pens were delivered with the dessert.

159 The questions were: 1) How appetizing is the dessert (visually, once
160 presented); 2) How much do you like the appearance of the dish overall; 3) How
161 intense is the color of the dessert; 4) How intense is the flavor of the dessert; 5)
162 How intense is the sweetness of the dessert; and 6) how much did you like the
163 dessert (gustatory). Additionally some basic demographic questions were
164 included.

165 The participants had to rate each question on 9-point scales labelled at their
166 anchors with “not at all” and “very much”. Questions 1-3 were meant to be
167 completed prior to tasting, while the others could be filled in during or at the end
168 (to keep the situation as natural for them as possible).

169 After the meal, the questionnaires were collected, the diners paid their bill as in
170 any normal restaurant, and they were thanked once again for their participation.

171 **2.3. Data analysis**

172 In order to determine whether the color of the plates exerted a significant effect
173 on the attributes in question, a three-way analysis of variance (ANOVA) was
174 performed on the data considering the meal session (lunch or dinner), the

Comment [B1]: Could we include a pic of this? I took several

175 dessert (A, B, or C), the plate (white or black), and their interactions as
176 explanatory variables.

177 When the effects were significant, honestly significant differences were
178 calculated using Tukey's test. Differences were considered significant when
179 $p \leq .05$. Statistical analyses were performed using XLStat 2011 (Addinsoft, NY,
180 USA).

181

182 **3. Results**

183 Importantly, it was observed that all the diners ate nearly all of the food served,
184 and that all of them finished the dessert (as reported by the restaurant
185 manager). This fact helps to match the conditions across participants.

186 **3.1. The effect on the pre-tasting attributes**

187 *Liking of the overall presentation.* According to the results of the ANOVA, the
188 dessert and the color of the plate exerted a significant effect on consumers'
189 liking ratings of the overall presentation of the dish ($p < .0001$ and $p < .01$,
190 respectively). However, this effect was not observed for all the desserts, as
191 indicated by the significant interaction effect between the plate and the type of
192 dessert ($p < .0001$). In fact, only Dessert A was significantly more liked on the
193 white plate than when served on the black plate ($M = 6.9$ vs. 4.7 ; see Fig. 3a).
194 The results also highlighted a tendency for Dessert C to be liked more on the
195 white plate, whereas the opposite results were observed for Dessert B. Note,
196 though, that these latter two differences between plate color were not
197 significant.

198 *Appetizing ratings.* The results of the appetizing ratings followed exactly the
199 same pattern as those described above. The color of the plate exerted a
200 significant effect on consumers' appetizing appraisal of the desserts ($p < .0001$).
201 Once again, this effect was only observed for Dessert A, which was perceived
202 as significantly more appetizing on the white plate as compared to the black
203 plate ($M = 7.7$ vs. 5.0). Very similar results to those of the liking ratings were
204 found for the other two desserts in this case (see Fig. 3b).

205 *Color intensity of the desserts.* Regarding the perceived color intensity of the
206 desserts, the color of the plates, the type of dessert, and their interaction had
207 significant effects ($p < .05$, $p < .001$, and $p < .01$, respectively). In general, taking
208 the three desserts as a group, their color was perceived as more intense from
209 the white plate ($M = 6.6$ vs. 6.0); However, at an individual level, the intensity of
210 the desserts' color was not significantly different when any of the desserts were
211 served from either a white or black plate (Fig. 3c).

212 **3.2. The effect of the plate on the desserts' gustatory attributes**

213 The results presented so far demonstrate an effect of the color of the plates on
214 the attributes rated, which are mainly based on the appearance of the
215 presentation of the desserts (presumably prior to their having been tasted). The
216 following section describes its impact on the oral perception of the desserts.

217 *Flavor intensity.* Contrary to what one might have expected, no main effects of
218 the color of the plate were observed. The flavor intensity was only affected by
219 the type of dessert and its interaction with the color of the plate ($p < .001$ and
220 $p < .01$, respectively). Only the flavor of Dessert B was perceived as significantly
221 more intense ($p < .05$) when presented on the black plate (Fig. 3d). It is
222 interesting to highlight that the pattern of results (Dessert B scoring higher on
223 the black plate and the contrary being observed for A and C, for all the
224 attributes, even if not reaching significant levels) is maintained.

225 *Sweetness intensity.* Only the dessert had a significant effect on the perceived
226 sweetness, which means that Dessert A was rated as sweeter than Desserts B
227 and C regardless of the color of the plate that they were served on (Fig. 3e).

228 **3.3. Overall liking**

229 Regarding the overall liking (assessed after having tasted the dessert), only the
230 interaction effect between the color of the plate and the dessert was significant.
231 Figure 3f reveals that Desserts A and C resulted in very similar scores for both
232 plates, while essentially the reverse pattern was obtained for Dessert B. Dessert
233 B was significantly more liked on the black plate than on the white one ($M = 7.6$
234 vs. 6.5 , $p < .05$), and marginal differences were observed for Dessert C, which
235 was slightly more liked on the white one ($M = 7.6$ vs. 6.8 , $p = .09$).

236 Taken together, then, these results suggest that the diners' actual liking of the
237 dessert was not necessarily influenced by their appreciation for the
238 presentation, or by how appetizing they appeared visually.

239

240 **4. Discussion and conclusions**

241 The present study investigated whether or not the color (either black or white) of
242 the plate would exert a significant influence on how appealing and appetizing
243 various desserts were rated as being (prior to consumption) and on the
244 perceived flavor intensity, sweetness, and liking of three different desserts
245 served in as similar a manner as possible from those plates. The results
246 demonstrated that consumers' perception varied, as highlighted by the
247 significant differences in the mean scores. The color of the plate exerted a
248 significant effect on participants' perception of the majority of the attributes that
249 were evaluated, but these effects varied as a function of the dessert that was
250 served.

251 Given the complexity in the visual appearance of the desserts (i.e., with layers
252 and decorations of different colors and tastes), no clear conclusions can be
253 extracted relating to the impact of any color contrast between the dessert and
254 the plate with respect to the diners' responses. What can be concluded, though,
255 regarding color perception, is that the flavor intensity patterns observed for all
256 the desserts (Fig. 3d) were similar to those of the perceived color intensity of
257 the desserts (Fig 3c), which could suggest that they perceived the flavor to be
258 more intense if the color was also perceived as such. Moreover, looking at all
259 the panels in Figure 3, it can be noticed that Desserts A and C had the higher
260 scores when served on the white plate, whereas the opposite occurred for
261 Dessert B. This overall result suggests that all of the attributes were somewhat
262 positively correlated within each dessert condition, as perhaps might have been
263 expected. That is, when the color of one dessert was perceived as being more
264 intense on a plate of one color, it was also rated as being more appetizing,
265 more liked, and more intense in flavor on the same plate (though this can only
266 be inferred given the pattern of results observed).

267 It is understandable that results regarding the gustatory attributes are not as
268 strong as in the study by Piqueras-Fizman *et al.* (2012), given that in the
269 context of a real restaurant, the stimuli cannot be perfectly matched for all
270 consumers, and the conditions for all the diners cannot be kept the same (i.e.,
271 they may or may not drink while eating, some may have eaten more rapidly
272 than others, etc.). For these reasons, these results are more ecologically valid,
273 and although no generalization can be put forward here as to which background
274 color is better 'flavor-wise' for a given food (dessert), our results nevertheless
275 do highlight the fact that the color of the plateware can exert a significant impact
276 upon consumers' appraisal of the food, prior and after consumption, in spite of
277 the complex uncontrolled conditions, which make obtaining significant effects in
278 the results even more challenging.

279 These results therefore contribute to the emerging literature about how extrinsic
280 variables can influence food perception, highlighting that the impact they might
281 have is dependent on the specific food being evaluated. In the future it would be
282 particularly interesting to further investigate the effects of other colors (or, more
283 correctly, plates having different hues) and characteristics of the plates in order
284 to discover possible ways in which to enhance the perception and experience of
285 food, apart from modifying the ingredients of the food.

286

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292

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331 liking for food. *Food Quality and Preference*, 21, 575-578.
- 332

333 **Figure captions**

334

335 **Figure 1.** Outline of the procedure followed during the two-week study.

| Week | | Wed | Thurs | Friday |
|------|--------|-------|-------|--------|
| 1 | Lunch | -- | White | Black |
| | Dinner | White | Black | White |
| 2 | Lunch | -- | Black | White |
| | Dinner | Black | White | Black |

Dessert A Dessert B Dessert C

336

337

338 **Figure 2.** Picture of Dessert B (a *fraicheur* of raspberry and vanilla) presented
339 on the black and white plates.

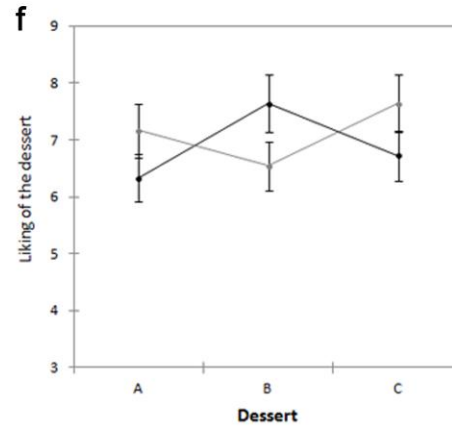
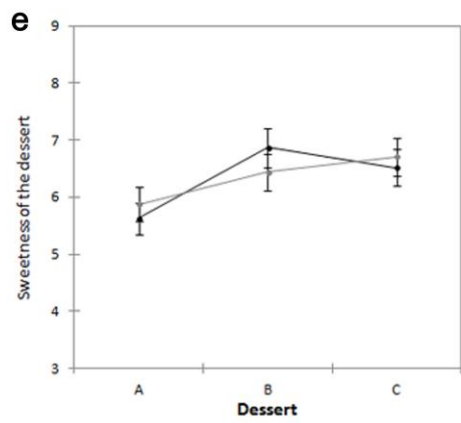
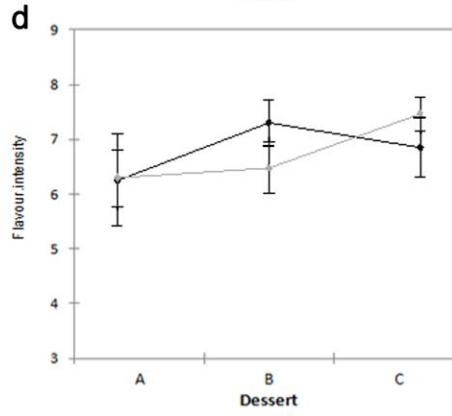
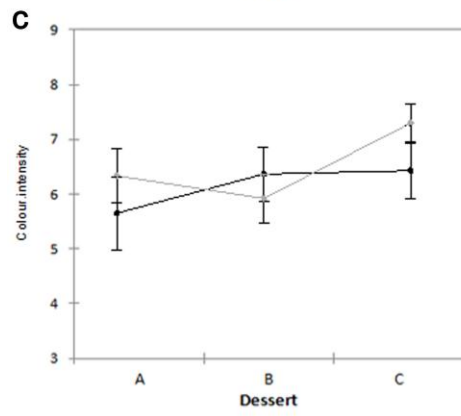
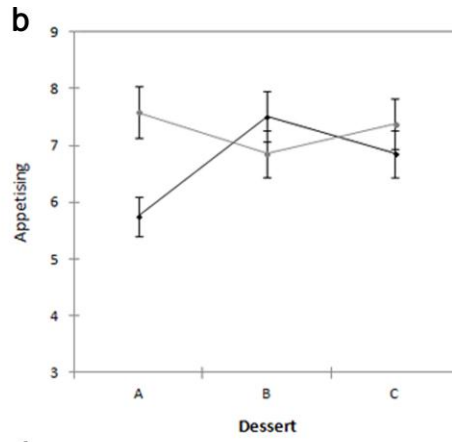
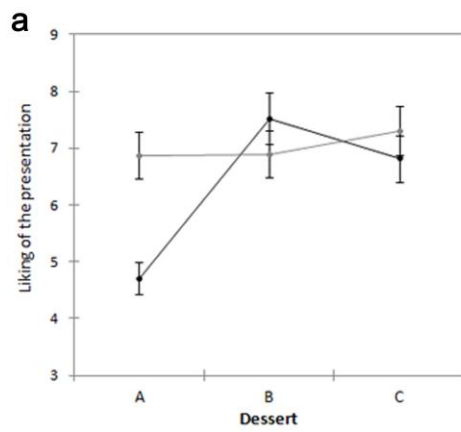


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341

342 **Figure 3.** a) Mean ratings of a) the liking of the presentation, b) appetizing
343 ratings; c) perceived color intensity; d) perceived flavor intensity; e) perceived
344 sweetness intensity; and f) gustatory liking of the desserts. All of the attributes
345 rated on 9-point scales.

346 Error bars represent the 95% confidence intervals.



347

348

349 **Tables**

350

351 **Table 1.** Information concerning the participants (males / females).

| | Wednesday | Thursday | Friday |
|-----------|-------------------|-------------------|-------------------|
| Lunch | -- | 19/32 | 18/34 |
| Dinner | 22/26 | 25/25 | 27/25 |
| Total (n) | 48 (22/26) | 101 (44/57) | 104 (45/59) |
| | Age: M=45, SD= 12 | Age: M=42, SD= 13 | Age: M=44, SD= 16 |

352