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Early Conceptual Knowledge About Food

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Abstract
Recent research suggests that preschool (three- to six-years-old) children's food cognition involves much more than the nutritional information usually conveyed by traditional food education programs. This review aims at collecting the empirical evidence documenting the richness of preschoolers' conceptual knowledge about food. After introducing the relevance of the topic in the context of the research in early food rejection dispositions (Sect. 1), we draw from empirical contributions to propose the first classification of food knowledge in the field, which includes taxonomic (2.1.), relational (2.2.), and value-laden food knowledge (2.3.). Finally, in Sect. 3, we highlight some theoretical shortcomings of extant literature, suggesting that the account of food knowledge we propose could be employed to develop more effective educational strategies that mitigate early food rejection behaviors (e.g., food neophobia).

Early conceptual knowledge about food.

1 Introduction - Food Knowledge and Children's Eating Behaviour

For many years, researchers aiming at devising food education interventions for young children have been sceptical about the importance of knowledge in shaping healthy dietary patterns (Gripshover and Markman 2013). The long-lasting assumption that young children are eminently perception-driven thinkers and eaters has brought many researchers to focus on strategies that aim at enhancing the sensory

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qualities of certain food items and their familiarity (Birch and Marlin 1982; Birch et al. 1987; Salvy et al. 2008), or at encouraging healthier food choices via rewards (Laureati et al. 2014) and different types of conditioning (e.g., flavour-flavour and flavour-nutrient conditioning, Hausner et al. 2012; social conditioning, Birch 1980).

Recently, a growing body of literature has begun to enrich this approach by investigating the role of conceptual knowledge in fostering dietary variety and countering food rejection tendencies (Lafraire et al. 2016; Rioux et al. 2018a, b; Pickard et al. 2021; Foinant et al. 2021a, b, 2022). However, as of today no account of the relevant notion of food knowledge at play in this field has been put forward. This gap might constitute an obstacle to design and test food education programs tailored for preschoolers.

During preschool age, namely the time span within the third and sixth year of life, individual dietary patterns first take shape. This is the time when food preference and refusal (e.g., food pickiness and neophobia) are first expressed, often with long-lasting and long-term consequences (Nicklaus et al. 2005). Moreover, recent findings suggest that improving *food knowledge* in three- to six-years-old children would foster the adoption of a varied diet throughout the whole life (Gripshover and Markman 2013).

Despite this evidence, most authors in this field endorse a narrow notion of food knowledge, i.e., they focus on nutritional information (Gripshover and Markman 2013; DeJesus et al. 2018, 2019) and evaluative categories (e.g., "healthy" vs. "junk food", see Sect. 2.3.1.; Nguyen 2007, 2012; Nguyen et al. 2011). The role of more nuanced knowledge in guiding children's food choices has been underappreciated thus far in the literature.

Drawing conceptual boundaries around the term "food" and its related domain of knowledge is difficult due to the complex ontological nature of food itself, which cuts across well-established cognitive domains, including the artifact-natural kind (Lafraire et al. 2020) or the biology-psychology divide (Raman 2014), and calls for complex and culturally mediated acts of interpretations (Borghini and Piras 2021). We thus draw on previous literature in cognitive science to put forward a tentative partition of the domain into three main kinds of food knowledge: in Sect. 2.1 we introduce *taxonomic food knowledge*, which involves concepts and categories that display hierarchical structures of inclusion; in Sect. 2.2, we tackle *relational food knowledge*; we then consider contributions devoted to *value-laden food knowledge* (2.3). In the final section, we sum up the main results of the review, single out some shortcomings displayed by extant literature in the field, and illustrate the import of the proposed account of conceptual food knowledge for research and intervention.

Figure 1 summarizes the structure of the typology of conceptual food knowledge that we will illustrate in the next section.

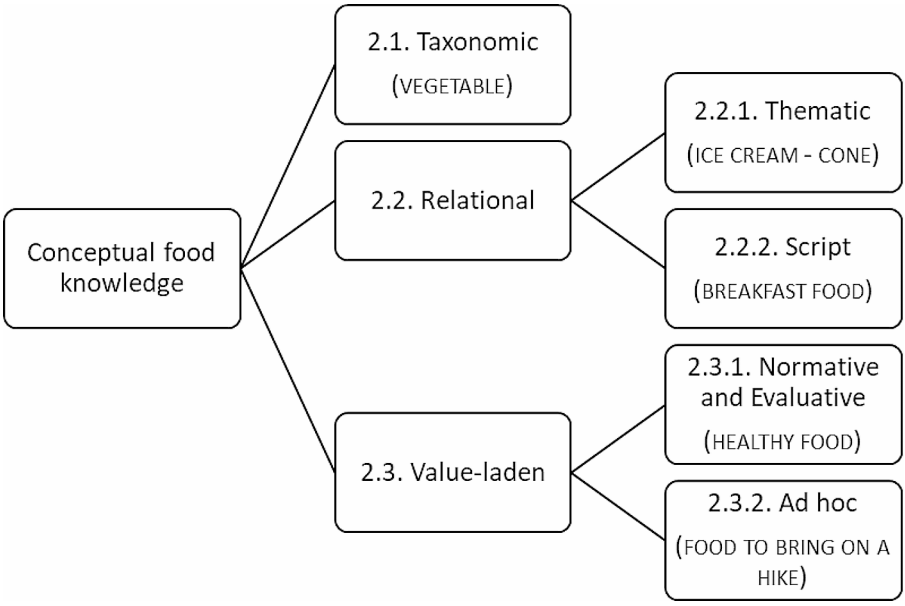

Fig. 1 The typology of conceptual food knowledge

2 Conceptualizing Food Knowledge among Preschool Children

2.1 Taxonomic Knowledge

Concepts featuring in eminent nutritional recommendations (e.g., USDA's five food categories, namely fruits, vegetables, grains, proteins, and dairy) are generally referred to as "taxonomic" in the literature (see for instance Mirman et al. 2017; Markman and Hutchinson 1984; Markman 1981). The hierarchical structure displayed by taxonomic concepts has led scholars to draw a distinction among basic level categories (e.g., apple, dog, guitar…), characterized as those that subjects spontaneously refer to in a variety of tasks, (see Murphy 2002); superordinate categories (e.g., fruit, animal, musical instrument…), which are higher up in the hierarchy with respect to the basic level; and subordinate categories (e.g., granny smith, labrador, classical guitar…) which are below the basic level and typically require some expertise to be mastered. However, this is a subject-dependent partition to some extent. As shown by Tanaka and Taylor (1991), the basic level of categorization varies according to the subject's expertise in a domain: when asked to categorise the image of a dog, the first name that comes to the mind of dog experts is more specific (usually breed-level, e.g., "German shepherd") than that given by non-experts ("dog").

Several studies investigated children's understanding of taxonomic hierarchies (e.g., Blewitt 1994; Johnson et al. 1997) and discovered that two-year-olds already prefer basic level categories in a variety of conceptual tasks, that three-year-olds are able to learn subordinate categories (Mervis et al. 1994) and sort items according to basic level categories (Rosch et al. 1976), and that five-year-olds can generalize the properties of a category to a subordinate one.

Taxonomic categories distinctively display other features too. One is the so-called *strong typicality effects*, namely, the fact that typically shaped and colored apples are usually considered good examples of fruit compared to tomatoes or grapes, which are known to be fruits, although in a somewhat different way (Murphy 2002: 22); furthermore, taxonomic categories display *correlational structures*, meaning that if a member of a category has a feature that is typical of said category, it is likely to have other typical properties. These structures are apparent in taxonomic food concepts: for instance, there are strong color-taste correlations among vegetables, such as greenish-bitter or reddish-sweet (Foroni et al. 2016; Foroni and Rumiati 2017). Correlational structures explain why members of the same taxonomic category often share many features and motivate the widespread assumption that taxonomic categories are similarity-based (see Nguyen and Murphy 2003; Mirman et al. 2017; Hampton 2006; Mervis and Rosch 1981)[1]. It is worth noting that scholars seem to understand food taxonomies as somewhat objective and grounded in the very nature of the items grouped in taxonomic categories (much like biological taxonomies), although there might in fact be countless different criteria for building culinary taxonomies (see for instance Borghini and Gandolini 2020; who build an authoriality-based taxonomy of recipes). Strong typicality effects and correlational structures jointly make taxonomic categories stable in users' minds, easy to access and to store in long-lasting memory (Barsalou 1991).

Researchers have devoted great attention to taxonomic food concepts in children, since taxonomic knowledge has been shown to support a variety of cognitive abilities (e.g., categorization and category-based induction). Three-year-olds already display some proficiency in using taxonomic food knowledge to tell apart vegetables from fruits (Rioux et al. 2016 https://doi.org/10.1016/j.cogdev.2016.09.003): when presented with a picture of a food item (for instance, a red apple), they are able to pick a taxonomic match (for instance, a green apple) instead of a more perceptually similar one (for instance, a red tomato) when asked to put the same kind of items in a box. Children's understanding of taxonomic knowledge undergoes significant development until the seventh year of life, as demonstrated by their performance in taxonomic matching and induction tasks (Nguyen and Murphy 2003). Nguyen (2012; Experiment 1) found that three-year-olds can use selectively taxonomic food categories for drawing biochemical inferences (e.g., inferences about the substance food items are made of). Perturbations in this developmental trajectory during preschool years are in fact predictive of food rejection dispositions in children (Rioux et al. 2018a, b).

Although prominent in the literature, information about taxonomies is not the only one that is relevant to children's representation of food: in everyday decision-making, it is hard to detach it from other kinds of knowledge that we are going to illustrate in the following sections.

[1] Although taxonomic categorization has been also contrasted to (perceptual) similarity-driven categorization in some experimental studies, see for instance Rioux et al. 2018a, b.

2.2 Relational Knowledge

Food knowledge often involves knowledge of *external* relations between food items, events, and concepts. For instance, in a grocery store one might find a section devoted to breakfast foods, a shelf dedicated to bakery ingredients and tools, maybe a corner for Halloween or Christmas treats.

Although many authors have considered the very concept of food to be eminently taxonomic (see for instance Estes et al. 2011[2]), relational thinking is indeed crucial in the food domain since food acceptability depends on certain relations holding between food items (e.g., food pairings consisting of otherwise acceptable foods like chocolate and chicken might appear disgusting or inherently wrong to somebody) and eaters (e.g., some foods might be rejected due to someone's food intolerances or religious beliefs).

Sometimes relational knowledge can be used to group items and form categories (Gentner 2005). To an extent, this is unsurprising: after all, taxonomic knowledge itself revolves around set-inclusion relations. Nonetheless, relational knowledge stresses the importance of *external* relations in conceptual representations, understood as relations holding between items that are represented as distinguished or not belonging to the same superordinate category (Markman and Stilwell 2001).

Recent empirical literature in food cognition focuses mostly on two kinds of relational knowledge: one hinges on complementarity or spatio-temporal co-occurrence between instances of two concepts ("thematic knowledge", see Estes et al. 2011), the other on the roles that two concepts play within a script, defined as a schema for a routine event (Nguyen and Murphy 2003). Both kinds of knowledge are crucial in determining food acceptance, since most human communities develop strong expectations about what counts as an appropriate way of serving and consume a given dish. Consider for instance fries, which are usually highly palatable among children. Fries for breakfast might trigger rejection among kids that are accustomed to eating sweet food in the morning and presenting a dish in which fries are paired with an unusual food associate (e.g., strawberry ice cream) might cause the same effect.

2.2.1 Thematic Knowledge

Thematic knowledge has been mainly framed as knowledge about the links between concepts that perform *complementary* roles in the same event or scenario (Golonka and Estes 2009; Wisniewski and Bassok 1999; Mirman et al. 2017). More specifically, the nature of said links can be either functional (e.g., fork and knife, spoon and soup…), causal (knife and watermelon, grill and meat), co-occurrence-based (established food pairings, e.g., strawberries and whipped cream, bread and butter…), or a combination of the former (e.g., buns and patty or ice cream and cone, which are arguably both co-occurrence- and function-based). Those links are often referred to as "themes" (for instance, see Estes et al. 2011) and are more culturally bound than the similarity and inclusion links underlying taxonomical knowledge (Markman 1989, 1994).

[2] A noticeable exception to this trend is Simone Nguyen (2003, 2007).

According to Estes and colleagues (2011), one distinctive feature of thematic relata is that they perform different roles in the context of their theme. For this reason, unlike cognate taxonomic concepts and items, thematic relata (e.g., bread and butter or soups and spoons) do not usually share many intrinsic features. Nonetheless, the authors have found that thematic knowledge is especially suited to support analogical reasoning and that sometimes it even intrudes in similarity-based judgements. For instance, it has been shown that subjects tend to judge milk and coffee as more similar than milk and lemonade, although lemonade and milk share more key perceptual features (namely, the color white)[3] (Wisniewski and Bassok 1999; Golonka and Estes 2009).

The centrality of role-based thinking in developing themes suggests a strong connection between thematic knowledge and role-governed food categories. According to Markman and Stilwell (2001), role-governed categories refer to *roles* within the relational structures underlying relational categories. Although it is not always clear what the theoretical purpose of categories is according to the authors (they alternatively state that categories either "name", or "identify", or "represent" ontologically heterogeneous entities such as objects, verbs, events, and relations), their distinction can prove useful when applied to food. Relational food knowledge in general may underlie the understanding of multiple configurations of food items and concepts (e.g., main course-side dish couplings, Russian- and French-style service, mereotopological structures[4]), whereas thematic knowledge involves more precisely our ability to fill up the (conceptual) slots of complementary relational structures with (concepts of) food items.

It is important to point out that thematic and taxonomic food concepts can be acquired by different means: while familiarity with certain items has a positive effect on children's ability to detect both taxonomic and relational matches, the recognition of thematic fit depends specifically on the capacity to rely on contextual cues in real-world scenarios (see McRae et al. 1998; Markman 1989). Due to the conventional nature of many themes, children need to get accustomed with a food item in several different contexts to grasp the relevant thematic connections that it bears to other entities. For instance, the shape of the cone lends itself to contain several kinds of foods equally well (e.g., ice cream, cheese, sauces…), and ice cream is in fact often served in different containers or recipes (e.g., cones, cups, glasses, cakes, and so on). Since the thematic association between ice cream and cones is not grounded in any principled reason, it is necessary to engage regularly with scenarios in which the two items are co-occurrent in order to grasp the relevant piece of thematic knowledge.

[3] These results raise two problems from a food-oriented standpoint: the first one is that the authors explain them by suggesting that test subjects' similarity judgments are affected by thematic knowledge, although alternative explanations are available, such as that milk and coffee often share a perceptual feature (temperature) that might be deemed more salient and support the taxonomic category "hot beverages", or that some essentialist bias towards breakfast food is at play here (Bian and Markman 2020a, b), or finally that the subjects simply fail to grasp what the experimenters mean by "similarity"; the second one is that coffee and milk can be either interpreted as co-occurrent or as alternative within a given food-script (more on this point in Sect. 2.2.2).

[4] Understood as spatial representations of the parts composing an object and the mutual relationship between their boundaries, see Casati and Varzi 2003.

Although there are indeed physical constraints involved in thematic relations (for instance, Estes and colleagues (2011) say that thematic fit is based on affordances[5]), the nature of themes is conventional and arbitrary to a certain degree.

Empirical evidence shows that humans usually acquire thematic thinking early during childhood (Lucariello et al. 1992; Waxman and Namy 1997; Blanchet et al. 2001) although significant interindividual differences may occur due to factors such as education, cultural norms, and language learning. Pickard and colleagues (2021) devised food-based analogy tasks to detect possible gaps in preschoolers' thematic knowledge: after being exposed to two pictures of food items exemplifying either taxonomically- or thematically-related couples, test subjects were asked to match a target stimulus with one of two options in analogy to the kind of relationship instantiated by the previous couple of pictures. Each participant was tested on sixteen trials, half of which assessed their ability to understand taxonomy-based analogies (e.g., apple: banana::burger patty: chicken leg), whereas the other half tested thematic analogies (e.g., ice cream ball: cone::burger patty: burger bun). The sixteen trials were presented in pseudo-randomized order. The study revealed that increased levels of food rejection were predictive of poorer thematic understanding. Since it conveys information about the cultural and conventional features of eating settings, poor thematic knowledge may in fact be a crucial factor triggering uncertainty among young eaters. In a series of three studies run on preschoolers, Pickard and colleagues (2023) investigated the links between food neophobia and different pieces of relational food knowledge. In study 1, they used a forced-choice trial task to assess the developmental differences in the acquisition of different kinds of relational food knowledge. Among the four associations investigated (which have been adapted from Lucariello et al. 1992), children showed proficiency in mastering food-utensils ("functional") associations earliest, then food-food ("conventional") associations, and event- or meal-based script relations later on (more about scripts in the next section). These results suggest that a more fine-grained distinction between kinds of thematic relations might be useful to better understand how children conceptualize the food domain and why some thematic relations are mastered earlier than others.

2.2.2 Script Knowledge

Another relevant kind of relational food knowledge that empirical research has focused on is the so-called script knowledge. We classify script food knowledge as relational for it conveys information about the items, processes, and relations that occur within a given customary scenario or situation ("script") (Ross and Murphy 1999; Nguyen and Murphy 2003; Estes et al. 2011). It is thus easy to see the relevance of this kind of knowledge in the food domain, both for grouping items and for

[5] The notion of affordance has been notoriously introduced by Gibson (1966, 1979) to explain the interaction of agents with their environments and has been applied in a variety of research domains. Although the author never provided a full-fledged definition of affordance, therefore giving raise to problems of (mis)interpretation (see Harwood and Hafezieh 2017), the notion "refers to whatever it is about the environment that contributes to the kind of interaction that occurs" (Greeno 1994; p. 338). Affordances depend on both object and agent's physical properties, and can indeed be learnt through exploration (Szokolszky 2003).

forming concepts: breakfast food, birthday cakes, and ritual food are all perspicuous notions which rest upon script knowledge. Empirical research confirms its importance as well. In a category generation task with American college-aged participants, Ross and Murphy (1999; Experiment 1) found that all the subjects spontaneously formed at least one script category[6] to group the food items they were presented with.

Unfortunately, the literature displays a high degree of ambiguity about the exact characterization of the notion of script knowledge, especially when it comes to its definition and relation with other kinds of knowledge. Some authors (see Lucariello and Nelson 1985; Nelson 1983; Lucariello et al. 1992) seem to conceive script knowledge as a sub-kind of taxonomic knowledge, which they call "slot-filler". According to these accounts, slot-filler categories are composed of items which share the same function within a given event, where said function "creates" slots that can either be filled *simultaneously* or *alternatively* by the items in the category (the authors exemplify slot-filler categories by mentioning *bologna*, peanuts, and cheese as members the category "items that can be eaten for lunch").

Others treat script knowledge as a subcategory of thematic knowledge. Estes and colleagues (2011) define scripts as "generalized sequence(s) of actions and instruments associated with the execution of some common event", in which the "various objects, concepts, people, and actions (…) are externally related by the event itself, and they perform complementary roles in the execution of the script" (p. 254). Scripts are thus an event-based subset of themes, where the relevant thematic associations are links between actions and instruments that are typical of a given common event. It is not clear whether this frame can accommodate available empirical data: for instance, some authors (Lucariello et al. 1992; Berger and Donnadieu 2006) suggest that thematic and script knowledge should be kept separated, for the second is mastered later in development due to his more cognitively demanding nature, but other studies have not found different developmental trajectories for the two kinds of knowledge (Nguyen and Murphy 2003).

Third, some authors (Nguyen and Murphy 2003; Nguyen 2012) propose a distinction between thematic and script associates in which the former play *complementary* roles within a scenario, whereas the latter play the *very same* role within the relevant script. Thematic associates are thus co-occurrent, while script associates are mutually *substitutable*. A principled distinction between complementarity and substitutability relations seems plausible because understanding these two different relations requires different kinds of knowledge and cognitive abilities, but it seems hard to draw clear-cut boundaries between the two kinds of relations in the food domain. Consider "breakfast food", a textbook example of script food categories (Bian and Markman 2020a, b): it seems uncontentious that both milk and cereals are typical breakfast foods to some people, although they cannot be strictly speaking substituted with each other; in fact, they are linked by a strong thematic association because they play complementary roles in breakfasts. Within this framework, more fine-grained role-based distinctions are called for to tell the two types of relation apart: for instance, some

[6] The authors mention as examples of said categories "breakfast foods", "snacks", "healthy food", and "junk food". As we will point out in what follows, this criterion for coding script categories is problematic.

items within the breakfast food category can be linked by substitutability relations relative to the role "beverage" (e.g., milk and orange juice), others by complementarity relations according to the "ingredients-to-the-same-recipe" role (e.g., peanut butter and jelly), while others by both (e.g., milk and coffee can be both co-occurrent or alternatives to the role of "beverages" within the breakfast script).

Finally, some studies endorse notions of script knowledge that do not comply with any of the aforementioned approaches. For instance, Thibaut and colleagues (2016; Experiment 1) tested children's abilities to extend psychological and biological properties on taxonomic or script food associates, but the stimuli used to exemplify script relations do not appear to be event-specific (fish-rice, carrot-fish, strawberry-whipped cream…), rather resembling thematic associates. In Ross and Murphy's (1999) studies, script associates were introduced to participants as "foods that are eaten at the same time or in the same situation" (p. 510), thus conflating script, thematic, and other kinds of food groupings under a single label (e.g. "junk food" counted as a script category in their study, while more recent research classifies it as an evaluative category, see Nguyen and Murphy 2003 and Sect. 2.3.1 of this paper).

Despite these differences in approaches and the lack of a commonly accepted definition, the intuition that script knowledge plays a central role in food cognition and that it hinges on the recognition of external relations among items occurring in a given scenario is shared by most researchers in the field and supported by empirical findings. Ross and Murphy's (1999) studies on food categories showed that script categories are almost as relevant as taxonomic ones in category generation and sorting tasks[7], and that both kinds of knowledge support the inference of various properties from a target stimulus onto another relatum with comparable strength (Experiment 6).

Some previously covered studies (Estes et al. 2011) studied thematic and script food knowledge alongside each other. This literature shows that children attend both kinds of knowledge since an early age (usually between the third and fourth year, see Pickard et al. 2023, Nguyen 2012[8]) and that knowledge gaps in both fields are positively correlated with increased levels of food rejection tendencies (Pickard et al. 2021).

Both scripts and thematic associations are difficult to investigate empirically, as they are highly sensitive to culture and to interindividual differences. For instance, Bian and Markman (2020a) have run a comparative study to assess the differences between the "breakfast food" notion endorsed by children in China and in America (four- and five-year-olds). They found that the former had more permissive categorization criteria and more graded category boundaries than the latter.

Another study by Bian and Markman (2020b) explored a further complexity of script food knowledge that might account for the interindividual differences in flex-

[7] Although some concerns could be raised about Experiment 3 (category sorting). Since test subjects were not allowed to put a given stimulus in more than one category, it is likely that some degree of arbitrariness occurred in settling situations in which multiple categorizations were available to the default group. Furthermore, almost half of the undergraduate participants considered eggs to be good examples of dairy food (p. 514), a detail that motivates some perplexity about their knowledge in the food domain.

[8] Although some conflicting evidence suggests that children may be able to master script knowledge in the food domain around the seventh year of age (see Nguyen and Murphy 2003).

ibility of script categories' boundaries in cognitive rather than cultural terms. Due to a phenomenon known as *inherence heuristic bias* (Cimpian and Salomon 2014), some people are inclined to misrepresent script categories as being objectively given and grounded in the "intrinsic" or "inherent" properties of the food items they refer to, rather than being conventional and historically determined. This bias has been detected in young children (see Hussak and Cimpian 2015; Tworek and Cimpian 2016) and might be a precursor of essentialist dispositions, defined as the tendency to represent categories as having non-obvious essences accounting for the typical features of their members (Newman and Knobe 2019; Neufeld 2022). Going back to Bian and Markman's study (2020b), the authors found that a substantial number of adults provided "inherent" explanations to their categorization of breakfast food items (e.g., some items are typical breakfast foods because they are highly energetic or easy to digest) and that such explanatory strategy negatively correlates to the willingness of trying new food items for breakfast. One can expect that the distinction between the biological (inherent) and cultural (conventional) dimensions of food in script-based tasks is especially hard to attend for children, for preschoolers are prone to essentialize spontaneously many kinds of categories (e.g., artifacts, see Gelman 2013).

In conclusion, the research on food script knowledge displays some shortcomings. Most importantly, the lack of a shared notion of script knowledge makes it hard to integrate empirical findings across different studies; then, many relevant food scripts, e.g., course-level (e.g., appetizer), meal-level (e.g., breakfast), or special event (e.g., birthday) scripts, are yet to be studied. Finally, due to the cultural nature of food scripts, further research is needed to assess the impact of factors such as linguistic cues and meal structures on children's food choices.[9]

2.3 Value-laden Knowledge

To be able to make certain food choices an agent requires knowledge about the most appropriate means to a certain end as well as the nature of the goal, be it health (Nguyen 2007), moral values (Lakritz et al. 2022), or practical aims (e.g., make the best recipe out of an almost empty fridge).In this section, we first discuss food knowledge concerning somewhat stable and general value assessments, then that involving provisional and impromptu means-to-an-end reasoning.

2.3.1 Normative and Evaluative Knowledge

Many food concepts and categories that are relevant for everyday food choices rest on judgments concerning abstract values. For instance, we often decide what to eat based on evaluations about healthiness, sustainability, or palatability. Sometimes said judgments are subjective in nature, other times they are culturally conditioned:

[9] For instance, the name and structure of meals in certain cultures may sometime establish certain arbitrary features of food as relevant within the script (e.g., the reference to small amounts of food in the French "*petit-dejeuner*" is absent in most translations, the Italian "*dolce*" includes a reference to sweet taste that is absent in its translation "dessert").

notoriously, most societies have cultural and religious beliefs that draw distinctions between pure and impure food items and practices. These axiological partitions are mirrored by evaluative categories, i.e., categories of items that share the same evaluation or assessment (Nguyen 2008).

In his extensive work on the topic, Rozin (1990; Rozin et al. 1985) singles out three fundamental evaluative food categories, which are identified through different psychological criteria: "good tastes" and "distastes" are grouped according to one's liking of food items' perceptual features, "dangerous" and "beneficial" foods according to anticipated consequences of ingestions, appropriate and "inappropriate" foods according to "ideational" considerations about the fact that certain potentially edible items ought not be considered as such due to their origin or constitution.

The literature on children's food evaluative concepts focuses mostly on the healthy/unhealthy spectrum. Various studies documented (Ross and Murphy 1999[10]; Nguyen and Murphy 2003; Nguyen 2008; Girgis and Nguyen 2018) that by four years of age children can form evaluative food categories alongside taxonomic and script ones, but were unable to assess whether their proficiency in distinguishing healthy and unhealthy food is due to the valence of the two categories ("healthy food = good" versus "unhealthy food = bad") or to specifically health-related knowledge.

Children's ability in categorizing food as healthy or junky displays great developmental changes over time (Nguyen 2007): three-year-olds' performance in categorization tasks is slightly above chance levels (59% of correct category matches), but four-year-olds show substantial improvement (73%); still, until the seventh year of age, subjects do not consistently provide justifications for their choices. These justifications tend to revolve around nutrients (e.g., "it contains calcium") more than health outcomes (e.g., "it gets you big", "gets you cavities") as the age of the subject increases. These developmental differences most likely mirror differences in the understanding of nutritional processes, moving from intuitions about vague food-health causal links to more theory-like explanations.

According to Nguyen (2007), children's categorization errors especially target stimuli which are supposed to be categorized as junk food, although their ingredients may count as healthy if considered separately (e.g., hamburgers and French fries). As the author herself points out, there may be a fundamental issue with the oversimplified healthy/junky dichotomy proposed in the study, as the two categories are designed according to a "nutritionistic" (Scrinis 2013) criterion (i.e., high nutritional value and low salt, fat, and additional sugar levels counted as healthy; vice versa, low nutritional value and high salt, fat, and sugar levels counted as junk), without taking into account information about the mode of consumption (e.g., amount of food consumed and frequency of consumption) nor assessing whether the high performance of adult control subjects in the task was due to actual health-related information rather than artificial salience induced by the experimental design: for instance, when asked to place chocolate within an evaluative category, a subject may be inclined to

[10] In a category generation task (Experiment 1), many participants resorted to the healthy/junky dimension to group food items. Unfortunately, the authors decided to code those groupings as script categories in the study, although they raised some concerns about it (p. 502).

compare it to other stereotypically healthy stimuli such as fruits and express a comparative judgement, although they may see chocolate as not-unhealthy per se.

This line of criticism can be (at least partially) pushed back by pointing out that children attend to these categories in drawing meaningful, non-comparative inferences about the different effects that they have on the eater's health, as shown by Nguyen (2008). Not only the participants in this latter study were able to correctly match a target food with the appropriate stimulus according to the effects they both have on the eater's body, but they also attended "healthy" and "junk food" categories only when asked to draw health-related inferences, rather than arbitrary generalizations. Furthermore, Girgis and Nguyen (2018) found that by the end of the fifth year of age children attend to subject-independent information (namely, substance and composition) to assess the name and healthiness of food items.

Finally, another work by Nguyen (2012) dedicated to children's preferences about the sources of information for building evaluative categories found and interesting asymmetry between "healthy" and "unhealthy food" categories. In study 2, the author found that subjects (three- and four-year-olds) are prone to accept external information about the palatability (e.g., "yummy" or "yucky" food) and unhealthiness, but they are rather cautious when it comes to accept information about healthy food. These results suggest that children do not represent healthy and unhealthy food as complementary concepts and that they find knowledge about unhealthy food more reliable or easier to access compared to that grounding the concept of healthy food.

2.3.2 Ad Hoc Knowledge

We have seen that evaluative categories are highly context dependent. A limit case of context-dependent categories is that of ad hoc food categories (Barsalou 1983), which are eminently provisional and arbitrary in nature. Categories such as "recipes that are quick to make" are value-laden in that they group items according to criteria such as practicality or time-efficiency. The ad hocness of said groupings consist in the fact that their content can vary considerably according to contextual circumstances, such as the availability of given food items or the situational constraints that one has to take into account within a given scenario (for instance, what counts as "quick to make" changes depending on whether one aims at having a snack before catching a train rather cooking a family supper).

Rather than serving the purpose of sorting entities into stable classes, ad hoc categories aim at providing means to the end of solving problems that are often contingent, temporary, unforeseen, and pragmatic in nature. Thus, the criteria for identifying members of an ad hoc category can be of many different kinds. Ad hoc concepts differ from non-ad hoc ones under at least four respects:

1. *Weaker concept-to-instance associations.* Ad hoc concepts usually do not have well-established representations in memory and display weaker concept-to-instance associations than other concepts (Barsalou 1983). For instance, coming up with instances of "food that can fit in your lunchbox" is comparatively harder than listing vegetables, for the connection between the ad hoc concept and its instances has to be flexible enough to accomodate the peculiarities of the

situation at hand (e.g., the size of the lunchbox and that of available food items). Upon repeated, frequent, and effective activation, subjects can reinforce such associations, thus turning an ad hoc concept in a "standard" one; but unless such reinforcement takes place, ad hoc categories are observed to be harder to access.

2. *Weaker instance-to-concept associations.* Ad hoc concepts have weaker instance-to-concept associations then other kinds of concepts as well. For instance, subjects seeing a glass full of milk are much more likely to associate the stimulus to the concept "breakfast food" or "beverage" than the ad hoc concept "food to consume when running low on calcium". In other words, ad hoc concepts are not activated by default, for they are only activated under the appropriate instance-context conjunction.
3. *Violation of correlational structures.* Ad hoc categories do not usually display correlational structures (see Sect. 2.1). The same can be said about most thematic and script categories, although to a lesser degree. It is thus reasonable to suggest that different kinds of categories may occupy different positions over the strength-of-correlational-structure spectrum. At one end there are taxonomic categories, at the other there are purely arbitrary ad hoc categories.
4. *Dependence on cross-classification.* The ability to build and activate ad hoc concepts depends on the proficiency in cross-classifying items. This link is unsurprising, as subjects need to come up with different groupings of previously known (and differently categorized) items to properly handle said concepts. For instance, a person going on a hike must build an ad hoc category "food that I can bring on a hiking trip", and, in order to assess its members, cross-classify food items that they are already acquainted with according to new criteria: hiking food has to be easy to transport, so it must be light weight, compact, and consumable at ambience temperature. A couple of sandwiches and a banana will do. These items, which may have been formerly represented as instances of thematic ("food that is eaten with bare hands"), script ("picnic food") or taxonomic ("fruit") categories, are now categorized as "food that I can bring on a hike".

Unfortunately, not many studies have been devoted to ad hoc food categories in children[11]. Some have touched upon the topic, but comparing their results is hard due to conflicting coding choices. For instance, Ross and Murphy's experiments 4 and 5 (1999) directly tested children's ad hoc food categories, but many of the ad hoc categories listed by the authors (e.g., "foods that you can eat with a spoon") seem to be typical examples of thematic categories (Sect. 2.2.1). Lucariello and colleagues (1992) in turn list categories that really fit as ad hoc (e.g., "items that can be put on while getting dressed in the morning", p. 979) within the class of slot-filler categories, a sub-type of taxonomic categories.

Still, ad hoc categories are likely pivotal to children's food knowledge: not being familiar with many food settings and before the repetition-induced reinforcement of

[11] A plausible reason for this is that researchers expect children to lack extensive experience and a well-developed understanding of causal relations, both of which are required to grasp ad hoc categories. Still, this is not a sufficient reason not to investigate children's ability to form and understand said categories, for many common food categories might start off as ad hoc ones. Thanks to an anonymous reviewer for bringing this point up.

conventional groupings into stable categories, children must often tailor several food categories on the spot to engage with the food concepts they are learning.

3 Discussion and Future Perspectives

The value of the proposed typology is best appreciated if it is understood as a map of the conceptual space that kids must navigate when thinking about and engaging with food, rather than as a static partition into distinct classes of concepts and categories. Although the analytical distinctions of experimental settings sometimes seem to suggest that researchers understand different types of knowledge as alternative to each other and food categories as depending on nothing but one of them, lexicalised food concepts and categories that are employed both in everyday discourse and in dietary advice rest instead onto multiple types of knowledge at once[12]. For instance, the "dessert" category affords several layers of taxonomic hierarchy (e.g., "dessert" as a superordinate category, "cake" as a basic-level category, and "chocolate cake" as a subordinate category), although it seems to be identified by the role of its members as last courses within a meal script, by some typically co-occurring ingredients, e.g., chocolate, cream, fruits, sugar (thematic knowledge), and perceptual properties, e.g., sweet flavour.

The correspondence of different types of food knowledge documented in the literature and a given lexicalised food concept is therefore a complex relationship between thought and language, the mastering of which requires conceptual flexibility and sensitivity to contextual and relational cues. The typology proposed in this paper is a useful tool for disentangling this intricacy, for effective knowledge-based educational strategies should aim at boosting all the different kinds of conceptual knowledge listed above in order to improve kids' ability to understand common food concepts and recognize unfamiliar food items and scenarios.

Furthermore, the typology proposed in the review allows us to detect and address some of the shortcomings of extant knowledge-based approaches to food education. Contributions in this field often endorse a narrow understanding of food knowledge that generally favors nutritional information (Lakshman et al. 2010; DeJesus et al. 2018, 2019), evaluative food categories (Nguyen 2007, 2012), or causal and quasi-scientific knowledge about the physiology of nutrition (Gripshover and Markman 2013). Most strategies built upon this narrow account of food knowledge have been met with mixed results and moderate (when not negligible) success in modifying children's food choices (e.g., Rekhy & McConchie 2014; Uetrecht et al. 1999). A richer picture of children's food knowledge enables us to identify two key features that have been somewhat disregarded thus far and play a crucial role in shaping preschoolers' food choices, namely *contextual dependence* and *relationality*.

[12] This feature is not unique of food concepts, as many Wittgensteinian cluster concepts lie at the crossroads of heterogeneous pieces of knowledge. Figuring out what are the relevant bits of knowledge to understand food concepts in educational settings is nonetheless a domain-specific endeavor.

3.1 Contextual Dependence

Alongside with objective features of food items and value-laden assessments, knowledge about eating contexts plays a major role in determining what kind of food concept is activated on a given occasion. Researchers working on adults have already stressed the intra-subject context-dependence of food categories: for instance, Blake and colleagues (2007), carried out a study on 42 adults in the US to assess how spontaneous food sorting was affected by changing eating context and found that personal-experience- (e.g., evaluative) and context-based (e.g., script) food categories were prevalent over object-based (e.g., taxonomic) ones in all scenarios, although both the extension and the number of the latter two types of concepts varied across settings. These findings show once more the importance of contextual information in guiding food categorization. Unfortunately, many of the context-dependent categories generated in this study (e.g., person-, location-, convenience-, and meal component-based categories) have not been studied in the literature about children yet.

Some researchers have instead studied inter-subject contextual variability: an example on point comes from Bian and Markman's (2020a) study on children's breakfast food category. Children's concepts of breakfast food across countries differ both in extension (namely, they refer to different food items) and boundaries (children in America are reluctant to accept unusual breakfast foods, e.g., lamb chops, as replacements for more typical ones, e.g., cereals). The more conservative and strict beliefs about what counts as appropriate breakfast food displayed by children in the US are an example of conceptual rigidity: they are not eager to extend their concept of breakfast food to new items that are not typically subsumed under that category. This phenomenon is probably due to a widespread "inherence heuristic bias" (Cimpian and Salomon 2014), a disposition to explain observed regularities in terms of intrinsic properties of the items belonging to a category. Food education should therefore find ways to overcome said cognitive rigidity: as another paper by Bian and Markman (2020b) on adults' breakfast food category shows, providing information about breakfast foods in other cultures and the history of the marketing campaigns behind staple breakfast food in the global West is enough to increase people's willingness to try atypical breakfast food and to change their appropriateness judgments.[13] Although to our knowledge no intervention of this kind has been tested on preschoolers yet, the findings on adults look promising for devising knowledge-based strategies to overcome overly rigid and objective-feature-oriented conceptualizations of foods among children.

3.2 Relationality

A cognate point concerns the fact that relational information in the food domain might be at least as relevant as knowledge about intrinsic features of food items. In fact,

[13] The effects of this intervention are especially remarkable among subjects that displayed essentialistic attitudes toward the category at stake. As the authors pointed out, enriching people knowledge about the arbitrary nature of some food categories might help them to mitigate the effect of the inherence heuristic bias we mentioned in Sect. 2.2.2.

along with lists of objective features like organoleptic and nutritional properties, food concepts convey knowledge about rich relational structures such as those underlying script and thematic categories. Similar structures might underlie information about ingredient-recipe, cook-meal, table companion-dish, and other relations that likely play a role in shaping children's food choices. Anchoring food concepts on relational information might be beneficial to conceptual flexibility. In fact, relational structures can support the inference of non-obvious commonalities between food items that look otherwise very different and unusual, to the extent that they are recognized as filling the same "slots" or "roles" within the structure (see for instance Lucariello and Nelson 1985; Markman and Stilwell 2001); instead, superficial modifications in the perceptual features of a food item (e.g., different presentations and servings) would be enough to undermine its recognition as a member of rigidly feature-based categories.

Although the aforementioned studies by Bian and Markman (2020a, b) are to our knowledge the only ones that directly tackle the issue, we can conjecture that a mature understanding of what counts as an instance of a side dish or healthy food depends on a number relational properties that one must flexibly adapt to the situation at hand: what makes for a good candidate to be the side of a given dish depends on thematic association that are context dependent, whereas deciding whether a pizza or a salad is the healthiest option for a meal calls for an assessment of each option's role in promoting variety and balance in broader eating patterns, the specificities of the subject at hand (e.g., intolerances, average physical activity), and preparation methods.

3.3 Upshot for Research and Intervention

Further research is needed to deepen our understanding of many aspects of children's food concepts (e.g., their acquisition, content, and causal/explanatory role in broader incipient theories of the food domain), but the literature reviewed thus far suffices to make a case for the complexity of conceptual food knowledge and its role in shaping preschoolers' food behaviors.

A promising avenue for further research concerns the relationship between preschoolers' conceptual food knowledge and food literacy (FL)-based educational programs (whose effectiveness in improving food knowledge in older children and overcoming rejection dispositions among preschoolers has already been documented, see for instance Stjernqvist et al. 2022; and Garcia et al. 2020). Held to be both an aim and a tool for effective food education, FL is a multi-faceted notion that has been defined in various ways in the literature. We therefore allow for a broad understanding of the term, according to which food literacy is the set of skills and competencies required to make well-informed and positive choices in complex food system (Cullen et al. 2015).

Although Benn (2014) includes food knowledge ("to know") among the five main components of FL and Ares and colleagues (2024) list food categorization as one of the functional competencies that are crucial for FL in preschool years, FL-based interventions only seldom focus on conceptual food knowledge. When they do, some interesting convergence with the literature we reviewed thus far emerges: for instance, Tabacchi and colleagues' (2020) work on the assessment of FL among

young children investigates their understanding of evaluative ("healthy food", "fresh food", "traditional food"), script ("food for breakfast", "food for lunch/dinner", "food for breaks"), and, most interestingly, yet-to-be-investigated concepts, such as "winter foods" or "summer foods" (which arguably involve both taxonomic, script, and ad hoc knowledge). Scholars working on FL can thus benefit from systematically applying the typology we propose in this paper to find ways of fostering the conceptual component of food knowledge, whereas future research in cognitive science will be equipped with an analytical frame to unpack and assess the effect of FL-based interventions and other holistic methodologies on each of the three types of knowledge we singled out.

Much work is yet to be done to develop and test full-fledged knowledge-based intervention strategies informed by the findings of experimental research, but we are positive that the theoretical remarks proposed in this review provide useful insights to this end.

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Declarations

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