Examining Biological Explanations in Chinese Preschool Children: A Cross-Cultural Comparison

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Abstract
Research with American preschool children has shown that in some core domains – such as naïve biological reasoning – young children's explanations can sensitively reveal their understanding, at times more sensitively than do their predictions and judgments. However, little is known about children's explanatory reasoning in cultural contexts outside the U.S. The present study examined Chinese preschool children’s (N=26) explanations for contamination and illness, as well as comparing their performance on parallel explanations and prediction tasks. In addition, their explanations and prediction were directly compared to those from American children (N=36) who responded to parallel and strictly comparable items. Chinese children provided both biological contamination and culturally-specific explanations that referred to unseen mechanisms and processes. Moreover, their explanations were as accurate as their predictions and compared favorably to performance by American children, providing evidence for sophisticated explanatory reasoning among Chinese children as well as cultural similarities and differences in early biological reasoning.

Keywords
Naïve biology, Chinese children, cross-cultural comparison, contamination understanding, children's explanations, children's predictions

Introduction
Young children’s biological reasoning – their naïve biology – has been the source of many recent studies in the U.S. (Wellman et al., 1997; Keil et al., 1999; Siegal and Peterson, 1999) and in East Asia (Au and Romo, 1999; Inagaki and Hatano, 2002, 2004; Au et al., 2008). Although most classic research on the development of biological reasoning with young children has focused on judgment tasks that ask for predictions (Rozin et al., 1985; Siegal and Share, 1990;
Kalish, 1999), emerging research on children’s biological explanations in particular (Au et al., 2008; Legare et al., 2009), and research on the development of explanation in early childhood in general provides compelling evidence that children’s explanations deserve a more important place in the study of cognitive development (Wellman, 2011). Our research focuses on young children’s emerging biological reasoning with special emphasis on their explanations and examines the extent to which insights about early explanatory understanding can be generalized across diverse cultural contexts.

For middle-class populations in Western Europe and North America, engaging in explanatory activity is a fundamental childhood experience; children frequently seek and provide explanations (Hood and Bloom, 1979; Callanan and Oakes, 1992; Hickling and Wellman, 2001). Indeed there is evidence that for these children, explanations may be developmentally privileged. Several studies indicate that explanations may sometimes be strikingly easier for children to provide than comparable judgments and predictions (Amsterlaw and Wellman, 2006; Legare et al., 2009). Additionally, there is now considerable evidence that explanation plays an important role in guiding the process of knowledge acquisition (Legare et al., 2010; Legare, 2012) and has important benefits for learning (Chi et al., 1994; Crowley and Siegler, 1999). Thus, explanations not only provide a window into conceptual understanding (Wellman and Liu, 2007; Wellman, 2011), they can guide the learning process.

The early-emerging interest in and facility with explanation that young children can evidence in appropriate situations is fortunate because in principle, when children provide coherent explanations, this provides a deeper look into their conceptual knowledge than predictions alone. This is because cogent explanations reveal the reasoning that characterizes children’s knowledge systems (and that influences their judgments and predictions about various phenomena). For young children, however, surprisingly little research has examined explanations, favoring instead predictions and judgments. (Wellman, 2011). Given the promise understanding explanation has to provide insight into conceptual development, more research examining children’s explanations is warranted. In particular, cross-cultural research seems essential for increasing our understanding, because little is known about the extent to which the early-developing proclivity for explanation now being found in American preschoolers is representative of diverse cultural contexts or is instead a function of particular American socialization experiences and cultural input.

We address the question of cultural communality and variability in the development of explanation by focusing on a context where the early childhood experience concerning explanation may be quite different than in North American cultural communities, namely, China. Explanation-centered interactions are frequent between Western children and their caretakers (Callanan
and Oakes, 1992; Wellman et al., 1997). Middle-class English-speaking children in the U.S. are asked “how” and “why” questions frequently, and in turn frequently ask “why” questions about a wide array of different phenomena (Calkin and Oakes, 1992; Hickling and Wellman, 2001). Perhaps because these children are frequently asked to generate explanations, they use explicit causal connective words (e.g., because, why, so) at a young age (Hood and Bloom, 1979). However, such experiences may not be representative globally. In particular, the development of explanation across early childhood in China may differ from Western contexts due to differences in linguistic input and socialization. Chinese children are argued to be delayed in the acquisition of “why” questions (relative to American children) and Miao (1986) claimed this “delay” can be explained by the fact that Chinese caretakers simply do not ask Chinese children many “why” questions, nor do they promote the child asking many such questions. Indeed, other research (Tardif et al., 1997) has found that Chinese caretakers provide far fewer justifications and explanations when disputing with their toddlers than do U.S. or British caretakers. The Chinese education system has been criticized within China as relying exclusively on the transmission of knowledge for children to remember and recite, without explanations, leading to recent calls to instead provide “education for all-around development” (Gao and Guo, 2008). Moreover, although Chinese languages have causal structures and connectives available to speak and ask about causation just as English does, Chinese speakers typically do not express such causal connectives explicitly (Li and Thompson, 1981; Gelman and Tardif, 1998). Conceivably this also might make causal explanations a less salient part of young Chinese children’s experiences. In spite of such differences, however, it is also possible that preschool children’s proclivity for explanation may be a robust feature of early knowledge acquisition and thus may not differ substantially cross-culturally, regardless of differences in cultural or linguistic context and input.

To examine early explanation (and contrastingly predictions) in Chinese children, we focused on their understanding of illness and contamination. There are several reasons for this focus. First, children’s understanding of contamination and illness constitutes a core component of biological reasoning. Second and relatedly, children’s reasoning about contamination and illness could be an especially informative domain for exploring children’s causal understandings including, in particular, their explanations, because biological reasoning often requires the recruitment of unobservable entities and processes (such as germs or toxins) to predict and explain more overt phenomena. Lay contamination understanding exemplifies this sort of reasoning: adults report that contact with a contaminating substance causes food or beverage to become undesirable and offensive (Fallon et al., 1984), even if the
contaminating substance is not toxic and leaves only an imperceptible physical trace. Thus, contamination provides a forum where children can potentially provide rich biological explanations based on unobservable as well as observable causal factors. Further, naïve biological reasoning about contamination provides an equally good content area in which to compare cultural differences. Although the specific kind of substance, process, or contact considered contaminating is likely to vary across different cultural contexts, sensitivity to contamination is probably universal (Rozin et al., 1985; Hejmadi et al., 2004; Raman and Gelman, 2004). Similarly, illness is a human universal, although the ways in which particular cultural communities explain, treat, and prevent ill health is deeply shaped by their worldview, particular belief systems, and valued cultural activities (Rozin, 1996). Yet, there is a dearth of comprehensive cultural studies of illness and contamination understanding in childhood in non-Western cultural contexts (but see Inagaki and Hatano, 2002, 2004, 2006 for research with Japanese children).

Finally, Legare and colleagues (2009) recently examined U.S. preschoolers’ reasoning about contamination and illness using parallel explanation and prediction tasks. Preschoolers and adults heard vignettes concerning contamination, and were asked either to make a prediction or to provide an explanation. Even 3-year-olds readily supplied contamination-based explanations, and most children mentioned an unseen mechanism (e.g., germs, contact through bodily fluids). Unlike adults who performed at ceiling across both explanation and prediction tasks, children were significantly more accurate with their explanations for contamination and illness events than their predictions for the same events. We designed our research with Chinese children to closely parallel that of Legare et al. (2009). If Chinese preschool children’s explanations are as precocious, early-developing, and similarly revealing as those of U.S. children this would confirm the importance of children’s early explanations in the conceptual development more widely. In the absence of research of this kind, whether young children offer cogent explanations and the extent to which young children’s explanations actually reveal insightful information about underlying processes and mechanisms in samples and contexts beyond those of advantaged U.S. preschoolers remains an open question.

**Current Study**

The current study investigated Chinese preschool children using explanation and prediction tasks to elicit biological understandings in young children for characters confronted with contaminated foods and beverages. We anticipated that Chinese preschool children’s explanations would be particularly revealing
of their biological understanding, and this could be determined in part by careful coding of those explanations and in part by comparing their explanations versus predictions for virtually identical phenomena.

To achieve our aims we need to be attuned to the possible sorts of explanations children might provide. Thus, in addition to the types of biological explanations U.S. children provided in Legare et al. (2009), we considered explanations and understandings more specific and appropriate to Chinese understandings and practices. In Chinese traditional medicine, energy (qi) is viewed as the source of life, matter is the material manifestation of energy, and health is the product of sufficient accumulation and flow of energy in the body. This concept is consistent with research done with Japanese preschoolers indicating an early-developing awareness for biological factors in illness and a belief that the biological world is based on “vitalistic causality” or a “vital power or life force taken from food and water that makes humans active, prevents them from being taken ill, and enables them to grow” (Inagaki and Hatano, 2004, p. 356). For East Asian children and adults, food is seen as the major source of energy that one absorbs every day, and thus the proper selection of foods becomes a salient method for manipulating energy and consequently increasing one’s level of health.

In China, specifically, different foods are believed to have different energy properties; there are qualitative distinctions of body energy based on a ‘hot’/‘cold’ polarized scale. External factors like the weather, material objects like food, and emotional experiences like anger (‘hot’) are all classified according to these polarized, temperature-based qualities (Koo, 1984). In Chinese medicine, this is related to the balance of Yin and Yang which is believed to be very important for maintaining health. The body is believed to contain a balance of hot and cold forces. If body energy is in balance, then extremes of excess ‘hot’/‘cold’ are not apparent. But when body energy equilibrium is disrupted, due to imbalances in a person’s diet or daily routine, one is at risk of becoming ill. Factors that may disrupt the balance specifically include forms of “qi” encompassing “wind”, “chillness”, “heat”, “dryness”, “dampness” and “fire” (Zhu et al., 2009). Ingestion of various foods in particular can provide “heat” and “chillness” and so culturally prescribed practices for maintaining body homeostasis by selecting and preparing food (and thereby preventing and treating illness) are widespread in China (Koo, 1984).

In short, knowledge of food restrictions and prohibitions mandating avoiding excess hot and cold qualities of the body energy (temperature) ascribed to food is prevalent among lay Chinese populations. Moreover, in Chinese society, these considerations are more than just folk traditions; Chinese traditional medicine encompasses an influential and frequently consulted formal
system of experts and institutions (Guo, 2000). Given this context, Chinese children might be especially inclined to consider and reason about “hot” and “cold” properties of food, bodies, and experiences. And because our situations involved food or substances that the characters ingest, they might prove particularly ripe for explanation in terms of temperature or even qi (energy).

Method

Overview

We included tasks in which children had the opportunity to respond to contamination events leading to illness (illness vignettes) as well as to contamination events leading a novel character to choose to consume or avoid consuming a contaminated food (behavior vignettes). As outlined in the Introduction, illness was our special focus, with the behavior vignettes providing a basis for comparison. Behavioral avoidance has been often tested in contamination studies (Rozin et al., 1985; Siegal and Share, 1990) and including it allows us to extend the generality of our findings by comparing and contrasting behavioral choice with illness. For similar reasons, Legare et al. (2009) included both illness and behavior vignettes, so including both measures further insures our methods closely parallel those of that study allowing us to compare findings across Chinese and U.S. samples of children.

Children responded to the same events either by predicting what the character(s) would do or by explaining what occurred. We were especially interested in explanations, but this prediction versus explanation contrast is also important. Because most studies use only prediction, prediction data allow more detailed comparison between our findings and others, and additionally prediction provides an important baseline against which to best understand children’s explanations. For example, in cases where explanations are as accurate as predictions, children’s explanations could prove more richly informative than predictions by motivating children to articulate their causal reasoning more comprehensively and with greater complexity, a topic we will return to in the discussion. We tested 4-year-olds, again to closely parallel Legare et al. (2009) and because early evidence for (and against) childhood biological understanding has focused primarily on preschoolers.

Participants

Twenty-six preschoolers (mean age 4 years, 9 months; range 4 years, 6 months to 5 years, 0 months) participated in this study, 16 males and 13 females, and were recruited from a preschool in Beijing, China.
**Materials**

Materials consisted of 8 pairs of pictures (see Figs A1 and A2); 3 pairs of beverages and 5 pairs of foods. Legare et al. (2009) used 4 beverages and 4 foods, but to keep our items as similar as possible to theirs yet also use instances familiar to Chinese children, one pair of items that were beverages in the US were better presented as foods in China. Items chosen were all edible (e.g., beverages: milk, juice; solid food; cookies, grapes). Beginning with the items used by Legare and colleagues (2009), several were adjusted to include flavors and varieties of similar items familiar to children in China (e.g., a cream cookie instead of an oatmeal cookie, lemon candy instead of raspberry candy). In addition, drawings and depictions of all foods were adjusted to be maximally familiar to Chinese preschoolers.

![Figure A1. Pictures of foods and beverages that accompanied the vignettes. This figure is published in colour in the online edition of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/15685373.](image-url)
Figure A2. Pictures of contaminants that accompanied the vignettes. This figure is published in colour in the online edition of this journal, which can be accessed via http://booksandjournals.brillonline.com/content/15685373.

These items are all shown in Fig. A1. As clear there, items in each pair were matched for size and shape and differed only in type of beverage or food. Four pictures of contaminants were used as shown in Fig. A2: a dog, a fly, a leaf, and the ground below an outdoor table. The same contaminants were used in Legare et al. (2009) with one exception: a fly was used instead of a grasshopper to include an insect familiar to urban Chinese children. The stimuli were selected specifically because they are contaminating but not strongly disgusting and thus permit us to assess beliefs about illness and contamination (and not strictly associational disgust). Several of these contamination events have been used in prior research with children (Rozin et al., 1985; Siegal and Share, 1990). Each participant saw all 8 pairs of foods and beverages once each and the four contaminants twice each, once for the explanation condition and once for the prediction condition.

**Procedure**

Each participant was tested in Mandarin (their native language) and responded to 4 prediction vignettes (the prediction task) and 4 explanation vignettes (the explanation task) – half received explanation first, half received prediction first. Chinese informants adjusted the items and protocols used by Legare
et al. (2009) to include names and objects familiar to Chinese children. Then the scripts were translated into Chinese, edited by native-language Chinese speakers who conduct research with children in China to be easily understood and child-friendly for Chinese children. The scripts were then back-translated into English and, in an iterative process, perfected by bilingual child-researchers one who was native to the U.S. and one native to China.

Within the explanation or prediction blocks there were two behavior vignettes and two illness vignettes. The behavior and illness vignettes were paired (e.g., for a given participant, if illness vignettes came first in the explanation task, they also came first in the prediction task) and randomized within blocks of 4 explanation and 4 prediction questions.

Contamination events for any beverage or food occurred in one of four ways: a fly flew in and then flew out, a dog licked it, a leaf blew into it and was taken out, or it fell on the ground and was picked up again. In order to make the tasks as comparable as possible, the prediction tasks paralleled the explanation tasks precisely, as shown in the following comparison.

**Illness Explanation.** There are two boys, one named Tongtong, one named Nan-nan. They are sitting outside eating. Tongtong has a box of milk ice cream, Nannan has a box of strawberry ice cream. A fly lands in Tongtong's ice cream. It flies away after a minute. An old brown leaf blows next to Nannan's strawberry ice cream. Then the leaf blows away. Tongtong eats the milk ice cream, Nannan eats the strawberry ice cream. Who eats the milk ice cream? Who eats the strawberry ice cream? The next day, Tongtong gets sick. Why do you think Tongtong got sick? Are there other reasons?

**Illness Prediction.** There are two boys, one named Dongdong, one named Lele. They are sitting outside eating. Dongdong has a lemon candy, Lele has a strawberry candy. A fly comes by, looks at Dongdong's lemon candy, then goes away. A dog comes by and licks Lele's strawberry candy, then runs away. Dongdong eats the lemon candy, Lele eats the strawberry candy. Who eats the lemon candy? Who eats the strawberry candy? The next day someone gets sick. Who do you think gets sick? Who do you think gets sick?

The two vignettes provide the same information except that for the prediction vignette the outcome was not specified and the child was asked to make a prediction. Notably, each food or beverage in the pair had something happen to them, a contamination action or a proximate non-contaminating action. The event (contamination or non-contamination) that was mentioned first was counterbalanced across illness vignettes. In both illness explanation and illness prediction questions, participants were told that illness took place; children were asked who got sick, not whether someone got sick.
Behavior vignettes focused on behavioral choice rather than becoming sick. In these vignettes there was a single character who had one preferred option and one well-liked, but less preferred option to choose from. Options got contaminated (and the contaminant removed) in the same ways as in the illness vignettes. For example:

Pingping is sitting outside. Mom brings a glass of chocolate milk and a glass of plain milk. It is windy outside and an old brown leaf blows into the glass of chocolate milk. Pingping takes the leaf out. Pingping can drink the chocolate milk; she can also drink the plain milk. Which one should Pingping drink, the chocolate milk or the plain milk?

In the behavior prediction questions participants were asked which of the items the character should eat (as opposed to which of the items the character will eat) to clarify that the question refers to a normative choice rather than an individual’s preference or idiosyncratic criterion for what counts as “too dirty”. For the behavior explanation tasks, the character explicitly chose the less-preferred (uncontaminated) option and participants were asked to provide an explanation for this choice. Explanatory prompts were used following the initial explanation question (“Why is that?” and “Can you tell me more about that?”). These prompts were kept to a minimum and included no additional information from the experimenter. Appendix A lists all vignettes used in the study.

Hotness or coldness (“temperature”) of the foods or the weather was deliberately not mentioned in any vignette, but the consumables varied in several ways including their potential temperature (e.g., ice cream, or yogurt – which is kept under refrigeration). This variation meant Chinese children had ample opportunity to mention temperature as an important illness factor if it was important to them, but we did not prompt for that sort of response directly.

Transcribing and Coding

Child interviews were audiotaped and transcribed verbatim in Chinese (in Chinese characters by the examiners that conducted the testing). Then a multi-step process, similar to that used to create the materials, was used to translate children’s answers to English so that coding could be conducted and monitored both by Chinese and English-speaking researchers. In essence, the answers were first translated by bilingual Chinese researchers into English and then separately translated by a fluent Chinese-English translator with exchanges back and forth between researchers and translator to obtain clear, faithful translations of children’s answers.
Explanations were coded into six categories: restatement, contamination, temperature, other-bodily, psychological, and miscellaneous. Restatements indicated that the participant answered the explanation question by merely restating the story events (e.g., when asked why a character got sick, responding “because a bug fell in her glass” or “because it fell on the ground”).

We were especially interested in contamination and temperature explanations (exemplified in Table 1) and indeed these were by far the two most frequent explanations provided. Explanations were coded as contamination if they referred to any of the following: mechanisms involving the transfer of contaminating substances, germs, transfer of bodily fluids, or disgust, and having to go to the doctor or getting sick. Mention of getting sick only qualified as a contamination explanation for behavior vignettes; in the illness condition, because illness was explicitly mentioned, simply mentioning illness was coded as a restatement. Contamination explanations were further examined to identify a subcategory that explicitly provided a mechanism, such as the transfer of fluids, substances, or germs. These explanations, termed contamination mechanism explanations, introduced elements (e.g., germs, slobber) that were never mentioned or depicted in the vignettes. The amount of information provided in contamination mechanism explanations was quantified by coding for the number of pieces of information provided. Table 2 outlines this additional coding along with illustrative examples of contamination mechanism explanations from these children.

Explanations were coded as temperature if the participant indicated excess temperature caused the problem or influenced the decision (e.g. “It is too cold, and he will get sick if he ate something cold in winter” or “It was cold of the yogurt because it was put in the refrigerator. And the yogurt was blew cool by the wind”). Temperature explanations were further examined to identify those that most clearly cited causal sequences where cold (or heat) were not merely cited as a relevant factor, but were elaborated further in more extended causal explanations. For example, “Because he ate ice cream. Ice cream is too cold. [Things] too cold will cause sickness and tummy ache”.

Explanations were coded as other-bodily if they referred to bodily processes that did not include contamination or temperature (e.g., “He ate too much, and the bowl of milk ice cream is bigger, the strawberry ice cream is smaller”; Table 1). Because such explanations could be biological or psychological (e.g., perhaps a young child believes eating too much sugar is morally rather than biologically “bad”), we were careful to separate them from those that unambiguously evidenced contamination.

Psychological explanations discussed only the characters’ desires, preferences or potentially their perception or knowledge (seeing or not-seeing
Table 1

Explanation Types with Examples

<table>
<thead>
<tr>
<th>Type</th>
<th>Example</th>
</tr>
</thead>
</table>
| Contamination | “The leaf on the ground was dirty and when it fell into it, germs are left inside".  
                “Germs are spread by the fly. Germs are most dirty. He drank germs into the tummy”.  
                “The fly has poison. Fell inside will poison. The fly has germs. If [it is] eaten, germs will get into the tummy.”  
                “The fly flies inside [the glass]. The fly is very dirty. [It] makes people get epidemic diseases. It [the fly] puts toxin gas inside”.  
                “The thing he drank has the leaf in it. Because dirty things on the leaf will spread dirty things in the glass like the bird stuff”. |
| Temperature   | “The yogurt [he] drinks is too cold. It should be placed [in room temperature] for a while before drinking. Do not drink [things] that are too cold, and do not eat cold [things] as well. Both of them illness and will cause coughing”.  
                “Eating ice cream is too cold. Cold will cause sickness, will cause coughing”.  
                “It is too cold, and he will get sick if he ate something cold in winter”.  
                “The strawberry yogurt is too cold. Cold causes illness”. |
| Other-bodily  | “He ate too much, and the bowl of milk ice cream is bigger, the strawberry ice cream is smaller”.  
                “If you eat one more box (of ice cream), you will get diarrhea”.  
                “He drinks too much yogurt, and starts to be sick”.  
                “He ate too many ice creams”. |
| Psychological | “He would like to have a taste of grapes”.  
                “The apple juice is delicious, he likes to drink it now”.  
                “He wants to try apple juice”.  
                “The lollipop has many colors. He wants to try the grapes’ taste to see whether they are sour or sweet”. |
Table 2
Analysis of Explanations in Terms of Causal “Pieces”

<table>
<thead>
<tr>
<th>Pieces</th>
<th>Explanation</th>
<th>Type of Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>The leaf has blown into the yogurt.</td>
<td>Restatement of information provided in the vignette.</td>
</tr>
<tr>
<td>1</td>
<td>Germs [1] get into his bowl. There is dirty dirt [1] in the yogurt.</td>
<td>Child supplies novel information relevant to contamination, information not provided in the vignette (i.e., “germs”, “dirt”).</td>
</tr>
<tr>
<td>2</td>
<td>The leaf is too dirty [1]. The germs [2] all go to his stomach. The fly lays fly babies inside [the yogurt][1]. Fly babies are also dirty[2].</td>
<td>Child supplies two pieces of additional novel information relevant to contamination, information not provided in the vignette, often indicating method of transmission.</td>
</tr>
<tr>
<td>3 or more</td>
<td>The leaf is very dirty [1]. It fell on the ground [2], very dirty. Do not eat leaves. Leaf is dirty. It is poisonous [3]. Do not eat poison. The fly is very dirty [1] so the ice cream becomes dirty [2]. Dirty things cannot be eaten into the tummy. The tummy cannot bear [things] so dirty without getting sick [3].</td>
<td>Child supplies at least three pieces of additional novel information relevant to contamination, information not provided in the vignette, often indicating a coherent causal link of transmission.</td>
</tr>
</tbody>
</table>

an event; Table 1). In fact almost all such explanations focused on changing preference or desire (e.g., “He would like to have a taste of grapes” or “The apple juice is delicious, he likes to drink it now”).

All other responses were coded as miscellaneous (e.g., if children indicated that they did not know why). Explanations that included both restatement and contamination were only coded as contamination explanations. Otherwise, if explanations included a combination of explanation types (e.g., psychological, other-bodily, and contamination), explanations were coded for both.

For the prediction tasks, for behavior prediction vignettes, responses were coded as correct if the participant predicted that the character should choose the less-preferred, non-contaminated option. For illness prediction vignettes, responses were coded as correct if the participant predicted that the character
who ate the contaminated option would get sick. Note that the correct prediction for the behavior vignettes (choice of the non-contaminated option) is the opposite of the correct prediction for the illness vignettes (contaminated option).

Results

Data from children’s explanations will be presented first, followed by data from children’s predictions and a comparison of explanation and prediction data. Finally, data from Chinese preschool children’s explanations and predictions will be compared to data from American preschool children.

Explanations

Chinese preschoolers freely provided several difference kinds of explanations for the outcomes in the explanation vignettes, depicted graphically in Fig. 1. Children’s mention of contamination explanations (M=2.5 out of 4, SD=1.5) vastly outnumbered their psychological explanations (M=0.88 out of 4, SD=0.91), t(25)=3.89, p<0.001. This was true for both illness and behavior vignettes. Psychological explanations were given only for the behavior vignettes – illness vignettes were never explained in terms of the character’s desires and preferences – but more contamination than psychological explanations were offered even for behavior vignettes. Restatements were never provided for either behavior or illness vignettes.

Contamination Explanations

Contamination explanations often included contamination mechanisms. The transmission of germs, disgusting substances, contaminating substances, and dirty substances were all examples of the kinds of contamination mechanisms described by children. Children mentioned such mechanisms in over 48% of their total responses; 88% of children provided at least one contamination mechanism explanation. We further coded contamination explanations for the number of new “pieces” of causally relevant information, not stated in the vignette, that the child provided, as outlined in Table 2. By definition all biological contamination explanations include at least one new, relevant piece above and beyond a restatement. However, many children often offered multiple pieces of causal information, linked together in a larger explanation. Of the contamination mechanism explanations, 58% included two new
pieces of causal information and 32% included 3 or more new pieces of causal information. Seventy-three percent of children provided at least one contamination mechanism explanation with 2 pieces of causal information.

**Temperature Explanations.** Temperature explanations were especially prevalent for foods or beverages served cold. For example, children most frequently provided temperature explanations for the illness explanation vignette that described two different kinds of ice cream (\(M=0.42\) out of 1, SD=0.50) and two kinds of refrigerated yogurt (\(M=0.19\) out of 1, SD=0.40). However, as shown in Fig. 1, contamination explanations were given far more frequently overall (\(M=2.5\) out of 4, SD=1.5) than temperature explanations (\(M=0.62\) out of 4, SD=0.80), \(t(25)=4.65, p<0.001\).

To better describe children’s temperature explanations, we coded for the presence of causal information. For example, “The yogurt [he] drinks is too
cold. It should be placed [at room temperature] for a while before drinking. Do not drink [things] that are too cold, and do not eat cold [things] as well. Both of them will cause coughing and illness,” includes several causal statements linking temperature and illness. As does: “It is too cold. If you eat something too cold in winter you will get sick”. There were fewer temperature (M=0.62 out of 4) than contamination (M=2.5 out of 4) explanations overall, nonetheless, 47% of temperature explanations included extended causal information. Many, but not all, of these explanations included explicit causal language. For example, “Eating ice cream is too cold. Cold will cause sickness, will cause coughing” and “Because he ate ice cream. Ice cream is too cold. [Things] too cold will cause sickness and tummy ache”.

Inter-rater reliability was established using a randomly selected sample of 25% of the data. Two persons independently coded the reliability sample with 94% agreement. Reliability was calculated for all explanatory coding categories, with Kappas ranging from 0.81 to 0.93. All of the Kappas for this coding fall within near perfect (0.81 and above) levels.

Predictions

Children’s predictions were also informative. We counted predictions that were consistent with contamination understanding (the girl who drinks the contaminated juice will get sick) as correct. In previous research with American children, preschoolers are typically at chance in making contamination judgments or predictions. To assess performance on the prediction tasks, summary accuracy scores were calculated separately for the illness (M=1.27, SD=0.72) and behavior (M=1.19, SD=0.94) prediction vignettes (out of 2 each). Performance on both the illness and behavior prediction vignettes were at chance, (t(25)=1.90, ns; (t(25)=1.04, ns, respectively), replicating the chance level performance by 4-year-olds in the research of Legare et al. 2009 (M=2.33 out of 4, t(23)=1.36, ns).

Comparing Performance on Explanation and Prediction Tasks

Children’s predictions set a baseline for further considering their explanations, and for comparing explanations with predictions as well. One informative way to compare explanations and predictions is in terms of their accuracy – whether children’s choice and reasoning indicates the “correct” options among the two items or protagonist, where “correct” means in accord with common adult intuitions about contamination and illness. In this sense not only predictions but also explanations can be considered as correct or not. For this analysis, we counted as correct explanations that provided a biological or medical explanation of the effect of the contaminant on illness or behavior-choice. Because
temperature explanations would be correct in the Chinese ethno-medical context, to begin with, we considered both cogent contamination and temperature explanations as correct. A task (explanation vs. prediction) × vignette (behavior vs. illness) repeated measures ANOVA yielded a significant main effect for task, \( F(1,25)=4.38, p<0.05 \), indicating that overall performance was higher for explanation questions (\( M=3.08 \) out of 4) than for prediction questions (\( M=2.46 \) out of 4). There was also a significant main effect for vignette, \( F(1,25)=6.81, p<0.05 \); performance was more accurate on the illness vignettes (collapsing across explanation and prediction) than on the behavior vignettes. Moreover, the task × vignette interaction was marginally significant, \( F(1,25)=2.64, p<0.09 \), which, along with our a priori focus on illness, underwrites examination of the illness and behavior vignettes separately.

Two repeated measures ANOVAs examined the number of correct responses on explanation and prediction tasks separately by vignette type (behavior vs. illness). For the illness vignettes there was a significant main effect for task, \( F(1,25)=11.79, p<0.001 \), indicating that overall performance was higher for explanation questions (\( M=1.84 \)) than for prediction questions (\( M=1.3 \)). For the behavior vignettes this was not the case; overall performance for explanation questions (\( M=1.27 \)) was somewhat higher than for prediction questions (\( M=1.19 \)) but not significantly so, \( F(1,25)=0.10, \) ns. Clearly, however, explanation accuracy on behavior vignettes was no lower than prediction accuracy, in spite of the fact that to be scored as correct, children had to articulate a sensible connection between contamination or temperature and the outcome and could not provide a correct response by merely choosing one of two options (as they could for the prediction tasks).

Individuals’ response patterns provide an important complementary analysis to these parametric findings. Overall we coded children as either consistently correct on the explanation vignettes (4 of 4) or not, and as consistently correct on the prediction vignettes (4 of 4) or not. Fifteen of 26 children (58%) were consistently correct on explanation vignettes, whereas only 7 of 26 (27%) were consistently correct on prediction vignettes. This difference is best examined by considering those children (\( N=11 \)) who were consistently correct on one type of vignette or the other (explanation or prediction) but not both. Of these, 10 were correct at explanation but not prediction, only 1 showed the reverse pattern; McNemar’s \( \chi^2(1)=5.82, p<0.05 \).

To examine illness versus behavior responses separately, we coded children as either consistently correct on the illness explanation vignettes (2 of 2) or not, and as consistently correct on the illness prediction vignettes (2 of 2) or not. Twenty-two of 26 children (85%) were consistently correct on illness explanation vignettes, whereas only 12 of 26 (46%) were consistently correct on illness prediction vignettes. Statistically this difference is best examined by
considering those children \((N=12)\) who were consistently correct on one type of vignette or the other (explanation or prediction) but not both. Of these, 11 were correct at explanation but not prediction, only 1 showed the reverse pattern; McNemar’s \(\chi^2(1)=5.82, p<0.05\). Similarly, we coded children as either consistently correct on the behavior explanation vignettes (2 of 2) or not, and as consistently correct on the behavior prediction vignettes (2 of 2) or not. 15 of 26 children (58%) were consistently correct on explanation vignettes, whereas 14 of 26 (54%) were consistently correct on prediction vignettes. Considering those children \((N=11)\) who were consistently correct on one type of vignette or the other (explanation or prediction) but not both, 6 were correct at behavior explanation but not prediction, 5 showed the reverse pattern; McNemar’s \(\chi^2(1)=1.00, \text{ns.}\)

These data show that Chinese children’s explanations were easily as accurate as their predictions, and even suggest an explanation advantage for Chinese preschool children in response to illness phenomena. To provide an alternate and arguably more conservative (but potentially less culturally-attuned) examination, in an additional analysis we considered only contamination explanations as correct. A task (explanation vs. prediction) x vignette (behavior vs. illness) repeated measures ANOVA examining the number of correct responses yielded a nonsignificant main effect for task, \(F(1,25)=0.02, \text{ns}\), indicating that overall performance was not lower but also not higher for explanation questions than for prediction questions. Even with this more conservative analysis, children’s performance on the explanation tasks was at least as accurate as their performance on the prediction tasks.

**Comparing Performance on Explanation and Prediction Tasks between American and Chinese Preschool Children**

The following analyses take advantage of our using nearly identical materials and methods with Chinese children’s as used by Legare et al. (2009) in a parallel sample of 4-year-old U.S. children \((N=36)\). (Our use of one coder who had coded the original US explanations to code the translated Chinese explanations as well, also helped insure nearly identical methods for this analysis.) The content of American and Chinese children’s explanations were first compared and two clear differences emerged. Temperature explanations for illness were culturally specific; none of the American children provided temperature explanations whereas many Chinese children did (11 out of 26 or 42%). Temperature explanations apparently competed with contamination explanations as both being acceptable bio-medical explanations for Chinese children, because complementarily, a one-way ANOVA indicated that American children provided more contamination explanations overall \((M=3.5, \text{SD}=1.2)\) than Chi-
nese children \((M=2.5, SD=1.5)\), \(F(1,61)=6.62, p<0.01\). However, contamination explanations remained the predominant explanation given by children in both locales (63% of all explanations in China and 88% of all explanations in the U.S. were contamination explanations). Furthermore, both American and Chinese children often went beyond contamination explanations to provide contamination mechanism explanations. A one-way ANOVA indicated that there were no differences in the number of contamination mechanism explanations provided overall by American \((M=2.5\) out of 4, SD=1.72) and Chinese children \((M=1.92\) out of 4), SD=1.47), \(F(1,61)=1.41\), ns.

Beyond this emphasis on contamination, there were other similarities. No child in either sample explained an item by mere restatement; Chinese children, just like their American counterparts, always included additional causal information in their explanations. Similarly, a one-way ANOVA indicated that there were no differences in the number of psychological explanations provided overall by American \((M=0.46, \text{SD}=0.78)\) and Chinese children \((M=0.88, \text{SD}=0.91)\), \(F(1,61)=3.15\), ns, and no differences in the number of other-bodily explanations provided overall by American \((M=0.21, \text{SD}=0.66)\) and Chinese children \((M=0.19, \text{SD}=0.49)\), \(F(1,61)=0.01\), ns.

If we consider temperature explanations as accurate for Chinese children, then children in both samples were equally accurate in their explanations and in their predictions. This was apparent in a task (explanation vs. prediction) \(\times\) vignette (behavior vs. illness) repeated measures ANOVA with country (China vs. U.S.) as a between subjects factor on the number of correct responses. For this analysis both temperature and contamination explanations were coded as correct (however, American children provided no temperature explanations). Notably, there was no significant main effect for country, \(F(1,60)=0.09\), ns, indicating that overall Chinese and American preschool children performed equally well across tasks. There was also a significant main effect for vignette, \(F(1,60)=14.80, p<0.001\); performance was more accurate on the illness vignettes (collapsing across explanation and prediction) than on the behavior vignettes. There was also an intriguing significant main effect for task, \(F(1,60)=22.07, p<0.001\), indicating that overall performance was higher for explanation questions \((M=3.28\) out of 4) than for prediction questions \((M=2.4\) out of 4).

The task \(\times\) vignette, task \(\times\) country, and vignette \(\times\) country interactions were not significant; however, the task \(\times\) vignette \(\times\) country interaction was, \(F(1,60)=7.26, p<0.01\). Posthoc tests indicated that performance on the behavior explanation vignettes was higher for the American \((M=1.75)\) than the Chinese \((M=1.27)\) preschool children, \(p<0.05\). Although there were no differences across these samples in providing psychological explanations (which were infrequent overall), for the behavior explanation vignettes specifically, Chinese children
gave relatively more psychological explanations (54% provided at least one psychological explanation) than American children did (29% provided at least one psychological explanation).

Discussion

Our data provide evidence for several key findings. First, the sophistication of Chinese children’s biological explanations for contamination and illness parallels earlier work with American preschool children. As with American children, Chinese children’s explanations provide evidence for a generative ability to reason about contamination by invoking constructs never mentioned in the study protocol (e.g., dirt) and recruiting biological processes (e.g., contamination, contagion, ingestion, illness) and entities (e.g., germs, virus, poison, dirt, dust) appropriately and specifically to explain novel contamination events. Given the structure of our explanation tasks, it would be especially easy for children to “explain” by simply restating information that was provided in the vignettes. However, no child ever responded to the explanation stories merely by restating the story event. Moreover, because the stories explicitly mentioned preferences, favorites, and likes as well as obviously likable things (candy), children might easily explain the outcome-events in terms of psychological phenomena, such as desires, preferences, and intentions. Some have proposed that children’s initial understanding of biological phenomena is framed in terms of psychological rather than biological processes (Carey, 1985). However, children’s mention of contamination explanations vastly outnumbered their psychological explanations, across both illness and behavior vignettes.

Although there is a lack of consensus in the literature over what constitutes a genuinely “biological” explanatory mechanism (Au and Romo, 1999; Kalish, 1999; Solomon and Cassimatis, 1995), following from Legare and colleagues (2009) we use the term mechanism to refer to an unobserved, inferred link whereby an observed cause produces an observed effect. Notably, this definition does not require that Chinese (or American) preschool children have a scientifically-based understanding of bacteria, germ propagation, or biochemical processes of nutrient uptake.

A contamination mechanism further refers to causes with distinctively bodily “active ingredients” (e.g., “germs”, “dirt”) rather than distinctively psychological contents (e.g., preferences). The mechanism is still more elaborate if it mentions some sort of transfer of those active ingredients (e.g., “The germs are spread by the fly. Germs are most dirty. He drank the germs into his tummy”). To elaborate, contamination mechanism explanations made use of unobservable entities (e.g., “fly germs”, “leaf poison”, “dirty saliva”, “toxic gas”), none of which were mentioned or depicted in the scenarios we
provided. Children’s contamination mechanism explanations also often mentioned inferred methods of transmitting contaminants. For example, a 4-year-old explained, “The fly came in, and there are germs on the flies” and another stated, “The leaf on the ground was dirty and when it fell into it, germs are left inside.” The prevalence of contamination mechanism explanations is compelling from a theoretical perspective because they included many inferred and imperceptible features to explain observable outcomes (Au et al., 1993; Rosen and Rozin, 1993). Explanations of this kind indicate that children inferred particulars that extended beyond anything visible or mentioned in the vignettes, thereby providing evidence for a sophisticated, early-developing belief system about contamination. Thus, these data provide evidence for the robustness and sophistication of young children’s explanations even in a cultural context in which childhood explanation is less emphasized by parents and early childhood educators than in Euro-American, middle-class populations.

Second, our data inform our understanding of early biological reasoning among Chinese children by providing evidence for the recruitment of culturally-specific biological explanations for illness. In particular, temperature explanations were given frequently to explain illness, especially when “cold” food was consumed. Although we did not undertake a formal count of the pieces of causal information children provided in their temperature explanations, clearly many explanations of this kind were also expansive in that they mentioned several discrete but connected causal points and ideas. For example, as one 4-year-old explained, “She got sick because of the cold of the yogurt because it [the yogurt] was put in the refrigerator. And the yogurt was also blown cool by the wind.” Another explained that, “Eating ice cream is too cold. Cold will cause sickness and will cause coughing”. Informally, it is clear that these examples include multiple separate pieces of causal information. As in the case of children’s biological mechanism explanations, children’s temperature explanations recruited concepts and processes never mentioned in these task-vignettes. Moreover, these explanations are unlikely to exclusively reflect mere repetition of information provided previously by parents or others (e.g., common adult expressions such as “qi” were never mentioned explicitly, although children frequently referred to temperature-related factors in their own words and via terms such as “cold”).

The prevalence of temperature explanations for illness provided by Chinese preschool children extends work by Inagaki and Hatano (2004) with Japanese preschool children on vitalistic reasoning in everyday biological reasoning. Our research also demonstrates the prevalence of early-developing, yet culturally-specific explanations that are nonetheless distinctly biological (as opposed to psychological). We identify a form of childhood biological reasoning, a naïve theory of temperature that, like vitalism in the Japanese context, is empha-
sized in the Chinese context. We propose that our data provide converging evidence for the importance of both culturally-specific biological beliefs but also demonstrate that naïve biological ideas about contaminants and transfer of substances is likely a universal feature of early-developing naïve biology, even in cultural contexts such as China in which temperature beliefs feature prominently as part of biological belief systems. As yet, little is known regarding how general constructs versus specific events, adult input and socialization, and other factors contribute to the development of causal understanding including contamination sensitivity. However, the content of children's explanations, especially explanations that appeal to culturally-specific content (i.e., temperature) and creative embellishments suggest an important role for their own productive inferences in constructing biological knowledge. And suggest ways to study these key issues by further examining children's explanations.

The final intriguing finding is that Chinese preschool children's explanations were as accurate (and in some cases more so) than their predictions, consistent with the findings of Legare and colleagues (2009) with American preschool children. This provides preliminary support that recent research with American preschool children demonstrating that in some core domains of understanding – such as naïve psychological and biological reasoning – children's explanations sensitively reveal their understanding and can do so more informatively than predictions or judgment tasks (Amsterlaw and Wellman, 2006; Legare et al., 2009) may extend to cultural contexts in which childhood explanation is less pervasive and less encouraged by caretakers.

Because explanations require the child to recruit and articulate additional processes and understandings, it is surprising that young children could be as accurate at providing them as when merely choosing one response choice among two. What could account for the relative ease and accuracy of childhood explanations? One issue to consider is methodological and concerns how to compare predictions and explanations. In particular, it is not clear exactly how best to statistically compare explanation and prediction data in terms of accuracy. For example, children could provide a great many possible explanations for the events we presented to them (and indeed they did provide five distinct categories of explanations). Thus, the baseline probability of providing any one category of explanation by chance alone must be very small. For the prediction tasks, however, children made binary judgments, so that chance alone provided a 50% opportunity of being correct. These differing baselines complicate precise comparisons. However, in the analyses above our approach was straightforward and conservative; we compared the response proportions regardless of baseline chance responding (both with and without culturally-specific temperature explanations). Doing this works against accurate performance on the explanation task. Nonetheless, it is clear that explanations were
no less accurate than predictions for these Chinese children; this was true for
the U.S. children in Legare et al. (2009) as well.

A more substantive possible factor is that a request for explanation often
includes an additional piece of relevant information over a request for pre-
diction, namely information about the outcome (Wellman and Liu, 2007). For
example, in our explanation tasks the child respondent knew who got sick (the
outcome) but in the prediction tasks that was exactly what must be predicted.
Thus, in philosophy of science, predictions are usually assumed to be more dif-
ficult, and a theory receives considerably more credit for predicting phenom-
ena in advance rather than simply explaining them after the fact (Kuhn, 1962).
This does not mean that explanations are easy, nor artifactually transparent,
because to be correct children had to use the outcome information to provide
an articulate answer based on processes and entities not explicitly provided to
them by the outcome or the task. However, this conceptual analysis does sug-
gest how explanations might helpfully scaffold children’s best thinking about
the events.

Our data are thus consistent with the possibility that explanations may
play a central role in the development of knowledge acquisition and do so
across diverse cultural contexts. By helping children recruit accurate and com-
plex reasoning, explanations could prompt enhanced understanding and so
provide a platform for enhanced development. Moreover, the nature of the
explanations observed in both Chinese and American preschool children, in
appealing to unobserved explanatory entities and processes, would potentially
be important for learning of the sort described by a naïve theory perspective
on cognitive development. To the extent that explanations appeal to theoreti-
cal unobservables, they engage children in the important interplay between
data and theory that leads to theory change. Our studies were not designed to
investigate explanation-based mechanisms for causal learning, but given our
results, this becomes an important topic for further research. Indeed, there is
mounting evidence that children’s causal explanations may in fact constitute
a unique mechanism for advancing causal learning (Wellman, 2011) and the
acquisition of knowledge (Callanan and Oakes, 1992; Chi et al., 1994; Legare
et al., 2010; Legare, 2012).

In sum, we propose that examining young children’s explanations cross-
culturally provides uniquely informative insights into the development of
causal reasoning. In the current study, explanations provided important entry
into children’s naïve biological reasoning, the sort of causal reasoning that
informs their judgments and predictions about everyday biological events
(and the sorts of deeper reasoning that may even lead their judgments and
learning developmentally). These advantages of examining young chil-
dren’s explanations more carefully and systematically held even for Chinese

...
children, a group chosen because explanations and explanatory reasoning is a less pervasive feature of child-caretaker interactions than in U.S. populations. Data from Chinese children’s explanations provide evidence for both the universality of early-developing, naïve biological reasoning and the cultural specificity of particular kinds of biological beliefs (e.g., temperature) about contamination and illness.

References


Appendix A. Vignettes

Illness Prediction 1
There are two boys, one named Dongdong, one named Lele. They are sitting outside eating. Dongdong has a lemon candy, Lele has a strawberry candy. A fly comes by, looks at Dongdong’s lemon candy, then goes away. A dog comes by and clicks Lele’s strawberry candy, then runs away. Dongdong eats the lemon candy, Lele eats the strawberry candy. Who eats the lemon candy? Who eats the strawberry candy? The next day someone gets sick. Who do you think gets sick?

Illness Prediction 2
There are two girls, one named Sisi, one named Yanyan. They are sitting outside eating. Sisi has a chocolate pie, Yanyan has a yolk pie. Then Sisi’s chocolate pie slips off the table onto the ground. Sisi picks it up, then puts it back on the table. A dog runs by, he looks at Yanyan’s yolk pie, then runs away. Sisi eats the chocolate pie, Yanyan eats the yolk pie. Who eats the chocolate pie? Who eats the yolk pie? The next day someone gets sick. Who do you think gets sick?

Behavior Prediction 1
A girl’s name is Pingping. Pingping likes to drink chocolate milk. Chocolate milk is Pingping’s favorite thing to drink. Pingping also likes plain milk, but comparing the two, Pingping likes chocolate milk more. What kind of drink does Pingping like the most, chocolate milk or plain milk? Pingping is sitting outside. Mom brings a glass of chocolate milk and a glass of plain milk. It is windy outside and an old brown leaf blows into the glass of chocolate milk. Pingping takes the leaf out. Pingping can drink the chocolate milk; she can also drink the plain milk. Which one should Pingping drink, the chocolate milk or the plain milk?

Behavior Prediction 2
A girl’s name is Tingting. Tingting likes to eat chocolate cookie a lot. Chocolate cookie is Tingting’s favorite cookie to eat. Tingting also likes cream cookie. But comparing the two, Tingting likes chocolate cookie more. Which does Tingting like more, the chocolate cookie or the cream cookie? Tingting is sitting outside, her mom brings a chocolate cookie and a cream cookie, and puts them on the table. Then, the chocolate cookie slips off the table onto the ground. Tingting picks it up, puts it back on the table. Tingting can eat the chocolate cookie, or the cream cookie. Which one should Tingting eat, the chocolate cookie or the cream cookie?
Illness Explanation 1

There are two boys, one named Tongtong, one named Nannan. They are sitting outside eating. Tongtong has a box of milk ice cream, Nannan has a box of strawberry ice cream. A fly lands in Tongtong's ice cream. It flies away after a minute. An old brown leaf blows next to Nannan's strawberry ice cream, then the leaf blows away. Tongtong eats the milk ice cream, Nannan eats the strawberry ice cream. Who eats the milk ice cream? Who eats the strawberry ice cream? The next day, Tongtong gets sick. Why do you think Tongtong got sick? Are there other reasons?

Illness Explanation 2

There are two boys, one named Niuniu, one named Feifei. They are sitting outside eating. Niuniu has a cup of peach yogurt, Feifei has a cup of strawberry yogurt. Niuniu puts his peach yogurt next to him on the ground. Then, he puts his yogurt back onto the table. An old brown leaf blows into Feifei's yogurt. Feifei takes the leaf out. Niuniu drinks the peach yogurt, Feifei drinks the strawberry yogurt. Who drinks the peach yogurt? Who drinks the strawberry yogurt? The next day, Feifei gets sick. Why do you think Feifei gets sick? Are there any other reasons?

Behavior Explanation 1

A boy's name is Yangyang. Yangyang likes to drink grape juice a lot. Grape juice is Yangyang's favorite juice to drink. Yangyang also likes to drink apple juice. But comparing the two, Yangyang likes grape juice more. Which kind of juice does Yangyang like more, the grape juice, or the apple juice? Yangyang is sitting outside. His mom pours a glass of grape juice and a glass of apple juice. Then a fly lands in the grape juice. After a minute, it flies away. Yangyang can drink the grape juice, or the apple juice. Yangyang decides to drink the apple juice. Why did Yangyang drink the apple juice? He really likes grape juice, but why did he drink the apple juice? Are there any other reasons?

Behavior Explanation 2

A boy's name is Duoduo. Duoduo likes to eat lollipops a lot, lollipop is Duoduo's favorite thing to eat. Duoduo also likes to eat grapes. But comparing the two, he likes lollipops more. Which one does Duoduo like more, lollipops or grapes? Duoduo is sitting at a bench in a park. He has a lollipop and a bunch of grapes besides him. Then a dog runs by, licks the lollipop, then runs away. Duoduo can eat the lollipop, or the grapes. Duoduo decides to eat the grapes. Why did Duoduo eat the grapes? Duoduo really likes to eat lollipops, but why did he eat the grapes? Are there any other reasons?