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Q4: Au: Please provide reference for citation [Inagaki & Hatano, 1993].
Q5: Au: Please provide reference for citation [Markman & Gentner, 1993].
Q6: Au: Reference [Gripshover and Markman, 2013] has been updated. OK?
Q7: Au: Please add an in-text callout for Table 3.
Q8: Au: Please spell out "Univ." in full in the first author's affiliation. Also, punctuation is "Univ. Bourgogne Franche-Comté" (hyphen) in the byline and "Univ. Bourgogne Franche Comté" (no hyphen) in the address for correspondence. Which punctuation is correct?
Q9: Au: "Age" correct as added after "*M*" in these three sets of parentheses?
Q10: Au: Change from "type of category" to "type of food" OK here to match the language in the previous paragraph?
Q11: Au: "Age" correct as added after "*M*" in these three sets of parentheses?
Q12: Au: You use decimal points in your mean ages and age ranges in the "Participants" section for Experiment 1 and semicolons here. Should the punctuation used be the same in both places? Use decimal points to indicate tenths of a year (e.g., 4.5 = 4½ years). Use semicolons to indicate years and months (e.g., 4;5 = 4 years and 5 months).
Q13: Au: Change from "BBQ" to "Barbecue" OK here to match the main text?
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Body and Soul: Do Children Distinguish Between Foods When Generalizing Biological and Psychological Properties?

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ABSTRACT

Research Findings: In 2 experiments, we tested whether children generalize psychological and biological properties to novel foods. We used an induction task in which a property (either biological or psychological) was associated with a target food. Children were then asked whether a taxonomically related and a script-related food would also have the property. In a yes/no task (Experiment 1) 9-year-olds preferentially generalized the property to taxonomically related foods, but 4-year-olds did not. In a forced-choice task (Experiment 2; 4- to 6-year-olds), children preferred the taxonomic choice over the script choice. This preference was weak at age 4 but established by age 5. In both experiments, age groups, biological properties, and psychological properties were treated similarly. It is argued that the children do not distinguish biological and psychological properties of food most likely because they believe that psychological properties are caused by biological dispositions. *Practice or Policy*: We argue that nutrition education should take advantage of children's existing knowledge of food categories and how children generalize knowledge from 1 food to another. In particular, children have good knowledge of taxonomic categories and can best access that knowledge when they are required to compare different foods.

One way that children can learn about the world is through category-based induction, the generalization of information from a known to an unknown category member. There is a large body of research documenting children's ability to use a premise category to make inferences about the properties of unfamiliar instances of that category (for a review, see Gelman & Davidson, 2013; Hayes, 2007; Murphy, 2002). For example, if a child learns a new fact about a tabby cat, the child may reasonably conclude based on category membership that the fact is also true of a Siamese cat.

The present research examines children's inductive inferences with food categories. Children's ability to use food categories for inferences about nutrition, and specifically the health-related effects of eating, carries both theoretical and practical importance. Theoretically speaking, children's behavior in induction tasks using food categories is related to developments in their naive theory of biology. A substantial body of research has documented children's naive theory of biology, including an early distinction between natural kinds and artifacts and an understanding of numerous biological processes (for a review, see Gelman & Kalish, 2006; Inagaki & Hatano, 2006; Wellman & Gelman, 1997). Past research has found evidence for increases in reasoning about some foods as natural kinds (e.g., fruits, vegetables) between preschool and second grade (Gelman, 1988). A recent study also found that 3- and 4-year-olds have knowledge of the origins of natural versus processed foods (e.g., orange vs. cookie), recognizing that the former foods grow outside whereas the latter are made in factories (Girgis & Nguyen, 2015).

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Many biological processes that have been studied within the context of children's naive theory of biology are highly relevant to nutritional issues, such as growth, illness, and organ functioning. Studying children's use of food categories for induction addresses how children acquire new information about nutrition and how this information is integrated into a broader biological framework that includes other biological processes. For example, if children believe that salmon is good for you, will they infer that trout is also good for you? Or if children believe that too much candy makes them sick, will they conclude the same thing about cake? Given that children may not have information about every single food item they encounter, induction from other foods of the same type could be important to influencing their food choices and eating behavior.

Although the literature on children's naive theory of biology has not directly studied children's use of food categories for induction, several studies have shown children's appreciation for the purpose of eating and its effects. For example, Inagaki and Hatano (2002) found that when 6-year-olds were asked why we eat every day, they tended to favor a vitalistic causal explanation that emphasizes the life force of foods (e.g., they chose an explanation such as "Because our stomach takes in vital power from the food" over an intentional cause ["Because our stomach wants it"] or a mechanistic cause ["Because we take the food into our body after its form is changed in the stomach and bowels"]). Slaughter and Ting (2010) documented similar increases in vitalistic and mechanistic explanations (movement of substances through the body) between the ages of 5 and 8 years. In addition, Wellman and Johnson (1982) found that kindergartners understood the relation between nutritional input and output (e.g., vegetables increase health, strength, and vigor) and the limits of a less varied diet (e.g., eating just one food is not good for you). Raman (2014) found that preschoolers understand that food can affect height and weight (see also Guerin & Thibaut, 2008). Furthermore, Toyama (2000) has shown that 4- to 8-year-olds have an awareness of food digestion and that a lack of food can be damaging to the body. Children's beliefs about food extend to psychological effects. Guerin and Thibaut (2008) and Raman found that children associate foods with emotions such as joy.

Practically speaking, it is essential for planning nutrition education to know what knowledge children bring to the table when learning about foods, especially given the alarming prevalence of overweight and obesity in children in the United States and globally (Centers for Disease Control and Prevention, 2015; World Health Organization, 2015a, 2015b). Data has shown that in France, where the present study was conducted, 15% of children are overweight or obese, compared with 23% of boys and 21% of girls, on average, in Organisation for Economic Co-operation and Development countries (Organisation for Economic Co-operation and Development, 2015).

Unfortunately, a vast number of nutrition education programs are designed mainly to present children with a list of basic facts without embedding them into children's emerging naive theory of biology (for a discussion, see Gripshover & Markman, 2013; Nguyen, McCullough, & Noble, 2011). If children are already using food categories to accumulate knowledge about nutrition by the time they begin school, it is crucial for educators to be aware of this so that they can design programs that capitalize on children's existing abilities and therefore better meet their needs. If children are limited in their use of food categories, then there is an opportunity for programs to intervene. In these ways, schools can play a critical role in building on and supporting young children's existing skills and knowledge to encourage optimal learning of new information about nutrition.

The present studies focused on taxonomic and script categories of food because each category type embodies a different kind of information and has the potential to support a different kind of inference (Ross & Murphy, 1999). Furthermore, there is evidence that children already use both types of category to represent foods (Nguyen & Murphy, 2003). Foods in a taxonomic category (e.g., fruit, vegetables, dairy products) share common features, whereas foods in a script category (e.g., breakfast foods, dinner foods, birthday party foods) play the same role in an event or routine. Past research has documented that children have knowledge of both taxonomic and script organization by ages 2 to 3 years (Nguyen, 2007). That children have knowledge of taxonomic and script organization at an early age suggests that they come to school with concepts of food in hand.

Whether children draw from taxonomic or script categories when reasoning about the effects of eating is an open empirical question that is pertinent to education. Taxonomic proficiency, for example, is often considered a prerequisite for understanding core ideas in biology given that taxonomic categories serve as building blocks for learning more complex biological concepts (Allen, 2015). Script-based categories have practical value (e.g., in knowing what sort of food should be prepared or will be encountered at breakfast) but are probably not a good basis for representing nutritional knowledge. Bacon and cereal are both likely to appear at breakfast, but their nutritional profiles are not similar.

To our knowledge, very few studies have investigated how children use taxonomic and script food categories as a basis for inductive inferences. Nguyen and colleagues have found that by age 4, children use taxonomic food categories to make inferences about the biochemical composition of food but use script food categories to make inferences about the situational contexts in which foods are usually eaten (Nguyen, 2012; Nguyen & Murphy, 2003, Experiment 5). In this research, children were shown picture triads consisting of a target food (e.g., ice cream) along with a taxonomically related match (e.g., milk, another dairy product) and a script-related match (e.g., cake, another birthday party food). When children were told that the target food has novel biochemical stuff inside (e.g., "an ingredient called *pary*") and were asked whether the taxonomically related or script-related match has the same stuff inside, children chose the taxonomic match. In contrast, when children were told that the target food is eaten during a novel "special time" and were asked whether the taxonomically related or script-related match is eaten during the same special time, children chose the script match.

The present research builds on these initial findings to investigate more closely the role of taxonomic food relations in induction about the effects of eating different foods. Taxonomic categories may be particularly relevant to reasoning about nutrition given that foods in these categories share important nutritional features. In this way taxonomic food categories should promote inductive inferences about health outcomes in the human body. Specifically, we examined whether children distinguish taxonomic and script food categories to infer the physiological (hereafter, "biological") and psychological consequences of food consumption. Because foods in a taxonomic category share internal properties, children might expect that these foods give rise to a common impact on the human body. Children may not hold this expectation for script categories because foods in these categories do not have the same internal properties but rather are related by an external event or routine.

A related issue was investigated by Nguyen (2008), namely, whether children use evaluative food categories to reason about nutrition. Foods in an evaluative category receive the same value-laden assessments (e.g., healthy foods, junky foods) and thus can cut across many taxonomic and script categories (e.g., healthy foods may include particular fruits, beverages, and so on). In that study, when children were told that eating a target food caused a novel bodily property (e.g., "Cheetos made Jake's body daxy") and were asked to generalize that property to either an evaluative category match (e.g., ice cream, an unhealthy food) or noncategory match (e.g., fish), children tended to select the evaluative category match. However, because the evaluative food categories tested in that study purposely mixed together foods from several taxonomic and script categories to ensure stimulus diversity (e.g., unhealthy foods included snacks, dairy products, and so on), the contribution of taxonomic versus script category membership to children's inductive inferences about nutrition remains unclear.

Nguyen (2008) did not address the difference between generalization of psychological and biological properties. Many studies have shown that children distinguish biological and psychological properties (Inagaki & Hatano, 1993), but it is unclear how young children would generalize them. For example, they might think that foods elicit only transitory psychological states and so do not prefer taxonomic over script choices. For example, Raman (2014) showed that preschool children did not distinguish between positive and negative long-term psychological outcomes for healthy and unhealthy foods, whereas older children did. It might then be that younger children make no distinction between foods along psychological dimensions (see also Guerin & Thibaut, 2008). Young children might also favor script choices for psychological properties, considering that similar psychological states are elicited by foods that are eaten in the same settings, given that settings themselves may be associated with distinct states.

Our goal was to systematically examine children's use of different categories as a basis of inductive reasoning about biological and psychological effects. To this end we conducted two studies. Experiment 1 included an inductive inference task in which children were told that eating a target food is associated with a particular property and then responded "yes" or "no" to whether a taxonomically related food, script-related food, or unrelated food has the same property. Given that food can have a variety of effects on the body and mind, we tested both biological properties (e.g., stomachache) and psychological properties (e.g., feelings of happiness). In order to emphasize distinctions among the category types, Experiment 2 used a forced-choice version of the inductive inference task in which children were asked to choose which of two foods (a taxonomically related food and a script-related food) would have the same property as a target food.

In general, if children distinguish the inductive potential of taxonomic and script categories, they should draw from taxonomic categories when reasoning about nutrition. Specifically, for both studies, we predicted that children would make more inductions for taxonomic choices than for the script and unrelated choices for biological properties. It is an open empirical question as to whether psychological properties would show the same effect. Younger children especially might associate psychological effects with different settings and the foods associated with them. Given that knowledge of the ingredients and properties of foods grows over time, we also predicted that taxonomic responding would strengthen with age, at least for biological properties.

Experiment 1: Testing induction in a yes/no paradigm

The purpose of Experiment 1 was to assess children's generalization of a novel property from a target food to other foods that were either taxonomically related, script related, or unrelated to the target food. We tested both biological and psychological properties that have biological underpinnings to capture the myriad effects of foods.

Two hypotheses can be contrasted. The first hypothesis is that children consider food a unified domain, in which all of the members potentially share the same properties. Especially at early ages, children may not strongly differentiate different foods with respect to their properties. If so, they should generalize properties to script-related or even unrelated categories of food. The second hypothesis is that children consider food a complex domain, in which different categories have different kinds of properties. Although the exact way in which children might distinguish categories is not known, one likely possibility is that they will extend both properties to the taxonomically related choices but be more limited in their generalization to script-based categories.

In this experiment, the experimenter presented a target food along with a biological or psychological property. Then the experimenter presented three stimuli, one by one: a taxonomically related food, a script-related food, and an unrelated food. For example, if the target stimulus was strawberry, the taxonomically related food was watermelon, another fruit; the script-related food was whipped cream, something often served with dessert in this population; and the unrelated food was barbecue meat. Children were asked whether each stimulus had the same property as the target stimulus.

Method

Participants

Q9 Participants were 11 kindergartners (*M* age = 4.8, range = 3.11–5.4), 17 first-grade children (*M* age = 6.6, range = 5.9–7.2), and 10 third-grade children (*M* age = 9.5, range = 8.9–10.2) . They were from the Burgundy region in eastern France, and French was their native language. They were recruited in schools from middle-class areas. Informed consent was obtained from their parents and from their teachers. Children were tested individually in a quiet room at their school.

Materials

There were 14 stimuli composed of a target food stimulus and a set of three test items, the first taxonomically related to the target, the second script related to the target, and the third unrelated to the target (see Table 1). Because the stimuli were all foods, in some sense they all belonged to the same category. Taxonomically related items were meant to belong to the same immediate superordinate category (e.g., fruits for strawberry and watermelon), whereas foods connected by a script relation were supposed to appear in the same routine or event (e.g., dessert) but without belonging to the same taxonomic category (e.g., whipped cream is not a fruit). Note that the script-related items were not necessarily familiar pairs, like bread and butter, but were items that often occurred in the same situation. Unrelated foods such as barbecue meat did not belong to the same superordinate category and did not appear in the same event. (Of course, we are not claiming that foods not in the same script are never eaten together. There is nothing to stop someone from eating strawberries with barbecue meat. However, such items were not both in a familiar script event like dessert or birthday parties.)

The stimuli were assessed by 10 psychology students from the University of Burgundy in France. They were given the entire list of foods and were asked to rate to what extent each food belonged to a food category, either a script category (e.g., dessert) or a taxonomic category (e.g., fruits), on a 1-to-7 scale. We selected foods that received a rating of at least 4 out of 7 in the category they were associated with for each category type, either taxonomic or script. (In Experiment 2, the materials had more stringent requirements; see below.) With these ratings, we then constructed a final set of stimuli (see Table 1). Each item was composed of the target food, a taxonomically related food, a script-related food, and an unrelated food. Because the experiment was run in France, the ratings reflect French food choices and associations. For each food, we selected a picture that clearly represented it.

We also constructed a set of seven biological properties and a set of seven psychological properties that a food was said to have on a puppet. The properties were chosen so that they could be understood by young children. The list of properties is presented in Table 2. For half of the participants, the first half of the food trials in Table 1 were associated with biological properties and the second half with psychological properties. For the other half of the participants, the assignment was reversed, thereby counterbalancing food with property type. Thus, each child had seven biological property trials and seven psychological property trials.

Table 1. Categories tested in experiment 1 (Translated From the French).

Target	Taxonomic	Script	Unrelated
Strawberry	Watermelon	Whipped cream	Barbecue meat
Chocolate	Pancakes	Lollipop	Peas
Melon	Kiwi	Parma ham	Hamburger
Chicken	Sausage	French fries	Muffin
Milk	Cream	Breakfast biscuit	Steak
Fish (trout)	Breaded fish	Rice	Fruit juice
Soft cheese	Yogurt	Bread loaf	Leek
Ice cream	Yogurt	Chocolate bar	Ham
Broccoli	Tomato	Pork chop	Honey
Croissant	Lemon pie	Chocolate spread	Vegetable sticks
Carrot	Artichoke	Fish (sole)	Brioche
Cake	Grapefruit cake	Milkshake	Plum
Gruyere	Cream cheese	Bread	Cereal bar
Pasta	Rusk	Butter	Biscuit

Table 2.

Biological properties
- gives Diddl spots on the stomach
- makes Diddl grow her hair faster
- makes Diddl walk very slowly
- helps Diddl to breathe
- makes Diddl's face itch
- turns Diddl's toes red
- gives Diddl a tummy ache
Psychological properties
- makes Diddl feel happy
- gives Diddl nightmares, bad dreams
- makes Diddl think sad things
- makes Diddl nervous, stressed
- helps Diddl to remember better things she has seen
- makes Diddl smart, clever
- makes Diddl tired, she does not do anything anymore

Table 3. List of Items Used in Experiment 2.

Target	Taxonomic	Script
Strawberry	Coconut	Whipped cream
Cutlet	Roulade	Pasta
Melon	Avocado	Parma ham
Chicken	Sausage	French fries
Glass of milk	Yogurt	Breakfast biscuits
Fish (trout)	Breaded fish	Rice
Soft cheese	Hard cheese	Bread
Ham	Steak	Green beans
Broccoli	Pumpkin	Pork chop
Croissant	Lemon tart	Hot chocolate
Carrot	Asparagus	Fish (sole)
Cake	Cake with prunes	Compote
Gruyere	Yogurt	Bread
Pasta	Rice	Butter

Procedure

During the task, the experimenter showed a puppet (a Diddl, which is very popular in France) and introduced the task: "We are going to talk about foods." The experiment showed the puppet and said,

> Do you know this puppet, Diddl? Let's talk about where she lives and what she eats. The puppet does not live here. She lives very far away, on a big island, with the sea all around. She lives with other puppets like her. There are many puppets who live there. Doctors have seen that when these puppets eat some types of foods, things might happen in their body (it is also the case for us, when we eat some sorts of foods, we can become sick), or change how they feel, what they think (like us, when we eat some sorts of food, we can feel happy).

Then the experimenter explained,

> Now, I will show you types of foods and I will tell you what this food does to the puppet when she eats it. And then, I will show you other foods and, for each of them, you will tell me whether these foods do the same thing as the first food to the puppet. It is important to know what the foods do to the puppet and to the other puppets who live on the same island, because we want to avoid the puppets from becoming ill.

Then children heard, for example, the following:

> Do you see this food [experimenter introducing the picture of one target food, e.g., a picture of a strawberry]? It's a strawberry. It gives Diddl spots on the stomach and other puppets too. Now, look at this watermelon [e.g., showing the picture of a watermelon], do you think it will give Diddl spots on the stomach too? You are the one who decides. You tell me whether you think the watermelon does the same thing as the first food to the puppet.

These instructions were designed to reassure children that they could respond even if they did not in fact know specifically which foods might result in spots on the stomach, or whatever. Some children are reluctant to make inferences at all, so the "you are the one who decides" instruction was meant to encourage them to give an answer rather than saying, "I don't know." The same question was asked for the two other foods (e.g., the picture of whipped cream and the picture of barbecue meat).

Results

We computed the number of "yes" responses to taxonomic, script, and unrelated choices for the biological and psychological property trials. The maximum score for each category choice per trial type was 7. We ran a 3 × 2 × 3 analysis of variance on children's choices, with age (5-year-olds, 6-year-olds, and 9-year-olds) as a between-subjects factor and type of property (psychological or biological) and type of food choice (taxonomic, script, and unrelated) as within-subjects factors. There was a main effect of type of property, $F(1, 35) = 5.38$, $p < .05$, $\eta_p^2 = .13$, with children answering "yes" more often for the psychological property trials than the biological ones (3.1 vs. 2.7, respectively). There was also a main effect of type of food and, more interesting, an interaction between age and type of food: type of food, $F(2, 70) = 31.07$, $p < .001$, $\eta_p^2 = .47$; Age × Type of Food, $F(2, 70) = 12.68$, $p < .001$, $\eta_p^2 = .42$. As shown in Figure 1, 9-year-old children answered "yes" to taxonomic choices more often than the other two age groups and had the smallest number of "yes" responses to unrelated choices (Tukey's honestly significant difference [HSD], $p < .01$). The two other age groups did not discriminate between the three choices (Tukey's HSD, *ps* > .05). The Type of Property × Type of Food interaction and the triple interaction were not significant: Type of Property × Type of Food, $F(2, 70) = 0.41$, $p > .5$; triple interaction, $F(4, 70) = 1.5$, $p > .10$. The sample size was a bit small in the youngest group, but its means were right in the middle of the scale and did not look at all like the results of the oldest group.

Discussion

Q10 The most noteworthy result was the interaction between age and type of food, showing that only 9-year-old children generalized properties to taxonomically related categories more often than to the two other category types (script and unrelated categories). It is interesting that 9-year-olds rarely considered unrelated categories as valid choices. This pattern is consistent with the second hypothesis described earlier, that children distinguish different food categories. It is interesting that these

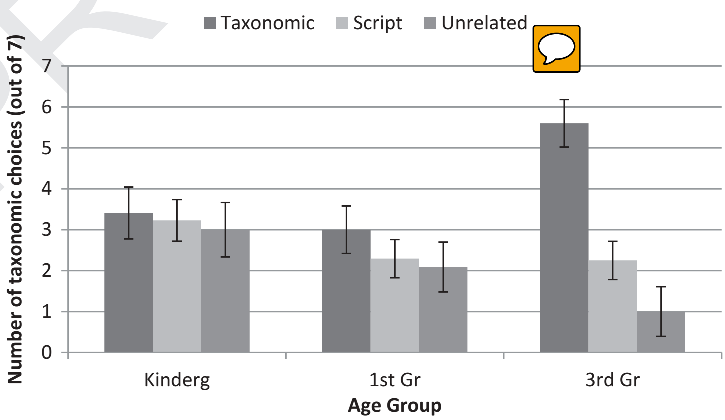

Figure 1. Number of taxonomic choices (out of 7) for each age group for the three types of relations. Error bars show the *SEM*. This interaction shows that third-grade children selected a majority of taxonomically related choices and many fewer script and unrelated choices. The two other age groups did not appear to distinguish the three choices. Kinderg = kindergarten; Gr = grade.

children did not make different choices for psychological and biological properties—both were generalized based on taxonomic categories, perhaps suggesting that 9-year-olds see a biological basis for both kinds of food effects.

By contrast, the two younger age groups selected the three types of food at the same rate. Kindergartners selected the three options essentially at chance (3.5 "yes" out of 7). One interpretation of this result is that young children treated all of the food categories as equivalent. This does not seem to be consistent with the existing literature. For example, Nguyen (2008) found that children treated the evaluative categories of healthy foods as distinct from junky foods, selectively attributing different properties to each type of food. However, evaluative categories are defined around one property: health. The present experiment tested the more general case of script-based categories, which children apparently are less likely to use as a basis for induction, at least for the types of properties we tested. Nguyen and Murphy (2003) found that children generalize situational features to other members of script-based categories. Our data show that neither biological nor psychological properties are strongly generalized on the basis of such categories.

It might be that the yes/no procedure underestimates children's competence. Perhaps it is difficult for them to judge whether a novel category has the same property as the target category because all of the items are foods, and it is difficult to decide at which level of categorization the target property should be generalized (e.g., from strawberries to other berries? To all fruit? To all plant-based foods?). One way to test children's sensitivity to levels of categorization would be to use a forced-choice task, in which they have to choose one food out of two, the first one being taxonomically related and the second one being script related. If the younger children truly do not distinguish the different categories, they should choose them about equally often in the forced-choice task, for both kinds of property. However, if children favor taxonomic relations over script relations as a basis for their inductions, a situation in which they have to explicitly choose between the two options might reveal their preferences. Past research has found evidence of children's inductive selectivity using this forced-choice technique (see Nguyen & Murphy, 2003). Therefore, we used this paradigm in Experiment 2. We also improved the materials in the sense that we more strictly distinguished taxonomically and script-related options.

Experiment 2: Forced choice

Experiment 1 revealed that younger participants did not generalize properties to the taxonomic choice more often than the other two choices. This result suggests that 6-year-olds may consider the different types of classification possibilities as equivalent: Belonging to the same taxonomic or the same script category is sufficient to generalize a food's properties, both psychological and biological. However, in fact, younger children did not generalize the target property strongly to any categories, as shown by the mean percentage of choice, which remained below 3.5 out of 7. One interpretation is that younger children were conservative in positively claiming that a food would have a property that they had never heard of. This could have made it difficult to find differences among the category types.

Another way to study whether children can distinguish between taxonomic and script choices is to provide more constraints on the task. Thus, in Experiment 2, children chose between a taxonomic and a script choice in each induction question. This avoids the conservatism problem, because children are not choosing between "yes" and "no" but between the two foods. We can contrast three hypotheses. First, if children believe that properties should be shared by foods that are closely related in a taxonomy, they will generalize the novel property to taxonomic choices. Second, if they think that foods that are eaten together should share properties, then they will choose the script choice, possibly more for the psychological properties than for the biological properties. Third, if they do not really distinguish between foods, they will generalize the property roughly equally to the taxonomic and script choices. In this experiment, we did not include 8- to 9-year-olds, who already gave a majority of taxonomic choices in Experiment 1. Instead, we also included 4-year-olds because we did not know a priori at what age children would fail to discriminate between taxonomic and script choices.

Method

Participants

French-speaking children were recruited at their school from the same population as Experiment 1. There were 20 four-year-olds (*M* age = 4;9, range = 4;4–5;4), 19 five-year-olds (*M* age = 5;9, range = 5;4–6;0), and 25 six-year-olds (*M* age = 6;4, range = 6;0–7;0).

Materials

We modified and improved the set of foods used in Experiment 1. Again, university students saw pairs of food and had to rate whether they belonged to the same taxonomic categories on a 1-to-7 scale. Students were told that the two foods had to belong to the same immediate superordinate category (e.g., apple and pear belong to the fruit category). In a similar way, all of the pairs were rated in terms of script relationships. Participants were told that the food had to be used in the same routine or event (e.g., strawberry and whipped cream belong to the dessert category and are served together, at least in France).

For the taxonomically related list, we kept pairs of foods that received high ratings on the taxonomic relation and low ratings on the script relation. There were 14 such pairs. Apart from one pair of stimuli, all of the differences between the two scales were beyond 3.3, with a mean difference of 3.8 (i.e., taxonomic ratings were on average 3.8 higher than script ratings for the same pair). The one exception had a difference of 2.8. The ratings for the script-related items were on average 3.7 points higher than the taxonomic rating for the same pair. Apart from one item (difference = 2.2), all of the differences between the two scales were greater than 3. We again selected pictures that clearly illustrated each item.

The biological and psychological properties were the same as in Experiment 1.

Procedure

We used the same procedure as in Experiment 1, except that the yes/no procedure was replaced by a forced-choice procedure in which participants were shown a picture of a food that was associated with a biological or a psychological property. Then they were asked which one of two foods (taxonomic or script) would produce the same effect as the target food. For example, the experimenter told children, “See this food. It is a strawberry [the experimenter shows a picture of a strawberry]. It makes Diddl smart. See these other foods here [the experimenter shows a picture of each of these two foods simultaneously], which one do you think will also make Diddl smart?”

Results

We computed the number of taxonomic choices in the forced-choice task. As in Experiment 1, the maximum score for each trial type was 7. We ran a 3 × 2 analysis of variance on children’s choices, with age (4-, 5-, and 6-year-olds) as a between-subjects factor and type of property (psychological or biological) as a within-subjects factor on the number of taxonomic choices. There was no effect of type of property (biological vs. psychological). However, there was a main effect of age, $F(2, 52) = 23.7$, $p < .0001$, $\eta_p^2 = .22$. Mean taxonomic choices were 5.5 for 6-year-olds, 4.4 for 5-year-olds, and 4.1 for 4-year-olds. Post hoc tests (Tukey’s HSD) showed that the 6-year-olds differed from the two other groups, which did not differ significantly one from the other. There was no interaction between type of property and age, $F(2, 52) < 1$.

For the 6-year-olds, taxonomic selection for both psychological ($M = 5.3$) and biological ($M = 5.6$) properties differed from chance (3.5) by *t* test (*ps* < .001). That is, they chose the taxonomically related food more often than the script-related food. For the 5-year-olds, taxonomic selection for both psychological and biological properties differed from chance (*ps* < .05, with 4.4 for both biological and psychological properties), whereas for 4-year-olds, psychological properties differed statistically from chance (*ps* < .05, $M = 4.3$) but biological properties did not ($p > .05$, $M = 3.9$).

Discussion

In contrast to Experiment 1, this forced-choice experiment showed that 5- and 6-year-old children selected the taxonomic choice over the script choice. Four-year-olds were at chance for biological properties, whereas psychological properties were beyond chance. Although the proportion of taxonomic responses was not very different for the two property types (4.3 vs. 3.9 for psychological vs. biological), it is somewhat surprising that biological properties did not give the stronger taxonomic preference. These results are consistent with previous findings showing, with different tasks, that children know that food can have both biological and psychological effects (Guerin & Thibaut, 2008; Raman, 2014). They are also consistent with the finding in Experiment 1 that younger children do not clearly distinguish the two kinds of properties in their inductions, even with a more sensitive forced-choice task. One might have thought that kindergartners simply did not understand the induction task in Experiment 1. However, the same-aged children did respond selectively to category members when given the questions in a forced-choice format, suggesting that they do understand about induction of properties. More generally, the induction task has been successfully used with children younger than the ones in our study (see Murphy, 2002).

General discussion

In two experiments, we investigated children's induction of biological and psychological properties toward taxonomically and script-related categories. The main question was whether young children would distinguish these two types of categories, and at what age. Another question was whether the two types of properties would be generalized in the same way.

Experiment 1, a yes/no task, showed that the two younger groups generalized properties equally often to taxonomic, script, and unrelated choices. Older children favored taxonomic categories. Using a different test, Experiment 2 showed that even kindergartners preferred taxonomic over script choices. This was true for both psychological and biological properties, although 4-year-olds chose taxonomically related foods above chance for psychological properties only. In sum, children chose taxonomically related foods for induction, starting at age 4 years for the psychological properties and at 5 years for the biological properties.

How can we account for the differences between the results of the two experiments? In Experiment 1, each food was assessed independently, one by one. Thus, participants were not required to compare the foods against each other to find one that would be more plausible. By definition all of the choices were foods and thus taxonomically related to the target food at some level, so perhaps children did not think very carefully about their particular relation to the target. Furthermore, it is possible that children were reluctant to positively assert that a food had an unfamiliar property, thereby lowering their overall induction rate. In Experiment 2, children always chose one food over the other, and so this conservatism would not operate. In this context, children preferred taxonomic choices over script choices. Finally, the items were more strictly selected in Experiment 2, and the stronger taxonomic relations may have exerted a stronger effect than in Experiment 1.

A priori, one could have hypothesized that children would judge foods belonging to the same meal or dish (whipped cream with strawberries) to share the same properties, especially for psychological properties. Although it seems clear from previous studies that children of these ages do have script-based categories (Nguyen & Murphy, 2003), they apparently are not a strong basis for induction of the effects of eating food. This may be helpful from a practical standpoint, as nutrition instruction may not have to overcome biases such as children thinking that all breakfast foods have protein or all birthday foods are bad for you.

How do these results relate to those of previous studies? The present research shows that even preschoolers can successfully extend a property to specific, taxonomically related categories. Guerin and Thibaut (2008) and Raman (2014) found a different pattern of results, but with different tasks.

Guerin and Thibaut showed that psychological properties were less distinctively associated with specific categories of foods. For example, they asked kindergartners and first-grade children whether increasing the consumption of different types of food (fruits, vegetables, dairy, meats) would change puppets' psychological and biological properties. Results revealed no difference between foods for psychological properties, although children mentioned that fruits could affect biological properties (health). Raman found that preschool children attributed the same number of positive and negative psychological properties to healthy and unhealthy foods. Possibly the present task was easier than those tasks. In those studies, participants had to assess whether a type of food could influence puppets. This required referring to explicit biological knowledge about the nature or the mechanism underlying this influence. In Experiment 2, by contrast, they had to decide to which type of category they should extend a property but not how this property works.

Previous research has also shown that 4-year-olds can sort foods into healthy and junky foods (Nguyen, 2007). In an induction task similar to ours, Nguyen (2008) showed that 4-year-olds generalized a fictitious property (e.g., "makes Jim's body daxy") given to a healthy food such as an apple to another healthy food rather than to a junk food. The main difference with our research is that Nguyen's foods were restricted to a conflict between two specific categories, healthy versus junk food, and to fictitious properties. Because the properties had no reference, the question of their type (psychological or biological) was moot. By contrast, we contrasted two general types of food categories (script or taxonomic) that participants could not reduce to any specific property (such as healthy vs. unhealthy), and the properties were unfamiliar but understandable reactions to eating the food. We also found that both psychological and biological properties were generalized in the same way.

Nguyen and Murphy (2003) also used a forced-choice inductive inference task in which participants were asked to choose whether a script or a taxonomically related choice had the same property as a target food (Experiment 5). They found that 4-year-olds chose the taxonomically related food less than chance for both biochemical properties (e.g., "bread has pary in it") and situational properties (e.g., "cake is eaten on a special holiday called *dax*"), whereas 7-year-olds and adults were selective in that they made taxonomic choices for biochemical properties and script choices for situational properties. Our study examined whether children would similarly infer biological and psychological reactions to eating taxonomically or script-related foods. The results showed that both types of property were extended to taxonomically related foods. In the Nguyen and Murphy study, situational properties were specifically matched to script-based categories in that both referred to contexts in which foods are encountered. Children may well be correct in thinking that if one kind of meat causes a psychological reaction, then another kind of meat might also. If eating cereal in the morning makes you depressed, it does not necessarily follow that eating bacon will have the same reaction. Overall, it seems that children more easily associate taxonomic categories to differences in food that are intrinsic, whether biological or psychological, consistent with theorizing about taxonomic categories more generally (Ross & Murphy, 1999).

Finally, even though a comparison of the two experiments was not an a priori goal of this research, it is interesting to note that children's choices were more evenly spread among the available options (including unrelated choices) in the first experiment than in the second experiment. This might mean that when participants have to choose between two foods, the comparison between the two leads to deeper encoding, which favors taxonomic choices. The positive effect of comparison has been widely demonstrated and has been shown to favor taxonomic choices over other encodings (perceptual or thematic; Augier & Thibaut, 2013; Gentner & Namy, 1999; Thibaut & Witt, 2015). Comparisons are useful in that the alignable differences between the items being compared are highlighted and more readily identified (Markman & Gentner, 1993). In this respect, the yes/no paradigm in which each food is evaluated by itself is less constraining and so might not lead children to think of the relevant properties.

This methodological difference has educational consequences. It suggests that when one wants children to learn properties of types of foods, a comparison format might be more efficient than a no-comparison format. Asking children to compare a dessert to a salad may cause them to attend to the salient differences between them, which would not at all be considered if they simply thought about one alone. Our second experiment shows that children between 4 and 5 are able to understand that related foods might share the same consequences. At about the same age, children using the same forced-choice format are able to treat foods that are defined by a salient property (healthy) as an homogeneous category (Nguyen, 2008). As shown by all of these studies, formats that explicitly encourage comparisons between foods might promote the emergence of conceptually salient dimensions.

In addition to highlighting differences, comparison can help children learn commonalities of category members. One way to enhance taxonomically based generalizations in children would be to show pairs or triplets of taxonomically related foods (as in Namy & Gentner, 2002, or Thibaut & Witt, 2015) about which one wishes to teach a property (chemical, biological, health, etc.), such as "These ones are poisonous" or "These have sugar inside" or "These ones give people headaches." The comparison story suggests that once the subset is attributed a target property, young children will compare the items and will be more efficient in generalizing the target property to taxonomically related items than in the case of a single item (Namy & Gentner, 2002). As pointed out by Thibaut and Witt (2015), the optimal number of items involved in the comparison is an empirical question. In a similar way, the role of contrasting items (e.g., "This one is daxy but this one is not daxy") is also an empirical question. Augier and Thibaut (2013) showed that contrasting items could disrupt younger children's learning and generalization, whereas it could contribute to better generalization for older children. As a general principle, comparison can be helpful, but one must take care in how it is implemented.

Finally, both Experiments 1 and 2 suggest that children have a general preference for using taxonomic categories in induction, as adults often do (see Ross & Murphy, 1999). This is probably a good thing for educational purposes, given that most benefits and problems associated with foods are based on their chemical composition, which in turn is most related to their taxonomic categories. For example, our children did not seem tempted to say that if strawberries had a given effect, that whipped cream, often consumed with the strawberries, would have the same effect. If confirmed, this finding suggests that nutritional education has a natural basis in children's category-based induction even before the elementary school years.

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