



**HAL**  
open science

## Do children with a high level of eating motivation consume less when foods are partitioned?

Natalie Rigal, Camille Champel

### ► To cite this version:

Natalie Rigal, Camille Champel. Do children with a high level of eating motivation consume less when foods are partitioned?. *Physiology & behavior*, 2019, 211, pp.112636 -. 10.1016/j.physbeh.2019.112636 . hal-03487825

**HAL Id: hal-03487825**

**<https://hal.science/hal-03487825>**

Submitted on 20 Dec 2021

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

**Title**

Do children with a high level of eating motivation consume less when foods are partitioned?

**Authors names and affiliation**

Natalie Rigal & Camille Champel, Department of Psychology, University Paris Nanterre, 200 avenue de la République, 92000 Nanterre, France.

**Corresponding author**

Natalie Rigal

Postal address: University Paris Nanterre, Department of Psychology, 200 avenue de la République, 92000 Nanterre, France.

E-mail address: [rigal@parisnanterre.fr](mailto:rigal@parisnanterre.fr)

Tel : +33 (0)608847270

1 **Title**

2 Do children with a high level of eating motivation consume less when foods are partitioned?  
3

4 **Abstract**

5 Eating behaviors, especially the control of intake, are modulated by both internal and external factors.

6 The objective of our study was to examine the effect of the interaction between eating motivation (as

7 an internal factor) and food partition (as an external factor) on chocolate intake in children, with the

8 hypothesis, based on the paradigm of motivated perception, that the effect of partition, i.e. reduced

9 intake, is higher for children with a high level of eating motivation than for other children.

10 A mixed model design was used in which 80 children aged 8-11 yrs were offered, in their natural

11 setting, two standardized afternoon snacks that included, among other things, 100 grams of chocolate

12 presented once as a whole (one bar) and once segmented (six pieces). The amount of chocolate eaten

13 was weighed and compared between conditions (Bar vs Pieces). Children completed questionnaires in

14 order to assess two of their eating motivational features (appetite arousal, chocolate specific appetite).

15 Results indicated no effect of Partition: children ate the same quantity of chocolate in the two

16 conditions (Bar or Pieces). Only chocolate specific appetite was associated with the amount of

17 chocolate eaten, with children with a higher level eating more than other children (+13 g). Contrary to

18 adults, children are not influenced by the "many is more effect". Methodological and developmental

19 interpretations were suggested, linked to the size of the portion, the network of attention and the

20 sensibility to the external cues underlying the control of intake.

21

22 **Key words:** eating behavior; motivation; appetite; partition; children; intake

23

24

## 25 **1. Introduction**

26 It is widely accepted that eating behavior is influenced by both internal and external factors.  
27 This assertion is particularly true when it comes to the control of food intake which, when poorly  
28 regulated, is one of the contributors to the current epidemic of childhood obesity (for a review, see  
29 [1]).

30 With regard to internal factors, we know in particular the effect of individuals' motivational  
31 eating characteristics. As noted by Berridge [2], the concept of motivation is essential for  
32 understanding, in the perspective of neurobehavioral science, the psychological processes that guide  
33 behaviors. The notion of "appetite arousal" is one of the ways of characterizing the motivation to eat.  
34 Appetite arousal corresponds to the intensity of the desire to eat foods [3]. This is a trait of  
35 temperament, relatively stable over time and independent of contexts and of specific foods. Similar  
36 concepts have been used in the literature: "external eating" from the Dutch Eating Behavior  
37 Questionnaire for Children (DEBQ-C) [4], "food responsiveness" from the Children's Eating Behavior  
38 Questionnaire (CEBQ) [5], and "food addiction" from the Yale Food Addiction Scale for children  
39 (YFAS-C) [6]. High scores on these food approach traits have been associated with larger portion  
40 sizes, overeating and/or higher BMIs in children [7, 8, 9, and for a review, see 10], leading to the  
41 assumption that the higher children's levels of appetite arousal, the more they will eat large quantities  
42 of foods.

43 Another concept relating to the motivation of eating is that of "specific appetite" or the desire to  
44 eat particular foods [11, 12]. It differs from the concept of appetite arousal in that it does not concern  
45 the desire to eat in general, but is characterized by the specificity of foods, among other things on the  
46 sensory level. It also differs from the notion of "craving" which refers to an intense desire to eat a  
47 specific food and which, because of this high intensity, is outside the scope of ordinary food intake  
48 [11]. Food cravings are widely believed to influence snacking behavior and especially the amount of  
49 food eaten, which has been demonstrated especially with chocolate [13]. Because of its proximity to  
50 the concept of craving, the concept of specific appetite, while remaining in the area of non-  
51 pathological food intake, is likely to make intake of a specific food higher.

52 With regard to external factors, some visual qualities of foods have been identified in the  
53 control of food intake. For example, experimental studies have shown that increases in portion size  
54 lead to increases in energy and/or the risk of becoming overweight, especially during childhood (for a  
55 review, see [14]). On the other hand, the effect of the shape of the portion remains insufficiently  
56 explored, especially with children. In adults, the “many is more effect” or “partition effect” has been  
57 demonstrated. This is the process by which high-energy foods offered in a partitioned manner  
58 (segmented, in pieces, several small units) are consumed in smaller quantities than the same foods  
59 offered non-partitioned (aggregated, as a whole, one large unit). Several experiments with adults have  
60 indeed shown that portioning an aggregate quantity of a food into smaller units reduced the consumed  
61 quantity of that resource [15, 16, 17, 18, 19, 20, 21]. To our knowledge, only one study has been  
62 undertaken with children invited to consume high-energy foods. Marchiori, Waroquier, and Klein  
63 [22] offered children aged 6 and 11 yrs cookies in their school. Cookies were cut in two for half of the  
64 children. Their results indicated that segmenting the cookies led to a 25% decrease in intake.

65 A question that remains unanswered is whether the effect of partition differs according to the  
66 children’s level of motivation to eat. The pioneering work of Bruner and Goodman [23] provides some  
67 elements of answer to this question. In their study, Bruner and Goodman found that children from  
68 disadvantaged backgrounds overestimated the size of coins, presumably because they had a higher  
69 desire for money than children from privileged backgrounds. More controlled and recent studies have  
70 confirmed that motivation could influence perception: people categorize ambiguous visual information  
71 in ways that fit with their desires (for a review, see [24]). Although, the effect has not been re-tested  
72 with children. So, in line with the motivated perception paradigm, one can predict that children with a  
73 high motivation to eat will perceive pieces of foods as being larger than do other children. Recalling  
74 the fact that partition tends to increase perceived size, one can argue that the effect of partition will be  
75 stronger for children who are highly motivated by eating than for less motivated children. The  
76 "partition effect" and "motivated perception" processes are thought to have an additive effect in the  
77 direction of reducing consumption.

78           This study examined the “partition effect” during childhood in interaction with some  
79 children’s motivational appetite features, with the hypothesis that the effect of partition, i.e. a  
80 reduction of intake, is higher for children with a high motivation to eat (appetite arousal, food specific  
81 appetite) than for other children. The effect of the Partition x Motivation paradigm on intake should  
82 be studied in children since childhood is the period during which education in portion sizes takes place  
83 [25]. It is also necessary to implement a within-subjects protocol due to high inter-individual  
84 variability in the traits of appetite and intake patterns.

85

## 86 **2. Methods and materiel**

### 87 **2.1 Overall design**

88           A 2x2 mixed design was used with the within-subjects factor of Partition (Bar versus Pieces)  
89 and the between-subjects factor of Motivational features (Lower versus Higher level) and Chocolate  
90 intake as the main outcome. Two eating motivational features were included in two different analyses:  
91 Appetite arousal and Chocolate specific appetite.

92           Children participated in their natural setting in two afternoon snack sessions contrasting  
93 Partition (Bar versus Pieces), but keeping the total amount of food constant, with the two conditions  
94 being randomly counterbalanced over all participants. The two sessions were separated by a period of  
95 two weeks ( $\pm 2$  days).

96           One of the two parents was present in the home. A research assistant was in charge of  
97 obtaining their consent, bringing food for the study, giving the child instructions, weighing the  
98 food at the end of the snack, administering the questionnaire to the children, then weighing and  
99 measuring them. Before each session, the children’s hunger state was measured. After each  
100 session, Hunger state, Chocolate-liking and Snack-liking were assessed. Eating motivational  
101 features (Appetite arousal and Chocolate specific appetite) were evaluated after the second  
102 session only, as were children’s weight and height. Eating motivational features were assessed  
103 afterwards so that the quantities consumed were not influenced by motivational characteristics  
104 elicited when children were replying to the questions.

### 105 **2.2 Participants**

106 Schools in a town in the Paris region (Asnières) whose residents have varied income levels were  
107 approached to take part in the study. Out of three schools contacted, two accepted the proposal. The  
108 parents of these schools with children between 8 and 11 years old were contacted by letter, and those  
109 who indicated that they were interested in the study were then contacted by telephone, so that the  
110 protocol and the conditions of eligibility could be explained to them. To be eligible, children had to  
111 meet four conditions: i/ Take their snack at home during the week; ii/ Have no food allergies; iii/ Like  
112 the foods provided for the snack; iv/ Receive parental consent. Families received monetary  
113 compensation for the study (€40 in vouchers).

### 114 **2.3 Snack sessions: Foods and Partition**

115 At each of the two sessions (Bar and Pieces), a snack consisting of 100 g of milk chocolate  
116 (developed for the purpose of the study, 548 kcal / 100 g), two slices of brioche bread (Harry's inc. 42  
117 g, 151 kcal / 100 g) and an apple juice (RikRok, 20 cl, 43 kcal / juice box) was offered to children in  
118 the middle of the afternoon at their home (4:00 PM  $\pm$  30 min). This snack was a French standard snack  
119 for children aged 8 to 11, except for the amount of chocolate, which can be considered high as  
120 children are not supposed to eat 100 g of chocolate on a single occasion. A large amount of chocolate  
121 was offered for two reasons: i/ to ensure that food intake would not be limited by the amount  
122 proposed; ii/ in France, the market is practically exclusively made up of 100 g bars: it is therefore a  
123 market norm which children are visually accustomed to. The recommendations for French children 8-  
124 11 years old are to take a snack of 400 kcal, which corresponds in our protocol to two pieces of  
125 chocolate, the two slices of brioche bread and the apple juice. Children's intake before the mid-  
126 afternoon snack was not standardized, but children were seen immediately on their return from school,  
127 between 3 and 4 hours after lunch taken in the canteen, having consumed no food since lunchtime. In  
128 fact, French children do not eat between lunch at school and snack time at home.

129 The chocolate was offered on the basis of a 100 g bar made up of 6 pieces (16.66 g / piece),  
130 each one consisting of 4 squares, that is to say the presentation that French children are used to.  
131 Depending on the session, the chocolate was presented either in the form of a whole bar, not cut up  
132 (Bar condition), or cut into 6 pieces of equivalent size (Pieces condition). In the Bar condition, visual

133 cues about the six pieces were present. For the children, the chocolate was easy to break into pieces  
134 themselves. The solid foods (chocolate, brioche bread) were served unpackaged on a tray,  
135 accompanied by the juice box.

136 The children had to eat the snack in the usual conditions (in the kitchen or in the living  
137 room, depending on the children). The instruction was to consume food according to their desire,  
138 "as much as they wanted". The children were left alone during the snack, with no access to a  
139 screen (television, mobile phone or tablet). During this time, the parents were in the next room  
140 with the research assistant.

## 141 **2.4 Food intake**

142 All the foods were weighed at the end of the session on a digital scale to the nearest gram by the  
143 research assistant with their own equipment. The quantities consumed were calculated by subtracting  
144 the remaining weight from the initial weight. They were expressed in grams and translated into  
145 calories when the analyses required it.

## 146 **2.5 Motivational eating features**

### 147 **2.5.1 Appetite arousal (AA)**

148 Appetite arousal was measured through the six items of one subscale of the Adolescent Eating  
149 Temperament Questionnaire which has been validated with French participants aged 10 to 14 yrs [3]  
150 (e.g., "As soon as I think about food, I feel like eating"). Children's answers were recorded using a 4-  
151 point frequency scale from 1 (never) to 4 (always). The reliability of the subscale was acceptable for  
152 the present data ( $\alpha = .68$ ).

153 We dichotomized the variable at the median ( $Med = 2.00$ ) in order to create a group of children  
154 with a lower level of AA ( $n = 41, m_{\text{Lower-AA}} = 1.75 \pm 0.22$ ), and a group with a higher level of AA ( $n =$   
155  $39, m_{\text{Higher-AA}} = 2.60 \pm 0.41$ ). The two group means were significantly different,  $t(78) = 11.69, p <$   
156  $.001$ .

### 157 **2.5.2 Chocolate specific appetite (CSA)**

158 Chocolate specific appetite was assessed on the basis of a food image extracted from the  
159 photographic document used for the SU.VI.MAX study [26]. Chocolate was presented in seven  
160 increasing portion sizes, quoted from size 1 (8 g) to size 7 (32 g). In accordance with the Ramaekers et

161 al.'s [12] formulation, children were asked: "How big is your appetite for chocolate in general?"  
162 "Show me the picture that corresponds to it."

163 CSA was dichotomized at the median ( $Med = 5.00$ ). The children with the lower level of CSA  
164 ( $n = 32$ ) had a mean level of CSA of  $3.66 (\pm 1.10)$ , and children with the higher level ( $n = 48$ ) of  $5.98$   
165 ( $\pm 0.67$ ), with the two group means being significantly different,  $t(78) = 11.78, p < .001$ .

## 166 **2.6 Other measures**

167 A number of measures were taken to verify the comparability between the two conditions. The  
168 Hunger state was assessed before and after each snack session. Children were asked to respond to the  
169 question "How hungry are you at this moment?" on a 10-point scale with responses ranging from "not  
170 at all" to "very much".

171 Liking for the chocolate and for the snack offered was evaluated after the two sessions with the  
172 same 10-point scale in response to the question "How much did you like the chocolate / the whole  
173 snack?".

## 174 **2.7 Children's weight status**

175 Children were asked to remove shoes and excess clothing prior to being weighed and their  
176 height measured. Weight was measured using an electronic scale calibrated to the nearest 100 grams.  
177 Height was assessed using a physical height calibrated to within  $\frac{1}{2}$  centimeter. The children's BMI-  
178 for-age and sex was calculated according to WHO guidelines [27]. The children were measured in the  
179 bathroom or the lounge by the research assistant, with the assistant's measuring equipment.

## 180 **2.8 Ethics**

181 Two independent scientific experts consulted by the Ethics Committee of Paris Nanterre  
182 University approved the study. The parents were informed of the aim of the study and parental consent  
183 was required for participation. In addition to parental consent, the children gave their verbal agreement  
184 to participate.

## 185 **2.9 Data analysis**

186 Preliminary analyzes were carried out to evaluate: i/ Differences in Chocolate intake according  
187 to sex (2), age (2) and weight status (2) (independent t-test); ii/ The equivalence between the two  
188 sessions of levels of hunger, appreciation of chocolate and snack, and quantities consumed throughout

189 the snack (paired t-test); iii/ The existence of a link between these variables and Chocolate intake  
 190 (correlations). As Hunger state before the snack session was positively correlated with Chocolate  
 191 intake in the Bar condition ( $r(40) = .29, p = .01$ ), the Hunger state before the snack session in the two  
 192 conditions was entered as covariates in the two analyses of variance.

193 To test the hypothesis, two mixed ANCOVA were performed on Chocolate intake with Partition  
 194 (2: Bar vs Pieces, Within-subject variable) and one of the two eating motivation features (2: Lower vs  
 195 Higher level, Between-subject variable) as independent variables, with the two Hunger states (assessed  
 196 in the Bar and in the Pieces conditions) entered as covariates. Appetite arousal (AA) was the eating  
 197 motivation feature for the first ANCOVA, and Chocolate specific appetite (CSA) for the second  
 198 ANCOVA.

199 Whatever the motivational variables considered, a simple effect of the two independent  
 200 variables (Partition, AA or CSA) and an interaction effect were expected, with the hypothesis that the  
 201 effect of partition, i.e. reduction in intake, would be higher for children with a high motivation to eat  
 202 (Higher AA or Higher CSA) than for other children.

203 Data were analyzed using the SPSS 25.0 statistical package (SPSS Inc., Chicago, IL, USA). An  
 204 alpha level of .05 was used for all tests.

205

### 206 3. Results

#### 207 3.1 Participants

208 The characteristics of the 80 children who completed the task and filled in the questionnaires are  
 209 presented in Table 1. The mean age of the children was 9.29 ( $\pm 1.09$ ) yrs. No difference with Age,  
 210 Gender or Weight status was observed on any variables (Chocolate intake, Hunger state, Appetite  
 211 arousal, Chocolate specific appetite).

212

213 Table 1. *Participants' characteristics and chocolate intake (g)*

	n (%)	Chocolate intake m (SD)	
		Bar	Pieces
Age (yrs.)			
8-9	44 (55)	46.50 (31.80)	47.36 (29.74)
10-11	36 (45)	44.47 (25.30)	43.08 (24.57)

Gender			
Girls	47 (58.8)	45.23 (27.54)	43.32 (26.50)
Boys	33 (41.3)	48.76 (31.27)	48.45 (28.89)
Weight status			
Normal weight	71 (88.7)	46.32 (28.53)	44.15 (27.16)
Overweight	9 (11.3)	49.55 (33.78)	55.55 (29.23)

---

214

### 215 3.2 Comparability between conditions

216 Over the entire snack (including chocolate, brioche bread and juice), the children  
 217 consumed 519 ( $\pm$  174) kcal in the Bar condition and 503 ( $\pm$  168) kcal in the Pieces condition,  
 218 with no difference between the two conditions,  $t(79) = 0.96$ ,  $p = .34$ .

219 More precisely, with regard to brioche, the children consumed 131 ( $\pm$  19.41) kcal in the  
 220 Bar condition and 129 ( $\pm$  13.99) kcal in the Pieces condition, with no difference between the two  
 221 conditions,  $t(79) = 0.83$ ,  $p = .41$ . With regard to juice, they consumed 32 ( $\pm$  2.78) kcal in the Bar  
 222 condition and 31 ( $\pm$  2.71) kcal in the Pieces condition, and no difference was observed between  
 223 the two conditions,  $t(79) = 1.75$ ,  $p = .08$ .

224 All of the brioche was consumed by 2.50% of the children in the Bar condition, and 1.25%  
 225 in the Pieces condition. All of the juice was drunk by 56.25 % of the children in the Bar  
 226 condition, and 60 % in the Pieces condition.

227 No differences between conditions were observed for Hunger state before the snacks ( $p = .95$ ),  
 228 Hunger state after the snacks ( $p = .55$ ), Chocolate liking ( $p = .31$ ), and Snack liking ( $p = .21$ ). The  
 229 mean score between the two snacks for these variables was respectively 7.29 ( $\pm$  2.44), 1.09 ( $\pm$  1.76),  
 230 8.34 ( $\pm$  2.64) and 8.53 ( $\pm$  2.11).

231

### 232 3.3 Chocolate intake according to conditions: Partition effect

233 No difference was observed for the order in which the modalities were presented: Chocolate  
 234 intake was equivalent when Bar or Pieces was offered in the first session,  $F(1, 79) = 0.21$ ,  $p = .65$ .

235 Chocolate intake was 46.69 ( $\pm$  28.95) g in the Bar condition and 45.44 ( $\pm$  27.45) g in the Pieces  
 236 condition, with no difference between conditions,  $t(79) = 0.46$ ,  $p = .64$ .

237 All of the chocolate was consumed by 12.5% of the children in the Bar condition, and  
 238 11.3% in the Pieces condition. Supplementary analyses were carried out without the data for the

239 children who had consumed all the chocolate (14 children throughout both conditions). Indeed,  
240 for these children, the portion of chocolate served may have been too small. Without this data,  
241 the difference between the two conditions remained non-significant ( $t(65) = 0.13, p = .89$ ):  
242 Chocolate intake was  $36.95 (\pm 20.78)$  g in the Bar condition and  $37.31 (\pm 20.27)$  g in the Pieces  
243 condition.

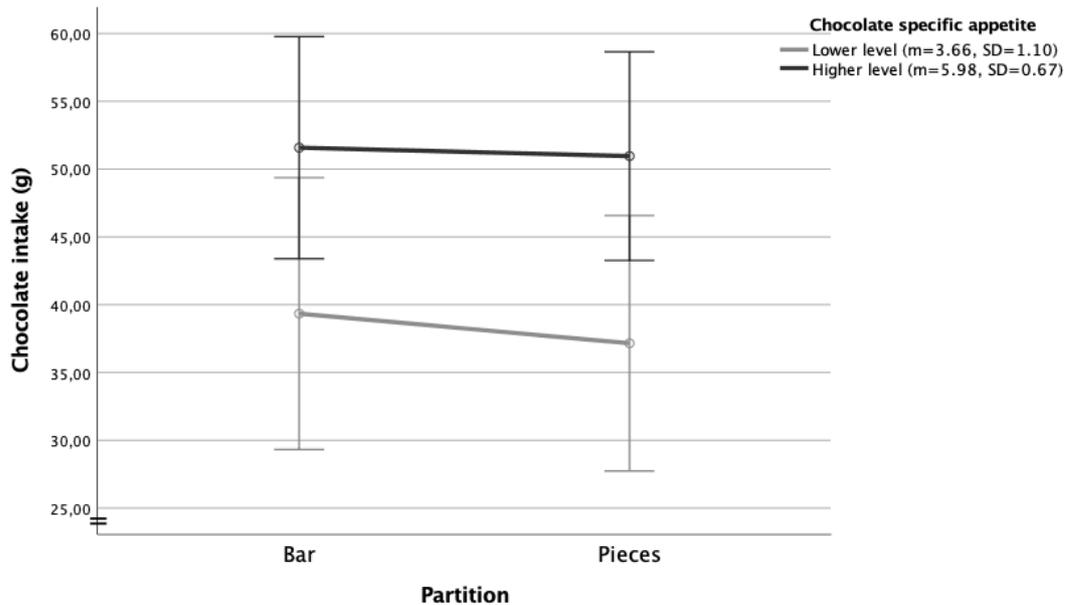
244 The children's two chocolate intake values were in fact highly and positively correlated between  
245 conditions,  $r(80) = .64, p < .001$ .

246

### 247 **3.4 Chocolate intake and motivational variables**

248 The results of the mixed ANCOVA with Appetite arousal (AA) as the motivational variable  
249 indicated that the two main effects (Partition and AA) were non-significant,  $F(1, 79) = 0.82, p = .77$   
250 and  $F(1, 79) = 1.14, p = .70$  respectively, as was the interactive effect,  $F(1, 79) = 0.05, p = .82$ . AA  
251 was not associated with Chocolate intake,  $r_{bar\ condition}(80) = .04, p = .72$  and  $r_{pieces\ condition}(80) = -.05, p =$   
252  $.67$ .

253 When Chocolate specific appetite (CSA) was considered as the motivational feature, only the  
254 simple effect of CSA was significant,  $F(1, 79) = 27.77, p = .038$  (Figure 1). The mean Chocolate  
255 intake was  $38.24 (\pm 3.45)$  g for children with the lower CSA, and  $51.26 (\pm 2.82)$  g for those with the  
256 higher CSA. The difference between the two conditions was 13.02 g, corresponding to 71 kcal. CSA  
257 was positively correlated with Chocolate intake,  $r_{bar\ condition}(80) = .38, p = .001$  and  $r_{pieces\ condition}(80) =$   
258  $.33, p = .003$ .



259

260 *Figure 1*– Mean amount of Chocolate intake (g) as a function of Partition conditions (Bar versus  
 261 Pieces) and Level of chocolate specific appetite (Lower versus Higher). Error bars represent standard  
 262 errors.

263

264 **4. Discussion**

265 This study examined the hypothesis that the effect of partition on food intake is higher for  
 266 children with higher eating motivation than for children with lower eating motivation. Because the  
 267 Partition effect failed to be confirmed, this interactive hypothesis could not be tested. However our  
 268 results showed that a motivational eating feature, i.e. Chocolate specific appetite, was positively  
 269 associated with chocolate intake. This was not the case for the motivational variable “Appetite  
 270 arousal”.

271 The lack of a partition effect is contrary to the majority of previous experiments with adults and  
 272 the one undertaken with children [22]. How can this discrepancy between our study and other studies  
 273 be explained? We suggest three explanations related to different potential mechanisms underlying the  
 274 effect of partition.

275           The first explanation is linked to methodological features and relies on the concept of unit bias  
276 to explain the partition effect. According to Geier et al. [15], unit bias is a sense that a single entity is  
277 the appropriate amount to consume and that, as a result, the consumption of one unit will inhibit  
278 further consumption of the same unit. In the study of Marchiori et al. [22], partition contrasted two  
279 reasonable sizes of unit, i.e. a cookie and a half-cookie. Children ate 9 units of the whole cookies and  
280 14 units of the half cookies. The higher number of units, in the second case, made food intake  
281 decrease. In our study, on the other hand, a whole chocolate bar corresponds to one unit in terms of  
282 packaging (as it is available on the market), but not in terms of consumption; this size was probably  
283 beyond the proper size of how much chocolate can be eaten. As a result, children were not confronted  
284 with two situations eliciting the unit bias.

285           The two other explanations are related to some developmental considerations. The first one  
286 relies on the network of attention. Cheema and Soman [28] claimed that partition draws attention to  
287 the consumption decision and, thus, provides more decision-making opportunities so that eaters can  
288 more easily control their intake. Konrad et al. [29] demonstrated with functional magnetic resonance  
289 imaging that children aged 8-12 yrs, compared to adults, showed reduced brain activity in the  
290 prefrontal cortex during executive control of attention. Their result was in line with some  
291 developmental studies [30, 31]. So, children, whose level of attention in general is lower than adults,  
292 and by extension in consumption situations, would be less sensitive to partition.

293           The second developmental explanation addresses the question of sensibility to external cues,  
294 versus internal cues, when eating. A number of studies have shown that, as people grow older, they are  
295 more likely to eat without hunger (for a review, see [32]). This evolution is interpreted as an increase  
296 in sensitivity to external signals of consumption (such as the shape or size of the portion) at the  
297 expense of sensitivity to internal signals (hunger and satiety). In other words, the accuracy of  
298 sensitivity to external cues seems to increase as a function of age: children adjust more to their hunger  
299 and satiety (internal cues), and less to visual cues (external cues) to monitor their intake. Insofar as  
300 partition affects the visual and not the energetic cues of food, it would be more effective in adults than  
301 in children.

302           The two developmental interpretations are not contradictory. They both refer to children's  
303 low receptiveness to the visual aspects of food due to: i) their lower attentional involvement  
304 according to the first interpretation ; ii) their lack of sensitivity to external signals according to the  
305 second interpretation. It is noteworthy that these two developmental interpretations can reinforce  
306 each other and might explain why our result is inconsistent with those obtained with adults,  
307 whereas the methodological one might highlight the discrepancy with the study of Marchiori et al.  
308 [22] undertaken with children.

309           Our second result concerned the notion of eating motivation and indicated that a specific  
310 appetite for chocolate was positively correlated with the amount of chocolate intake. This result is not  
311 surprising. The amount of food eaten is associated with the degree to which children desire to eat the  
312 targeted food. It actually consists of two similar measurements, one collected through a questionnaire  
313 and the other through a food task. On the other hand, chocolate intake was not related to appetite  
314 arousal in our study, which is contrary to our hypothesis. Here again, one can suggest a developmental  
315 interpretation. Children's food choices are mainly explained by some specific nutritional [33] and  
316 sensorial [34] characteristics. As a result, it seems that children's intake is more specifically predicted  
317 by specific measures, connected to particular foods (e.g. chocolate appetite), than by general measures  
318 (e.g., appetite arousal). However, the absence of any connection between food intake and appetite  
319 arousal in our study is not consistent with the results of previous studies carried out with children.  
320 Here, the explanation could be methodological. In fact, previous studies linked appetite arousal to  
321 quantities consumed which corresponded to mean consumption of different foods whereas our study  
322 focused on a particular food. This implies that the motivational and consumption measures must  
323 remain consistent with children: either based on particular foods or on food in general.

324

## 325 **5. Strengths and limitations**

326           To our knowledge, our study was the first to rely on a within-subject design to test the partition  
327 effect. Moreover, it was undertaken with children in their natural setting (home), without distractions  
328 (screens or peer group), and with hunger state and food pleasantness being controlled. In these

329 conditions, the effect of partition on food intake has not been replicated. This result has been  
330 interpreted at two levels: a methodological one (size of the units) and a developmental one (children's  
331 capacities of attention and sensitivity to external food cues).

332         However, some methodological limitations should be noted. With regard to the intervention,  
333 the absence of standardization of the location (kitchen versus living room) and the potential  
334 availability of other sweet-tasting foods may have impacted children's chocolate intake. Another  
335 issue could be the absence of standardization of children's intake before the mid-afternoon snack  
336 (children were served the same menu at school, yet their intake was not evaluated), but French  
337 children don't consume any food between lunch in the canteen and snack time, and their hunger  
338 levels before snack time was measured and incorporated them into the analyses.

339         With regards to the selection of participants, the sample size can be considered as large given  
340 the ecological nature of the intervention and the paired nature of the protocol, but it would be worth  
341 increasing it. Moreover, as our sample was rather unbalanced with regard to the BMI variable  
342 (normal weight versus overweight), with only 11.3% of children being overweight, the difference of  
343 the partition effect in relation to ponderal status could consequently not be effectively tested. Finally,  
344 with regard to the protocol, the choice of the product could be reconsidered in order to test the effect  
345 of partition with foods that are not highly appreciated. Indeed, the effect of partition depending on the  
346 level of liking of the product should be tested, with the hypothesis that the effect is greater when  
347 products are less liked.

348         Further studies should then be carried out with a larger sample of children, including a  
349 substantial number of overweight children, invited to consume a moderately liked food in a natural  
350 and standardized context, without the presence of other foods. The two versions (partitioned and not  
351 partitioned) of the target food should be presented in reasonable forms. Finally, more varied age  
352 brackets, in particular including younger children, should be considered in order to test the  
353 developmental interpretations proposed in line with the children's attention capacities and their  
354 sensibility to the external cues underlying the control of intake.

355

356 **6. Conclusion**

357 Contrary to the study by Marchiori, Waroquier, and Klein [22], our study failed to validate the  
358 hypothesis of the effect of partition on food intake in children. Consequently, at our stage of  
359 knowledge, the effect of partition in children, and the underlying mechanisms, cannot be supported by  
360 any definitive conclusion. Further studies with other products, other unit sizes and different  
361 participants' characteristics must be performed in order to confirm or not confirm the existence of the  
362 partition effect and the nature of the underlying processes. It is only through carrying out this work  
363 that the interaction effect between partition and children's eating motivational characteristics can be  
364 tested. A measure of the desire to eat, specific to the food included in the protocol and not a general  
365 measure of the desire to eat, should be therefore chosen.

366

367

## 368 **References**

369

370 [1] C. Llewellyn, J. Wardle, Behavioral susceptibility to obesity: Gene–environment interplay in the  
371 development of weight, *Physiology & Behavior*. 152 (2015) 494–501.

372 doi:10.1016/j.physbeh.2015.07.006.

373 [2] K.C. Berridge, Motivation concepts in behavioral neuroscience, *Physiology & Behavior*. 81 (2004)  
374 179–209. doi:10.1016/j.physbeh.2004.02.004.

375 [3] V. Godefroy, L. Trinchera, L. Romo, N. Rigal, Modelling the effect of temperament on BMI  
376 through appetite reactivity and self-regulation in eating: a Structural Equation Modelling approach in  
377 young adolescents, *International Journal of Obesity*. 40 (2016) 573. doi:doi:10.1038/ijo.2016.6.

378 [4] T. van Strien, P. Oosterveld, The children's DEBQ for assessment of restrained, emotional, and  
379 external eating in 7- to 12-year-old children, *International Journal of Eating Disorders*. 41 (2018) 72–  
380 81. doi:10.1002/eat.20424.

381 [5] J. Wardle, C.A. Guthrie, S. Sanderson, L. Rapoport, Development of the children's eating  
382 behaviour questionnaire, *The Journal of Child Psychology and Psychiatry and Allied Disciplines*. 42  
383 (2001) 963–970.

384 [6] A.N. Gearhardt, C.A. Roberto, M.J. Seaman, W.R. Corbin, K.D. Brownell, Preliminary validation  
385 of the Yale Food Addiction Scale for children, *Eating Behaviors*. 14 (2013) 508–512.  
386 doi:10.1016/j.eatbeh.2013.07.002.

387 [7] S. Carnell, J. Wardle, Appetite and adiposity in children: evidence for a behavioral susceptibility  
388 theory of obesity, *Am J Clin Nutr*. 88 (2008) 22–29. doi:10.1093/ajcn/88.1.22.

389 [8] S.E. Domoff, A.L. Miller, N. Kaciroti, J.C. Lumeng, Validation of the Children’s Eating  
390 Behaviour Questionnaire in a low-income preschool-aged sample in the United States, *Appetite*. 95  
391 (2015) 415–420. doi:10.1016/j.appet.2015.08.002.

392 [9] V. Godefroy, L. Trinchera, N. Darcel, N. Rigal, Behavioural measures of child’s eating  
393 temperament and their link with BMI, *Appetite*. 110 (2017) 6–14.

394 [10] S. Carnell, L. Benson, K. Pryor, E. Driggin, Appetitive traits from infancy to adolescence: Using  
395 behavioral and neural measures to investigate obesity risk, *Physiology & Behavior*. 121 (2013)

396 [11] M.L. Pelchat, Of human bondage: Food craving, obsession, compulsion, and addiction,  
397 *Physiology & Behavior*. 76 (2002) 347–352. doi:10.1016/S0031-9384(02)00757-6.

398 [12] M.G. Ramaekers, S. Boesveldt, G. Gort, C.M.M. Lakemond, M.A.J.S. van Boekel, P.A. Luning,  
399 Sensory-Specific Appetite Is Affected by Actively Smelled Food Odors and Remains Stable Over  
400 Time in Normal-Weight Women, *J Nutr*. 144 (2014) 1314–1319. doi:10.3945/jn.114.192567.

401 [13] A. Meule, J.M. Holmes, Chocolate versions of the Food Cravings Questionnaires. Associations  
402 with chocolate exposure-induced salivary flow and ad libitum chocolate consumption, *Appetite*. 91  
403 (2015) 256–265. doi:10.1016/j.appet.2015.04.054.

404 [14] L.L. Birch, J.S. Savage, J.O. Fisher, Right sizing prevention. Food portion size effects on  
405 children’s eating and weight, *Appetite*. 88 (2015) 11–16. doi:10.1016/j.appet.2014.11.021.  
406 79–88. doi:10.1016/j.physbeh.2013.02.015.

407 [15] A.B. Geier, P. Rozin, G. Doros, Unit Bias: A New Heuristic That Helps Explain the Effect of  
408 Portion Size on Food Intake, *Psychol Sci*. 17 (2006) 521–525. doi:10.1111/j.1467-9280.2006.01738.x.

409 [16] K. Kerameas, L.R. Vartanian, C.P. Herman, J. Polivy, The effect of portion size and unit size on  
410 food intake: Unit bias or segmentation effect?, *Health Psychology*. 34 (2015) 670–676.  
411 doi:10.1037/hea0000160.

412 [17] D. Marchiori, L. Waroquier, O. Klein, Smaller Food Item Sizes of Snack Foods Influence  
413 Reduced Portions and Caloric Intake in Young Adults, *Journal of the American Dietetic Association*.  
414 111 (2011) 727–731. doi:10.1016/j.jada.2011.02.008.

415 [18] N. Stroebele, L.G. Ogden, J.O. Hill, Do calorie-controlled portion sizes of snacks reduce energy  
416 intake?, *Appetite*. 52 (2009) 793–796. doi:10.1016/j.appet.2009.02.015.

417 [19] E. Van Kleef, C. Kavvouris, H.C. van Trijp, The unit size effect of indulgent food: How eating  
418 smaller sized items signals impulsivity and makes consumers eat less, *Psychology & Health*. 29  
419 (2014) 1081–1103.

420 [20] B. Wansink, C.R. Payne, M. Shimizu, The 100-calorie semi-solution: Sub-packaging most  
421 reduces intake among the heaviest, *Obesity*. 19 (2011) 1098–1100.

422 [21] P.L. Weijzen, D.G. Liem, E.H. Zandstra, C. De Graaf, Sensory specific satiety and intake: The  
423 difference between nibble-and bar-size snacks, *Appetite*. 50 (2008) 435–442.

424 [22] D. Marchiori, L. Waroquier, O. Klein, “Split Them!” Smaller Item Sizes of Cookies Lead to a  
425 Decrease in Energy Intake in Children, *Journal of Nutrition Education and Behavior*. 44 (2012) 251–  
426 255. doi:10.1016/j.jneb.2011.07.007.

427 [23] J.S. Bruner, C.C. Goodman, Value and need as organizing factors in perception., *The Journal of*  
428 *Abnormal and Social Psychology*. 42 (1947) 33–44. doi:10.1037/h0058484.

429 [24] D. Dunning, E. Balcetis, Wishful Seeing: How Preferences Shape Visual Perception, *Curr Dir*  
430 *Psychol Sci*. 22 (2013) 33–37. doi:10.1177/0963721412463693.

431 [25] M. Spence, M.B.E. Livingstone, L.E. Hollywood, E.R. Gibney, S.A. O’Brien, L.K. Pourshahidi,  
432 M. Dean, A qualitative study of psychological, social and behavioral barriers to appropriate food  
433 portion size control, *International Journal of Behavioral Nutrition and Physical Activity*. 10 (2013) 92-  
434 100. doi:10.1186/1479-5868-10-92.

435 [26] N. Le Moullec, M. Deheeger, P. Preziosi, Monteiro P., P. Valeix, Validation du manuel photos  
436 utilisé pour l’enquête alimentaire de l’étude SUVIMAX., *Cahiers de Nutrition et de Diététique*. 31  
437 (1996) 158–164.

- 438 [27] M. de Onis, A.W. Onyango, E. Borghi, A. Siyam, C. Nishida, J. Siekmann, Development of a  
439 WHO growth reference for school-aged children and adolescents, *Bull World Health Organ.* 85 (2007)  
440 660–667. doi:10.1590/S0042-96862007000900010.
- 441 [28] A. Cheema, D. Soman, The effect of partitions on controlling consumption, *Journal of Marketing*  
442 *Research.* 45 (2008) 665–675.
- 443 [29] K. Konrad, S. Neufang, C.M. Thiel, K. Specht, C. Hanisch, J. Fan, B. Herpertz-Dahlmann, G.R.  
444 Fink, Development of attentional networks: An fMRI study with children and adults, *NeuroImage.* 28  
445 (2005) 429–439. doi:10.1016/j.neuroimage.2005.06.065.
- 446 [30] A. Abundis-Gutiérrez, P. Checa, C. Castellanos, M. Rosario Rueda, Electrophysiological  
447 correlates of attention networks in childhood and early adulthood, *Neuropsychologia.* 57 (2014) 78–  
448 92. doi:10.1016/j.neuropsychologia.2014.02.013.
- 449 [31] M.R. Rueda, J. Fan, B.D. McCandliss, J.D. Halparin, D.B. Gruber, L.P. Lercari, M.I. Posner,  
450 Development of attentional networks in childhood, *Neuropsychologia.* 42 (2004) 1029–1040.  
451 doi:10.1016/j.neuropsychologia.2003.12.012.
- 452 [32] R.K. Lansigan, J.A. Emond, D. Gilbert-Diamond, Understanding eating in the absence of hunger  
453 among young children: A systematic review of existing studies, *Appetite.* 85 (2015) 36–47.  
454 doi:10.1016/j.appet.2014.10.032.
- 455 [33] S. Nicklaus, V. Boggio, S. Issanchou, Food choices at lunch during the third year of life: high  
456 selection of animal and starchy foods but avoidance of vegetables, *Acta Paediatrica.* 94 (2005) 943–  
457 951.
- 458 [34] L.L. Birch, Dimensions of preschool children’s food preferences, *Journal of Nutrition Education.*  
459 11 (1979) 77–80. doi:10.1016/S0022-3182(79)80089-8.