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Vitalistic causality in young children's naive biology

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One of the key issues in conceptual development research concerns what kinds of causal devices young children use to understand the biological world. We review evidence that children predict and interpret biological phenomena, especially human bodily processes, on the basis of 'vitalistic causality'. That is, they assume that vital power or life force taken from food and water makes humans active, prevents them from being taken ill, and enables them to grow. These relationships are also extended readily to other animals and even to plants. Recent experimental results show that a majority of preschoolers tend to choose vitalistic explanations as most plausible. Vitalism, together with other forms of intermediate causality, constitute unique causal devices for naive biology as a core domain of thought.

A growing number of researchers on conceptual development have argued that young children possess bodies of knowledge about important aspects of the world. They assume that such bodies of knowledge often constitute naive 'theories' containing ontological distinctions, coherent organizations among pieces of knowledge, and causal devices as essential components [1]. Several studies have shown that by about 6 years of age children have acquired at least three core domains of thought: naive physics, naive psychology (or theory of mind), and naive biology (e.g. [2]). Moreover, young children apply these theories differentially to human behaviors (e.g. [3]). Considering that human beings are a distinctly social species, use objects as tools as well as inhabit the physical world, and possess physiological bodies that must be fed and kept healthy, it may be plausible that children are endowed with capabilities to construct naive theories about physical, psychological, and biological phenomena early in life and universally across cultures.

These naive theories arguably possess characteristic causal devices, in other words, for predicting and interpreting the target phenomenon, even young children can consistently rely on relevant preceding events or properties and sometimes even verbalize in part the mediating processes. Assuming that children's understanding of psychological phenomena is based on intentional causality which refers to the protagonist's mental states whereas that of physical phenomena on mechanical causality embodied as physical principles, what kind of causality do they rely on when trying to explain biological phenomena? Several investigators have recently proposed that young children might rely on types of causalities other than mechanical and intentional causalities, such as teleology, essentialism and vitalism, for explaining entities, properties, and phenomena in the biological world (e.g. [4]). In this article we focus on vitalism, and discuss the roles that vital power plays in young children's understanding of biological functions. In the final section we relate notions of vitalism to other forms of intermediate causalities.

How vitalistic causality operates

The notion of vitalistic causality in naive biology was first proposed by Inagaki and Hatano [5] as a form of causality between intentional and mechanical causalities, which is somewhat similar to the Japanese endogenous science before Japan's rapid modernization. For bodily and other biological processes and properties, intentional causality means that a person's mental states cause the target phenomenon, whereas mechanical causality means that physiological and biochemical mechanisms cause the phenomenon. By contrast, in vitalistic causality the target phenomenon is attributed to the workings of vital power, which can be conceptualized as unspecified substance, energy, or information for maintaining and enhancing life. Vital power in children's naive biology is supposed to play a few different roles to enhance life – unlike fuel or electricity for complex machines, it enables living things to grow and maintain health as well as to be vigorous and active.

Vitalistic causality presupposes that internal processes in living organisms are governed by different laws from those of physics and chemistry that are valid for non-living entities, and is applied only to living things. Human minds interpret behaviors of humans and other living entities differently from those of non-living things (e.g. [6,7]). For example, infants differentiate between an inanimate object motion and human action (e.g. [8,9]), and preschool children give different causal explanations for animate versus inanimate things, or living versus non-living things (e.g. [10–12]).

With regard to the workings of vitalistic causality, we assume the following three principles. First, young

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children believe that vital power is taken in from the outside, and the major sources are food and water. The process of inducing vital power from food/water is so slow that children might feel as if it emerged from inside. In more elaborated forms of vitalism, some additional sources are included; for example, air (taken through breathing) and other people's vital power (taken through sympathy). However, in young children's biology food and water are far more salient than other sources.

Second, in young children's naive biology the activity of bodily organs is considered for the goal of maintaining life [13,14] and vital power or life force is taken essential for this activity. More specifically, vital power makes living things alive and lively, prevents them from being taken ill, and enables them to grow. These three clusters of bodily phenomena are causally connected to vital power taken from food and water (see Figure 1). Young children's vitalist biology, unlike sophisticated versions of vitalism developed by famous Eastern scholars such as Shoeki Ando (1703–1762), leaves many other biological phenomena unexplained.

Third, vitalist biology is primarily about human bodily processes in industrialized societies, although this human-centered tendency may be weaker in societies where folks are familiar with non-human animals and plants [15,16]. However, the relationships among the human bodily phenomena described in Figure 1 can readily be applied to non-human animals that also possess bodies. The relationships may be applied to plants as well, because the relationship between food and animals can promptly be mapped to that between plants and water, partly owing to young children's lack of understanding of photosynthesis. To put it differently, as shown in Box 1, young children group together animals and plants based on vitalism about human bodily processes.

Young children's understanding of biological functions of ingesting food and water

Studies to date have indicated that, when asked to choose one from several explanations presented, young children prefer vitalistic explanations for bodily phenomena. As shown in Box 2, for example, pre-school children chose vitalistic explanations as most plausible most often. This was observed among not only Japanese children but also

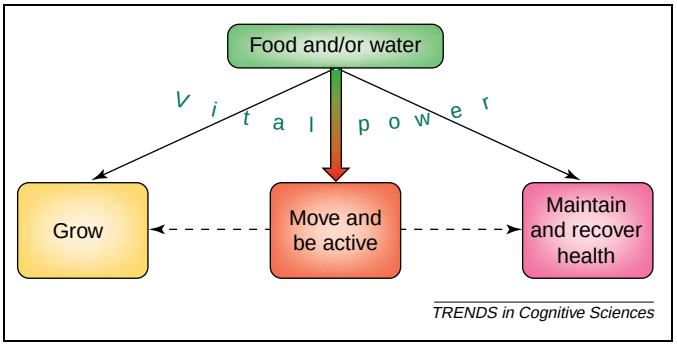

Figure 1. Relations among core bodily phenomena. Vital power taken from food/water primarily enables humans to move and be active (as shown by thick arrow). Beyond that, extra vital power is used for growing, and the more vital power, the more likely humans are to maintain and recover health.

Box 1. Animals and plants are put together based on vitalistic causality

The living/non-living distinction, or recognition of commonalities between animals and plants, which are perceptually so different, is one of the important elements constituting naive biology differentiated from naive psychology, because this means that living things are not treated just as behavioral beings. Young children can aptly project biological properties that humans share with other animals and plants, if the properties are phrased appropriately, especially when the information indicating biological functions of the properties are given [50]. More specifically, vitalistic account of the human properties described in general terms helps them recognize that humans, nonhuman animals and plants share some commonalities, and thus all three belong to the higher-order category of living things.

In an inductive projection experiment with 5-year-old children, two experimental conditions were set [21]; in the 'context' condition children were given short, vitalistic descriptions about the function of the target property for a person, whereas in the 'no-context' condition they were not given such descriptions. There were nine target objects, three each from the animal, plant, and non-living thing categories.

Example descriptions are as follows (the words in italic were given only to the children in the context condition):

- Grows: a person becomes bigger and bigger, *by taking in energy from food and water*. Well, does X become bigger and bigger?
- Needs food/water: a person needs water and/or food. *If he does not take in energy or vital power from water and/or food, he will die*. Well, does X need water and/or food?
- Is taken ill: a person is sometimes taken ill, *because his energy or vital power is gradually weakened when he feels too cold or too hot*. Well, is X sometimes taken ill?

The children's responses showed that they appropriately extended the essential biological properties of growing, needing food/water, and being taken ill from humans up to plants, especially in the context condition (Figure I). This suggests that young children consider both animals and plants to be biological entities with the same underlying mechanisms as humans, based on vitalistic causality.

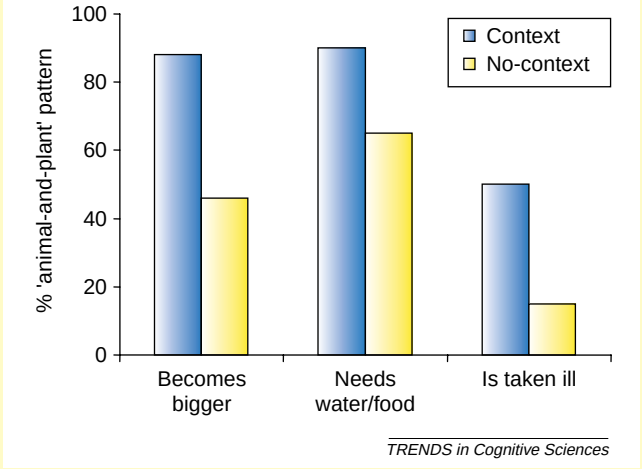

Figure I. Occurrence of 'animal-and-plant' patterns assigned by 5-year-old children [21,12]. The 'animal-and-plant' pattern means assigning the target property to both animals and plants, but not non-living things. The children, especially in the context condition, appropriately extended the essential biological properties of growing, needing food/water, and being taken ill from humans up to plants; they showed animal-and-plant patterns at high rates. Adapted from [12] with permission of Psychology Press.

Australian [17] and American children [18]. Although mechanical explanations came to be chosen with increasing age, a substantial portion of college students still preferred vitalistic explanations.

Box 2. Young children's preference for vitalistic explanations

Inagaki and Hatano [4] investigated whether young children would prefer vitalistic causal explanations to intentional ones for bodily phenomena, even though they were not prepared to offer mechanical causality spontaneously. The children were presented with three possible causal explanations (intentional, vitalistic, and mechanical) for each of six bodily phenomena (e.g. eating, breathing, blood circulation) and asked to choose one from the three. The intentional explanation ascribed the phenomenon to the mental states of the person owning the body. The vitalistic explanation explained the phenomenon by referring to a relevant bodily organ's active and/or effortful engagement in activity, which is the giving and/or taking of unspecified material, energy or information (vital force). The mechanical explanation was the children's version of scientific (physiological) causation, and was constructed by consulting an illustrated reference book on the human body written for primary school children.

What follows are examples of questions. (In the original Japanese language, the three alternatives had about the same length):
(1) **Why do we eat food every day?**
Intentional: *Because we want to eat tasty food.*
Vitalistic: *Because our stomach takes in vital power from the food.*
Mechanical: *Because we take the food into our body after its form is changed in the stomach and bowels.*
(2) **Why do we take in air?**
Intentional: *Because we want to feel good.*
Vitalistic: *Because our chest takes in vital power from the air.*
Mechanical: *Because the lungs take in oxygen and change it into waste carbon dioxide.*

The results clearly showed that young children preferred the vitalistic explanation most often, whereas older children, and particularly adults, shifted to a preference for the mechanical explanation most often (Figure I). This pattern was also seen in a replication study with Australian participants, showing that it is not culturally dependent. However, some adults (college students) still preferred the vitalitic explanation, suggesting that vitalistic causality continues to work as a basis for understanding some biological phenomena, perhaps to be used in situations where people are not required to give precise and detailed answers based on scientific knowledge about the specific mechanisms.

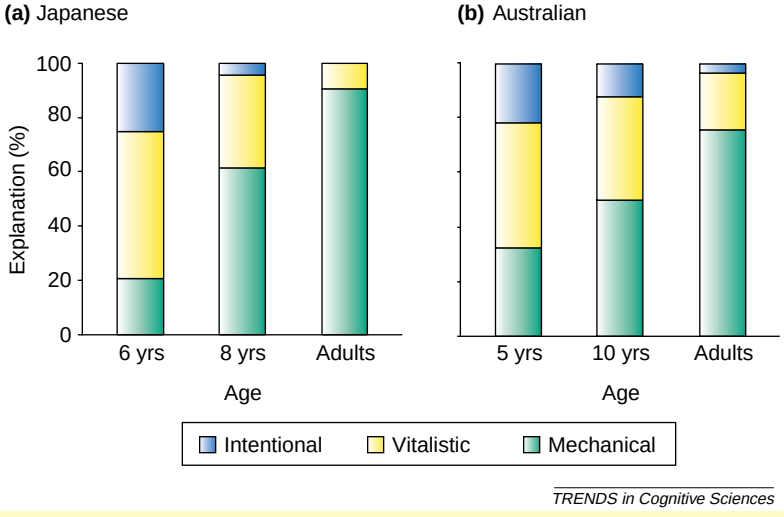

Figure I. Average percentages for three types of causal explanations for six bodily phenomena (e.g. eating, breathing, blood circulation). **(a)** Results of the original study with Japanese participants [5]. **(b)** Results of the replication study with Australian participants [17]. The 6-year-olds in (a) and the 5-year-olds in (b) were both kindergartners. A clear and significant shift in the preferred mode of causal explanation was observed: young children chose the vitalistic explanation as most plausible most often, and as age increases, participants came to choose the mechanical explanation most often. However, some adults (college students) still preferred the vitalitic explanation, suggesting that vitalistic causality continues to work as a basis for understanding some biological phenomena. (a) Adapted from [5] with permission of the Society for Research in Child Development. (b) Data constructed from Table 1 in [17], with permission of the authors.

To determine whether young children can generate vitalistic explanations as well as make predictions based on vitalistic causality, Inagaki and Hatano gave 5- and 6-year-old children six prediction questions followed by justification questions [12]. The questions concerned eating, relationships between eating and living long, susceptibility to illness, and recovery from an injury, and two other important bodily phenomena, breathing and working of the heart. They were mostly about novel situations with which young children were unlikely to have any direct experience (see Box 3 for the questions and children's responses). For the eating question, almost all the children predicted that a person would die if he ate nothing day after day. About a half of the 6-year-olds gave explanations referring to the lack of energy or nutriment. When asked to define the word 'nutriment', many of the 6-year-olds paraphrased it with their own words representing vital power, such as, '*It's what makes the body active*', '*It gives us power*', '*It is something like the source for becoming vigorous*', and so on. For the 'grandgrandpa's living long' question, a large majority (85%) of the 6-year-olds predicted, consistently with vitalistic causality, that eating much would make the grandpa live long, and one-third of them justified their predictions in terms of vital power. For the six questions, 70% of the 6-year-olds (30% of the 5-year-olds) gave at least one explicitly vitalistic explanation that included a word referring to 'power', 'energy', 'vigor', or unspecified substance (e.g. '*something good for the body*'). The 6-year-olds' vitalistic explanations occupied 61% of their comprehensible justifications for those questions.

In sum, a substantial ratio of the 6-year-olds gave vitalistic predictions and explanations for eating and other related bodily phenomena; they tended to consider

Box 3. Examples of children's vitalistic explanations for bodily phenomena

Below are some examples of the children's responses to questions given in the study by Inagaki and Hatano [12]. The child's age in each case is given by the numbers in parentheses (years;months). Further questions by the experimenter are denoted by E:

(1) **What will happen, if you eat nothing day after day?**

Boy (6;5) *If we don't eat food, we lose energy and die.*

Girl (6;4) [If we eat nothing] *we shall die, because there is no nutriment inside the body*.....[E: What does nutriment do inside the body?] It may give us power…although *I am not sure.*

(2) **Taro's grandpa is old and now 80 years old. Does he live long, say until becoming 100 or 200 years old, if he eats much?**

Boy (6;9) *Probably he can live long. 'Cause power comes out from eating food.*

Boy (6;7) [If the grandpa] *has the nutriments*, [he] *may live long*.....[E: what is the nutriment?] *It is something good for the body*.....[E: What does the nutriment do inside the body?] *It makes the body not dull.*

(3) **Haruko always eats a little, while Akiko eats much. When cold is going around, who is more likely to catch cold?**

Girl (6;4) *The child eating little is easy to catch cold. 'Cause power doesn't come out from eating little.*

Girl (6;10) *Because the child eating little doesn't have something to get rid of the cold.*

Boy (6;10) *Germs are in the air, aren't they? If the child has little nutriment, germs enter through the screen in her throat.*

(4) **Natsuko got her leg injured in a traffic accident. Does she recover quickly from her injury, if she eats much?**

Boy (6;5) *If the nutriment in the tummy travels to her leg,* [she] *may recover*.....[E: What is the nutriment?] *It makes the tummy healthy.*

Girl (6;9) *Yes… 'Cause nutriment is sent to different parts. The nutriment comes out from the tummy.*

(5) **What will happen with a person, if she doesn't breathe for hours?**

Girl (6;10) *She will feel bad and fall down, and die*.....[E: Why?] *If she doesn't breathe, she cannot take in air, so she will feel bad and die*.....[E: What does the air do inside the body?] *It makes her feel good…I think.*

(6) **What will happen with the heart, after a person has run?**

Girl (6;4) [The heart] *beats fast*.....[E: Why does her heart work hard after she has run?] '*Cause* [she] *uses energy for running, it has to work hard.*

that energy or power taken in through eating would help people live long, resist to be taken ill, and recover quickly even from an injury. It is also reported in other studies [19–21] young children believe that eating causes human growth and both animals and plants do not grow if they are fed or watered only little. One of the participants said, when asked whether we could keep a baby in the same size forever, '*No, we can't, because he takes food. If he eats, he will become bigger and bigger and be an adult.*' [19].

Although living things becoming vigorous by taking vital power from food/water is analogous to the functioning of complex artifacts (e.g. cars, vacuum cleaners) by input of energy from the outside, studies to date indicate that 6-year-old children distinguish these two processes in terms of speed and spontaneity. Whereas machines 'recover' immediately from malfunctioning states when energy is supplied to them, the spontaneous recovery of living things takes some time. Children also give explanations in terms of the emergence of power/vigor from taking in food for humans and non-human animals, such as '*Power/vigor comes out* [from eating food]', whereas they seldom give such explanations for the complex artifact (e.g. car); instead they give either no explanation or explanations referring simply to the working of energy, such as '*The car moves by energy of gasoline/by electricity.*' [12].

Vitalism applied to illness causality

A person's falling ill can be explained in several different ways, because diseases usually involve the interplay of multiple factors [22]. Vitalistic explanations of disease seem to be a variant of the imbalance theory assuming that disease is caused by an imbalance of a person's humors or other bodily constituents [23], an alternative to the germ theory assuming that germs are always involved in the etiology of disease. Many Western researchers who are strongly influenced by the germ theory have examined young children's understanding of microbes as causes of illnesses [24–28], and tended to ignore the role of susceptibility to illness in determining whether a person gets sick. Vitalist versions of the imbalance theory assume that a human body full of vital power is unlikely to be taken ill, even when its owner comes in contact with a person suffering from the illness. Although the imbalance theory has not developed very much in Western cultures, it has prevailed in East Asia. Even nowadays many East Asians believe that, the more imbalanced a person's diet, or the more irregular his or her daily routines, the more susceptible he or she is to illness.

In a series of studies (reviewed in [29]) children aged 4–6 years were presented with a pair of drawings of two boys, who were allegedly different in terms of biological/bodily (e.g. imbalanced diet or insufficient fresh air) or psychological/social factors (e.g. misbehaviors) in their daily activity, and asked which of the two was more likely to catch cold. Results indicated that a majority of the children in each age group chose often, as being more likely to catch cold, the boy who engaged in biologically bad activities. Although the 4- and 5-year-olds could give few reasons for their choices, about half of the 6-year-olds justified their responses to the items of eating a little or eating few vegetables, such as, '[A boy who has] *little nutriment does not have energy, so germs easily enter his body*' or '*When this boy X eats a lot, his throat is full of nutriment. This boy Y eats little, so his throat is not full of nutriment, and so the coughing can pass through his throat.*' Because the choice patterns of the 4- and 5-year-olds were very similar to those of the 6-year-olds, we can surmise that the younger children would consider that a lack of energy or vital power is likely to make children susceptible to illness.

The results also indicated that these children believed that social/psychological factors would influence susceptibility to illness. A majority of the 6-year-olds as well as the 4- and 5-year-olds similarly answered that the boy who misbehaved was more likely to catch cold than the boy who behaved well. These findings indicate that most of the children recognized that biological aspects of daily activities would affect one's susceptibility to illness through the accumulation or loss of vital power, but at the same time they believed that social/psychological factors also contributed to vital power. However, when forced to choose one between the biological and psychological factors, the

children evaluated the former factor more important than the latter for determining susceptibility to illness.

Relationships with teleology and essentialism

Although vitalism plays an important role in naive biology, not all 'biological' phenomena are explained by young children in terms of the vital power. Unlike prominent scholars in history, young children usually do not commit to a single type of causality. Thus, they use not only different explanations for different domains [3,4] but also multiple explanations within the domain of biology. More specifically, depending on types of phenomena, questions and contexts, young children rely on teleological or essentialist causality rather than vitalistic causality for predicting and explaining characteristics and behaviors of animals and plants [30]. (see Figure 2). In other words, teleological and essentialist causalities are complementary rather than competing notions with vitalistic causality in young children's naive biology [31].

Teleology is the view that any enduring property of an entity has some functions for it or for other related entities. Although young children often apply teleological causality indiscriminately [32], self-beneficial, goal-directed action is taken to characterize living things [33]. Especially, teleological-functional explanations for biological properties (such as proposed by [34]) have some common features with vitalistic explanations for biological phenomena. For example, when its version called life teleology is applied to bodily organs (i.e. they exist to sustain life), it provides vitalistic explanations with some foundation; the heart is to sustain life of its owner, and thus it works hard to send vital power with blood to all bodily parts so that they can be fine. We assume that, whereas vital power is basically for biological processes (bodily processes among others), teleology is primarily for parts or properties of the biological kind. Children's and lay adults' understanding of evolution is often teleological in the sense that animals' body parts or bodily properties have evolved '*in order to*' adapt to the ecological niches they lived [35]. Their understanding of workings of the body parts, however, can be vitalistic, in that they consider that body parts operate to take in and exchange vital power. The behaviors of living things can often be interpreted in teleo-vitalistic ways, that is, to sustain life by taking in and exchanging life force.

Psychological essentialism means a folk belief that there is the underlying essence for a set of observed facts; as long as this essence is preserved, the entity maintains its identity, and as long as the essence is shared, entities that are perceptually very different constitute a single kind [36,37]. An important aspect of essentialism is that it serves as a causal device – the essence gives rise to a set of those observable properties, for example, characteristic features of animals and plants [7,38]. It is clear that the naive-biological taxonomy presupposes essentialism [6]. It must be especially important in children's distinction between animals and artifacts [39,40], because even young children correctly recognize that animals alone possess essence inside their body that are endowed from their parents. We also speculate that when taxonomy, identity of an entity, or inheritance from ancestors to offspring is the target, or when a living thing's overt behaviors or characteristics are connected to its internal structures, explanations in terms of essentialism tend to be induced; by contrast, teleological and vitalistic causality is basically for explaining in a global fashion what functions those behaviors or characteristics have and how these functions are fulfilled.

Conclusion

Young children possess a considerable amount of biological knowledge [12,41]. Moreover, they use different causal devices when they predict and/or interpret bodily and other biological processes of living things from those

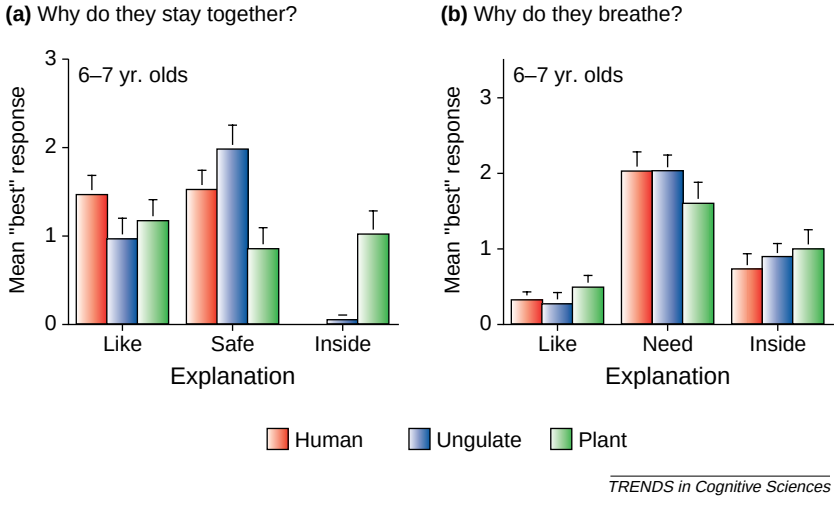

Figure 2. Patterns of explanation preference across properties and biological entities. 6–7-year-olds were asked to choose one explanation as the 'best' out of three possible explanations for a property relating to three biological entities (humans, ungulates, and plants). **(a)** Mean 'best' response (±standard error) for a neutral property question: '*Why do these X's stay together*?'; **(b)** for a biological property question: '*Why do these X's breathe*?'. The three possible explanations are: intentional (Like), '*They stay together because they like each other*'/'*They breathe because they like to breathe*'; teleological (Safe/Need), '*They stay together because they will be safe from danger*'/'*They breathe because their bodies need air to stay alive*'; essentialist (Inside), '*They stay together because of what they all have inside*'/'*They breathe because of what they all have inside*'. As shown, the children's choice of 'best' response (mean±standard error) depended on the type of question and biological category. (From the present authors' perspective, the teleological explanation for question (b) is equivalent to the vitalistic explanation.) Adapted from [30] with permission of the British Psychological Society.

used to explain the operation of artifacts and also for human intentional actions. They seem to understand behaviors of living things as directed to sustain life and adapt their potentiality to the environments. However, many issues concerning biological causal mechanisms remain. The origins of these causal mechanisms are not yet known, partly because there have been few studies on naive biology among infants and non-human animals (although the representation of goal-directed actions may be a precursor of teleo-vitalism [42,43]). We know very little about cultural and experiential influences on the development of teleology [44], essentialism [45], or vitalism [17], although several excellent cross-cultural studies have been conducted concerning biological categories and category-based reasoning [16,46–47]. And, in spite of recent rapid progress in brain imaging research, we have almost no understanding of the neural bases for these intermediate causalities that might align with those for intentional causality or mentalizing (for reviews, see [48,49]). With the goals of investigating the acquisition and change of coherent knowledge systems containing causal underpinnings, naive biology will continue to be a fascinating and demanding research area in coming decades [12,31].

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