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Camille Rioux, Jérémie Lafraire, Delphine Picard

Institutions: Aix-Marseille University, School for Advanced Studies in the Social Sciences

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Camille Rioux[a,b*], Jérémie Lafraire[a] & Delphine Picard[b]

[a] Center for Food and Hospitality Research, Paul Bocuse Institute, Ecully, France

[b] Aix Marseille Université, PSYCLE EA3273, 13621 Aix en Provence, France

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Abstract

We studied children's inductive inferences within the domain of food categories. There has so far been little research on inductive reasoning about food among children, despite the theoretical and practical importance of knowing what knowledge children bring to the table and how they use it. We tested the hypotheses that children's food category-based induction performances and their food rejection are negatively correlated, and that these performances are influenced by the color typicality of the food items. We recruited 126 children aged 2-6 years, and administered a category-based induction task. Participants were successively shown 8 sets of three pictures containing one target picture (a vegetable) and two test pictures (a vegetable dissimilar in color to the target picture and a fruit similar in color to the target picture). For each set, participants were told a novel property about the target picture and asked to generalize this property to one of the two test pictures. Additionally, the parents of each child filled out a questionnaire about his or her food rejection tendencies. Results on accuracy (i.e., if participants generalized the properties according to category membership, not perceptual similarity) provided the first empirical evidence in favor of a negative relationship between children's food rejection and food category-based induction.

Keywords: children, food rejection, food category-based induction, cognitive development, individual differences.

Introduction

Category-based induction is a central process underlying much of our reasoning in everyday life (Hayes, 2007; Murphy, 2002; Smith & Medin, 1981). For example, at lunchtime, children will pick carrots as a side from the school cafeteria buffet because they know that carrots are vegetables. Even if they have never seen a particular variety of carrot before, they can infer its properties (e.g., tasty, satisfying) from their knowledge of the *carrot* or *vegetable* category. By allowing us to disregard insignificant perceptual differences (size, color etc.), categories enable us to take advantage of our past experiences and to generalize our knowledge to new instances or new situations, thereby avoiding the need to examine each and every object or situation de novo (Gelman & Markman, 1986; Murphy, 2002; Murphy & Ross, 1999).

The majority of recent research has focused on the process by which category-based inferences are drawn (Fisher Godwin, & Matlen, 2015; Gelman & Davidson, 2013; Sloutsky, Deng, Fisher, & Kloos, 2015). The present study addressed one specific issue of how these inferences are drawn, namely we explored the role of individual differences (e.g., in food rejection behaviors) in children's induction within the domain of food categories. So far, there has been little focus on food induction among children, despite the theoretical and practical importance of knowing what knowledge children bring to the table and how they use it. At the theoretical level, children's performances on food category-based induction tasks reflect the way they acquire new knowledge about nutrition and edibility. Moreover, several research studies argue in favor of certain food domain specificity effects. For instance, adults and children attend mainly to shape information when viewing artifacts, but attend to color or texture information when viewing foods (Foroni, Pergola, & Rumiati, 2016*;* Foroni & Rumiati, *in press*; Lavin & Hall, 2001; Macario, 1991; Shutts, Condry, Santos, & Spelke, 2009). Additionally, a recent neuropsychological review on food representations reporting how brain-damaged patients recognize food and nonfood items, suggested that representations of foods dissociate from representations of animals or other living things (Rumiati & Foroni, 2016). More precisely, using for instance a word-to-picture matching task, Rumiati, Foroni, Pergola, Rossi and Silveri (2016) showed that both natural and manufactured food tended to be processed better than non-foods in patients with Alzheimer dementia or primary progressive aphasias. At the practical level, it is important that we understand the relationship between food behaviors (e.g., food rejection disposition) and cognitive development (e.g., development of category-based induction) if we are to design efficient education programs aiming at promoting healthier eating behaviors (Thibault, Nguyen, & Murphy, 2016). This is especially crucial given the widening gap between children's actual consumption of fruit and vegetables and the recommended intake needed for normal and healthy development (Cockroft, Durkin, Masding, & Cade, 2005).

Development of Food Category-Based Induction and Sensitivity to Individual Differences

There is much evidence showing that young children intuitively focus on perceptual similarities when making induction (i.e., children draw many inferences from one item to a perceptually similar item and few inferences from one item to a perceptually dissimilar item) and maintain this focus until they have developed the knowledge base necessary to support the shift toward a focus on category membership (Badger & Shapiro, 2012; Fisher et al., 2015a; Sloutsky & Fisher, 2004; Sloutsky et al., 2015, but see Gelman & Coley, 1990; Gelman & Davidson, 2013; Gelman & Markman, 1986; 1987 for diverging evidences and counterarguments). For example, in a study conducted by Chi, Hutchinson, and Robin (1989) where children were presented with unknown exemplars of dinosaurs, children who had prior knowledge about dinosaurs tended to make taxonomic category-based inferences (e.g., a child said that a novel exemplar of a dinosaur labeled *duckbill* was probably "a good swimmer because *duckbills* are good swimmers"). By contrast, novices were likely to make inferences based on a salient perceptual feature of the exemplar (e.g., a child said that a novel exemplar of dinosaur labeled duckbill "could probably walk real fast 'cause *he has giant legs*").

Prior knowledge of a particular domain is acquired mainly through experience and learning. Within the food domain, preschoolers have extremely diverse experiences and learning opportunities that could well influence their inductive performances in this domain. Precisely, the two main kinds of food rejection in children, *food neophobia* (defined as the reluctance to eat novel food items; Pliner & Hobden, 1992) and *pickiness* (defined as the rejection of substantial amounts of familiar foods, and rejection of certain food textures; Taylor, Wernimont, Northstone, & Emett, 2015), contribute to narrowing children's dietary variety and reducing their experiences with fruit and vegetables (Carruth, Ziegler, Gordon, & Barr, 2004; Cashdan, 1998; Dovey Staples, Gibson, & Halford, 2008; Falciglia, Couch, Gribble, Pabst, & Frank, 2000; Heath, Houston-Price & Kennedy, 2011; Lafraire, Rioux, Giboreau, & Picard, 2016).

A relationship between children's food rejection behaviors and their cognitive performances in the food domain was uncovered in a recent study. Using a forced-sorting task involving exemplars of the fruit and vegetable categories, Rioux, Picard, and Lafraire (2016) showed that, at a given age, highly picky and neophobic children displayed poorer categorization performances than their non-picky and neophilic peers. More precisely, categorization performances were roughly equivalent for 2-4 years old children and highly picky-neophobic children, while categorization performances were roughly equivalent for 4-6 years old children and low picky-neophobic children. These results were especially striking, given that food rejection scores were not correlated with age. Rioux and colleagues (2016) then hypothesized that food rejections could arise because of a miscategorization of food items and could be partly seen as the behavioral consequences of an immature categorization system.

"One important function of categories is to allow inferences that extend beyond surface appearances" (Gelman & O'Reilly, 1988, p. 876), it is therefore possible that neophobic and picky children, who fail to categorize certain food items, focus preferentially on superficial appearances to generalize knowledge (and maintain this focus until they have developed the conceptual knowledge allowing a shift toward a focus on category membership, Badger & Shapiro, 2012; Fisher et al., 2015a; Sloutsky & Fisher, 2004; Sloutsky et al., 2015). For example, if a highly neophobic and picky child believes that the round and red tomatoes served at home are edible, will he/she infer that a new tomato served at the school cafeteria is also a tomato, if it differs in shape, texture, color, or even mode of presentation? We would expect that, as young children, highly picky and neophobic children will use more perceptual similarity (rather than category membership) to draw inductions compared to children with a low level of food rejection. So far, however, at least to our knowledge, this assumption has never been tested.

Importance of Color in Food Induction

Most studies investigating induction mechanisms and development within real-world categories have used paradigms where taxonomic category membership is pitted against overall perceptual similarity. As far as we are aware, only a handful of studies have assessed the role of the similarity of a specific feature, while within the food domain, the features that potentially influence children's food selection need to be further investigated alongside certain individual characteristics. In particular, if highly neophobic and picky children are likely to make inferences based on a salient perceptual feature instead of category membership, it is important to know which feature they will primarily attend to.

One important finding in the food domain is that children from the age of 2 years old attend to information about color, rather than shape, when discriminating between edible and inedible substances or between different kinds of foods (Lavin & Hall, 2002; Macario, 1991;

Ross & Murphy, 1999; Shutts, et al., 2009). This finding seems at odd with the literature on the *shape bias* that put forward that preschoolers usually match two or more objects on the basis of shape (Landau, Smith, & Jones, 1988; Yoshida & Smith, 2003).

Recent findings (Rioux et al., 2016) however indicate that, in the food domain, color is important because it conveys information about typicality (unlike shape, which usually changes across servings and recipes). In the study by Rioux et al., children were presented with fruit and vegetables that differed in shape, color, or color typicality, and asked to sort them according to category. Rioux and colleagues found that color typicality was the most salient variable, predicting whether or not food items would be correctly categorized. As typicality is an important determinant of category-based induction (i.e., a novel property involving typical exemplars of a category is believed to apply to other members of the category, whereas a premise about atypical exemplars is more narrowly generalized to other members; Dunsmoor & Murphy, 2014; Murphy, 2002), it would be useful to investigate the role of color similarity and typicality (rather than overall similarity) in children's food inductive inferences. For example, if children believe that typical red tomatoes are edible, will they infer that atypical green tomatoes are also edible, and vice versa? Additionally, if highly neophobic and picky children are likely to make inferences based on color similarity instead of category membership, is color typicality a more salient feature for these children?

The Present Study

To summarize, we designed the present study to determine whether and how children's induction performances within the domain of food vary according to individual characteristics (e.g., food rejection disposition) and food item characteristics (e.g., color typicality). We conducted a property generalization task, when perceptual and categorical pieces of information were pitted against each other, as in the seminal study by Gelman and Markman (1986), with children from 2 to 6 years of age. We chose fruit and vegetable categories because by the age of 2-6 years, children have usually encountered several exemplars of these foods and have developed the corresponding taxonomic categories (Nguyen & Murphy, 2003). Fruit and vegetables were also chosen because they are likely to be rejected by children in this age range, and are usually available in different colors. Importantly, we manipulated the color typicality of the vegetables used as target and test items in our picture sets, so as to test the impact of color typicality on children's performances on a property generalization task. Finally, as in Gelman and Markman's study (1987), we used three separate conditions, where participants could either see the pictures *and* hear the labels (word-and-picture condition), just see the pictures (picture-only condition), or just hear the labels (word-only condition). By varying what information is available to children, we can determine on what bases children draw inferences and whether the information used is influenced by individual differences, namely food rejection disposition. Compared to the *word-and-picture* condition, the *picture only* condition draw children's attention to information conveyed by perceptual cues (i.e., both category and perceptual information). The *word-only* condition draw children's attention to the information conveyed by labels (i.e. only category information). In this latter condition, as no perceptual cues are available, no difference should appear between highly neophobic children and non-neophobic children.

Our main hypotheses were as follows:

(1a). Children with high food rejection dispositions will focus on color similarities (instead of categorical membership) to draw induction within the food domain.

(1b). Difference between highly neophobic children and non-neophobic children will be greater in the condition where both categorical and color information is given (*word and picture* and *picture-only* conditions) compared to the condition when only categorical information is given (*word-only* condition).

(2a). Atypically colored food items will be more liable to induction errors than typically colored food items.

(2b). Difference between highly neophobic children and non neophobic children will be greater in the triad with atypically colored food items compared to the triad with typically colored food items.

Method

Participants

The participants were 126 children (63 girls and 63 boys; age range = 24-82 months; mean age = 51.4 months, *SD* = 11.9). They were all pupils at preschools in the Paris or Lyon urban area (France). They were predominately Caucasian and came from middle-class communities. An additional (control) group of 30 young adults recruited from the universities of Aix-Marseille and Lyons (France) also took part in the study.

Prior to the study, the parents of each child filled out a questionnaire about his or her food rejection disposition. We used the Child Food Rejection Scale (CFRS; Rioux, Lafraire, & Picard, 2017) for this purpose. The CFRS was developed to assess food rejection disposition in children aged 2-7 years, and includes two subscales: one is measuring children's food neophobia (6 items) and one is measuring their pickiness (5 items). Scores can range from 11 to 55 with high scores indicating high food rejection dispositions (both high neophobia and pickiness). Parents were also asked to indicate whether or not their child had been exposed to each of the fruit and vegetable exemplars used in the experiment (6 different fruits or vegetables were used; thus exposure score possibly ranging from 0 to 6).

Materials and Procedure

Materials

The materials consisted of color photographs of real fruit and vegetables, controlled for contrast and luminosity. There were 8 triad sets in total, each set containing three pictures: one target picture and two test pictures. Each triad set was printed on a laminated card measuring 21 x 29.7 cm. As existing studies on category-based inferences (Gelman & Markman, 1986; Fisher, et al., 2011; Fisher, et al., 2015b) in each set, one of the test pictures (*Test picture 1*) belonged to the same taxonomic superordinate category as the target picture, but was perceptually dissimilar, while the other test picture (*Test picture 2*) belonged to a different taxonomic superordinate category from the target picture, but was perceptually similar (see Fig. 1). The main difference between the present study and previous studies of category-based inferences with natural kinds was the focus on i) food categories and ii) color similarity instead of overall perceptual similarity (including shape, color, size etc.).

Because vegetables are extremely prone to food rejections, in the present study we were particularly interested in the way children generalize knowledge to new vegetables, therefore, the target picture was always a vegetable. Test picture 1 was another vegetable dissimilar in color to the target, while Test picture 2 was a fruit similar in color to the target. This is illustrated in Fig. 1, where the target picture is a red tomato (vegetable), Test picture 1 is an orange-colored squash (another vegetable, but with a dissimilar color), and Test picture 2 is a red apple (a fruit, but similar in color to the target). As the emphasis was put on color, all of the pictures in a given set were similar overall in shape and size.

--Insert Figure 1 about here--

To generate our trial set, we first visited a school cafeteria to see which fruits and vegetables were frequently served to children, and therefore familiar to them. On this basis, we selected four vegetables (carrot, tomato, squash and zucchini) and two fruits (apple and banana) that were commonly served and were available in different colors (according to caregivers' report and exposure scores, each of these fruits or vegetables were consumed at home by more than 82% of the children). For each vegetable, we chose two varieties that differed in color (either *typically colored* or *atypically colored*). Color typicality was assessed based on results from a pretest in which we asked 10 adults to rate the typicality (either *typical* or *atypical*) of the colors chosen for each vegetable. The different foods pictured are shown in Table 1.

--Insert Table 1 about here--

We selected two of the four chosen vegetables as targets: tomatoes (red and green), and zucchini (purple and yellow). To avoid any confounding effect of a particular shape, we used both a round and a long-shaped vegetable as target. The two other chosen vegetables were used as Test pictures 1: carrots (orange and purple) and squashes (orange and white). The two fruits served as Test pictures 2: apples (red and green) and bananas (yellow and green). The full set of triads is shown in Table 2. As can be seen from this table, each target food was presented two times and was always paired with the same Test picture 2 (different category, but similar color). The red tomato was therefore always paired with the red apple, the green tomato with the green apple, the green zucchini with the green banana, and the yellow zucchini with the yellow banana. Test picture 1 (same category, but dissimilar color) varied across the two presentations, and could be ii) a different vegetable from the target and typically colored (see Fig. 1), or ii) a different vegetable from the target and atypically colored.

The present study design differs from existing studies on category-based induction because the same target picture was presented several times. This design was chosen because we were particularly interested in the color typicality effect (and not the kind typicality) and it was therefore important to maintain constant the target picture while varying Test pictures 1 in term of color typicality. Additionally the design differs from existing studies because we used the same color-match fruits two times (across the two presentations of a given target picture). This was mainly due of practical reason. Indeed because we worked with ecological stimuli and familiar food items it was not possible to find enough familiar color-matched fruits.

--Insert Table 2 about here--

Two additional sets containing pictures of animals were used in a training session. In these two sets the target picture was a dog that "had an organ called a vesibule". Test picture 1 was another dog dissimilar in overall shape and color, while Test picture 2 was a cat similar in overall shape and color.

To make sure that the pictures we thought were more perceptually similar (because they shared the same color) were indeed perceived of as such by participants, we asked the control group of 30 young adults to rate the perceptual similarity of our 8 triad sets. To this end, we converted each of the 8 triads into two pairs: the target and *dissimilar-in-color* test picture (Test picture 1), and the target and *similar-in-color* test picture (Test picture 2). In line with Gelman and Markman's study (1986; Exp. 1), for each pair, participants were asked to rate "how alike the two pictures look" on a scale of 1 (*not at all similar*) to 7 (*extremely similar*). An example of a very similar pair (thin slices of a yellow banana and crisps) was given. Adults' ratings of the pictures validated the experimental design pitting color similarity against category membership. Overall, pictures designed to be more perceptually similar (e.g., red tomato and red apple; see Fig. 1) were rated as significantly more similar ($M = 4.60$, $SD = 1.60$) than pictures belonging to the same taxonomic category (e.g., red tomato and orange squash; see Fig. 1, $M = 2.67$, $SD = 1.47$) (Student's t test: $t = 11.07$, $ddl = 29$, $p < 0.0001$). Within each of these triads, we observed the same pattern, where the target picture and Test picture 2 (fruit) were judged to be more similar to each other than the target picture and Test picture 1 (other vegetable).

Procedure

Children were tested individually for approximately 10 minutes in a quiet room at their school and the procedure was approved by the local ethical committee. They sat at a table with an experimenter on their right side. During the task, the children were shown the 8 triad sets of pictures, one after the other. For each set, they were told a novel property about the target picture and asked to generalize this property to one of the two test pictures[1]. To ensure that the children did not draw on prior knowledge to make these decisions during the task, we used blank predicates, as in Fisher, Godwin, Matlen, & Unger. (2015b), such as "contains zuline". Previous studies had indicated that blank predicates can be successfully used with children as young as 2 years (Fisher Matlen, & Godwin, 2011; Godwin Matlen & Fisher, 2013). However, blank predicates place relatively heavy information processing demands on young children, as they are required to focus their attention on several pictures at the same time and to learn new facts for each novel set of pictures (Gelman & Coley, 1990). Instead of using 8 different blank predicates, we therefore used just three ("contains zuline", "contains lima", and "contains kazole"), each predicate being repeated three or two times across the sets. To this end, we divided the 8 triad sets of pictures into three groups, each assigned one of the blank predicates. Each group contained three (or two) different vegetable targets, so that the children could not associate a predicate with one particular target. It is important to notice that from the behavior of children during the task we did not see any

[1]It is worth noting that in Gelman and Markman's seminal study (1986), facts were given about individual test pictures, meaning that several different facts were provided for each set. As the children in our study were younger than in hers, we used the reverse procedure, as in Gelman and Coley (1990) and Gelman and Markman (1987), and administered a forced-choice task, as the yes/no paradigm used in Gelman and Markman (1987) is not always appropriate for young children (Thibaut, et al., 2016).

apparent carry over effects from the repetition of the properties or the repetition of the Test picture 2 for a given target picture. Indeed children actually often justified their choice during the task, saying for instance that because the apple was also red it has the same property that the red tomato. Nevertheless they never made comments like "the red tomato can't contain zuline because the green tomato does" or "the apple contained zuline before so it does too now". The order of presentation of the three groups was randomized (but all trials telling a child that a food 'contains zuline' were presented one after the other), as was the order of set presentation within the three groups.

Following the example of Gelman and Markman (1987), we created three conditions that varied in terms of whether the pictures were both labeled *and* shown (*word-and-picture* condition), shown without their labels (*picture-only* condition), or labeled but not shown (*word-only* condition). By varying what information is available to children, we can determine on what bases children draw inferences and whether it is influenced by food rejection disposition (namely food neophobia and pickiness). As condition was used as a between-participants variable, children were randomly assigned to one condition only (42 children per condition), with the constraint that conditions were roughly equivalent for, age and rejection level (mean age=48.50 months, age range = 24-75, mean rejection score=34.00, rejection range = 11-46 in the *word and picture* condition, mean age=48.50 months, age range = 37-69 months, mean rejection score=37,00, rejection range = 11-55 in the *word-only* condition, and mean age=48.50 months, age range = 35-82 months, mean rejection score=34.00, rejection range = 11-50 in the *picture-only* condition).

Word-and-picture condition. In this condition, for each triad, the experimenter began by pointing to the three pictures, labeling each of them in turn (starting with the target picture, then the two test pictures in a balanced order). For example, the experimenter pointed to the target picture and said "Look, it's a tomato" and then pointed to the test pictures and said

"Look, it's a squash and an apple". She then provided a fact about the target picture, while pointing to it, such as "This tomato contains zuline". Finally, she asked children about the two test pictures (e.g., "Do you think this squash [pointing to the squash] or this apple [pointing the apple] also contains zuline?"). Children could only choose one of the two test pictures. It should be noted that although we were testing fruit and vegetable category membership, we decided to use the labels of the basic-level categories (e.g., *tomato* or *apple* instead of *vegetable* or *fruit*). We wanted these labels to activate category membership (and children were familiar with all these labels) and young children are said to believe that count labels denote categories (Fisher et al., 2015a). But we did not want to emphasize the vegetable items' overall similarity (identical labels are sometimes thought to enhance similarity between items; see Sloutsky & Fisher, 2004). This condition provided children with category information and perceptual information.

Picture-only condition. In this condition, the difference with the word-and-picture condition was that the foods were never labeled (e.g., the experimenter said "Look at *this*. *It* contains zuline"). This condition was used to draw children's attention to perceptual cues and did not facilitate category recognition. For instance we did not expect children to categorize as a tomato the green tomato because it was really an atypical color for this vegetable.

Word-only condition. In this condition, contrary to the word-and-picture condition, the foods were never shown to the children (e.g., the experimenter said "I see a picture of a tomato"). This condition was used to draw children's attention to information conveyed by labels, as it was the only available source of information. Category recognition was therefore facilitated. This latter condition placed heavier memory demands on children. However, as demonstrated in recent studies, preschoolers can remember the identity of hidden objects with a high degree of accuracy (Fisher, et al., 2011; Godwin, et al., 2013).

Scoring

The experimenter recorded participants' responses to the task, assigning a score of 1 to category-consistent responses (i.e., if the participant generalized the property to the other vegetable) and a score of 0 to perceptual-consistent responses (i.e., if the participant generalized the property to the fruit). The scores were then summed across all the sets to obtain the number of category-consistent responses for each participant. This number was divided by the total number of set (8) to obtain the child's induction score (possibly ranging from 0 to 1).

It should be noted that despite the fact that taxonomic categories are not always the most pertinent categories to draw inferences (see Coley, Shafto, Stepanova, & Baraff, 2005, for the use of thematic categories and causal relations in induction), the emphasis on taxonomic relatedness as "good answer" in the present research is based on the type of properties used. Indeed, in this study, the properties to be generalized were *biological* properties, and children and adults used taxonomic categories to generalize these kinds of properties (Coley et al., 2005; Nguyen & Murphy, 2003, Thibaut et al., 2016). Nevertheless, one could argue that in the food domain color is as predictive as taxonomic category membership (for instance it is been showed that color is used to predict caloric content of a food; Foroni et al., 2016). However adults' participants in the present study chose the category-consistent response to generalize knowledge 88.8% of the time (significantly above chance level, t =11.36, ddl = 21, $p < 0.0001$) strengthening the choice of scoring category-consistent responses as "good answers".

Results

Linear model repeated measures analysis was performed with scores on the category-based induction task (possibly ranging from 0 to 1) as dependent variable, triad's complexity (*typically colored target and test picture 1; atypically colored target and test picture 1; typically colored target and atypically colored test picture 1; atypically colored target and typically colored 1est picture 1*) as within-participants factors and condition (*word-and-picture*; *picture-only*; *word-only*), age, CFRS scores and exposition scores as between-participants factors. As preliminary analyses revealed no effect of the order of presentation of the triads ($p > 0.15$), we collapsed the data across this variable for the analyses reported below.

This analysis revealed a significant effect of condition, $F(2, 114) = 4.60$, $p = 0.012$, $\eta_p^2 = 0.046$. Bonferroni corrected post hoc comparisons indicated that the *word-only* condition differed significantly from the *word-and-picture* condition ($p = 0.018$). Children performed significantly better in the *word-only* condition ($M = 0.58$, $SD = 0.30$)-and were almost above chance level ($t = 1.75$, $ddl = 41$, $p = 0.08$) - than children in the *word-and-picture* condition ($M = 0.40$, $SD = 0.25$) who were below chance level ($t = -2.44$, $ddl = 41$, $p = 0.019$). The post hoc analysis also revealed that the *picture-only* condition did not significantly differ from either the *word-and-picture* condition or the *word-only* condition.

This analysis also revealed a significant effect of CFRS scores, $F(1,114) = 6.33$, $p = 0.01$, $\eta_p^2 = 0.033$. As predicted by the hypothesis 1a of the study, food rejection scores were negatively correlated with performances (as attested by Spearman's correlation coefficient, $r = -0.19$, $p = 0.029$, see the black line on Fig. 2). The more the neophobic and picky the children were the more they seemed to focus on perceptual cues to draw induction.

No significant effects of triad complexity (contrary to hypothesis 2a), age or exposure scores were found (all $ps > 0.15$). Contrary to hypothesis 1b and 2b, we also did not find any interaction effects between triad complexity and other main factors or interaction effects between condition and other main factors (all *ps* > 0.35).

--Insert Figure 2 about here--

To further assess the potential influence of food rejection disposition on category-based induction performances, we looked at the correlation between generalization scores and food rejection scores in the two significantly different experimental conditions (*Word-and-picture* and *Word-only*). The correlation was significant in the *Word-and-picture* condition (Spearman's correlation coefficient, *r1* = -0.35, *p* =0.019, see the blue dashed line on Fig. 2), but not in the *Word-only* condition (Spearman's correlation coefficient, *r2* = -0.16, *p* = 0.31, see the red dashed line on Fig. 2). To compare these two correlation coefficients we used a Fisher transformation to obtain *r'1* = -0.36 and *r'2* = -0.16 with the following formula (Cohen & Cohen (1983) :

$$r' = \frac{1}{2}\ln\left|\frac{1+r}{1-r}\right|$$

We then measured a Z-score for the differences between the correlation coefficients:

$Z = \frac{r_1' - r_2'}{E}$ with $E^2 = \frac{1}{n1-3} + \frac{1}{n2-3}$ = -0.90 indicating that the two correlation coefficients did not significantly differ ($p > 0.1$).

Discussion

The present study had two aims. First, we sought to investigate the role of individual differences in food rejection behaviors in children's induction within the domain of food categories. Second, we wanted to shed light on the mechanisms behind the existing consensus on the central role of color in the food domain.

Development of Food Category-Based Induction and Sensitivity to Individual Differences

Results concerning the sensitivity of category-based induction performances to food rejection dispositions supported our hypothesis 1a. First statistical analyses indicated that overall children with high food rejection dispositions demonstrated poorer induction performances than children with lower food rejection dispositions. This suggests that the children's level of food rejection partly predicted their performance on the fruit and vegetables induction task: neophobic and picky children tended to generalize knowledge based on perceptual cues (in this case color cues) rather than category membership. Furthermore, statistical analyses within the two significantly different experimental conditions (*word-only and word-and-picture*) revealed that contrary to the hypothesis 1b, the correlation coefficient between children CFRS scores and category-based induction scores in the *word–and-picture* condition, did not differ significantly from the correlation coefficient in the *word-only* condition. This later result suggests that differences between neophobic children and their counterparts could arise from (i) the fact that, compared with children with few rejection dispositions, highly neophobic children are more likely to rely on color similarity to draw inferences when this information is available. This is in line with a study using an eye tracking procedure (Maratos & Staples, 2015), where the authors found that neophobic children demonstrated an attentional bias toward the visual aspect of food stimuli. Because we found no differences in the two correlation coefficients, differences between neophobic-picky children and their counterparts could also arise from (ii) differences in their semantic development. Indeed in a recent study using a paradigm highly similar to our *word-only* condition, Fisher and colleagues (2015b) showed that category-based induction abilities were strongly and positively correlated with semantic development. This is less likely however because in a follow up study we conducted with the older children of our sample (n= 63; age range = 48-82 months) we did not find any correlation between CFRS scores and performances to a semantic space task (similar to Fisher and colleagues 'task; 2015b). Highly neophobic and non-neophobic children performed equally to a semantic task where they were asked to help us organize our groceries of fruits and vegetables by placing food items similar in kind (e.g. two vegetables) close together in the shopping trolley and food items dissimilar in kind (e.g. a fruit and a vegetable) far away from each other in the shopping trolley. Unpainted wooden blocks were used as game pieces to put in the trolley to encourage children to use their knowledge about kinds rather than rely on perceptual similarity.

In the light of these original results, we hypothesized that we could be facing a vicious circle. Food rejection may be seen as the result of an immature food categorization system (Brown, 1990; Dovey, et al., 2008; Lafraire et al., 2016; Rioux et al. 2016). Indeed, food acceptance depends on recognition because children are more comfortable eating food items for whose they can anticipate the consequences of ingestion (Pliner & Hobden, 1992). Food rejections exhibited by certain children may in turn discourage caregivers to present fruit and vegetables to their children because of reluctance to waste food (Carruth et al., 2004). This lack of exposure to fruit and vegetables will lead to fewer learning opportunities which, in turn, impacts negatively on food categorization and inductive reasoning (as the present study revealed). A promising way to break this circle would be to investigate the early food categorization system to design interventions aiming at enriching it. It could be more effortless for caregivers to provide children with games designed to enhance their conceptual knowledge, especially if it occurs outside mealtimes that carry the stress associated with ensuring the child is consuming a healthy diet (Dazeley & Houston-price, 2015) than to repeatedly present vegetables to them. Nevertheless future research exploring with longitudinal designs the relationship between cognitive development and food rejection dispositions is needed to better grasp causal influences in the original relationship revealed in the present study.

Importance of Color in Food Induction

Results concerning the effect of color typicality did not support our hypothesis 2a and 2b. Food items with atypical colors were no more prone to induction errors than food items with typical colors. Additionally, results did not reveal any interaction effect between color typicality and children food rejection dispositions. This absence of a significant effect of color typicality was not in line with previous studies focusing on the role of either color typicality in food categorization (Rioux et al., 2016) or typicality in inductive inferences (Dunsmoor & Murphy, 2014). Rioux and colleagues found that when children were presented with fruit and vegetables that differed in shape, color or color typicality, color typicality was the most salient variable, predicting whether or not food items were correctly categorized. Additionally, Dunsmoor and Murphy (2014) found that for adult participants, novel properties involving typical exemplars of a category were applied to other members of that category, whereas a premise about atypical exemplars was more narrowly generalized to other category members. An important difference between Dunsmoor and Murphy's study (2014) and the present study is that we used fairly common and typical kinds of fruit and vegetables (apples, bananas, carrots, tomatoes, squashes and zucchini), and manipulated *color* typicality instead of *kind* typicality as Dunsmoor and Murphy did. It is therefore possible that even atypically colored vegetables were recognized by children, and they perceived no differences in typicality in the presented triad sets. In fact we did not find any significant differences between the *Word-and-picture* condition and the *Picture-only* condition suggesting that children were able to recognize the vegetables (either typically or atypically colored) even without hearing the labels. The absence of any significant effect of color typicality could also be explained by our rather small triad sample (8 triads in total). A much broader sample may have been needed to detect a significant typicality effect (in Rioux et al.'s study, 2016, a typicality effect was found with a sample of 36 pictures). However, children as young as 2 years have a short attention span and the present induction task therefore had to be brief in order to maintain their attention throughout the test. More research on the importance of color typicality within the food domain is therefore required with older children (e.g., 4- to 6-year-olds), who can be asked to perform tasks with more stimuli.

Conclusion and Perspective

Our results provided the first piece of evidence in favor of a negative correlation between food rejection and food category-based induction performances in young children and reinforced recent findings demonstrating the same pattern of results, namely that young children perform the same as neophobic and picky children on a fruit and vegetable discrimination task (Rioux et al., 2016).

We nevertheless acknowledge that the present study had several limitations. First, we used photographs of real food items. Color similarity was therefore not total (e.g., the red of the tomato and the red of the apple were not exactly the same), and may have reduced children's use of color similarity to draw inductive inferences. However, children are thought to be faster at distinguishing between two colors that belong to different categories (e.g., yellow and red) than two colors that belong to the same category (e.g., two different reds), even when the distance in hue is objectively the same (for a review of color perception, see Timeo, Farroni, & Maass, 2016). Nevertheless, it would be worth confirming the patterns of results of the present study by controlling for color similarity.

Second, as we were interested in color similarity, we selected fruit and vegetables with similar overall shapes, to control for that possible effect. However, the children may have found that shape similarity was greater for the two vegetables than for the vegetable and the fruit, thus reducing the conflict between perceptual information and categorical knowledge. It would be worth confirming these patterns by controlling better for shape similarity.

Finally, color typicality had to be assessed by an external sample of adults, rather than by the children themselves, as it is rather difficult to directly ask children as young as 2 years whether they think that a color is typical of a given fruit or vegetable, as t*ypicality* is an abstract concept they probably do not understand. That said, when children are simply asked to categorize items, they prove to be more accurate with typical items than with atypical ones (Murphy, 2002). In future studies, it would therefore be worthwhile assessing children's performances on a categorization task with this same set of colored stimuli, in order to gain an estimation of their typicality for children.

Despite these limitations, we believe that the present experiment opens up promising new research avenues, and sheds light on the relationships between cognitive mechanisms and different kinds of food rejections (neophobia and pickiness). For instance, it will be of interest to investigate children induction performances with other food categories that are less prone to rejections (such as starchy foods) or with non-food items and investigate whether the negative correlations between induction performances and food rejections scores continue to exist. A second promising line of research would be to explore the effect of training in food category-based induction tasks on food rejection disposition during childhood. The highly neophobic and picky children who relied heavily on color similarity to draw inferences in the present experiment should benefit from such training, as they would learn that color similarity should be disregarded in favor of labels that facilitate recognition of category membership, when making predictions about food items. They might then reject fewer food items because they are not perceptually close enough to the food prototype.

Such a strategy grounded in conceptually-based approach is in line with the recent research by Grishover and Markman (2013). In their study, they compared the usual educational programs about nutrition (where simple facts about nutrition are given to children) with a nutritional education program that adopted a *knowledge-based approach*, giving children a rich conceptual framework so that they would understand the need to eat a variety of healthy foods. These authors found that children who attended the latter program ate more vegetables at snack time (similar findings were found by Nguyen, McCullough, & Noble, 2011, using a comparable theory-based education program).

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Conflict of interest statement

All authors declare that they have no conflicts of interest.

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Table 1. *Description of all the Food Items (Based on School Cafeteria Observations).*

Carrot	**Tomato**	**Squash**	**Zucchini**	**Apple**	**Banana**
Orange (T)	Red (T)	Orange (T)	Green (T)	Red	Yellow
Purple (A)	Green (A)	White (A)	Yellow (A)	Green	Green

Footnote. (T) = typically colored; (A) = atypically colored. The colors reported here are the skin colors of each fruit or vegetable, and in the pictures, the food items were shown uncut and unpeeled.

Table 2. *Description of the 8 Sets of Fruit and Vegetable Pictures.*

Target food	**Test picture 2 (fruit similar in color)**	**Test picture 1 (vegetables dissimilar in color)**
Red tomato (T)	Red apple	(a) Orange squash (T) (b)White squash (A)
Green tomato (A)	Green apple	(a) Orange squash (T) (b)White squash (A)
Green zucchini (T)	Green banana	(a) Orange carrot (T) (b) Purple carrot (A)
Yellow zucchini (A)	Yellow banana	(a) Orange carrot (T) (b) Purple carrot (A)

Footnote. (T) = typically colored vegetable; (A) = atypically colored vegetable; (a) = different vegetable but typical color; (b) = different vegetable and atypical color.

Figure 1. Example of a triad of pictures used in the property generalization task.

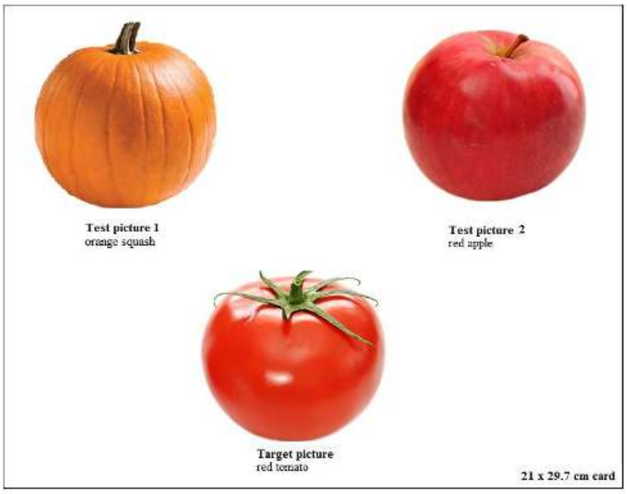
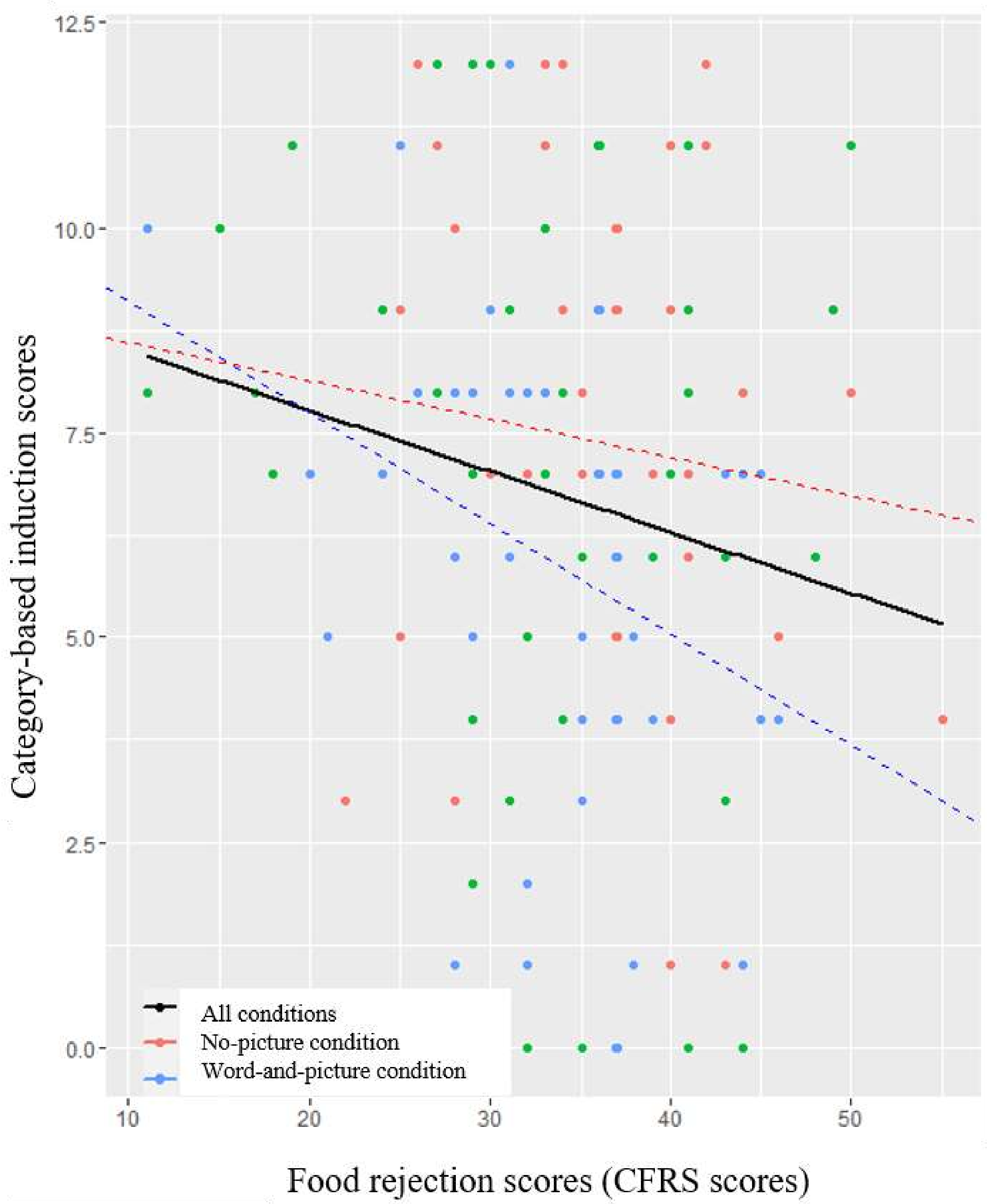


Figure 2. Children's scores on the property generalization task as a function of their food rejection scores.



Footnote. Only the *word-and-picture* and the *no-word* conditions are depicted in dashed lines as they significantly differ.