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Abstract

This study assessed young children's abilities to discriminate visually between food and non-food items, and the possible relationships between these abilities and their level of food neophobia. A sample of 42 children, aged 36-53 months, participated in a rapid categorization task in which they were presented with color photographs of food and non-food items for 80 ms. Their task was to respond as quickly as possible, whether or not each item was edible. Both accuracy measures (hits, false alarms, discriminability) and response times were recorded. The children's food neophobia score was assessed using a standardized scale. Results indicated that children showed a high rate of hits (81%), but also a high rate of false alarms (50%), to the rapid categorization task. Discriminability and neophobia both increased with chronological age, whereas response times decreased. There were no significant correlations between categorization performances and food neophobia scores when controlling for age effects. It was concluded that a *liberal* food categorization system (i.e., accepting a large amount of non-food items as edible) was present in children aged 3-4 years.

Keywords: children; food; categorization

Highlights

- Children aged 3 to 4 years performed a rapid visual categorization task
- Color photographs of food and non-food items were flashed for 80 ms
- Children showed high rates of hits (81%) and false alarms (50%)
- A liberal food categorization system is present in young children

**Introduction**

Categorization is a basic mean of organizing the world around us, and is critical for the organization and stability of our cognition (Mareschal & Quinn, 2001). Categorization abilities develop during early childhood mainly, as children encounter many new stimuli. Without such abilities, children would have to learn to respond anew to each novel stimulus they encounter (Bornstein & Arterberry, 2010). Therefore categorization abilities play a major role in children's cognitive development. In the present study, we focused on children's abilities to categorize objects as edible or not. So far there has been little research into food categorization in children, despite the crucial role of being able to distinguish between food and non-food items for adaptation and survival.

Deciding whether an object is edible or not is not easy as categorization does not occur on a perceptual basis (where items are classified according to physical resemblances), but on a functional basis (where items are classified according to function only, without any perceptual resemblance between members of a class) (see e.g., Rosch & Mervis, 1975; Tomikawa & Dodd, 1980). Previous studies on functional categorization involving food have shown that a variety of non-human animals demonstrated an ability to categorize objects as edible or not: this ability was observed, for instance, in pigeons (Watanabe, 1997), chimpanzees (Savage-Rumbaugh, Rumbaugh, Smith, & Lawson, 1980), baboons (Bovet & Vauclair, 2001), or rhesus monkeys (Fabre-Thorpe, Richard, & Thorpe, 1998). In children, studies have pointed to limited abilities to differentiate between food and non-food items below the age of 2 years. For instance, using a looking time procedure, Shutts, Condry, Santos, & Spelke (2009) showed that 9-months-old infants equally directed their attention to domain-relevant properties (such that color and texture) and domain-irrelevant properties (such as the shape of the food's container). By contrast, at around three years of age, children started to generalize learning about novel foods according to color, texture, and odor information, whereas they generalized learning about novel artifacts according to shape (Lavin & Hall, 2002: Macario, 1991; Santos, Hauser, & Spelke, 2002). Using a sorting procedure, Bovet and Vauclair (2001) observed that at age 3 the majority of the children successfully sorted food and toys pictures into different boxes, thus showing basic ability for conceptual categorization in the food domain.

Children's abilities to perform functional categorization in the food domain appear to undergo rapid improvements by the age of 3 years. However the characteristics of the underlying categorization system that develops at this period of childhood have not been investigated yet. We designed the present study to fill this gap. We tested 3-to 4-years old children's abilities to classify color photographs of objects as edible or not. Unlike previous studies that have used long time exposure to stimuli, we set up a rapid categorization procedure, following the example of Fabre-Thorpe *et al*. (1998) in their study with rhesus monkeys. The advantage for using a rapid categorization task is that brief presentations of stimuli rule out the use of exploratory eye movements; according to Fabre-Thorpe *et al*. (1998, p. 307), this demanding task "encourages subjects to make rapid intrinsic decisions on the basis of the first rapid pass through the system". In addition, the food and non-food items used in our study were individually matched on color and shape, thus making the rapid categorization task even more complex.

Two main research questions motivated the present study. First, how did 3- to 4-years old children perform in a rapid categorization task involving food items, and what did this reveal about the characteristics of the underlying categorization system? We considered the following two alternative hypotheses. One the one hand, children may have produced many hits and many false alarms, suggesting that a liberal system was in place. On the other hand, children may have produced many correct rejections and many omissions, suggesting that a conservative system was in place. Second, were there any relationships between children's performance at a rapid categorization task, and their level of food neophobia? This question was worth being explored because food neophobia, or the reluctance to eat novel food (Dovey, Staples, Gibson, & Halford, 2008), peaks between 2 and 6 years of age (Cashdan, 1994), that is to say precisely at the moment when a food categorization system is assumed to develop in the child's cognitive system. Is it mere coincidence or are both phenomena related somehow?

## Method

### *Participants*

Forty-two French children (23 boys, 19 girls; *M* age = 3 years 8 months, *SD* = 5 months; age range = 36 to 53 months) took part in the study, with written parental assent and consent. Prior to the study, parents filled up a questionnaire about their child's food neophobia. Children's scores at the Food Neophobia Scale (Pilner, 1994) ranged 14 to 68 ($M = 39$, $SD = 14$), and distributed normally (Shapiro-Wilk test, $w = .98075$, $p = .69$). Food neophobia scores correlated with age in months (Pearson's correlation, $r = .403$, $p = .008$), with scores increasing as children's age increased. These scores did not vary according to sex (One-way analysis of variance, $F(1, 40) = .74$, $p = .39$).

### *Stimuli and Apparatus*

The test stimuli were 40 color photographs, including half food, half non-food items. The food items were fruits and/or vegetables (lemon, blackcurrant, kiwi, blueberry, apple, orange, raspberry, green bean, cauliflower, red beetroot, carrot, broccoli, potato, peas, mushroom, tomato, eggplant, cucumber, bell pepper, corn). Each food item was paired with a non-food item that had an overall similar color and shape (e.g., yellow lemon was paired with a yellow and ovoid soap). Six additional stimuli, which were neither fruits nor vegetables, were used for practice (half food, half non-food items). Figure 1 shows samples of test stimuli.

-Insert Figure 1-

The visual stimuli were displayed on a PC computer screen. The E-Prime® 2.0 program controlled all the experimental events and the data recording. The ‘‘S’’ and the ‘‘L’’ keys of the computer keyboard were used to provide the responses. Because we were testing young children who may encouter difficulties pressing the keys with their index finger, we adapted the keyboard in such a way that the S and L keys were connected each to a large buttom. To differentiate between buttons, one has a black cross on its top, the other button showed a black circle on its top. Children put their whole hand on the buttom and pushed it down to provide their responses.

*Procedure*

Children were observed individually in a quiet room inside their kindergarten. They sat at a table in front of a computer screen, with the experimenter on their left side. The distance separating children and the computer screen was 50 cm. The keyboard was located at 30 cm from the child, and each button could be reached by hand. The experimenter explained the child that they were going to play a game with pictures showing things that can be eaten and things that cannot be eaten. The rule of that game was to respond as quickly as possible whether the picture shows a thing that can be eaten or not. If the picture shows a thing that can be eaten, the child had to press the button with a circle (“yes” response); if the picture shows a thing hat cannot be eaten, the child had to press the button with a cross (“no” response). The spatial location (right/left) of the “yes” (circle) and “no” (cross) buttons was counterbalanced across participants (i.e., for half of the children, the circle or “yes” button was located right; for the other half, it was located left).

The session starts with a familiarization phase, followed by a test phase. For both sessions, the temporal events were as follows. A fixation point (star) first appeared at the center of the screen for 500 ms in order to capture the child's attention. Afterwards, a first picture was flashed for only 80 ms. This very rapid presentation has already been used with success with rhesus monkeys (Fabre-Thorpe *et al*., 1998). Pilot tests indicated that 80 ms duration was also adequate for a rapid visualization of the stimulus by children aged 3-4 years. Once the child has provided an answer, the experimenter asked him/her to prepare to the next trail, and to look again attentively at the screen. A fixation point appeared (500 ms), followed by a second picture (80 ms), and so on. During the familiarization phase (6 practice pictures), the experimenter showed the child how to respond to the first two pictures. For the remaining four practice pictures, the child had to work by him/herself. Whenever necessary, the experimenter explained again to the child how to play the game. The order of presentation of the practice pictures was randomized for each child. During the test phase, four series of 10 pictures were successively presented to the child, with a 30 seconds break between two successive series. During these breaks, a cartoon was displayed on the computer screen. The order in which pictures appeared in a series was randomized for each participant, with the constraint that each series included 5 pairs of food/non-food items. In both the familiarization and test phases, verbal encouragements were given to the child, but there were no feedback regarding whether responses were correct or not.

*Data recording and off-line analysis*

Individual response times (ms), and type of response for each food item (either hit or miss) and non-food item (either correct rejection or false alarm) were recorded online via the E-Prime® 2.0 program. Offline analyses assigned each participant a score for hits (i.e., « yes » answers when the stimuli were food items), and a score for false alarms (i.e., « yes » answers when the stimuli were non-food items). Both scores could vary between 0 and 20.

Based on signal detection theory, we measured A', an index of discriminability, and B'', an index of the child's decision criterion (see Grier, 1971; Stanislaw & Todorov, 1999). The A' index ranges from 0 to 1, with .50 indicating responses at chance level, and 1 indicating maximum discriminability. This index was computed according to Grier's formula: $A' = ½ + [(y - x)(1 + y - x) / 4y(1 - x)]$, where $y$ stood for the probability of a hit and $x$ corresponded to the probability of a false alarm. The B'' index ranges from -1 to +1, with -1 indicating a liberal criterion (i.e., children tended to answer 'yes' whatever the stimuli), and -1 indicating a conservative criterion (i.e., children tended to answer 'no' whatever the stimuli). The *B''* index was computed according to Grier's formula: $B'' = [y(1 - y) - x(1 - x)]/[(y(1 - y) + x(1 - x)]$, where $y$ corresponded to the probability of a hit and $x$ to the probability of a false alarm. As both indexes significantly deviated from normality (*A'* : Shapiro-Wilk test, $w = .91949$, $p = .005$; *B''* : Shapiro-Wilk test, $w = .90186$, $p = .001$), we used non parametric tests. Response times distributed normally (Shapiro-Wilk test, $w = .95780$, $p = .123$), and were analyzed using parametric tests. We set up an alpha level of .05 for all statistical analyses.

## Results

Table 1 summarizes the main results.

-Insert Table 1 -

### *Discriminability A'*

Overall, children showed a high rate of hits ($M = .81$, $SD = .22$), but also a high rate of false alarms ($M = .50$, $SD = .24$). Mean discriminability index A' was .76 ($SD = .11$ ; range .50 to .97). Age in months correlated significantly with discriminability index (Spearman rank correlation, $r_s = .30$, $p = .05$), with discriminability slightly increasing as children's age increased. We also found a significant effect of sex on discriminability index, with girls outperforming boys on this index (Girls: *M* = .80, *SD* = .10, *n* = 19; Boys: *M* = .73, *SD* = .10, *n* = 23; Mann-Whitney U test, *U* = 121.5, *p* = .01).

*Decision criterion B''*

Mean decision criterion B'' was -.38 (*SD* = .44 ; range .68 to -.92), meaning that overall children were rather liberal in their responses. The B'' index did not correlate significantly with age in months (Spearman rank correlation, $r_s = -.11$, $p = .49$). This index did not vary significantly according to sex (Girls: *M* = -.45, *SD* = .49, *n* = 19; Boys: *M* = -.31, *SD* = .41, *n* = 23; Mann-Whitney U test, *U* = 182, *p* = .36).

*Response times*

Overall, mean response time was 5477 ms (*SD* = 2533; range 1566 to 10659). Age in months correlated significantly with response times (Pearson's correlation, $r = -.66$, $p < .001$), with response times decreasing as children's age increased. Sex was not a significant factor for variation in response times (Girls: *M* = 4923, *SD* = 2221, *n* = 19; Boys: *M* = 5935, *SD* = 2728, *n* = 23; t-test for independent samples, $t(40) = -1.30$, $p = .20$). Response times did not differ significantly according to whether items were food (*M* = 5541, *SD* = 2929) or non-food (*M* = 5414, *SD* = 2230) (t-test for dependent samples, $t(41) = .69$, $p = .49$). There was no significant correlation between response times and discriminability A' when age was controlled (partial correlation, $r_p = -.14$, $p = .39$).

*Relationships with food neophobia*

Correlation analyses were run to assess the possible relationships between food neophobia scores and categorization performances (A', B'', and response times). None of the correlations were significant, regardless of whether or not age was partialled out (*r* ranging between -.12 to .09, all *p*s > .45 ; with age partialled out : $r_p$ ranging between -.10 to .23, all *p*s > .13).

**Discussion**

The general aim of this study was twofold and consisted in (i) investigating 3-4 years old children's abilities to discriminate between edible and non-edible items in a rapid categorization task, and (ii) finding evidence in favor of the putative relationship between children categorization performances and their level of food neophobia.

First, our results indicated that children were able to discriminate between food and non-food items quite efficiently, even with extremely brief stimulus presentation times. Their ability to correctly categorize food items increased with age, whereas their response times decreased. Our findings thus demonstrated that the rapid categorization paradigm successfully applied to young children. We assumed that the main advantage of this experimental design was to limit higher-level processing of the stimuli (Macé, Joubert, Nespoulous & Fabre-Thorpe, 2009), in order to assess the influence of basic visual properties (mainly shape and color) on the food categorization system.

Second, our results showed that, whereas children displayed a high rate of hits, they also considered non-food items as edible in half of the cases. This meant that they were rather liberal in their decision criterion (see also Cashdan, 1994). Similar findings were obtained by Thorpe *et al*. (1998) with rhesus monkeys also displaying a bias toward making *yes* responses in a rapid food discrimination task. We cannot rule out the possibility that in our study children's *yes* responses were elicited by the mere wording of instructions used by the experimenter, and social desirability effects. To control for these, it would be worth either constructing a reverse experimental setting in which children have to respond whether the picture showed a thing that *can't* be eaten, or using a puppet procedure (e.g. Lavin & Hall,

2002) to distract children's attention from the experimenter. In our view, a more likely interpretation of this response bias would be that at age 3-4 children's categorization system was initially crude and highly liberal, as it accepted a large set of items as edible. With increasing age, we would assume that this liberal system would turn out more conservative. In support to this hypothesis, some authors provided evidence for a reverse response bias in adults: Morin-Audebrand, Mojet, Chabanet, Issanchou, Moller, Köster, and Sulmont-Rossé (2012) reported that adults displayed a bias toward making *no* responses in a food recognition task.

Third, our results showed that girls had better discrimination abilities than boys. Few studies have yet linked human's visual discrimination and recognition capabilities and gender, and there is a contention in the literature as to whether women outperformed men when the task required visual identification of items (James & Kimura, 1997; Brander, 2007). The unexpected finding of a gender effect on discrimination abilities is not easy to account for. We might related it to observations that girls are often more familiar with fruits and vegetables than boys due to kitchen play behaviors (see Matheson, Spranger & Saxe, 2002), and/or are more inclined to like fruits and vegetables than boys (see Cooke & Wardle, 2005).

Fourth and finally, our results replicated previous findings (Cashdan, 1994; Cooke, Wardle, & Gibson, 2003; Harper & Sanders, 1975) showing an increase in food neophobia scores between 3 and 4 years of age. However, we failed to demonstrate significant correlations between children's categorization performances and their food neophobia scores when controlling for age effects. These non-significant findings prevent us from drawing conclusions on the second research lead of the study.

Additional investigations into the developmental characteristics of children's food categorization system during the period of food neophobia would be required. The small age range (3 to 4.5 years) used in the present study indeed clearly limited the conclusions that were drawn from our data. Future studies could therefore extend the investigation of children's categorization abilities in the food domain to a larger age span (e.g., from age 2 to age 6), as well as to alternative categorization tasks or instructions (e.g., picture sorting task). Moreover, it would be worth considering in future studies children's food likes and dislikes, their familiarity with the targeted food items, and the size of their lexical repertoire, as these factors might also play a role in the development of a food categorization system during childhood.

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Table 1. Summary statistics for performance measures at the rapid categorization task.

| | | | Correlation coefficients (r) | |
|---|---|---|---|---|
| | Mean | *SD* | Chronological age | Food Neophobia score |
| Hit rate | .81 | .22 | | |
| False Alarm rate | .50 | .24 | | |
| Discriminability A' | .76 | .11 | .30 * | .09 *n.s.* |
| Decision criterion B" | -.38 | .44 | -.11 *n.s.* | -.11 *n.s.* |
| Response Time (s) | 5477 | 2533 | -.66 ** | -.10 *n.s.* |

*Note*. * $p < .05$; ** $p < .01$, *n.s.*, non significant at $\alpha = .05$


Figure 1. Samples of the test stimuli.