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Food rejections in children: Cognitive and social/environmental factors involved in food neophobia and picky/fussy eating behavior

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Abstract

Food neophobia and picky/fussy eating behavior are presented as the two main forms of children's food rejections responsible for a reduction of their dietary repertoire. We review the key factors, presented in the literature, that are involved in food rejections during childhood. We first consider a range of "cognitive factors", such as food perception, mental representations, categorization of food items, and emotions and feelings toward food. We then focus on "social and environmental factors", as these might also significantly influence and modulate children's food rejections. We then summarize the findings to provide a comprehensive view of the factors involved in children's food rejections. Finally, we discuss the need for future studies on food rejections, regarding (i) the distinction between food neophobia and picky/fussy eating, and (ii) the potential link between food categorization abilities and children's food neophobia and pickiness.

Keywords: Children; Food rejection; Food neophobia; "Picky/fussy" eating; Cognitive and social factors.

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Introduction

Food neophobia and picky/fussy eating behavior are presented as the two main forms of food rejections in children, and mostly concern the rejection of healthy items like fruits and vegetables (Brown, 2010; Cashdan, 1998; Carruth, Skinner, Houck, Moran, Coletta, & Ott, 1998; Jacobi *et al.*, 2003). Therefore they are responsible for the reduction of the child's dietary variety (Birch & Fisher, 1998; Falciglia, Couch, Gribble, Pabst, & Frank, 2000), along with a possible lack of essential micro-nutriments and fibers that are necessary for normal and healthy child development (Carruth *et al.*, 1998).

A recent research review by Dovey, Staples, Gibson, and Halford (2008) provided an interesting and comprehensive understanding of the concepts of food neophobia and picky/fussy eating and how they affect children's dietary repertoire. However, despite extensive research in the area, the mechanisms underlying these two types of food rejection in children are still unclear, as the main factors influencing food rejection have not been clearly identified yet. Our aim is to review a range of research studies on food neophobia and picky/fussy eating so as to point to a series of factors that play a key role in food rejections in childhood. Accordingly, and unlike previous available research reviews, we emphasize the "cognitive factors" underlying food rejections in children. We use the notion of "cognitive factors" in the broad sense of the term, that is to say we include the following: food perception, mental representations and categorizations of food items, and emotions and feelings toward food. We also include a range of "social and environmental factors" as they might also significantly influence and modulate children's food rejections. To that end, a search of published research papers on children's food rejections was conducted using the ScienceDirect, PubMed, and JSTOR databases. We used a combination of keywords to compile peer-reviewed articles on the two constructs of interest (food neophobia and picky/fussy eating), and on the factors that influence these behaviors. Accordingly, "food neophobia", "picky-fussy eating", "food aversion", and "food rejection" were used jointly with "infants", "toddlers", and "children" as keywords, to circumscribe our research within the sensitive period of food neophobia (i.e., from 18 months to six years of age; see Cashdan, 1994). We additionally included studies on adults and nonhuman primates when they potentially revealed interesting aspects of food rejections.

We start with a brief summary of food neophobia and picky/fussy eating behavior regarding their definitions, measure assessments, developmental trends, and negative consequences on children's dietary repertoire. We then review a range of cognitive factors

that potentially influence and explain food rejections in children. In the subsequent section we review social and environmental factors that may affect and modulate food rejections in children. We then summarize the findings to provide a comprehensive view of the factors involved in children's food rejections. We conclude by suggesting new lines of research.

Food neophobia and picky/fussy eating behavior in children

Definitions

Food neophobia is defined as the reluctance to eat, or the avoidance of, new foods (Dovey et al., 2008). This behavior is present among omnivorous species (Adessi, Galloway, Visalberghi & Birch, 2005), and is considered an efficient adaptive strategy to avoid the risk of ingesting novel (unknown) and potentially poisonous items (see Milton, 1993; Rozin, 1977, 1979). Whether or not food neophobia is a true phobia is an important question. The literature provides some good reasons to think it is. For instance, it has been shown food neophobia is associated with physiological responses reflecting fear toward novel foods (Raudenbush & Capiola, 2012). Moreover, the fact that the same techniques have been used to treat food neophobia and other phobias (Marcontell, Laster, & Johnson, 2003; Nicholls, Christie, Randall, & Lask, 2001; Singer, Ambuel, Wade, & Jaffe, 1992) also suggests that food neophobia actually belongs to the latter category.

Picky/fussy eating is defined as the rejection of a substantial number of foods that are familiar (as well as unfamiliar) to the children (Birch, Johnson, Andresen, Peters, 1991; Galloway, Fiorito, Lee, & Birch, 2005; Smith, Roux, Naidoo, & Venter, 2005; Story & Brown, 1987). Picky/fussy eating may also include the consumption of an inadequate amount of food (Rydell, Dahl, & Sundelin, 1995), or the rejection of certain food textures (Smith *et al.*, 2005).

Another distinction between food neophobia and picky/fussy eating is based on the point of rejection of the food itself: unlike food neophobia, picky/fussy eating does not occur only before the tasting step, it may also occur after tasting is realized (Brown, 2010).

Since food neophobia is defined roughly as the rejection of novel or unknown food whereas picky/fussy eating is the rejection of a large proportion of familiar as well as unfamiliar foods, food neophobia is sometimes considered a subset of picky/fussy eating (Dovey *et al.*, 2008; Potts & Wardle, 1998; Raudenbush, van der Klaauw, & Frank, 1995). In their review, Dovey *et al.* (2008) assumed that the two phenomena are behaviorally distinct (Pelchat & Pliner, 1986; Pliner & Hobden, 1992), because different factors predict the

severity and expression of the two constructs (Galloway, Lee, & Birch, 2003; Raudenbush *et al.*, 1995; Potts & Wardle, 1998). However, other authors argue that these two constructs are clearly related (Potts & Wardle, 1998; Raudenbush *et al.*, 1995; Wardle & Cooke, 2008). There is no decisive empirical evidence in favor of a robust sharp distinction between food neophobia and picky/fussy eating. From a theoretical point of view, the definitions of these constructs are ambiguous in that they both depend on an unanalyzed (and viewpoint-dependent) notion of familiarity.

Assessment of measures

Food neophobia is usually measured by The Food Neophobia Scale (FNS) designed by Pliner and Hobden (1992).. Originally designed to score adults' neophobia, the FNS was then adapted to measure children's neophobia (Children Food Neophobia Scale, CFNS; Pliner, 1994). These measurement tools have successfully been used to predict Anglophone responders' attitudes toward new foods and have been translated into other languages, such as French (Ton Nu, MacLeaod, & Barthelemy, 1996; Nicklaus, Boggio, Chabanet, & Issanchou, 2005), Spanish (Fernandez-Ruiz, Claret, & Chaya, 2013), and Italian (Laureati, Bergamaschi, & Pagliarini, 2015). In addition, because food neophobia concerns mainly fruits and vegetables, Hollar and colleagues have recently adapted Pliner's work to investigate responders' attitudes toward these specific items (the Fruit and Vegetable Neophobia Instrument, FVNI; Hollar, Paxton-Aiken, & Fleming, 2013).

In most studies using Pliner's scales (or adapted versions), parents were asked to complete the questionnaire to assess their child's food neophobia. This hetero-assessment raises several well-known difficulties which lead to the development of auto-assessment questionnaires, for instance The Food Situations Questionnaire (FSQ) designed for 7- to 12-year-old Anglophone children Pliner (2000). Since this first attempt, two other questionnaires suitable for children have been developed, one in France (Reverdy, Chesnel, Sclich, Kôster, & Lange, 2008; Rubio, Rigal, Boireau-Ducept, Mallet, & Meyer, 2008), and the other in Italy (Laureati, Bergamaschi, & Pagliarini, 2014).

Concerning picky/fussiness, not much attention has been dedicated to its measurement. To date, this construct is usually assessed through general questionnaires on food habits, which include scales that measure problematic eating, fussiness, food neophobia, low enjoyment when eating, among others. Noticeable questionnaires are The Child Eating Questionnaire (see Birch, Fischer, Grimm-Thomas, Markey, Sawyer, & Johnson, 2001; Tharner *et al.*, 2014), The Child Eating Behavior Questionnaire (see Wardle, Guthrie,

Sanderson, & Rapoport, 2001), and The Children's Eating Difficulties Questionnaire (see Rigal, Chabanet, Issanchou, & Monnery-Patris, 2012). Other authors have recorded picky/fussiness by simply asking parents whether or not their children are picky (Carruth, Ziegler, Gordon, & Barr, 2004; Jacobi, Agras, Bryson, & Hammer, 2003; Jacobi, Schmitz, & Agras, 2008). These disparate methods may have added to the inconsistent understanding of this construct. Clearly, there is a need for a more applicable, validated, and homogenous picky/fussiness assessment method.

Developmental trends

Both food neophobia and picky/fussy eating are age-related and temporary behaviors, but according to some authors each follows a specific developmental path (Dovey *et al.*, 2008; McFarlane & Pliner, 1997).

On the one hand, neophobic behavior increases as a child becomes mobile, and peaks between 2 and 6 years of age (Addessi *et al.*, 2005; Cashdan, 1994; Cooke, Wardle, & Gibson, 2003; Harper & Sanders, 1975). After that period, the expression of food neophobia decreases (Koivisto-Hursti & Sjöden, 1997), until it reaches a relatively stable plateau in adulthood (McFarlane & Pliner, 1997). According to some authors, there is a general decrease until early adulthood (Koivisto-Hursti & Sjöden, 1996; Raynor & Epstein, 2001; Rigal, Frelut, Monneuse, & Hladik, 2006). From an evolutionary point of view, one plausible hypothesis is that food neophobia attenuates because dietary variety is essential to the survival of omnivorous species. But some studies suggest that the neophobic behavior remains stable from adolescence (13 years old) until adulthood (Nicklaus *et al.*, 2005). Note that the decline in food neophobia implies overcoming the fear induced by the presentation of a novel food item. Therefore, the mere fact that fewer things are novel for an adult or an adolescent than for a child, automatically reduces the gradient at which food neophobia disappears (Cooke & Wardle, 2005).

On the other hand, picky/fussy eating increases during infancy. Overall, 19% of 4- to 6 month-old infants were judged to be picky by their mothers whereas this percentage rises to 50% in the 19- to 24-month-old children (Carruth *et al.*, 2004). The prevalence of this behavior was shown to remain relatively stable during early childhood from 2.5 to 4.5 years of age (Dubois, Farmer, Girard, Peterson, & Tatone-Tokuda, 2007). The precise developmental path of picky/fussy eating is however unknown and a variety of factors may bias the understanding of it (Dovey *et al.*, 2008; Wardle, Herrera, Cooke, & Gibson, 2003). A

recent longitudinal study by Mascola, Bryson and Agras (2010) showed that the highest incidence of picky/fussy eating occurs in early childhood (at around 2 years), and declines to very low levels by the age of 6 years.

Cognitive factors involved in children's food rejections

In this section we review research studies on the potential cognitive mechanisms that underlie food rejections during the sensitive period of food neophobia and picky/fussy eating. We use "cognition" in the broad sense of the term, that is to say we included any kind of operations on mental representations, understood as theoretical or concrete entities whose role is to convey information coming from the world. Within this framework, we incorporated the following: i) how information (food) is perceived; ii) how information is internally represented and categorized; and iii) how emotions and feelings accompany and affect food processing. Indeed, as stressed by Marcel Proust, cognition is often colored by various feelings and emotions in the food domain (Damasio, 2005).

Food perception mechanisms

A variety of perceptual cues contribute to the visual evaluation of food (Wadhera & Capaldi-Phillips, 2014). These cues have a key role in food rejection mechanisms, as food rejections in toddlers primarily occur on sight.

It has been shown that vision is more important than touch in the process of sensory decision making in children, unlike adults who use touch more than vision (Dovey, Aldridge, Dignan, Staples, Gibson, & Halford, 2012). Indeed, children generally use color rather than shape to classify novel food items whereas they use shape rather than color to classify novel items if they think the novel items are something to play with (Macario, 1991). It is plausible that food behavior depends partly on preferences for certain colors in the food domain. For instance, green vegetables are more often rejected (Harris, 1993), and their acceptance is difficult to foster (Mennella, Nicklaus, Jagolino, & Yourshaw, 2008) compared to orange vegetables (Gerrish & Mennella, 2001). Some research suggests that toddlers have a hypothesis about the predictive validity of color in the food domain (Macario, 1991).

The visual presentation of the novel food is obviously important. The consumption of a novel fruit can be promoted through a visually appealing presentation (Jansen, Mulken, & Jansen, 2010). Children from 5 to 12 years of age also have a clear preference for a variety of

food items, a variety of colors, and space between items on their plates more than adults do(Zampollo, Kniffin, Wansink, & Shimizu, 2012), and for having their vegetables cut into geometric shapes at 9-12 years (Olsen, Ritz, Kramer, & Møller, 2012). Moreover,some aspects of the mode of presentation of the food affect children’s food behavior, maybe by helping the child to identify the food items. This hypothesis is consistent with the fact that picky/fussy children are less likely to consume dishes that were mixed together and thus harder to identify (Carruth *et al.*, 2004), and with parents’ reports according to which children like “food where all of the ingredients are without sauce and easily identifiable” (Cashdan, 1998, p.623).

Beyond color, it has been shown that children are sensitive to local changes such as food containing “bits” or pips (Wardle & Cooke, 2008. For instance, Werthmann and colleagues (2015) manipulated the color, the texture and the taste of yoghurts offered to the children. In that context, they observed that lumpy texture influenced yoghurt acceptance understood as the number of spoons the children consumed. More generally, one sensory cue that can elicit food rejection, through disgust before tasting, is visually perceived texture (Martins & Pliner, 2006). For instance, evidence suggests that a texture fading strategy, a gradual addition of higher textures based on the result of periodic probes, can be effective to treat food selectivity in toddlers (Johnson & Babbitt, 1993; Shore, Babbitt, Williams, Coe, & Snyder, 1998).

Regarding olfaction, some research studies mention that neophobic young adults rated the odors of foods as less pleasant and sniffed them less vigorously (Raudenbush, Schroth, Reilley, & Frank, 1998). They also have weaker odor identification abilities (Demattè *et al.*, 2013) than neophilic young adults. However, to our knowledge, in young children only a difference in sniffing proximity has been found (Bunce & Gibson, 2012).

However,the large majority of sensory preferences above-mentioned are not innate (Desor, Maller, & Turner, 1973; Harris, Thomas, & Booth, 1990; Rosenstein & Oster, 1988). Rather, most of our food choices are learned through exposure (Birch, Gunder, Grimm-Thomas, & Laing, 1998; Birch & Marlin, 1982; Birch, Mcphee, Shoba, Pirok, & Steinberg, 1987; Nicklaus *et al.*, 2005; Pliner, 1982; Wardle *et al.*, 2003).The following paragraphs are devoted to review the different forms of exposure influencing food preferences and acceptance.

It has been shown that visual exposure during infancy increases the appeal of a target food and of food items similar to the target (Birch *et al.*, 1998), thereby reducing food neophobia (Birch *et al.*, 1987). Similarly, the early introduction of a variety of solid foods was shown to

foster the child's acceptance of solid foods (Gerrish & Mennella, 2001; Mennella *et al.*, 2008). Interestingly, the effect was strengthened when a variety of foods was presented both within meals and between meals (Mennella *et al.*, 2008).

Some data suggested that up to 15 positive experiences may be needed for the successful acceptance of a target food into the child's dietary repertoire (Birch *et al.*, 1987; Wardle, Carnell, & Cooke, 2005; Wardle *et al.*, 2003). Interestingly, the number of exposures to reach food acceptance is also age-dependent. During the first year of life a single positive exposure can lead to the acceptance of the novel item (Birch *et al.*, 1998). This interaction with novel food items may result in a different habitual diet (Skinner & Carruth, 2002). However, exposure effects are limited. For instance, while visual exposure produces enhanced visual preference judgments, it does not produce enhanced taste preferences (Birch *et al.*, 1987). Thus, exposure to food in one particular modality will produce a change in preference within that modality only (Birch *et al.*, 1987). Moreover, the effect of early exposure to foods does not generalize since repeated exposure to fruits does not vegetables at least in very young children from 4 to 7 months of age (Birch *et al.*, 1998). Even in the same category (i.e., vegetables), repeated exposure to one item (pureed potatoes) does not promote acceptance of other items belonging to the same category (carrots) (Mennella *et al.*, 2008).

Despite evidence that repeated exposure may increase acceptance of a target food, two potential problems may occur. The first one is "sensory specific satiation", or the reduction of a food's hedonic value after consumption (Rolls, 1986; Temple, Chappel, Shalik, Volcy, & Epstein, 2008). The effect can lead to food rejection in infancy (Mennella & Beauchamp, 1999) and early childhood (Birch & Deysher, 1986). Interestingly, consumption is not even necessarily required to produce a reduction in reported liking. Indeed, the sensory specific satiety can be olfactory (Rolls & Rolls, 1997). The second problem is "monotony" (Rozin & Vollmecke, 1986), through which a prolonged access to a small number of unchanging foods produces lower rating of liking. For instance, it has been shown that while exposure decreases children's willingness to taste familiar¹ vegetables, it increased their willingness to taste unfamiliar fruits (Houston-Price, Butler, & Shiba, 2009). Research studies have also highlighted a decline in pleasantness of the appearance of eaten foods relative to uneaten foods, a phenomenon called appearance-specific satiety (Wadhera & Capaldi-Phillips, 2014).

¹ In that study, familiarity with a food stimulus is determined on the basis of the frequency of encounter with the food item reported by the parents. "Unfamiliar" means encountered less than once per month according to the parents answers to the Food Familiarity Questionnaire.

In spite of these qualifications, the positive effect of repeated exposure on preferences and attitudes toward food is a now matter of consensus. However, the exact nature of the mechanisms underlying exposure remains unclear. The standard view is that the missing link between exposure and positive effects on preferences is a certain feeling of recognition/familiarity (Tichener, 1910 quoted in Zajonc & Markus, 1982). Recognition (as well as categorization) decisions “(...) *involve similarity computations performed on a common representational substrate, namely collection of individual exemplars.*” (Nosofsky, 1992, p. 392). Our hypothesis in line with Tichener’s thought is that exposure enriches that “collection” which in turn has positive effects on food preferences and behavior.

Mental representations and categorization of food items

If exposure does affect positively food preferences and behavior in young children (and thereby is a psychological lever to overcome food rejections) because it facilitates a particular type of recognition process, it is likely that food rejections could, on the contrary, be associated with a certain type of recognition deficiency. To assess this hypothesis, we review the recent results on the development of categorization abilities in young children. On the basis of these results, we argue that the developmental characteristics of the categorization system might contribute to an explanation of food rejections. Research on food categorization and mental representations in humans has shown that before 2 years of age, infants show very limited ability to differentiate food and non-food items based on their relevant visual properties. For instance, 9-month-old infants were shown to equally direct their attention to domain-relevant properties, such as color and texture, and domain-irrelevant properties (such as the shape of the food’s container) (Shutts, Condry, Santos, & Spelke, 2009). Between 16 and 29 months of age, more than half of the children were willing to put crayons, dish soaps, and even imitation feces in their mouth (Rozin, Hammer, Oster, Horowitz, & Marmora, 1986). Also, children under 2 years were more likely to accidentally poison themselves than older peers (Cashdan, 1994). This surprisingly indiscriminate behavior in infants might be attributed to the fact that human infants rely on adults to guide their eating until 2 years of age (Cashdan, 1994, 1998). Accordingly, infants may learn about food through observing others’ behavior, actions, and emotions, rather than by evaluating and classifying foods solely on the basis of relevant perceptual properties.

However, a rapid change occurs between 2 and 3 years of age, when children begin to categorize and reason about food items. At around 3 years of age, children were shown to generalize learned knowledge about novel foods according to color, texture, and odor

information, whereas they generalized learned knowledge (including linguistic knowledge²) about novel artifacts according to shape (Lavin & Hall, 2001; Macario, 1991; Santos, Hauser, & Spelke, 2002). Namely, 3- and 4-year-old children were more disposed to use color than shape to classify novel items when they think the items are something to eat.

A research study by Nguyen and Murphy (2003) showed that 3-year-old children have taxonomic and script categories for food. Taxonomic categories are organized into hierarchies of increasingly abstract categories, such as terrier-dog-mammal-animal, and are based on common properties or similarity. Script categories are formed when items play the same role in a schema for a routine event (e.g., eggs and cereal are both in the script category of breakfast foods). From age 4, children are able to cross-classify items, meaning they can subsume a food item under both taxonomic and script categories (Nguyen & Murphy, 2003).

It has been claimed that the rapidity with which children (3-year-olds) as well as baboons and chimpanzees are able to categorize, in particular in the food domain, is “likely to result from the early construction of a food category, because of its importance in their daily life” (Bovet, Vauclair, & Blaye, 2005, p. 57). Food neophobia peaks around 2-3 years of age, that is to say precisely the period during which a food categorization system starts developing in the child’s cognition. From this perspective, Dovey *et al.* (2008) suggested that “children build up schemata of how an acceptable food should look, and perhaps smell, and so foods not sufficiently close to this stimulus set will be rejected” (p. 183). Similarly, Brown (2010) suggested that some foods are rejected on sight because they do not match a prototypical representation³ or category of food in children’s cognition.

Emotions and feelings about food

Emotions and feelings about food are intimately associated with food rejections (MacNicol, Murray, & Austin, 2003). Among negative emotions, disgust has been related to food

² In an experiment conducted by Lavin & Hall (2001), 3 years old children were taught a neutral word “X” referring to an unfamiliar object. The object was either described as being a toy or a food. Then the experimenters ask the subjects to extend the word “X” to one of two other objects. One object differed in shape with the initial object, the other object differed in color, texture or smell. The results reveal that children were more likely to select the same-shaped entity only when the initial object was described as being a toy.

³ The three competing views about categories are the exemplar, the prototype, the knowledge theories (see Murphy, 2002). At the end of the previous section on the perceptive mechanisms, we quoted Nosofsky (1992) who seems to endorse the exemplar theory. By contrast, we now mention Dovey (2008) and Brown (2010) respectively using the notions of schemata and prototypes which have a prototype theory flavour. We will not cut the Gordian knot in the present review because it seems that we are still in need of a precise and reliable method to “gain a window on the exact nature of children’s conceptual representations.” (Murphy, *Ibidem*, p. 383). Moreover, we share Murphy’s opinion that for “real-life concepts, we would do best not to assume that a single form of conceptual representation will account for everything” (*Ibid.*, p.65)

neophobia (Tuorila *et al.*, 2001), specifically in children after age 4 (Fallon, Rozin, & Pliner, 1984; Rozin, Millman, & Nemeroff, 1986) and in adults (Nordin, Broman, Garvill, & Nyroos, 2004). For some authors, the feeling of disgust, and the corresponding facial expressions, may be associated with food items that are bitter and/or potentially harmful for the subject (Martins & Pliner, 2005; Stein 1973). Food rejections based on disgust are sometimes assumed to imply high-level/conceptual representations regarding the nature and the origin of the rejected substance (Fallon *et al.*, 1984). Accordingly, genuine disgust-based rejections might not occur below the age of 4 or even 7, because they require that children have mastered an adult-like concept of contagion (Fallon *et al.*, 1984).

However, some studies highlighted that some aspects of contamination and contagion can influence even young children, who showed some understanding of the transfer of properties instantiated by one item to another (Cashdan, 1998; Rosen & Rozin, 1993; Siegal, 1988; Springer & Belk, 1994; Toyama, 1999). Because some aversive properties of food items can be visually perceived, like aversive textural properties (Martins & Pliner, 2006), disgust-based rejections may also occur on the basis of visual experience without appealing to complex conceptual representations of contamination (Brown & Harris, 2012a).

Food neophobia is connected to an increase in anxiety over food (Galloway *et al.*, 2003; Pliner, Eng, & Krishnan, 1995; Pliner & Hobden, 1992; Pliner, Pelchat, & Grabski, 1993). Moreover, even an increase in anxiety that is not initially related to food might increases the neophobic response (Pliner *et al.*, 1995). Interestingly, it has been shown that when a child is pressured to consume a food item while he/she is experiencing disgust toward it, the disgust and the correlated anxiety response are likely to increase. This may result in a long-lasting food aversion (Batsell & Brown, 1998; Batsell, Brown, Ansfield, & Paschall, 2002). By contrast, foods highlighted positively, pairing the foods with positive emotional expressions, emotional words or safety information, are more likely to be accepted (Martins, Pelchat, & Pliner, 1997; Pelchat & Pliner, 1995). The direction of the observed relationship between disgust/anxiety and food aversion is unclear. Some authors have suggested that disgust could trigger food rejection (Brown & Harris, 2012b; Toyama, 2000). Alternatively, it has recently been argued that disgust could be a catalyst for food neophobia (Brown & Harris, 2012a).

A causal link is suspected between strong forms of picky/fussy eating and a personality trait called “tactile defensiveness” (Nederkoorn, Jansen, & Havermans, 2015). Tactile defensiveness is defined in many different ways in the scientific literature (see Royeen, 1986, for a review of the evolution of the theory of tactile defensiveness from the

seminal work of Ayres, 1963; see also Smith *et al.*, 2005; Wilbarger, 2000). The notion includes overreactions to the experiences of touch, or rejections or withdrawal responses to some typically inoffensive tactile stimuli perceived as offensive. This disposition could impact the expectation of enjoyment of certain perceived textures and consequently the child's eating behavior. More precisely, it has been shown that tactile defensive children refused vegetables to a higher degree than non-tactile defensive ones (Smith *et al.*, 2005).

Another personality trait whose influence on food neophobia is discussed in the literature is the "sensation seeking disposition" (measured via the sensation seeking scale) (Zuckerman, 1979). Persons who are high sensation seekers, that is to say people who require a lot of stimulation to reach the appropriate level of arousal, are more open to new food experiences, and thus tend to be less neophobic (Galloway *et al.*, 2003; Pliner & Melo, 1997). In this case, low food neophobia would be a particular mode of a lower general neophobia (Pliner & Hobden, 1992).

Finally, some studies (Blisset & Fogel, 2013, Keller, Steinmann, Nurse, & Tepper, 2002) have associated another trait called "bitterness sensitivity" to food dislike and rejections. Bitterness is known to serve as a warning about poisonous foods, especially vegetables (Bradbury, 2004; Catanzaro, Chesbro, & Velkey, 2013) and has been reported as a sensory deterrent for vegetable consumption (Dinehart, Hayes, Bartoshuk, Lanier, & Duffy, 2006). The ability to detect bitterness in a certain food item is a genetic trait encoded through specific genes, such as TASR38 encoding for the phenylthiocarbamide (PTC) taste receptor (Bufe *et al.*, 2005; Kim, Jorgenson, Coon, Leppert, Risch, & Drayna, 2003). It has been shown that individuals with low thresholds for PTC (thus highly sensitive to bitterness) display more food dislikes and rejections than those with high thresholds (thus less sensitive to bitterness; Blisset & Fogel, 2013; Dinehart *et al.*, 2006; Keller *et al.*, 2002). Moreover highly sensitive individuals seem to be more picky eaters and less adventurous (Catanzaro *et al.*, 2013). However, according to some other studies "bitterness sensitivity" does not predict food preferences and rejections (Jerzsa-Latta, Krondl, & Coleman, 1990; Mattes & Labov, 1989).

Social and environmental factors involved in children's food rejections

In this section we review research studies on the potential social and environmental factors underlying food rejections during the sensitive period of food neophobia and picky/fussy eating. These factors are important because the very act of eating is a socially grounded

behavior (see e.g., Shutts, Kinzler, & DeJesus, 2013). Food consumption is socially and culturally shared with congeners, and is based on previous experiences and previously acquired habits in the food domain. We first address the role played by the child's previous experiences (antecedents) and immediate environment (namely, parental practices). We then focus on the role played by the social context on food behavior, focusing on social facilitation effects.

Child's previous experiences and immediate environment

A handful of studies suggested that the antecedents of the child play an important role in the determination of the child's food preferences and rejections. These antecedents are the child's genes and prenatal food experiences. To estimate the genetic influence, Cooke, Haworth, and Wardle (2007) compared intraclass correlations between monozygotic pairs of twins and dizygotic pairs of twins for food neophobic phenotypes. They concluded that food neophobia is highly heritable and is partly in the genes. Regarding prenatal experiences, evidence suggests that babies develop preferences for flavors they have experienced through amniotic fluid and breast milk (Schaal, Marlier & Soussignan 1998, Mennella, Jagnow, & Beauchamp, 2001).

Taste preferences can also be learnt by means of conditioning. If a child is exposed to repeated pairings of a particular taste (neutral stimulus) with a positive satiety effect, this taste will come to elicit that pleasurable state which in turn will lead to preference for that taste. This form of classical conditioning mainly concern the taste of foods which are energy dense (sweet or rich in fat, carbohydrate) (Birch, McPhee, Steinberg, & Sullivan, 1990 ; Johnson, McPhee, & Birch, 1991; Kern, McPhee, Fisher, Johnson, & Birch, 1993). However, Havermans and Jansen (2006) observed in 13 young children (M age: 5.2 years) a significant increase in flavor preference for the vegetable taste paired with dextrose. Even if the long term effects remain unclear, it has been recently shown that caloric conditioning can be combined fruitfully combined with another powerful mechanism: social learning/modelling (Jansen & Tenney, 2001) which is discussed in the next section. Regarding the influence of the child's (post-birth) immediate environment on his/her food behavior, certain characteristics of the primary caregiver significantly affect food neophobia expression in children (Dovey *et al.*, 2008). The most obvious is parental food neophobia (Carruth &

Skinner, 2000; Pelchat & Pliner, 1986, 1995; Pliner, 1994)⁴, but socio-economic status (Flight, Leppard, & Cox, 2003; Giskes, Turrell, Patterson, & Newman, 2002; Lien, Jacobs, & Klepp, 2002) and educational level (Vereecken, Keukelier, & Maes, 2004) also seem to modulate the degree of expression of the disposition to reject fruits and vegetables.

Parental practices are clearly important in determining the child's acceptance of versus aversion toward food items because they impact both flavor exposure through milk (maternal compared to formula) and social aspects guiding food behavior. The difficulty is of course to disentangle the respective contributions of these two types of factors. During infancy, different parenting and nutrition-related attitudes in mothers could positively influence the subsequent food behavior of the child (Taveras, Scanlon, Birch, Rifas-Shiman, Rich-Edwards, & Gillman, 2004). For instance, infants were shown to eat more formula when caregivers provided social interaction during feeding (Lumeng, Arbor, & Blass, 2007). Compared to formula-feeding, breastfeeding may facilitate the future acceptance of solid foods (Sullivan & Birch, 1994; Nicklaus, 2009). Girls were shown more likely to be picky/fussy if they were breastfed for fewer than 6 month (Galloway *et al.*, 2003). Moreover, some research studies have observed statistical relationships the between mother's diet, the nature of their parental strategies, and the behavioral dispositions of their daughters toward fruits and vegetables. In a nutshell, mothers's with a diet of more fruits and vegetables seemed to be less disposed to pressure their daughters to eat and had daughters who were less picky/fussy and who consumed more fruits and vegetables during childhood (Galloway *et al.*, 2005).

Evidence suggested that high controlling parental practices, including restriction and pressure to eat, created an emotionally negative environment around food, with negative consequences for children's reactions to food (Birch *et al.*, 1987; Faith & Kerns, 2005; Galloway, Fiorito, Francis, & Birch, 2006; van der Horst, 2012; Webber, Cooke, Hill, & Wardle, 2010). Some studies indeed revealed that many long-lasting food dislikes and rejections could be traced back to forced consumption episodes involving an authority figure (parent or teacher) (Batsell *et al.*, 2002). It has also been shown that parental attempts to control food intake in children reduces the positive effect of exposure (Galloway *et al.*, 2006). Some data showed that presenting a food as a reward enhanced children preference for that food (Birch, Zimmerman, & Hind, 1980). By contrast, when disliked foods are used as a

⁴ However, further research is needed to determine either the direction of a putative causal arrow between the variables or rather the existence of a vicious circle.

reward, these foods become even less desirable (Birch & Marlin, 1982; Birch, Marlin, & Rotter, 1984).

It is hard to determine what parents think about these coercive strategies. On the one hand, some evidence suggested that most parents know that these strategies are ineffective (Casey & Rozin, 1989). On the other hand, research studies showed that when infants are between 6 and 12 months old, mothers use pressure and restriction in reaction to the perceived size of their child (Brown & Lee, 2011). It is worth noting that the direction of the causal arrow between parental pressure and children's reactions to food is unclear (Galloway *et al.*, 2005, 2006). Namely, we do not know whether children's food rejections elicit more parental pressure, or whether parental pressure and restriction foster food rejections in children. A vicious circle including both aspects is a living option.

Interestingly, research studies suggested that children's participation in and enjoyment of cooking has a direct influence on picky/fussy behavior but also increases eating enjoyment, which in turn decreases picky/fussy eating (van der Horst, 2012). This is explained by the fact that through cooking, children are exposed to a wide variety of foods. A cooking context is also positive, as most children like hands-on activities and the concrete results of these activities can give them a feeling of ownership and pride (van der Horst, 2012). Modifying the home food environment through activities that engage both parents and children can be a key factor in the improvement of food intake in children and can increase consumption of fruits and vegetables (Heim, Bauer, Stang, & Ireland, 2011).

Social facilitation effects

Shutts *et al.* (2013) stated that "humans at any age rarely face the challenge of food selection alone. (...) Infants and young children therefore have numerous opportunities to watch members of their culture choose, cook, eat, and react to different kinds of foods in social settings" (p. 420). Accordingly, one major influence of the social context on children's reaction to food is social modeling or social facilitation. Clayton (1978) defined "social facilitation" as an increase in the probability of performing a class of behaviors in the presence of conspecifics performing the same class of behaviors at the same time (see also Tomasello & Call, 1997; Visalberghi & Fragaszy, 1990; Whiten & Ham, 1992). Put differently, social facilitation means that when a child eats in the presence of others eating food, his/her behavior is socially facilitated toward food intake (see Herman, 2014, for a recent review of the social facilitation of eating).

Research studies in this area have shown that social facilitation effects are not restricted to humans. They are observed in many omnivorous species, such as chacma baboons (Cambefort, 1981), tufted capuchin monkeys (Visalberghi & Frigaszy, 1995; Visalberghi & Addessi, 2000), rhesus macaques (Weiskrantz & Cowey, 1963), juvenile and infant marmosets (Vitale & Queyras, 1997; Voelkl, Schrauf, & Huber, 2006), gerbils (Forkman, 1991), rats (Galef, 1993), and human children (Harper & Sanders, 1975). Interestingly, monkeys were shown to exhibit a social facilitation effect even across species (i.e. from an human model) (Santos *et al.*, 2002).

In human children, unlike other primates, social facilitation effects are specific. Adessi *et al.* (2005) have shown that young children aged 2-5 years learned to accept new foods through observing significant others eating the same food (but not if the food is different or if the model is present without eating). By contrast, capuchin monkeys accepted and ate more of a novel food when their group members were eating a food, even if it had a different color (Addessi & Visalberghi, 2001; Visalberghi & Frigaszy, 2002; Visalberghi & Addessi, 2000).

Adults can serve as models for food acceptance: an encouraging teacher (Hendy & Raudenbush, 2000; Highberger & Carothers, 1977) or a friendly visitor in a classroom can foster food acceptance in young children (Harper & Sanders, 1975). However, one person has a limited effect and the greatest effect occurs when everyone in the immediate environment of the child is eating the food (Birch, 1980). In addition, the social facilitation is enhanced when models are familiar to the children (Salvy, Vartanian, Coelho, Jarrin, & Pliner, 2008). Harper and Sanders (1975) showed that children aged 14-20 and 42-48 months were willing to put unfamiliar foods in their mouth when adult models were eating the food, more than when adult models were simply offering the food; but the facilitation was more effective when the mother was the source of the food than when the food came from a stranger.

In the same vein, Shutts, Kinzley, McKee, and Spelke (2009) showed that 12-month-old children selected a food endorsed by an adult speaker of the child's own language over one endorsed by an adult speaker of a foreign language, even when the children knew that both foods were highly palatable. Salvy *et al.* (2008) showed that social facilitation occurred in children aged 5-11 years only when the co-eaters were familiar: children eating alone or with strangers ate less than children eating with their siblings. Social facilitation with peer modeling appeared to be the most effective way to foster novel food acceptance, as shown in children aged 2-4 years (Birch, 1980) and children aged 3 and 6 years (Hendy, 2002). Interestingly, the effects of peer modeling are long lasting as they endure beyond the immediate context in which the modeling occurred (Birch, 1980; Laureati *et al.*, 2014). Two

recent studies also showed that social modeling of food intake by children was enhanced when the peers acting as models (on TV) displayed emotions instead of a neutral expression (Bevelander *et al.*, 2013), and when other approaches were combined with peer modeling (such as food exposure and rewards; Laureati *et al.*, 2014).

Interestingly, many research studies revealed that social facilitation could also change the food preferences of children (Laureati *et al.*, 2014). More precisely, if preschool children were exposed to peer models who were choosing and eating a target food that did not belong to the set of foods initially preferred by the children, the probability that the children chose the target food increased. The effect of peer modeling was such that a significant number of children ended up choosing the target food even when presented with an initially preferred food (Birch, 1980; Hendy, 2002). These results confirm the Social Cognitive Theory (Bandura, 1997), according to which peer models are one of the social factors that most effectively foster food acceptance during preschool lunch.

Finally, it is worth mentioning that there is conflicting evidence in the literature as to whether younger children are more affected by the behavior of peers than older ones. For instance, Birch (1980) has found that food preferences of 3-year-old children are more socially affected than those of 4-year-old children. Lumeng's investigations of social cognition development in infancy (Lumeng, 2013) supported this perspective and showed that between 3 and 4 years old, children develop the capacity to modify their food choices, based on the understanding that adults can have different food preferences than their own and can provide false information about food items. Younger toddlers who are not capable of this mind reading would therefore be more affected by the behavior of parents pretending to like usually rejected food items. But another study has not found such a difference between two groups of children, aged 14-20 months and 42-48 months (Harper & Sanders, 1975). A similar conflicting evidence exists regarding the impact that sex/gender has on peer models' ability to modify children's food preferences. According to some authors, girls are more influenced than boys (Hendy & Raudenbush, 2000), but older research studies have not found such sex/gender differences (Birch, 1980).

Summary

To summarize, food neophobia and picky/fussy eating behavior in children have been shown to contribute to food rejections (mostly concerning healthy items such as fruits and vegetables) and reduction of dietary diversity. Hence these two phenomena have negative

consequences for health, and a better understanding of the factors underlying food rejections will help to overcome these concerns.

The following diagram proposes a review of the different factors (displayed in boxes) presented above (see Fig. 1). The structure of this diagram is similar to the structure of the present review.

Fig1.

Visual and olfactory cues play a key role in food rejections. It is likely that food neophobia and pickiness depend partly on preference for certain perceptual properties of food (color, visually perceived texture, shape, smell, etc.) or even mode of presentation. For instance, it is possible that some children prefer dishes with space between items because overlaps can cause contamination-based disgust. In addition, because the large majority of preferences are learned through experience, food rejections are often reduced by repeated visual exposure during infancy.

Information given by the physical context is perceived and categorized by the child, with the food categorization system possibly delivering output on edibility, familiarity, or attractiveness of items. Because food rejections peak around 2-3 years when rapid improvements appear in the categorization system, one might consider food neophobia and pickiness the result of a perceptual mismatch between food items and prototypical food categories embedding perceptual properties. Besides, some traits, such as bitterness

sensitivity, sensation seeking disposition, or tactile defensiveness, may influence children's perception of and feelings toward foods and thus lead to potential rejections.

The capacity to select non-dangerous foods in early childhood mainly depends on learning from others. Thereby, facilitation and modeling effects play major roles in children's willingness to try new food and even in changing their food preferences. Food selection is a risky endeavor and even if children understand that models can provide false information they assume that the latter will at least target safe foods. Children's inclination to modify their choices based on mind reading seems to be weaker for food than non-food items and therefore the food domain is a specific and unique domain in social cognition. Food neophobia and pickiness are also influenced by genetics and prenatal food experiences (namely flavors experienced through the amniotic fluid), as well as breastfeeding and weaning practices. The child's immediate environment after birth (cultural customs, socio-economic status, characteristics of the caregiver) should also be taken into account because it might influence how foods are presented and accepted.

Conclusion and future directions

Food rejections by children have been referred to as food neophobia and pickiness behaviors, but the conceptual definitions and assessments of these two constructs as well as their inter-relations are still not entirely clear. In addition, the literature showed that food rejections by children fell under the scope of multiple cognitive and social/environmental factors. Whereas the role played by some of these factors (namely the social and environmental factors) has been extensively investigated, the implications of other factors, such as children's developing food categorization system, have been comparatively under-researched. In our view, there is a need for studies on food rejections, regarding (i) the distinction between food neophobia and picky/fussy eating, and (ii) the potential link between food categorization abilities and children's food neophobia and pickiness.

First, the literature lacks decisive empirical evidence in favor of an independence or a correlation between the two components of food rejection, food neophobia and pickiness. To clarify this aspect, it would be useful, for instance, to conduct psychometric studies in order to develop and validate a scale of food rejections for children, including items relative to food neophobia and pickiness behaviors. Specifically, investigations of the factorial structure of such a scale would help to disambiguate the relationships that food neophobia and picky/fussy eating entertain with one another. The scientific study of children's food rejections, including

the efficacy of techniques for reducing them, would also be greatly facilitated by such a measurement tool.

Second, from a developmental perspective, few studies have yet linked cognitive capabilities of children and their inclination toward food rejections. Food rejections peak at around 2-3 years, precisely when rapid changes and improvements appear in the child's food categorization system. In our view, the concomitance of these two phenomena is not a sheer coincidence, and calls for investigation. An important role of the food categorization system is to deliver edibility output, that is to say, to discriminate food items from non-food items. However, little is known about the properties of this function's development, or about its relation to children's food neophobia. Future studies might assess the developmental characteristics of children's food categorization system during neophobia's peak, and test i) whether children's level of food rejection is a behavioral manifestation of the developmental characteristics of their food categorization system and ii) whether children's level of food rejection acts as a variable that moderates (as silencer or an enhancer) their developing ability to discriminate between food and non-food items. We are currently designing studies with this objective.

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