Impact of a front-of-pack nutritional traffic-light label on the nutritional quality and the hedonic value of mid-afternoon snacks chosen by mother-child dyads

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Abstract

The aim of this study was to assess the impact of a nutritional traffic-light label, the Nutri-Score, on snack choices in mother-child dyads and to assess a potential hedonic cost associated with a change in favour of healthier choices. French mothers and children (n=95; children's age: 7–11 years) who participated were asked to choose, for themselves and for the other dyad member, a snack composed of one beverage and two food items selected among several products with different nutritional quality. In the first step, the products were presented without any information. In the second step, the products were labelled with the Nutri-Score. Mothers and children were asked to rate their liking for all proposed products before being informed of their nutritional quality. The nutritional quality, the hedonic score, and the estimated budget of the selected snacks were compared before and after labelling. As hypothesized, the Nutri-Score label led to a significant increase in the nutritional quality of the chosen snacks. The budget for the chosen snacks was unchanged or decreased after the nutritional labelling was applied. Children and mothers had significantly lower liking for the snacks after nutritional labelling than before nutritional labelling, suggesting a hedonic cost associated with a change in favour of healthier snack choices. This raises the question of the sustainability of the behavioural change induced by the Nutri-Score label.

Keywords

Nutri-Score label, mid-afternoon snack, food choices, hedonic cost, healthiness, intervention.

1. Introduction

The French National Nutrition and Health Program (PNNS) recommends a mid-afternoon snack for children to help them have energy throughout the day and diversify their diet (Francou & Hébel, 2017). In France, the mid-afternoon snack is a common practice among children (Francou & Hébel, 2017) but also among their mothers. Mothers with a child in the household have been found to consume snacks with a higher energy density and a lower nutrient density than women without a child in household (Si Hassen et al., 2018). This eating occasion, which represents 14% of total daily energy intake in French children up to 10 years of age, is usually characterized by the consumption of energy-dense and fatty, sweet foods (Anses, 2017). These survey results on the nutritional composition of children's mid-afternoon snacks are in line with those obtained by sociologists. In social representations, this eating occasion remains resolutely associated with the universe of sweetness, pleasure of eating and gluttony (Comoretto, 2015; Tibère, Rochedy, & Sarrat, 2018). In this context, it appears relevant to identify ways to orient mid-afternoon snack choices towards beverages and food items with good nutritional quality for mother-child dyads.

One way to increase healthy food choices is to deliver information about the nutritional quality of a food product. Providing nutrition information via front-of-pack labels improves consumers' awareness of the healthiness of food products (Campos, Doxey, & Hammond, 2011; Cowburn & Stockley, 2005; Grunert & Wills, 2007; Hawley et al., 2012; Hersey, Wohlgenant, Arsenault, Kosa, & Muth, 2013). There are two main types of front-of-pack labelling systems: nutrient-specific systems, in which the product is characterized in terms of specific nutrients (sugar, fat, saturated fats, salt and energy), and summary systems, which provide a global evaluation of the nutritional quality of the food (Hersey et al., 2013).

In France, the principle of front-of-pack nutritional labelling was planned in the 2011-2015 National Programme for Nutrition and Health (PNNS) in line with European Regulation 1169/2011 and with the WHO recommendation of promoting consumer-friendly labelling (WHO, 2014). Two experiments were launched in 2016 to compare the efficiency of five different formats of front-of-pack nutritional labels, one in 60 supermarkets (Allais, Albuquerque, Bonnet, & Dubois, 2017; Ministère des Affaires

77 Sociales et de la Santé, 2017) and one in an experimental food store (Crosetto, Lacroix, Muller, &
78 Ruffieux, 2017).
79 Among the five different formats, we decided to test the impact of the Nutri-Score, a 5-colour
80 synthetic labelling system, on the nutritional quality of mid-afternoon snacks based on the results of
81 previous experiments. Research found that a five-colour nutrition label was perceived as the easiest
82 label to identify and as the label requiring the lowest amount of effort and time to understand (Ducrot
83 et al., 2015). Moreover, a study on the impact of different front-of-pack nutrition labels on consumer
84 purchasing intentions showed that in a virtual web-based supermarket, the five-colour nutrition label
85 was associated with a significantly higher nutritional quality of shopping cart items compared with a
86 control condition without any front-of-pack label (Ducrot et al., 2016). Finally, in an experimental
87 supermarket, the five-colour nutrition label, which was associated with communication about the logo,
88 led to a significant improvement in the nutritional quality of purchased items for the sweet biscuits
89 category, one of the three food categories that were tested, compared to the control condition without a
90 label or communication (Julia et al., 2016). To the best of our knowledge, no study has investigated
91 the impact of the Nutri-Score logo on the nutritional quality of mid-afternoon snack choices in mother-
92 child dyads.
93 The present research was conducted within mother-child dyads because food purchases are still mostly
94 made by mothers in French households (Mathé & Hébel, 2013) and because it appears that mothers
95 take their children's desires into account when offering them foods for their mid-afternoon snack
96 (Tibère et al., 2018). Some studies have reported the effect of nutritional information (Bannon &
97 Schwartz, 2006; Gonçalves et al., 2018; Miller, Seiders, Kenny, & Walsh, 2011) on children's food
98 choices, but only a few studies have investigated the impact of front-of-pack labels on school-age
99 children's food choices (Graham, Lucas-Thompson, Mueller, Jaeb, & Harnack, 2016; Privitera,
100 Phillips, Zuraikat, & Paque, 2015). These studies produced divergent results, which could be partly
101 due to the different label formats and different settings they used. However, in all these studies, the
102 choices were only declarative; in other words, the chosen food items were not consumed (Graham et
103 al., 2016; Privitera et al., 2015). Declarative methods have been described to bias participants toward
104 the choice of the more socially desirable option (Camerer & Hogarth, 1999). In this context, the aim of

105 the present study was to assess the impact of the nutritional label Nutri-Score on the nutritional quality
106 of mid-afternoon snack choices in mother-child dyads while limiting the effect of social desirability by
107 using a protocol that strengthened participant involvement. We hypothesized that the nutritional
108 quality of mothers' and children's choices would be higher after labelling. We also studied the effect
109 of socio-demographic characteristics on the potential change in the nutritional quality of chosen
110 snacks since it has been shown that such characteristics, particularly level of education and income,
111 have an impact on the understanding and use of food labels (Campos et al., 2011; Cowburn &
112 Stockley, 2005). In the literature, it is well established that healthier diets cost more than unhealthy
113 diets. Lower-quality diets, with a higher content of added sugars and fats, are generally less expensive
114 on a per calorie basis (Darmon & Drewnowski, 2015; Darmon & Maillot, 2010). Since price could
115 hinder the adoption of healthy food choices among a population with a low socio-economic level, we
116 studied the budget for snacks chosen before and after labelling.
117 Research has shown that delivering information about the health benefits of a food product could lead
118 to a counterproductive effect, particularly in children. A study showed that presenting food as
119 instrumental in achieving a goal, for example, outlining the health benefits of consuming a food
120 product, reduced perceived tastiness and decreased consumption in pre-school children (Maimaran &
121 Fishbach, 2014). Another study showed that children rated a "healthy labelled" drink as less pleasant
122 than the same drink presented without such a label (Wardle & Huon, 2000). Since focusing attention
123 towards healthiness of a food can decrease its liking and consumption, the second main goal of our
124 study was to assess the potential hedonic cost associated with a change in favour of healthier snack
125 choices.
126

127 **2. Material and method**

128 *2.1. General design*

129 The experiment was run in Dijon, Burgundy, France, from June-July 2017, before the market
130 introduction of food products labelled with the Nutri-Score. (The French government signed a decree
131 announcing the voluntary adoption of the Nutri-Score front-of-pack nutritional labelling in October

2017.) The general design is presented in Fig. 1 and summarized afterwards. During the sessions conducted in the laboratory, participants were asked to choose one beverage and two food items for a mid-afternoon snack, first for themselves and then for the other dyad member (step 1). Then, participants completed a questionnaire in which they rated their liking and perceived healthiness of all items, first for themselves then for the other dyad member (step 2). An explanation of the Nutri-Score label was then provided via a video (step 3). Mothers and children were again asked to choose one beverage and two food items first for themselves and then for the other dyad member among the same set of products, which were now labelled with the Nutri-Score label (step 4). Finally, participants completed a questionnaire in which they rated their perceived healthiness for all items, first for themselves then for the other dyad member (step 5). At the beginning of the experiment, participants were informed that one of the four chosen snacks – the two selected by the participants for themselves and the two selected by the other member of the dyad for this participant – would be randomly selected for their consumption on site at the end of the session.

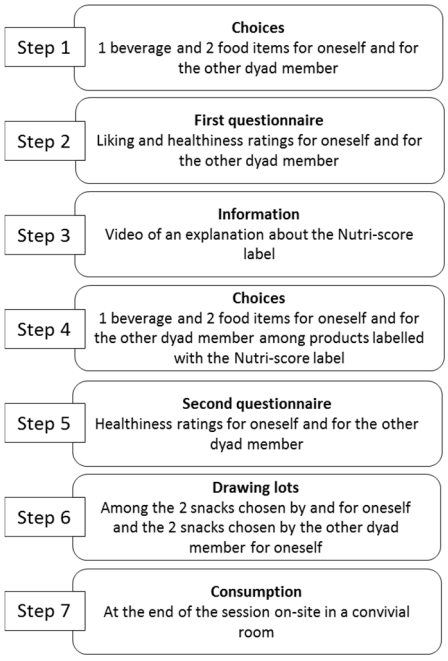


Fig. 1. General design of the experimental procedure

2.2. Products

Preliminary tests (qualitative survey and pre-tests) were conducted with children who did not participate in the main experiment in order to establish a possible list of products for our study. Then, a Nutri-Score was calculated for all these products (see 2.2.3). A final list was then established.

2.2.1. Qualitative survey

First, from January to March 2017, twenty-two semi-structured interviews were carried out to identify the mid-afternoon snack habits of mothers and children aged 9 to 11 years. These interviews were conducted at home with twenty-two mothers residing in Dijon and its suburbs. Second, observations were performed during extracurricular time in four schools located in Dijon and its suburbs to determine the kinds of beverages and food items that were distributed by leisure centres to children aged 9 to 11 years for their mid-afternoon snack. Following this qualitative study, a list of eight beverages and eighteen food items (not shown), representative of mid-afternoon snack habits, was established to formulate pre-tests.

2.2.2. Pre-tests

In April 2017, pre-tests were conducted to evaluate children's liking and perceived healthiness of the eight beverages and eighteen food items. These pre-tests were conducted in three leisure centres located in Dijon and its suburbs with twenty-nine children aged 8 to 11 years. During the face-to face interviews, children were presented the eight beverages and eighteen food items one at time and asked to rate their liking by answering the question "How much do you like this beverage/food?" using smiley face items and to rate their perceived healthiness by answering the question "How healthy is this beverage/food? using a thumb scale (Marty, Nicklaus, Miguet, Chambaron, & Monnery-Patris, 2018). This pre-test phase allowed us to compare the beverage and food items in terms of perceived healthiness and liking by children.

2.2.3. Nutri-Score calculation

The nutritional score based on the 5–C system was calculated using the data available on the products' nutrition labels regarding their contents in terms of energy density, five nutrients and fruits and

vegetables (Anses, 2016). According to the final score, a letter from A to E was assigned to each product. Each letter was written on a colour background, with green for A and red for E. The five colours appear on the label with a magnifying glass placed over the colour and letter assigned to the product (Fig. 2).

Fig. 2. Nutri-Score labels ranging from A to E

2.2.4. Final list of products

The final choices of products to include in the experiment were made based on the pre-test results. The products were contrasted in terms of their nutritional quality. All products were available in packaging with individual portions. Table 1 shows the list of 6 beverages and 9 food items used in the present study along with their Nutri-Score. During the laboratory experiment, the banana was labelled even though the Nutri-Score is intended to label only manufactured items.

Table 1. Beverages and food items and their Nutri-Score

6 beverages and 9 food items	Nutri-Score	Unit price (€)
Still water - Evian ®	A	0.32
Sparkling water - Perrier ®	A	0.35
Orange juice - Tropicana ®	C	0.89
Juiced strawberry - Volvic ®	D	0.51
Iced tea peach - Lipton ®	D	0.43
Chocolate dairy drink Candy'Up - Candia ®	E	0.33
Banana	A	0.17
Applesauce - Materne ®	A	0.40
Drinkable strawberry yogurt - Yoplait ®	B	0.32
Fruit salad - Douceur du Verger ®	B	0.57
Vanilla cream - Mont-Blanc ®	B*	0.52
Strawberry brioche - Pasquier ®	D	0.18
Chocolate biscuit Prince - Lu ®	D	0.18
Chocolate filled crepes - Whaou ®	E	0.20
Chocolate bar Kinder Bueno - Ferrero ®	E	0.64

Note: * The Nutri-Score of this food item was C but was mislabelled during the experiment. The score shown during the experiment was taken into account in the calculations.

197 *2.3. Participants*

198 Ninety-five mother-child dyads participated in this study. They were recruited through our internal
199 database (Chemosens Platform's PanelSens, CNIL no. 1148039), through leaflets distributed at the
200 exits of schools located in Dijon, and by a recruitment agency. The inclusion criterion for mothers was
201 to have an afternoon snack at least once to twice a month. The inclusion criterion for children was
202 grade level (3rd, 4th or 5th grade). Participants who indicated that they had a food allergy or a chronic
203 health disease were excluded. At the beginning of the experiment, mothers and children signed a
204 consent form to indicate their agreement to participate in the study. A consent form was also obtained
205 from mothers for the participation of their child. The research was approved by the Ethics Evaluation
206 Committee of Inserm (IRB00003888). At the end of the experiment, mothers received a €20 voucher
207 to thank them for their participation. The mean age of the participating children was 9.38 years
208 (range=7-11 years). Table 2 shows the socio-demographic characteristics of the participants.
209

Table 2. Socio-demographic characteristics of participants (n=95 dyads)

Children's sex (%)	
Male	43.2
Female	56.8
Children's grade level (%)	
3rd grade	34.7
4th grade	35.8
5th grade	29.5
Mothers' age (%)	
≤ 40	66.3
> 40	33.7
Mothers' education (%)	
GCSE'S under C grade (D-G)/Youth Training (NVQ level 1,2)/BTEC First Diploma	11.6
A level	21.0
Second-year university level	24.2
More than second-year university level	37.9
PhD	5.3
Monthly net income of the household (%)	
≤ 3000	42.1
]3000-5000[	44.2
≥ 5000	11.6
Don't know	2.1

2.4. Experimental procedure

The procedure was based on a protocol previously used with mothers and children in the same age range (Marette, Issanchou, Monnery-Patris, Ginon, & Sutan, 2016). During the experiment, mothers and children were placed in front of a wall. Moreover, to avoid oral and visual interactions between mothers and their children they sat back to back with one another and screens were installed between them at the centre of the room. Thus, participants' choices were not made in front of the experimenter. To ensure anonymity, each participant was identified by a code. Once participants were seated, the experimenter provided instructions. At the beginning of the experiment, participants were advised that one of the four chosen snacks (the two selected by the participant and the two selected by the other member of the dyad for this participant) would be randomly selected for their consumption.

2.4.1. Participants' snack choices for themselves and for the other dyad member among products without the Nutri-Score label (step 1, Fig. 1)

Two boxes, one containing six beverages and another containing nine food items, were distributed to each participant (Fig. 3). Mothers and children were asked to choose one beverage and two food items for their own mid-afternoon snack. The three selected products were placed in the first bag, and once filled, the bags were taken away by the experimenters. Boxes containing beverages and those containing food items were replenished with the missing products. Next, mothers and children were asked to choose one beverage (among six) and two food items (among nine) for a mid-afternoon snack for the other dyad member. After this second choice, full bags and boxes were taken away.

Fig. 3. Picture of two boxes with food products without labels

2.4.2. First questionnaire (step 2, Fig. 1)

The experimenters distributed a questionnaire to each participant. First, mothers and children were asked to guess the three products (one beverage and two food items) that the other dyad member had chosen for them (results not shown). Then, they rated their liking of all items, first for themselves ("How much do you like this food?") and then for the other dyad member ("How much do you think your mom/child likes this food?"). Responses were given on a 5-point scale labelled at the left anchor with "I don't like it at all" and at the right anchor with "I like it very much" (Fig. 4. A) and coded from 1 to 5 for the analyses. Lastly, they rated their perceived healthiness of all items, first for themselves ("How healthy do you think this food is for you?") and then for the other dyad member ("How healthy do you think this food is for your mom/child?"). Responses were given on a 5-point scale labelled at the left anchor with "It is not healthy at all" and at the right anchor with "It is very healthy" (Fig. 4. B) and coded from 1 to 5 for the analyses. The scales were based on the scales used by Marty et al.

(2018). While participants completed the questionnaires, the experimenters recorded the contents of the bags.

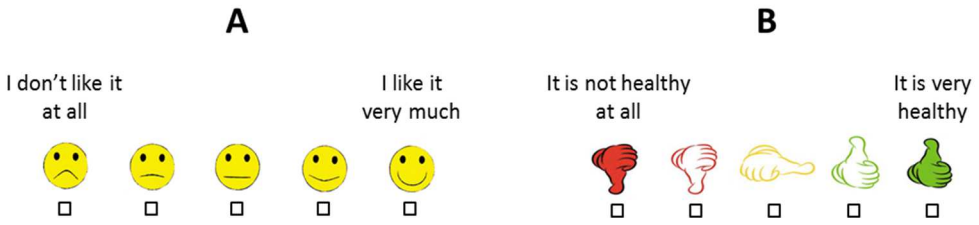


Fig. 4. Liking scale (A) and perceived healthiness scale (B).

2.4.3. Nutri-Score information presentation (step 3, Fig. 1)

Since the experiment took place before the Nutri-Score label was actually used in the market, it was necessary to provide some information about this labelling system. To limit a potential desirability bias, information about the Nutri-Score label was not read by an experimenter but was provided via a short video. The message, delivered by a voice-over, was "The Nutri-Score logo – what is it? This label guides us to choose healthy foods: low in fat, low in sugar, low in salt and high in fibres and vitamins. Food products with the letter 'A' or 'B' are healthy. Food products with the letter 'C' are neither healthy nor unhealthy. Food products with the letter 'D' or 'E' are unhealthy. In summary, the greener the letters are, the healthier the foods are, and the redder the letters are, the unhealthier the foods are".

2.4.4. Participants' snack choices for themselves and for the other dyad member among products with the Nutri-Score label (step 4, Fig. 1)

After this information was provided, new boxes with products that were the same as those used in step 1 but were now labelled with the Nutri-Score were distributed to each participant. Fig. 5 represents an example of one of the nine food items without and with the Nutri-Score label. The procedure was the same as in step 1.

Fig. 5. Picture of a food item without and with the Nutri-Score label

2.4.5. Second questionnaire (step 5, Fig. 1)

A second questionnaire was distributed to each participant. Mothers and children were asked to guess the three products (one beverage and two food items) chosen for them by the other dyad member (results not shown). Then, they rated their perceived healthiness of all items (results not shown), first for themselves ("How healthy do you think this food is for you?") and then for the other dyad member ("How healthy do you think this food is for your mom/child?"). Then, mothers answered questions on their socio-demographic characteristics, and children answered questions on their mother's feeding practices regarding restrictions and pressure to eat (Monnery-Patris et al., 2011). As participants completed the questionnaires, the experimenters recorded the contents of the bags.

2.4.6. Drawing a snack and end of the experiment (steps 6 and 7, Fig. 1)

The four bags (the two chosen by participants for themselves and the two chosen for participants by the other dyad member) were shown to each participant. Mothers and children were asked to indicate which bag they wanted to have (results not shown). Then, one of the four snacks was randomly selected, and participants were asked to indicate their satisfaction with the snack (results not shown) before consuming it in another room that was especially designed for a social eating occasion. Before leaving, they were asked to note their impression in a guestbook.

2.5. Statistical analyses

292 Statistical analyses were performed with R software for Windows version 3.4.2.

293 *2.5.1. Liking and perceived healthiness ratings*

294 Friedman tests were carried out to compare the medians of the liking and perceived healthiness ratings
295 issued by participants for themselves and for the other dyad member for beverages and for food items.
296 To complete these analyses, multiple comparison tests were performed based on pairwise comparisons
297 using the Wilcoxon signed rank test with Bonferroni adjustment.
298 The slopes of the individual regressions of the perceived healthiness ratings on the Nutri-Score values,
299 given by the children and the mothers for themselves, were calculated separately for the beverages and
300 the food items. Then, we tested whether the mean of the individual slopes was different from 0. The
301 same process was performed for the liking ratings.

302

303 *2.5.2. Nutritional quality of choices*

304 For each chosen snack, the nutritional quality was evaluated by calculating a score, called the
305 "nutritional score", according to the Nutri-Score of the chosen products. Five points were assigned to a
306 product with a Nutri-Score of "A", four points to a product with a Nutri-Score of "B", three points to a
307 product with a Nutri-Score of "C", two points to a product with a Nutri-Score of "D" and one point to
308 a product with a Nutri-Score of "E". Thus, the nutritional score could range from 3 to 15. A bilateral
309 Wilcoxon test for paired samples was used to compare the medians of the nutritional scores of the
310 snacks chosen by children and mothers for themselves and for the other dyad member before and after
311 receiving information about the Nutri-Score system and product labelling.

312

313 *2.5.3. Hedonic scores of choices*

314 For each chosen snack, a hedonic score was calculated according to the ratings, coded from 1 to 5,
315 given in the first questionnaire for each chosen product (step 2, Fig. 1, i.e., before nutritional
316 labelling). Thus, these scores could range from 3 to 15 for the snacks. A bilateral Wilcoxon test for
317 paired samples was used to compare the medians of the hedonic scores of the chosen snacks before
318 and after information was provided on the Nutri-Score system and product labelling. These

comparisons were conducted on the snacks chosen by the children and the mothers for themselves. Two Kendall tau correlation tests were carried out to evaluate the link between the change in nutritional scores and the change in hedonic scores given by mothers and children.

2.5.4 Effect of socio-demographic characteristics on the change in the nutritional quality of product choices

Two multiple linear regression models were carried out to explain the difference in the nutritional quality of the chosen snacks (by children for themselves and by mothers for themselves) before and after the presence of nutritional labelling by the socio-demographic characteristics of children and mothers.

2.5.5. Budget for choices

The budget for the chosen snacks was estimated according to the purchase prices of the products at the time of experiment (Table 1). The median budgets for the snacks chosen before and after the provision of information about the Nutri-Score system and product labelling were compared with a bilateral Wilcoxon test for paired samples. These comparisons were conducted on the snacks chosen by the children and the mothers for themselves and for the other dyad member.

3. Results

First, in this section, we describe the liking and perceived healthiness ratings for the different beverages and food items provided to children and mothers to make their snack choices. Second, we present the results related to our main objectives, i.e., the nutritional and hedonic scores of choices before and after the provision of nutritional information. Finally, we present the effect of socio-demographic characteristics on the change in the nutritional quality of choices and then the estimated budget for the different choices. Following the mislabelling of the vanilla cream (as noted in table 1), statistical analyses were also conducted without considering the data for children and mothers who have chosen this item. Since the conclusions obtained with these analyses were identical to the

conclusions obtained with all data, the results without considering the data for children and mothers who have chosen the vanilla cream are presented only in Supplementary Fig. 1 and Fig. 2.

3.1. Liking and perceived healthiness ratings for beverages and food items

Our aim was to propose beverages and food items that were relatively well liked but contrasted in terms of perceived healthiness. Thus, the distributions of liking and perceived healthiness ratings given to beverages and food items by participants for themselves and for the other dyad member were examined and are presented in Supplementary Fig. 3. Friedman tests indicated significant differences between products (beverages and food items) in terms of the liking and perceived healthiness ratings given by children and mothers for themselves and for the other dyad member (all $P < 0.001$).

The results showed that water was the beverage most liked by children and mothers, with a median equal to 5. The beverage least liked by children was sparkling water, with a median equal to 2, and the beverage least liked by mothers was the chocolate dairy drink Candy'Up, with a median equal to 2. Among food items, the chocolate bar Kinder Bueno was product the most liked by children, with a median equal to 5. The chocolate bar Kinder Bueno was also one of the products most liked by mothers. The least liked food item was vanilla cream, with a median equal to 3 for children and 2 for mothers. Despite significant differences, all medians were equal to or higher than 3 for five out of six beverages for children and mothers, for all food items for children, and for eight out of nine food items for mothers.

Water was significantly perceived by children and mothers as the best for their health, with a median equal to 5, while tea peach was considered by mothers as the worst for their health, with a median equal to 2. Surprisingly, the health value of sparkling water was underestimated by children and mothers compared with the Nutri-Score value. This misperception may be attributed to the fact that sparkling water is a fizzy drink. Among food items, the banana was significantly perceived to the best for their health, with a median equal to 5, whereas the chocolate bar Kinder Bueno had a median equal to 2.

The results indicate that the means of the individual slopes of the regressions of the liking ratings on the Nutri-Score values for beverages were significantly negative for children but significantly positive for mothers (Table 3). The same result was found for food items for children and mothers. The means of the individual slopes of the regressions of the perceived healthiness ratings on the Nutri-Score values for beverages and food items were significantly positive for children and mothers. Thus, the perceived healthiness ratings were higher for higher Nutri-Scores. This shows that children and mothers had a good perception of the nutritional value of the beverages and food items. The lower mean slope observed for beverages in children was due to the underestimation of the healthiness of sparkling water.

Table 3. Mean slopes of the regressions of liking ratings or perceived healthiness on Nutri-Scores

	Mean slopes of the regressions of			
	liking ratings on Nutri-Scores		perceived healthiness ratings on Nutri-Scores	
	Beverages	Food items	Beverages	Food items
Children	-0.07 ($P = 0.03$)	-0.08 ($P = 0.006$)	0.19 ($P < 0.001$)	0.49 ($P < 0.001$)
Mothers	0.31 ($P < 0.001$)	0.11 ($P < 0.001$)	0.42 ($P < 0.001$)	0.58 ($P < 0.001$)

3.2. Nutritional scores of children's and mothers' chosen snacks

The percentages of each beverage and food item chosen by children and mothers before and after labelling are presented in Supplementary Tables 1 and 2.

As shown in Fig. 6, children's and mothers' choices for themselves and for the other dyad member were significantly more oriented towards products with good nutritional quality after labelling than before labelling ($P < 0.0001$), which is in accordance with our hypothesis. Moreover, the increase in nutritional quality of snacks that participants chose for themselves was higher ($P < 0.05$) among children than among mothers (Fig. 7). More precisely, the median nutritional quality of choices participants made for themselves increased by 4 points among children and 2 points among mothers. This result could be partly attributed to the fact that the nutritional quality of choices made by children

for themselves was initially lower than the nutritional quality of choices made by mothers for themselves ($P < 0.0001$). The median nutritional quality of choices made by children for their mother and by mothers for their child increased by 4 points. Moreover, as shown in Fig. 7, the nutritional score of participants' choices for themselves increased for more than 75% of participants.

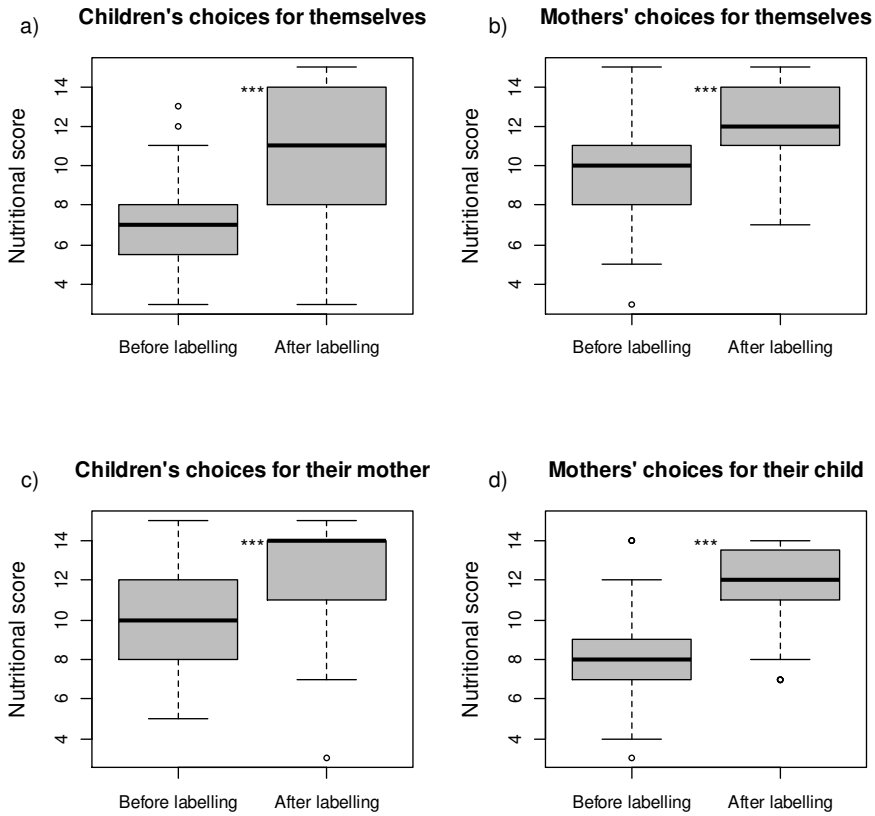


Fig. 6. Distributions of the nutritional scores of snacks chosen before and after labelling by participants for themselves (a, b) and for the other dyad member (c, d).

For each boxplot, the bottom and top of the box indicate the 25th and 75th percentiles, respectively, and the line within the box indicates the median. The whiskers extend from the box as far as the data extend to a maximum distance of 1.5 × the interquartile range. Any values more extreme than this value are marked by a circle (°).
*** $P < 0.0001$, bilateral Wilcoxon test for paired samples.

407

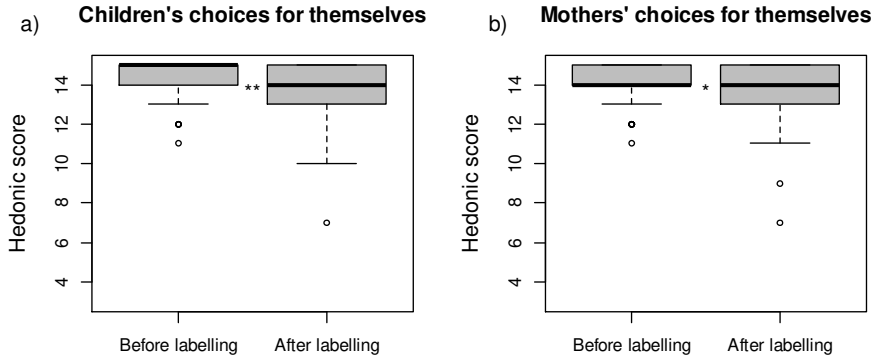
408 **Fig. 7.** Distribution of the variation in the nutritional scores between the "before labelling" and "after labelling"
409 conditions for participants' choices for themselves.

410 * $P < 0.05$, bilateral Wilcoxon test for paired samples.

411

412 *3.3. Hedonic scores of children's and mothers' choices*

413 As shown in Fig. 8, the hedonic scores were very high before and after labelling, but the snacks
414 children chose for themselves were significantly ($P < 0.001$) less liked after labelling than before
415 labelling. The same result was observed for mothers ($P = 0.004$), and as shown in Fig. 9, no difference
416 was found between the change in hedonic score of snacks chosen by children compared with mothers
417 ($P = 0.35$). Moreover, a decrease in the hedonic score was observed for 75% of participants.

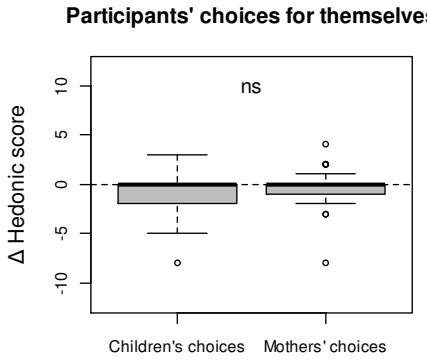


418

419 **Fig. 8.** Distributions of the hedonic score of snacks chosen by participants for themselves before and after
420 labelling (a, b).

421 ** $P < 0.001$, * $P < 0.004$, bilateral Wilcoxon test for paired samples.

422



423

424 **Fig. 9**. Distribution of the variation in hedonic scores between "before labelling" and "after labelling" conditions
425 for participants' choices for themselves.

426

427 Negative associations between the change in the nutritional score and the change in the hedonic score
428 of chosen snacks were found. These associations were significant for mothers' choices for themselves
429 (τ = -0.19, P = 0.02) but did not reach significance for children's choices for themselves (τ = -0.15, P
430 = 0.052).

431

432 *3.4. Effect of socio-demographic characteristics on the change in the nutritional quality of chosen*
433 *snacks*

434 Table 4 presents the results of two regressions conducted to estimate the effect of socio-demographic
435 characteristics on the change in the nutritional quality of the chosen snacks. The only significant effect
436 was the mother's age, which had a negative effect on the change in nutritional quality. This result
437 could be partly attributed to the fact that the nutritional quality of choices made by the youngest
438 mothers for themselves was initially lower than the nutritional quality of choices made by the older
439 mothers for themselves (result not shown).

440

441 **Table 4.** Effect of the socio-demographic characteristics on the change of the nutritional quality of
442 chosen snacks

	Dependent variable: variation in the nutritional score	
Independent variables	**Children for themselves**	**Mothers for themselves**
Children's sex (male)	-0.061 (0.642)	-0.423 (0.474)
Children's grade level (3rd grade)	1.411 (0.768)	-0.844 (0.568)

Children's grade level (5th grade)	-0.567 (0.802)	-0.485 (0.593)
Mother's diploma (low)	0.046 (0.727)	-0.261 (0.537)
Mother's age	0.006 (0.072)	**-0.139 (0.053)**

Numbers in brackets are standard errors.
The value in bold is statistically significant with P < 0.05

3.5. Estimated budget for children's and mothers' chosen snacks

As shown in Fig. 10, there was no significant difference between the budget for snacks chosen by children for themselves (P = 0.50) and snacks chosen by mothers for their child (P = 0.11) after labelling compared with before labelling. In contrast, the budget for snacks chosen by mothers for themselves and by children for their mother were significantly lower after labelling than before labelling (P = 0.01)More precisely, the median budget for choices made by mothers for themselves decreased by € 0.11, and for choices made by children for their mothers from € 0.15..

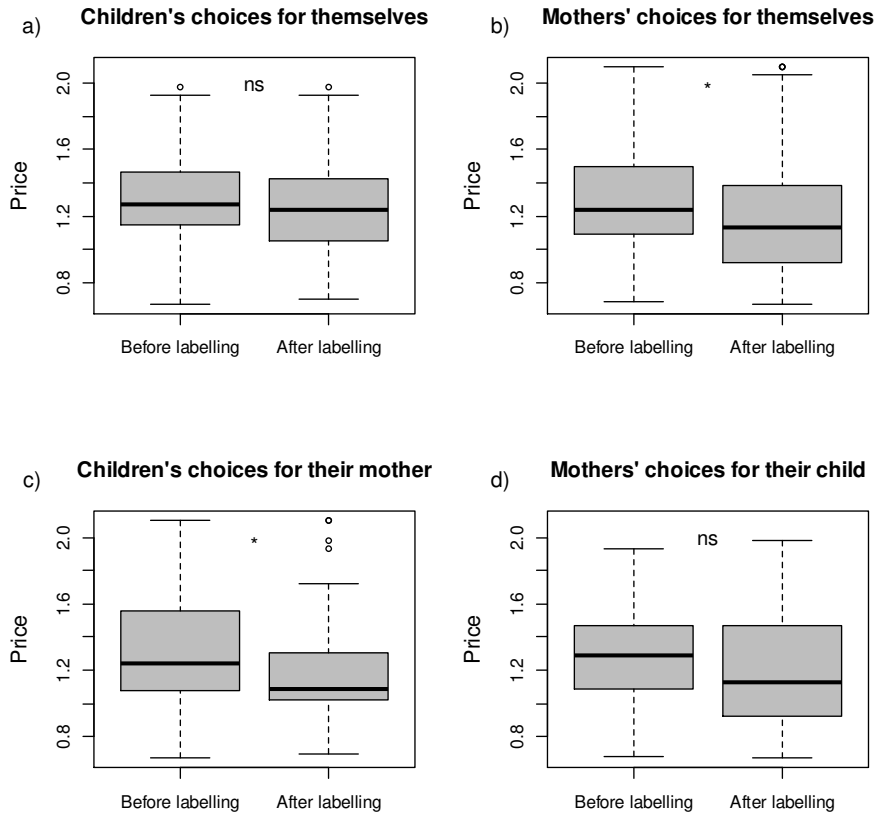


Fig. 10. Distributions of the estimated budget for snacks chosen before and after labelling by participants for themselves (a, b) and for the other dyad member (c, d).

* P < 0.01, bilateral Wilcoxon test for paired samples

4. Discussion

Our results showed that the nutritional quality of snacks chosen by participants for themselves and for the other dyad member was significantly better when products were labelled with the Nutri-Score, which was in accordance with our hypothesis. These findings are in line with those from a recent study showing an improvement in the nutritional quality of shopping cart items in a condition in which food products were labelled with the 5-colour nutrition label compared with a control condition without product labelling (Ducrot et al., 2016). Our findings are also consistent with those from a study that was conducted in an experimental food store and found an improvement in the nutritional quality of food products chosen by adults when products were labelled with the Nutri-Score than when three other nutrition labelling systems were used (Crosetto et al., 2017). The efficacy of the Nutri-Score label in terms of improvement in the nutritional quality of chosen snacks could be due to this label's summary and prescriptive format (Crosetto et al., 2017; Crosetto, Muller, & Ruffieux, 2016; Hersey et al., 2013). A simple label that provides an overall evaluation of the nutritional value of a food product seems to be more effective (Hersey et al., 2013) and easier to understand and to interpret (Muller & Ruffieux, 2012) than a label with a nutrient-specific format, i.e., a label that provides information about the content of different specific nutrients. The efficacy of the Nutri-Score label could also be linked with its colours, which draw consumers' attention and resemble traffic-light signals. Red colour is typically associated with avoidance and danger (Elliot & Maier, 2007), and French teachers usually use red pencil to underline students' errors, both of which increase the alarm connotation of this colour. The representations associated with red colour are thus well identified by school-aged children, which could explain why the Nutri-Score label seems to be particularly effective in children. Indeed, the results of our study showed that the difference between the nutritional quality of chosen snacks before and after labelling was more significant for the snacks chosen by children for themselves than for the snacks chosen by mothers for themselves. These findings are in accordance with those from a study that showed that when choosing snacks for themselves, children reacted more to health-based information than their mother (Marette et al., 2016). Interestingly, our results highlight that both

485 children and mothers have accurate knowledge of the nutritional value of the targeted food products.
486 In fact, the mean of the individual slopes of the regressions of the perceived healthiness ratings, given
487 before information was provided, on the Nutri-Scores values for beverages and food items was
488 significantly positive for children and mothers. Children's ability to correctly classify foods in the
489 categories of "good" or "bad" for health was previously demonstrated (Nguyen, 2008). Moreover, a
490 cognitive processing model posits that consumers with prior nutrition knowledge pay attention to
491 information on a food label, are able to understand this information, and store this information to apply
492 it to a food related-decision (Soederberg & Cassady, 2015). Thus, one could argue that the significant
493 effect of the Nutri-Score labels is due to the activation of a previous nutritional knowledge by the
494 presence of the Nutri-Score which acts as a nudge leading to healthier food choices.

495 Both mothers and children had a significantly higher liking for the snacks before they were labelled
496 with the Nutri-Score than after they were labelled. Moreover, a significant negative association
497 between the change in the nutritional score and the change in the hedonic score of chosen snacks was
498 found in mothers and a tendency was observed in children. This means that when the Nutri-Score of
499 the chosen snack increased, its liking scores decreased. This hedonic cost was observed despite the
500 fact that several products with good nutritional quality were as well liked as products with poor
501 nutritional quality (see Supplementary Fig. 3). Since liking is a strong driver of food choices,
502 especially in children (Nguyen, Girgis, & Robinson, 2014), the hedonic cost associated with a change
503 in favour of healthier snack choices after labelling raises the question of the sustainability of such a
504 behavioural change. A recent study (Marty et al., 2017) highlighted that children with more
505 hedonically based implicit and/or explicit attitudes towards food were more likely to choose healthy
506 food options from a buffet. Conversely, children with both implicit and explicit nutrition-based
507 attitudes chose less healthy foods (Marty et al., 2017). These results suggest that food preferences do
508 not necessarily constitute a threat in the adoption of a healthy diet and underline that pleasure could
509 constitute a lever in the implementation of interventions to encourage healthy snack choices by
510 highlighting the attractiveness of healthy food products (Marty et al., 2018).

511 The result of the regressions showed that mothers' age had a negative effect on the change in the
512 nutritional quality of snacks they chose for themselves. This result could be partly attributed to the fact
513 that the nutritional quality of the choices made by the youngest mothers for themselves was initially
514 lower than the nutritional quality of the choices made by older mothers for themselves. This finding is
515 in accordance with those of a recent study showing that energy density and energy intake from daily
516 snacks decreased with age in women (Si Hassen et al., 2018). However, this result is different from
517 those of studies showing that people with lower levels of education are likely to have the most
518 difficulty understanding food labels (Campos et al., 2011; Cowburn & Stockley, 2005). This may be
519 because more than half of the mothers of our sample had a high level of education.

520 In this study, we also examined the economic cost of the chosen snacks. Our results showed that the
521 budget for snacks with a higher nutritional quality, i.e., those chosen after labelling with the Nutri-
522 Score, was not higher. On the contrary, while the nutritional quality significantly increased, the price
523 significantly decreased in two out of four cases, i.e., for the snacks chosen by the children for their
524 mother and the snacks chosen by the mothers for themselves. Of course, these results were obtained
525 with a given set of food products. Our results are consistent with those of a study showing that higher
526 diet quality is not necessarily costlier (Marty et al., 2015). According to the results of our study, the
527 lower budget associated with healthy snack choices could constitute an argument to promote healthy
528 snack choices among a population with a low socio-economic level. Thus, this budget argument could
529 also help reduce social inequality in food accessibility.

530 The present study has several limitations. First, although the message was not read by an experimenter
531 during the experiment, a social desirability bias cannot be totally excluded. However, we tried to
532 reduce this effect since the voice of the person delivering the message that explained the nutritional
533 labelling system was a neutral voice that did not belong to one of the experimenters. In addition, with
534 the aim of involving mothers and children and to limit the social desirability bias, we informed
535 participants at the beginning of the session that one of the four chosen snacks would be randomly
536 selected for consumption on site. Nevertheless, the within-subject design used in the present
537 experiment could have induced a purely cognitive demand effect. However, we have chosen a within-

subject design because this design has greater statistical power than a between-subject design. Moreover, since our experiment was conducted before the market introduction of food products labelled with the Nutri-Score, our purpose was to test what could happen when such a labelling would be introduced and thus a within-subject design makes sense. Additionally, our results showed that the Chocolate bar Kinder Bueno, which was the most liked product (see Supplementary Fig. 3), was still the most chosen item by children after labelling (see Supplementary Table 1). This result clearly shows the limited impact of the social desirability bias or a relatively "weak wish" to satisfy the organizer. Our results also showed that while the vanilla cream and the drinkable strawberry yogurt were both labelled with a Nutri-Score B, the children's and mothers' choices for themselves of the vanilla cream did not increase as much as the choices for the drinkable strawberry yogurt (see Supplementary Tables 1 and 2), and this is in line with the fact that the drinkable strawberry yogurt was more liked than the vanilla cream (see Supplementary Fig. 3). This indicates that the choices were mostly guided by the liking and not by the demand effect. Second, as mentioned by Crosetto et al. (2017), the experimental approach directed participants' attention to the nutritional labelling system, which could lead to an amplification of the effects measured. Eventually, we know that a laboratory experiment is not a field experiment (directly in stores), which is a limitation of our study. Indeed, several studies showed that the proliferation of messages, the imperfect recall, the lack of attention to messages before purchasing, and the great number of purchased products affect many consumers in stores. Reaction in the laboratory experiments with focused consumers is an upper boundary regarding the possible consumers' reactions in the store. Thus, one can suppose that the effects that would be observed in a real shopping experience would be lower than the ones observed in our experiment. Despite this limitation stemming from the artificial environment, an experiment conducted in the laboratory allows a precise observation of participants' choices. As mentioned by several authors (Crosetto et al., 2017; Marette et al., 2016), the experimental method constitutes a strength since an experiment conducted in the laboratory allows the isolation of participants' choices for themselves, which is particularly difficult to study in a natural field experiment.

Conclusion

The front-of-pack nutrition label "Nutri-Score" can help improve the healthiness of mid-afternoon snack choices in mother-child dyads. However, the experimental situation could have strengthened the effect of this label. Moreover, the hedonic cost associated with this change raises the question of the sustainability of such a behavioural change, since pleasure is a strong driver of food choices, particularly in children. Thus, it seems important to develop strategies to increase the pleasure of consuming healthy foods in order to avoid a potential hedonic cost. One strategy could be the promotion of healthy food products to increase their attractiveness. This study provides implications for public health policy, emphasizing the importance of reinforcing the association between healthiness and sensory pleasure.

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