

1 ***Eating with the eyes? Tracking food choice in restaurant's menu***

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14 **KEYWORDS**

15 Eye-tracker, menu design, dish choice, Real context, Multinomial logit model

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18 **ABSTRACT**

19 Digitalization is considered the industrial revolution of the 21st century, helping companies to
20 become more efficient and value-driven. This trend also reaches the restaurant sector, being
21 present in all its spaces and activities, from the kitchen to customer service. The present study
22 aimed to determine if the eye-tracker is a suitable tool to predict diners' choices in the context
23 of a restaurant. Three menu presentations were designed for the study: a basic menu with the
24 name of the dishes and the prices; a menu that included the same information of the basic one,
25 and a descriptive information of each dish; and a menu with an infographic of nutrition-related
26 composition. A total of 180 consumers participated in the study ($n \approx 60$ per menu), who
27 evaluated one of the menus presented on a tablet with an integrated eye-tracker. Then,
28 consumers completed a questionnaire indicating their dish choice and their opinion about the
29 menu. Results showed that, when basic or descriptive information was displayed, the eye-
30 tracking could be used to predict consumer's decisions in the restaurant. A higher fixation
31 duration resulted in a higher probability of choice when consumers looked at the basic menu
32 and at the one with descriptive information, but the inclusion of an infographic with nutritional
33 data diminished the prediction ability of the eye-tracker.

34 **1. INTRODUCTION**

35 Choosing a food is a behavior that has been studied to explain how and why a person decides
36 on what they consume (Köster & Mojet, 2018). One of the first stimuli that connects consumers
37 to the product is visual information, which has been widely used to understand how to stimulate
38 the senses, get people's attention, and to provide proper information about a product or its
39 brand (Piqueras-Fiszman & Spence, 2015). Visual cues play an important role in the perception
40 of food quality and have a great impact on food choice (van der Laan et al., 2011). Romeo-Arroyo
41 et al. (2022) showed that using a "low in sugar" label decreased overall liking of reformulated
42 cookies, while the same samples without the label were liked as the original ones. Other studies

43 have shown a lack of influence of production-related messages in overall liking and perceived
44 intensity of the main attributes of vegetable dips (Mora et al., 2020).

45 Eye-tracking has been used to study the potential connections between consumers' visual
46 attention and food choices (e.g.: Danner et al., 2016), because the eye-tracking technology can
47 inform about eyes' movement or visual behavior when a stimulus is presented (Duerrschmid &
48 Danner, 2018; Vu et al., 2016). Fenko et al. (2018) reported that the visual attention to health
49 labels was a poor predictor of healthy choices. However, Gere et al. (2021) suggested that
50 applying statistical choice prediction models to gazing data was a suitable approach to predict
51 food choice in different product categories. Different authors have reported that during a
52 decision-making task, higher fixation counts, and longer fixation duration were related to the
53 alternative selected (Danner et al., 2016; van der Laan et al., 2015). Similarly, "the gaze bias
54 theory" postulates that people spend more time looking at the preferred and chosen items
55 (Schotter et al., 2010).

56 In the context of a restaurant, one of the ways to influence specific meals selection is by changing
57 the design/content of the menu. Different approaches have analyzed the food choice impact of
58 the disposition of the information (Wansink & Love, 2014), dishes description (Wansink et al.,
59 2001), inclusion of nutritional information (Roberto et al., 2010), sustainable information (Bacon
60 & Krpan, 2018), and visual design of the menu (Guéguen et al., 2012). However, up to date, it is
61 still unclear which are the main factors of the menu that drive consumer's choice.

62 Most of the previous eye-tracking studies have been done in laboratory settings, leading to poor
63 predictability of consumer data (Bangcuayo et al., 2015; Peng et al., 2021). Investigating the
64 applicability of the eye-tracker in the real context of the restaurants could provide an interesting
65 knowledge to contribute to the digital transformation of the HORECA sector (García-Madrugá et
66 al. 2021). Therefore, the aim of this study was to determine the capability of the eye-tracker for
67 predicting the choice of dish from diners at restaurants. Additionally, because three different

68 menus were designed and presented to customers, a second analysis was done to study if the
69 way of presenting the information of the dishes on the menu could affect diners' choice.

70 **2. MATERIAL AND METHODS**

71 The protocol and procedures used in this study were approved by the Basque Culinary Center
72 scientific committee (BCC21/1702). All articles from the Declaration of Helsinki and the
73 2016/679 EU Regulation on the protection of natural persons regarding the processing of
74 personal data and on the free movement of such data were met. The experimental procedure
75 was explained and a written consent indicating voluntary participation was obtained from each
76 participant before beginning the study.

77 **2.1. Menus' selection**

78 Three sample menus were designed for the present research: a) a "basic menu" (BM) with only
79 the name of the dish and the price, b) a menu that included the same information of the BM
80 and a brief description of each dish to elicit the consumption experience, "descriptive menu"
81 (DM), and c) a menu with a colorful infographic of nutrition-related composition of each dish
82 inspired in the Healthy Eating Plate© of Harvard (HSHP, 2011) (proteins, carbohydrates and
83 vegetables), "nutritional menu" (NM). Price of the dishes, typography, and presentation order
84 of the dishes were the same in all menus (Figure 1). Menus were randomly presented to
85 participants in different testing days.

86 The dishes listed in the menu were the ones offered in the restaurant: sea bass tartar brioche
87 with avocado cream ("brioche"), guanciale and pecorino croquettes ("croquettes"), kokotxas -
88 cod cheeks- with artichokes and pilpil ("kokotxas"), sautéed mushrooms with chicken and sherry
89 broth and cured egg yolk ("mushroom"), and seasonal pumpkin with Stracciatella ("pumpkin").

90 **2.2. Procedure**

91 The study was conducted in the Basque Culinary Center (BCC) restaurant and the same table
92 was used for all experiments at lunchtime; decoration, surroundings, environment, and number
93 of diners at the table were predefined (maximum two consumers). Being a regular customer of
94 the restaurant was the only recruitment criteria, and customers were invited to participate in
95 the study when entering the restaurant. Participants were sited in front of the tablet to proceed
96 with the eye-tracker calibration (5-point calibration), the menu observation, and the dish
97 selection. Finally, consumers answered a brief questionnaire about: 1) their dish choice, 2) their
98 degree of liking about the design and content of the menu using a 9-point hedonic scale (1 =
99 dislike extremely; 9 = like extremely). Menus were presented in a 12.3-inch screen tablet
100 Microsoft Surface Pro 7 (Microsoft Corporation, Redmond, USA) with the Hiru eye-tracker
101 system (IRISBOND, Donostia-San Sebastián, Spain) with a sample rate of 20±2 milliseconds.

102 **2.3. Data analysis**

103 The data analysis was done establishing Areas of Interest (AOIs), being each dish information
104 the corresponding AOI of the specific menu. The AOI of each dish included the basic information
105 (name and price) in the BM, the basic information and its description in the DM, and the basic
106 information and its nutritional infographic in the NM ([Figure 1](#)). The data processing consisted
107 of the computation of the fixation count and fixation duration (fixation count*length of each
108 fixation) per AOI, as well as the total time spent in the whole task (from starting until choosing
109 a dish). These parameters and the explicit questionnaire results were collected for further
110 statistical analyses.

111 A chi-square test was used to verify the independence between the type of menu evaluated,
112 and the gender/age groups of consumers.

113 A multinomial logit model was applied to analyze the dish choice predicting capability of the
114 eye-tracker for each menu. Each consumer data corresponded to an observation, the nominal
115 response variable was the observed choice (explicit dish choice) and the explanatory variable
116 was the number of fixations per AOI, where each dish was defined as a category. Goodness-of-
117 fit statistics, such as χ^2 , Cox and Snell's R^2 index, and Nagelkerke's R^2 index, were calculated.
118 Confusion plots were obtained to study the observed vs. predicted choices of the different
119 menus. The Goodness Classification Index (GCI) was used to compare the predictive quality of
120 the models. GCI is used to provide a simple and realistic assessment of the quality prediction of
121 a classification model by calculating, in percentage, a global balance of the ratio of rightly
122 classified observations (RC) and uncertain classified observations (UC) versus the incorrect
123 classifications (IC): $GCI = [RC - IC + UC / 2] / N$.

124 A two-way ANOVA followed by Post hoc test (Tukey's HSD) was done on the fixation duration,
125 using the type of menu and dish as fixed factors, as well as the interaction menu*dish. Three-
126 way ANOVA followed by Post hoc test (Tukey's HSD) were carried out on liking scores, being the
127 type of menu, gender, and age the fixed factors of the analysis. The interactions menu*gender
128 and menu*age were also included in the model. All statistical analyses were done using XLSTAT
129 (XLSTAT Version 2022.1.2, USA).

130 **3. RESULTS**

131 A total of 196 consumers (women = 60.2 %; age mean = 27.9, SD = 10.2) participated in the
132 study: 69 costumers assessed the BM (women = 56.5 %; age mean = 27.6, SD = 9.5), 62 assessed
133 the DM (women = 54.4 %; age mean = 27.0, SD = 9.9) and 65 assessed the NM (women = 54.4
134 %; age mean = 27.0, SD = 9.9). Gender/age groups were independent of the type of menu
135 evaluated (Chi square p-values of gender and age were 0.575 and 0.329, respectively). [Table 1](#)
136 summarizes the results of the eye-tracker measures calculated during the study.

137 The analysis of the multinomial logistic regression model showed the suitability of developing
138 models to predict consumers' choices for each menu with a minimum percentage of failure.
139 Differences were found among menus on the goodness-of-fit of the models. The BM model
140 presented a χ^2 of 95.17 (p-value < 0.0001), and a Cox and Snell's and a Nagelkerke's R^2 index of
141 0.748 and 0.758, respectively. The DM model had a χ^2 of 55.74 (p-value < 0.0001), Cox and Snell's
142 $R^2 = 0.593$, Nagelkerke's $R^2 = 0.599$. Both menus, BM and DM, reached appropriate goodness-
143 of-fit values. On the contrary, results of the NM model indicated a worse goodness-of-fit.
144 Although the observed χ^2 of 12.79 (p-value = 0.012) was still significant, the Cox and Snell's and
145 a Nagelkerke's R^2 index were 0.179 and 0.184, respectively.

146 The contribution of each AOI in the model was analyzed to verify if all of them provided a
147 significant amount of information to explain the variability of the response variable. In the BM
148 model, the contribution of all AOIs were statistically significant (p-values < 0.05). However, not
149 all the AOIs contributed to the DM and NM models. In DM the AOIs corresponding to the
150 "brioche", "croquettes", "kokotxas" and "pumpkin" dishes/categories were significant, while
151 "mushroom" was not. "Mushroom" was the only statistically significant AOI (p-value < 0.05) in
152 the NM model.

153 The prediction capability of the different models was compared using confusion matrices. [Figure](#)
154 [2](#) shows the confusion plot where the grey squares represent the observed choices ("from"),
155 and the black squares represent the predicted choices by model ("to"). BM confusion plot
156 indicated that the model was consistent and there was an adequate relationship between
157 choices and predictions. DM confusion plot showed that not all AOIs were equally well
158 predicted, particularly prediction choice of "croquettes" was not aligned with observed choices
159 of "croquettes". Finally, the NM confusion plot revealed that the model was not as good as the
160 other ones, showing an acceptable performance to predict the choice of "brioche" and
161 "mushrooms".

162 The GCI indicated that BM model was the one with the best GCI, followed by the DM (Table 2).
163 BM presented the highest percentage of correct predictions compared with the other models;
164 the correct classifications outperformed wrong classifications in both BM and DM menus. On
165 the contrary, the NM model presented the highest percentage of incorrect classifications, which
166 was above the percentage of correct classifications.

167 Differences on fixation duration by type of menu and dish were studied using ANOVA. Significant
168 differences were found among menus, being DM the one with a higher fixation duration,
169 followed by the NM (p-value <0.001; $\eta^2 = 0.12$). Not surprisingly, the fixation duration in the BM
170 was significantly lower than in the DM and NM, probably because the BM had less information
171 than the other menus. Also, significant differences were found among dishes (p-value <0.0001;
172 $\eta^2 = 0.06$), being “mushroom” the one that had a lower fixation duration when compared with
173 the other ones.

174 Figure 3 shows the interaction menu*dish, in which significant differences in the fixation
175 duration of dishes by menu was found (p-value = 0.034; $\eta^2 = 0.06$). Tukey’s post hoc test showed
176 significant differences between BM and DM for all dishes. However, differences were found only
177 for the “brioche” AOI between the BM and NM. Also, chi-squared test revealed that the two
178 qualitative variables “dishes choice” and “menu” were independent, indicating a lack of
179 relationship between the type of menu and the selected dish (p-value = 0.460).

180 ANOVA results showed no effect of menu on liking of the design and content among menus (p-
181 value = 0.076). Other factors such as gender (p-value = 0.127), interaction menu*gender (p-value
182 = 0.184) and interaction menu*age (p-value = 0.502) were not significant. However, a significant
183 age effect was found (p-value = 0.029; $\eta^2 = 0.07$); younger participants (< 25 y/o) reported
184 significantly higher liking scores than the older ones (≥ 25 y/o).

185 4. DISCUSSION

186 The present study evaluated the capability of the eye-tracker to predict dish choices of diners at
187 restaurants, using three alternatives of presenting the information on restaurant menus (basic,
188 descriptive, and infographic-nutritional-related). The models developed to predict choice when
189 using the BM and the DM menus were quite accurate, while the NM model was not as precise.
190 The introduction of nutritional information using a colorful infographic (NM) could have
191 modified the behavioral response and consumers' choice, resulting in the failure of developing
192 a visual predictive model of choice when this health-related information was included.

193 Results suggested that higher fixation durations were not related to choices in all menus. A
194 positive relationship between visual attention and choices was detected in the BM and the DM,
195 following "the gaze bias theory" (Schotter et al. 2010). This relationship was not observed in the
196 NM. Van der Laan et al. (2015) stated that visual fixation was strongly driven by decision goals,
197 and, to a smaller extent, it could also be driven by the preference formation process during the
198 observation task if personal goals were not previously established. Results of NM showed a
199 different pattern than the ones of the other menus, suggesting that the information shown in
200 the NM could have had recalled health-related personal goals of consumers (e.g.: having a
201 healthy diet, a low-carb diet, a high-protein diet, etc.). No information was collected to segment
202 consumers by goals or attitudes in the present study; future studies could consider the variations
203 in choice behavior linked to individual goals and/or personal profiles on the development of
204 predictive models, allowing to adjust the models by individuals' group. DM was the one with a
205 higher fixation duration. Siegrist et al. (2015) reported that mean fixation duration could be
206 considered a measure of information process efficiency. No conclusion could be extracted from
207 the fixation duration parameter of DM in the present study. It is impossible to know whether
208 the higher fixation duration could be attributed to the length or the nature of the information
209 included in the menu.

210 The information shown in the different menus did not influence designs' liking or dish choice.
211 Similar results were found in the study conducted by Feldman et al. (2014), who found that
212 including nutritional labeling or applying marketing strategies in the design of menus (e.g.:
213 dishes emplacement) had little effect on students' choice behavior, although a positive trend of
214 selecting healthier alternatives was observed. On the contrary, Wansink & Love (2014) reported
215 that using words and tools for shifting attention to enhance taste expectations and increase
216 perception of value could help to change consumers' choices to make dining out a profitable,
217 pleasurable, and nutritious experience.

218 The DM designed for the present study included information on the sensory characteristics of
219 the products, and this information did not have any impact on meal choice. All ingredients of
220 the meals presented in the menus were well-known ingredients of the Spanish gastronomy;
221 therefore, it is possible that the descriptive information provided in the menu to elicit specific
222 expectations on consumers was redundant or not needed to recall the experience of
223 consumption. Further studies could examine if including exotic/unknown ingredients, for which
224 the descriptive sensory properties are needed to elicit some expectations, has an influence on
225 meals choice (basic information vs detailed sensory description of the ingredients and meal).

226 The NM designed for the present research used a pictogram with different colors for vegetables,
227 proteins, and carbohydrates contents. Several authors have reported that the way of presenting
228 nutritional information may modify consumers' choices (Ellison et al., 2014; Roberto et al.,
229 2010). Results suggested that the pictogram used in the present study did not influence choice,
230 but no other methods were assessed (e.g.: caloric content). Further research could be conducted
231 to determine the best way of promoting healthy choices through the menu design.

232 Some of the main limitations of the present study are linked to the real context setting.
233 Environment, company, and other stimuli present in the restaurant may have affected
234 consumers choices (Köster & Mojet, 2006). In addition, some variables of the design of each

235 menu (e.g.: colors in the NM, number of words, etc.) could have affected some of the measures.
236 Despite all this, the present research shows interesting data related to the utility of eye tracking
237 technologies and suggests a new approach to analyze the collected data, being useful to help
238 researchers in further experimental designs research including eye-tracker.

239 **5. CONCLUSIONS**

240 The eye-tracker resulted a suitable tool to predict consumer choice in restaurants, but its
241 predictive capability varied depending on the type of menu, being a better predictor when basic
242 information or a brief description of each dish was presented. A positive relationship between
243 fixation duration and dish choice was found when menus with basic information or with
244 information about the sensory description of the dishes were provided. However, the eye-
245 tracker system was not a good predictive tool when a colorful infographic with nutritional-
246 related information was included in the menu. Health-related information could have altered
247 the decision-making process linked to the individual's health concern that deserved further
248 research.

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253 of the NM.

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327 **8. TABLES**

328 **Table 1. Results of eye-tracking measures for each AOI during participants' choice of dishes.**

Menu	AOI	Choices	Total fixation duration
BM	Brioche	15	2640
	Croquettes	16	3834
	Mushroom	6	1690
	Kokotxas	12	2956
	Pumpkin	20	3724
DM	Brioche	8	5371
	Croquettes	19	6020
	Mushroom	9	4304
	Kokotxas	12	5457
	Pumpkin	14	5720
NM	Brioche	9	4234
	Croquettes	14	3784
	Mushroom	8	2629
	Kokotxas	20	3767
	Pumpkin	14	4013

329 **Table 2. Percentage of correct, uncertain and incorrect predictions and Goodness Classification**

330 **Index of the prediction model developed for each menu.**

Statistic	BM	DM	NM
% Correct	52.17%	38.71%	30.77%
% Uncertain	28.99%	38.71%	30.77%
% Incorrect	18.84%	22.58%	38.46%
GCI	47.83%	35.48%	7.69%

331

332

FIGURE and CAPTIONS



Figure 1. Menus used the eye-tracking experiment (from left to right: basic menu, sensory menu, and nutritional menu)

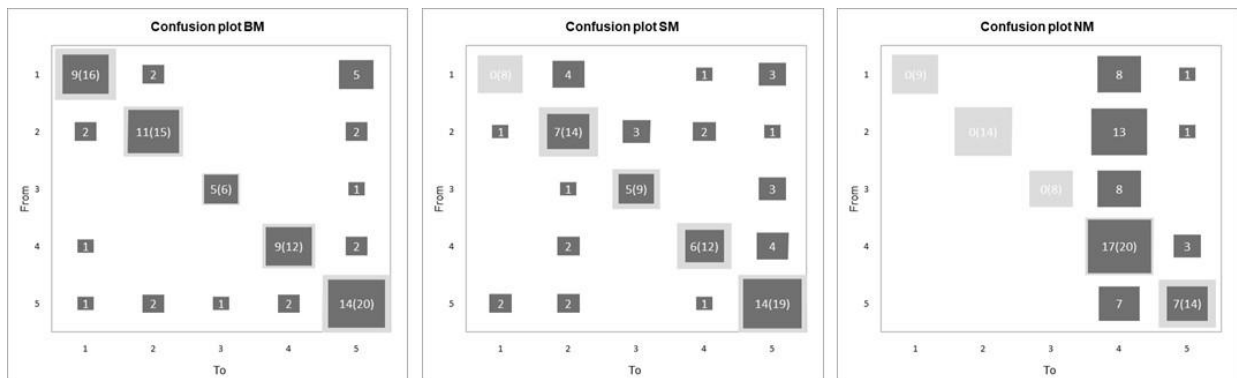


Figure 2. Confusion plots resulting from the calculation of the observed choices for each dish in grey, and the predicted choices by the model represented in black. Note: 1 = croquettes, 2 = kokotxas, 3 = pumpkin, 4 = brioche and 5 = mushroom.

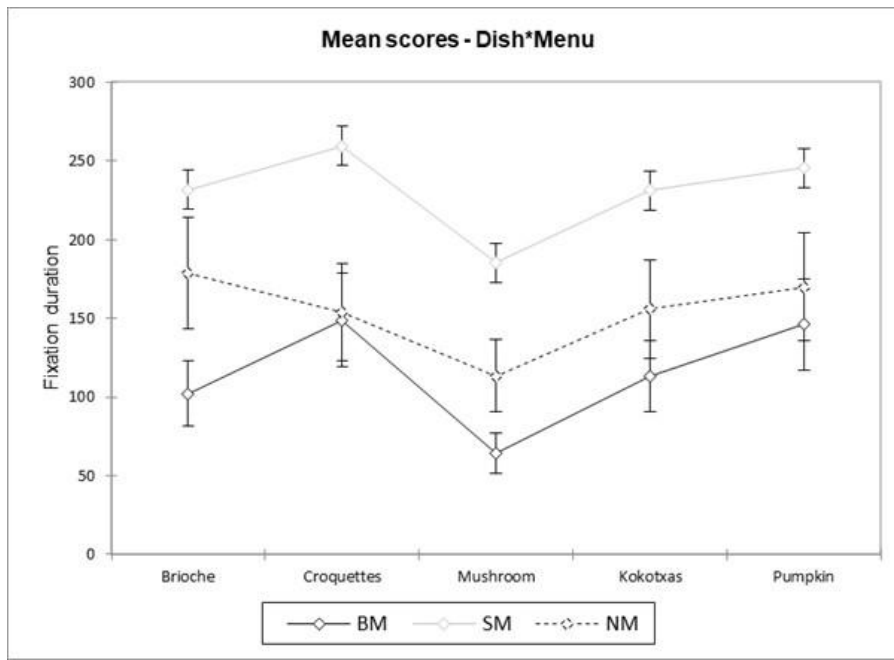


Figure 3. Two-way ANOVA results of the fixation duration showing the interaction dish*menu.