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Effects of a family-based sensory education on vegetable and fruit variety in children

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ABSTRACT

Several experimental studies implemented in schools have shown that sensory education reduces children's neophobia and increases their sensory discrimination abilities. However, it is not known whether sensory education has an effect on children's consumption, particularly on the variety of fruits and vegetables consumed, and whether it is effective when implemented in families.

The effect on fruit and vegetable intake of a five months family-based sensory programme was examined in children aged 7–11 (with 32 children in the intervention group and 19 in the control group). The children's parents completed four 24-hour recalls at the beginning and after the intervention to assess their children's fruit and vegetable intake. Variety indexes were calculated on the basis of the number of different fruits or vegetables consumed during the four 24-hour recalls.

The results showed that the vegetable variety decreased in the control group, while it remained stable in the intervention group. No effects of the programme were observed for the fruit variety.

The sensory education programme implemented in families prevented the variety of vegetables from decreasing over time. The results of this preliminary study and its long-term effects need to be confirmed by further investigations, with a different methodology than the 24-hour recall.

1. Introduction

As defined by Sandell et al. (2016), sensory-based food-education offers activities for the food-learning process via our senses (sight, touch, hearing, and more specifically smell and taste). Through child-centred activities and by emphasizing learning through experience, the objective of sensory education is to teach children about the pleasures of food by increasing their sensory awareness and their individual capacities of verbal expression, to allow the discovery of new foods and, therefore, the implementation of well-balanced eating behaviours.

Various sensory programmes have been carried out, based on the French "Classes du Goût" programme (Puisais et al., 1999). Their effects were tested experimentally on school age children's behaviours with three main outcomes. The first outcome was the children's skills in chemosensory perception. The results from Mustonen et al. (2009); Wahl and Majchrzak (2019) showed an improvement of gustatory and olfactory perception due to sensory training in children aged 8–11 and 11–14 years respectively. More studies have focused on children's behaviour with respect to novel foods as an outcome (neophobia and/or willingness to taste food in children between the ages of 3 and 11). The level of food neophobia, measured by questionnaires, decreased following the programme in three studies (Mustonen & Tuorila, 2010; Reverdy et al., 2010; Woo & Lee, 2013), but not in a fourth (Battjes-Fries et al., 2016). The willingness to taste new or unappreciated foods, measured mostly by experimental tasks, increased in four studies (Battjes-Fries et al., 2016; Hoppu et al., 2015; Mustonen & Tuorila, 2010; Reverdy et al., 2008), but this was not the case in a fifth (Woo & Lee, 2013). Finally, food intake was the outcome in only one study: Battjes-Fries et al. (2016) evaluated daily vegetable consumption using two questions with 10-year-old children, and their results indicated no significant effects of the intervention. In summary, although few in number, the results of these experimental studies were fully consensual with regard to sensory abilities (2/2 indicating a positive effect), rather consensual with regard to the ability to accept novel or unappreciated

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foods (7/9 with a positive effect), and not significant with regard to daily vegetable consumption (1 indicating no effect). It appears that the effects of sensory education, despite differences in the programme content and in the methodology of evaluation, are generally positive, but are still insufficiently explored with regard to children's dietary intake, and especially to food variety.

In adults, various studies have shown the importance of food variety for the quality of the diet, especially in terms of nutrient adequacy (Murphy et al., 2006; Krebs-Smith et al., 1987), for the reduction of diabetes (Wahlqvist et al., 1989), colorectal cancer (Jayawardena et al., 2013), and obesity prevalence (Jayawardena et al., 2013), as well as mortality risk (Huang et al., 2014; Lee et al., 2011; Masset et al., 2015). Specifically, variety in healthy foods appears to have a protective effect against mortality and chronic disease (McCullough et al., 2002; Michels & Wolk, 2002). Studies on children are fewer in number, but a review (Marshall et al., 2014) found that variety scores predicted positive child growth. Evans et al. (2018), more specifically, showed that the proportion of children meeting individual micronutrient requirements is higher as the number of listed foods consumed increases. In France, the national recommendation of the National Nutrition and Health Programme (PNNS) has been five daily portions of fruit and vegetables since 2001. The results of the CRÉDOC's French Food Consumption and Behaviour (CCAF) surveys in metropolitan France showed an increase in the proportion of low fruit and vegetable consumers among children between 3 and 17 years of age (32 in 2010 and 45 in 2016 consume less than two portions of fruit and vegetables per day) (Tavoularis & Hébel, 2017).

While food variety appears to be associated with good health outcomes, there is still a lack of consensus on its operationalization. In their review, Marshall et al. (2014) analysed different quality indices associated with health-related outcomes in children and adolescents. Thirty-one papers included indices of food variety or food diversity (that the authors considered to be equivalent). The indices were based on accounting for the number of different foods consumed over a given reference period. However, two elements varied according to the definitions (Ruel, 2003). The first element concerned the classification of foods included in the count. Some authors relied on the total variety of the diet (number of different foods consumed), while others considered only the variety within some food categories (for example, the number of different vegetables consumed). The second element that varied between studies was the reference period. The number of days considered varied between 1 and 7. In our study, we chose to focus on food variety in the two food categories that are the least consumed by children despite their good nutritional quality, i.e., fruits and vegetables, and we initially considered the longest period of time, i.e. seven days. Due to difficulties encountered by participants in filling out the food booknotes, a four-day period was finally chosen.

The objective of our study was to investigate the effects of a sensory education programme on children's dietary intake. Our control trial had two major original features compared to previous studies. On the one hand, its outcome was fruit and vegetable variety, which is an essential indicator of the quality of children's diets. The variety was evaluated based on the number of different fruits and vegetables consumed during four days. On the other hand, the programme was not implemented at school, but in families, since children eat the majority of their meals at home. We hypothesized that the sensory based education implemented in families increases the variety of fruits and vegetables in French children aged 7–11 years.

2. Material and methods

2.1. Participants

The "Goûts en Famille" project was aimed at families with children between the ages of 7 and 11. The study was implemented in Guadeloupe as it is one of the most disadvantaged regions of France in terms of nutritional status with 22% of children suffering from overweight or obesity in 2013 (Anses, 2017). The inclusion criteria were: (a) an internet connection and computer equipment (computer or tablet); (b) the absence of chronic disease in parents and children (to avoid imposing additional burdens on these individuals); (c) in the case of families whose parents were separated, that the child was in the care of the same parent at the time of completing the dietary records at T0 and T1.

Families were recruited through schools, canteens, and sports clubs. Ninety-eight families registered for the project, signing a consent form to participate in the entire study.

The families were divided into two groups: the control group and the intervention group, taking care to balance the groups according to the following criteria collected during the recruitment interview: (a) mother's highest education level (middle or high school/college); (b) type of family (couple with child(ren)/single-parent family); (c) mother's employment status (work/home); (d) number of children under 25 years of age (1, 2, 3 and more). The cut-off was considered at 25 years in order to consider elder children that could possibly still be living at home, which is not an uncommon situation due to financial constraints. In Guadeloupe, in 2019, 70.4% of 18–29-year-olds live with their parents (INSEE, 2020).

Only about half of the families completed the entire protocol. The final sample consisted of 51 families (19 in the control group, 32 in the intervention group) with 63 children (24 in the control group, 39 in the intervention group) (Table 1). At the end of the study, these families received a voucher worth 100 euros. No significant differences were observed between the control and intervention groups for the above criteria.

2.2. Study design

Using a controlled trial, the study was conducted in three stages. Stage 1 (T0) consisted of the baseline evaluation: parents of both groups had to complete four 24hr food recalls (see "variety assessment"). Stage 2 concerned only the parents of the Education group: parents and children were involved in the Education programme for a period of five months (see "programme design"). Stage 3 (T1) consisted in the follow-up evaluation with parents of the two groups: all parents had to complete the 24hr recall ± 5 to 10 days after the end of the intervention.

2.3. Variety and consumption assessment

The participants completed a seven-day food intake survey in an online format (food notebooks). The participants reported the types and portions of all foods and beverages consumed during the day (portion data will not be presented in this manuscript). They were provided with the validated SUVIMAX atlas (Hercberg et al., 2002) for the estimation

Table 1
Participants' characteristics at the time of inclusion.

Group	Control	Intervention
Families (n)	19	32
Children (n)	24	39
Families with 2 children involved in the study (n)	5	7
Children's gender (%)		
Females (53,8)	35	65
Males (46,2)	41	59
Children's age (years) (%)		
7 (3,2)	50	50
8 (22,22)	43	57
9 (31,8)	40	60
10 (22,22)	29	71
11 (20,6)	38	62
Mother's level of education (%)		
Middle or high school (47,3)	37	63
College or higher (52,7)	38	62

of food quantities, showing various common foods and beverages (including typical foods of the country, 42 different vegetables, 9 dishes with vegetables, 18 different fruits). The respondents could add foods not presented in the atlas. Foods consumed were computed for the whole day and for separate eating occasions (main meals and snacks).

Dietary intake was reported by parents or caregivers, in the presence of the child, particularly with respect to food intake outside the home. The instruction was: "You are now able to start filling out your child's food notebook at the end of each day. You must be accompanied by your child when filling it out. For seven days, you will record all the food and beverages your child has eaten. Do not forget any food or drinks." The participants were asked to record the dishes, not the ingredients. In the case of home-cooked or already prepared dishes composed of several foods or ingredients, we have referred to the most usual recipe for the dish to identify the different components.

Probably because of the time needed to complete the notebooks, not all of them were completed for 7 days. On the other hand, the booklets were completed over the first 4 days by all participants. Therefore, we kept all the diaries completed over 4 days in order to be able to establish the variety of foods consumed over 4 days by the same individual. The four-day duration corresponds to the intermediate number of days in the protocols of previous studies (between 1 and 7 days, see Introduction).

The variety of vegetables consumed (eaten as is or as an ingredient in a dish) was estimated as the number of different vegetables consumed at least once during the 4 days of consumption, without distinction of portion. If the same vegetable was cooked in different ways or eaten raw, it was only counted once. Variety was also assessed concerning fruits. If a vegetable (or a fruit) was eaten on more than one occasion during the day, it was counted only once.

To further understand the results, consumption scores were calculated. Food consumption was evaluated as the number of vegetables (or fruits) consumed per day. Thus, if a vegetable (or fruit) was consumed twice in the same day, it was counted twice. Two average scores were calculated over the four days: one for fruits and one for vegetables.

2.4. Programme design

The intervention group took part in a pedagogical programme over a period of five months (Table 2). This programme was modelled on and adapted from the 'Classes du Goût' created by Puisais et al. (1999) for primary school pupils: it began with sensory education, helping children to become more aware of their sensory abilities, and ended with food education and cooking, to enhance the links with everyday life and practices. This programme was thus of a hybrid type, combining sensory and culinary education.

First, the mothers involved in the pedagogical programme participated in a sensory workshop in order to learn about the sensory mechanisms of tasting and some key elements of children's eating behaviours.

Then, one video and one worksheet describing a sensory experiment were sent to the mothers every two weeks. Each video had to be watched by the mother and her child. Each sensory experiment, aimed at the child, was prepared and led by the mother, at home. Six videos and six worksheets (related to the topic of the video) were sent in total.

To conclude the programme, two more worksheets, specific to Caribbean food culture, were sent to the mothers.

During this period of five months, the experimenter regularly checked that the families conducted the pedagogical activities effectively: for each video and sensory experiment, the mothers had to send the experimenter a brief message describing the children's reactions.

2.5. Data analysis

The variety score corresponds to the number of different fruits or vegetables consumed at least once during the four days by each participant (one score for the variety of fruits, and one score for the variety of vegetables). To test the hypothesis, two mixed ANOVAs were performed with Group (2: Control vs Intervention, Between-subject variable) and Period (2: T0 vs T1, Within-subject variable) as independent variables. The dependent variable was the Vegetable variety in the first ANOVA, whereas it was the Fruit variety in the second ANOVA. The two consumption scores were subjected to the same analyses. The specific effect of the intervention was identified through a significant interactive Group X Period effect, with a significant difference as $((T0 - T1_{Intervention}) - (T0 - T1_{Control})) > 0$. A preliminary ANOVA was performed to assess the quality of the filling out of food notebooks with the total number of different foods consumed during the four days as the dependent variable, and with Group (2: Control vs Intervention, Between-subject variable) and Period (2: T0 vs T1, Within-subject variable) as the independent variables.

The SAS 9.4 software program (SAS Institute, Inc., Cary, NY, USA) was used for statistical analyses and for database management. The statistical significance level was set at p-value < 0.05.

Table 2
Main contents of the pedagogical programme by step.

Steps	Main contents
1	Sensory workshop with the mothers of the intervention group (1 h) • Determinants of food preferences and plasticity of preferences over life span (preference test between a non-spicy and a spicy guacamole) • Individual differences in olfaction (olfactory test) • Importance of olfaction while eating (testing of retronasal odour perception) • Effect of temperature on sensory perceptions (comparison of the same yoghourt at 2 different temperatures) • The 5 senses and their contribution to the tasting process (5 min. video)
2	Video "What is sensory education?" (3 min.) • Aims and pedagogical principles of sensory education Worksheet "Sensory cooking N°1" • Use of the 5 senses to cook a Caribbean recipe (gratin of pumpkin)
3	Video "Children's eating behaviour" (5 min.) • Key stages of eating behaviour during childhood (0 to 11 years) Worksheet "Impact of sight on taste perception" • Impact of colour on the sense of taste (same juice with different colours)
4	Video "How to smell odours?" (3 min.) • Differences between normal and forced sniffing and learning about olfactory mechanisms Worksheet "Odour adaptation" • Impact of adaptation on the perception of odour intensity (same odorant presented twice)
5	Video "Differences between eaters" (3 min.) • Differences in olfactory and gustatory sensitivities between tasters, differences due to food cultures. Worksheet "Sensitivity to bitterness" • Determination of the child's reactivity to bitterness (perception of bitterness in different samples of grapefruit juices, more or less concentrated)
6	Video "How to smell aromas?" (3 min.) • Importance of retronasal olfaction and olfactory mechanisms Worksheet "Effect of temperature on the perception of flavours" • Impact of temperature on the perception of aromas (same ice cream at 2 different temperatures)
7	Video "How to perceive textures?" (3 min.) • Impact of the operating mode on the perception of textures Worksheet "Effect of the acoustic environment on the perception of texture" • Impact of noise on the perception of a crunchy food (same crunchy food tasted in silence then in a noisy environment)
8	Worksheet "Food heritage" • Use of the 5 senses to taste different varieties of a tropical fruit (mango)
9	Worksheet "Sensory cooking N°2" • Use of the 5 senses to cook a Caribbean meal (salad of raw vegetables in a Creole sauce vinaigrette, chicken Colombo and tropical fruit skewers)

3. Results

3.1. Preliminary analysis

3.1.1. Foods recorded in the notebooks

The vegetables that were cited in the dietary records are presented in

Table 3
Vegetables recorded in the dietary record (% of consumers at T0 and T1*) ($N_{vegetables} = 44$).

Vegetables	T0	T1	Vegetables	T0	T1	Vegetables	T0	T1
Artichoke	2	5	Eggplant	17	10	Pois Pays**	3	0
Avocado	3	6	Endive	3	0	Pumpkin	2	3
Beetroot	30	37	Garlic	71	52	Romanesco cabbage	2	0
Broccoli	13	11	Giraumon**	11	8	Salsify	2	0
Brussels sprouts	0	2	Green beans	49	25	Seaweed	2	0
Caper	0	3	Green cabbage	5	0	Shallot	10	6
Carrot	79	67	Green pepper	17	32	Soy	6	0
Cauliflower	8	2	Green salad	43	51	Spinach	11	11
Spring onion	14	10	Leek	25	27	Squash	2	0
Celery	30	22	Mushroom	6	13	Tomato	87	92
Chestnut	2	2	Olive	14	11	Turnip	37	24
Christophine**	13	6	Onion	87	75	Watercress	2	2
Corn	24	24	Palm heart	2	0	White cabbage	3	6
Cucumber	29	24	Pea	51	24	Zucchini	25	17
Djondjon**	2	2	Pickle	16	16			

Percentages of children who cited the fruit has having been eaten at least once.
** Typical vegetables from the Caribbean.

Table 3, while the fruits mentioned are presented in Table 4.

For information, the percentages of children who cited the fruit or the vegetable at least once during the four 24hr-recalls are reported in these tables. There is a very high variability in the frequency of consumption depending on the food. The vegetables that are very frequently consumed are carrots, tomatoes and onions. The more often consumed fruits included apples, bananas and oranges. With the exception of banana and passion fruit, the typical foods from the Caribbean are not eaten frequently.

3.1.2. Quality of filling out of food notebooks

In order to check changes in the quality of the filling out of food notebooks, a preliminary ANOVA was carried out on the mean of the number of different foods recorded for the four days per child. The results indicated that only the Period effect was significant ($p < .001$): regardless of the Group, fewer foods were recorded in T1 than in T0. While during the four 24-hour recalls at T0 the children consumed an average of 16.25 different foods per day, they consumed an average of 13.45 at T1 (Fig. 1). This result reflects a poorer quality of filling out of notebooks at T1 compared to T0.

3.2. Hypothesis analysis

3.2.1. Vegetable and fruit variety

Statistical analyses revealed an interactive effect of Group X Period on the vegetable variety ($p = .022$). The results indicated that, while the variety decreased between T0 and T1 in the Control group (from 9.2 to 6.4 = -2.8), it remained stable in the Intervention group (from 8 to 7.7 = -0.3) (Fig. 2). The hypothesis can be considered as validated to the extent that the difference of the differences is significant and positive ((-0.3)-(-2.8) = 2.5). This difference does not reflect a *per se* increase in the variety of vegetables in the Intervention group, but an absence of the decrease that was observed in the Control group.

Contrary to our hypothesis, no interactive effect was observed for fruit variety ($p = .63$). In fact, for both groups, fruit variety tended to decrease equivalently between T0 and T1 ($p = .08$) (Fig. 3).

3.2.2. Vegetable and fruit consumption

The mean number of vegetables consumed per day over the four-day period was 3.19 (±1.57). Concerning fruits, it was 2.91 (±2.34). No interactive effect was observed for vegetable or fruit intake ($p = .24$ and $p = .39$, respectively).

4. Discussion

The aim of our study was to test the hypothesis that a sensory programme increases the variety of fruit and vegetables consumed by children. Interpretation of the results was complicated by the decrease in variety scores in the control group for the two categories of food. One way to understand this decrease relies on the general decrease observed of the quality of the filling out of the notebooks. This suggests that the mothers were less motivated to complete the food notebooks at T1 than at T0, probably because this is a time-consuming task (about 45 min/day). Thus, with a less detailed report of the food consumed due to a decrease in the quality of completion, the measured variety might have decreased, which is a limitation of our assessment method. A lower quality of food notebook completion over time is consistent with previous studies on food consumption measures (EFSA, 2009; Gersovitz

Table 4
Fruits recorded in the dietary record (% of consumers at T0 and T1*) ($N_{fruits} = 38$).

Fruits	T0	T1	Fruits	T0	T1	Fruits	T0	T1
Apple	68	56	Grenadine**	3	8	Pear	16	5
Banana**	65	51	Guava**	40	25	Pineapple**	29	37
Blackberry	2	0	Khaki	5	0	Prune	3	2
Breadfruit	6	5	Kiwi	13	0	Quince	0	2
Carambola**	2	0	Lime	13	5	Raspberry	29	16
Cherry	8	13	Lychee**	2	0	Red berries	6	3
Cither plum**	2	0	Mango**	17	35	Redcurrant	3	0
Clementine	27	17	Melon	21	33	Strawberry	13	2
Coconut fruit**	5	10	Mirabelle plum	2	0	Sugar cane**	5	0
Dried grapes	10	22	Orange	57	44	Watermelon**	16	22
Grape	11	5	Papaya**	0	2	Yellow lemon	33	43
Grapefruit	6	5	Passion fruit**	43	40			
Green banana**	5	3	Peach	3	5			

Percentages of children who cited the fruit has having been eaten at least once.
**Typical fruits from the Caribbean.

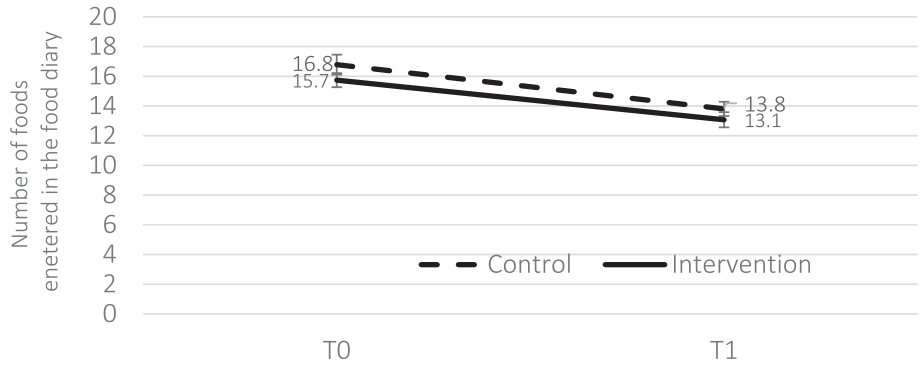

Fig. 1. Number of foods recorded in the food notebooks according to the Period (T0 -before the intervention- *versus* T1 -after the intervention-) and to the Group (Control *versus* Intervention). Error bars represent the standard error of the mean.

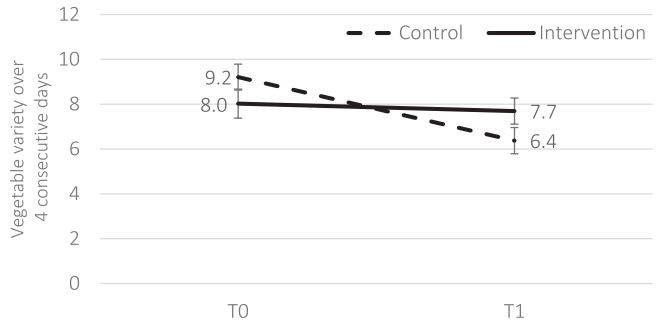

Fig. 2. Vegetable variety according to Period and Group Number of different vegetables recorded in the food notebooks according to the Period (T0 -before the intervention- *versus* T1 -after the intervention-) and to the Group (Control *versus* Intervention) Error bars represent the standard error of the mean.

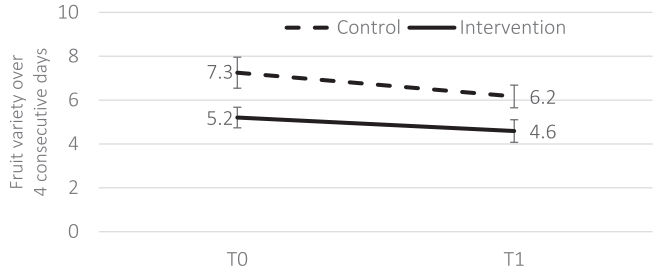

Fig. 3. Fruit variety according to Period and Group Number of different fruits recorded in the food notebooks according to the Period (T0 -before the intervention- *versus* T1 -after the intervention-) and to the Group (Control *versus* Intervention) Error bars represent the standard error of the mean.

et al., 1978).

A second explanation for this decrease might be the seasonality of fruits and vegetables in Guadeloupe, as T0 occurred in November-December, while T1 occurred in June. Although temperature fluctuations are very limited in tropical climates, the availability of Caribbean fruit and vegetables is slightly more restricted in June than in November-December in Guadeloupe

In the context of the decrease in variety scores in the control group, the stability of the variety score in the intervention group indicated a positive effect of the educational programme in the case of vegetables. DeCosta et al. (2017), in a review of experimental studies, indicated that social facilitation is a powerful learning mechanism for changing children's food behaviours: social facilitation increases preferences for foods that are negatively judged by children when parents have a positive attitude toward these foods. As the sensory programme implemented in our study was mainly based on activities shared by mothers and children, one can suppose that it fostered positive modelling within the family. The programme was also based on hands-on approaches, such as food preparation and cooking, two strategies identified by DeCosta et al. as encouraging greater vegetable consumption and which may have a bigger effect compared to nutrition education.

Moreover, interestingly, the impact of the pedagogical programme was not limited to the vegetables that were tasted during the sensory activities: after completing the programme, the children in the intervention group consumed a lot of vegetables that were not presented in the sensory experiments. One interpretation could be that familiarity with foods cooked during the programme had spread (generalized) to other foods in the same category, i.e. vegetables, as was experimentally observed by Birch et al. (1998) amongst infants. Thus, the underlying processes of generalization could be social facilitation and culinary experiences.

Our hypothesis was not validated for the fruit category. Our interpretation relies on the fact that vegetables are more strongly rejected during childhood than fruit (Gibson & Wardle, 2003). Indeed, vegetables lack drivers of liking (Poelman et al., 2017), whereas fruits are sweet and higher in energy. For this reason, learning mechanisms (i.e., sensory and social learning, exposure and familiarity processes) are particularly necessary for learning to overcome children's rejection of vegetables.

Food consumption did not evolve with the programme: children did not consume fruit or vegetables on more occasions after the intervention. This result is consistent with the only previous result that evaluated the effect of sensory education on consumption (Battjes-Fries et al., 2016). It indicates that the effect of sensory education, when it occurs as in the case of vegetables, acts only on variety, not on consumption occasions.

5. Conclusion

To our knowledge, "Goûts en Famille" is the first sensory programme aimed at families. A sensory education programme implemented at home may be relevant for enhancing vegetable variety, but not consumption, in children: a family-based education programme helps to change daily food choices and consumption, as well as cooking habits. These results should be confirmed by future studies including the evaluation of the long-term effects of the programme and the estimation of variety on the basis of observational data in order to circumvent the difficulties of filling out the food notebooks.

CRediT authorship contribution statement

N. Rigal: Conceptualization, Investigation, Methodology, Writing - original draft, Writing - review & editing. **A. Salmon-Legagneur:** Conceptualization, Data curation, Formal analysis, Writing - original draft. **P. Hébel:** Conceptualization, Formal analysis, Writing - original

draft. **D. Cassuto:** Conceptualization, Writing - original draft. **N. Politzer:** Project administration, Funding acquisition, Methodology, Supervision, Writing - original draft.

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